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International Competition of
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BLACK SEA SCIENCE 2020

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Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2020

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НЕ ОРИГІНАЛ

1. FOOD SCIENCE AND TECHNOLOGIES

НТБ ОНАХТ

IMPROVEMENT OF FISH SNACKS TECHNOLOGIES WITH THE APPLICATION OF BIOTECHNOLOGICAL FAT REMOVAL

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Abstract. *The work contains research aimed at developing an enzymatic method for removing subcutaneous fat in fish snack technology. Based on the results of the research, a technological scheme for the production of snacks from small Azov-Black Sea fish was developed. The paper also describes the recipe and technology of freshwater fish snacks.*

Currently, fish snacks are popular with consumers. But in the conditions of fierce market competition the priority activity is the development of new raw materials, improving the taste characteristics of snacks and increasing the shelf life of finished products.

The most widespread industrial fish species of Ukraine that are caught in sufficient numbers there are Azov-Black Sea fishes Sprattus sprattus and Engraulis encrasicolus. The main problem in the production of quality snack products from these raw materials is the fat content of fish. Oxidation of the subcutaneous layer of fat leads to the appearance of odor and taste, that is, to reduce the shelf life of the product. One of the possible ways to solve the problem is to remove the lipids biotechnologically.

For economic viability, the process of removing the subcutaneous fat was performed using a complex of plant lipolytic enzymes extracted from wheat bran (Technical conditions of Ukraine 46.22.014-95) – flour milling by-products, which are a solid shell of grain obtained by grinding grain and sorting by size and weight.

Keywords: *snacks, chips, fish, fat removal, enzymes, wheat bran, technology.*

I. INTRODUCTION

At present, the main tasks of processing enterprises are to improve the quality and increase output by maximizing the full utilization of raw materials.

Fish is one of the most important sources of animal protein for the human body. Fish proteins include all essential amino acids. Fish proteins are easily absorbed by the human body. Due to its special chemical composition and taste properties, fish is one of the first among the products of animal origin.

The modern buyer prefers products that are environmentally friendly, which are not subject to the processing of synthetic additives, such as dyes, preservatives (except natural), etc. Such products include salt-dried fish. Currently, world and Ukrainian producers produce salt-dried fish in the form of snacks - products intended for rapid consumption and long-term storage. Fish snacks are not only a traditional snack for beer, but also a product that perfectly quenches hunger, packaged in convenient consumer packaging.

The modern technologies make it possible to leave many unique and valuable substances in salt-dried fish products. The optimum amount of salt and the precise selection of residual moisture emphasizes the natural taste of dried fish. The snack

industry in supermarket-oriented societies generates billions in revenue annually. The snack market is huge and large corporations are constantly competing, so snacks are moving forward. Therefore, the development of the snack industry in Ukraine is incredibly relevant.

Changes in the raw material base, species composition of raw materials, the development of freshwater fish farming make their adjustments to the technology of production of fish snacks. Their creation on the basis of the most widespread industrial fish species of Ukraine, including freshwater ones, becomes promising.

The purpose of the work is to improvement of fish snacks technologies with the application of biotechnological fat removal.

II. ANALYTICAL REVIEW OF LITERATURE

2.1. Current status and outlook for the fish snack market

Snacks are products for quickly quenching hunger. Light snacks consumed between chores on the go.

At the beginning of its development, food concentrates (snacks) developed very rapidly and grew in the Ukrainian market. Mostly potato chips and salted peanuts were presented.

Fish snacks are in high demand in cities with a population of more than 500 thousand people [23].

Snack products presented on the Ukrainian market today are united by the following product characteristics: long shelf life (about 10 months), mandatory packaging, light weight (less than 100 grams) and readiness for immediate use.

According to «Snack Export» LLC, Ukrainian snack market is estimated at $ 400… 450 million, market growth is 15… 20% per year [22].

Competition in the Ukrainian snack market is high, so manufacturers are constantly looking for new ways to reach new customers: expand the range, use different types and tools of marketing communications, in advertising focus on cheaper snacks. For example, in addition to traditional potato chips, «Kraft Foods Ukraine» also produces corn, and «Technocom» produces rice chips, fruit chips - apple, pear, banana.

Also known technologies for the production of Jerusalem artichoke chips, persimmon, white root vegetables, quince [22].

Due to the lack of culture of consumption of salty snacks in Ukraine as a separate type of production, the domestic market for these snacks is dependent on the beer market. Unlike Ukrainian producers, international companies do not track the relationship between these two markets, abstracting from beer producers. Ukrainian companies are now also trying to get rid of "beer dependence" and increase the market by expanding the range and the production of salty snacks in large-sized packaging. However, since fish snacks are still considered an accompanying beer in Ukraine, the market for such products is directly dependent on the seasonality of the beer market, which falls between April and October. [23].

Currently, the range of fish snacks is quite wide. Salt-dried products are made from these types of fish: anchovy, plaice, pollock, eel, hake, goby, tuna, horse mackerel, perch, cod, and others.

But in the conditions of fierce market competition the priority activities are the

development of new raw materials, improving the taste characteristics of snacks and increasing the shelf life of finished products. Creating a novelty allows the manufacturer to capture a larger segment of the market and strengthen its position relative to competitors [1, 22].

The urgent issue is the possibility of producing snack products from the *Sprattus sprattus*, *Engraulis encrasicolus* and freshwater fish *Hypophthalmichthys nobilis*. These are the most widespread industrial fish species of Ukraine, which are caught in sufficient numbers and in close proximity to the production capacities of Ukrainian producers. In 2018, the total catch of aquatic bioresources in the Black Sea, compared to 2017, increased by 3.3 thousand tons and amounted to 8.6 thousand tons. The basis of fishing is: rapana - 5.5 thousand tons; sprat - 1.6 thousand tons, shrimp - 0.5 thousand tons and mussels - 0.3 thousand tons [18, 19]. The catch volume of aquatic bioresources in inland reservoirs has also been increasing in recent years. Thus, in 2018, compared to the previous year, it increased by 4.6 thousand tons and amounted to 46.8 thousand tons, which is 54% of the total catch volume. [15, 18].

The main problem that prevents the production of snack products is the high fat content of fish. Fat oxidation causes odor and taste, that is, spoilage of the product [13, 17].

To ensure a long storage term (10 months), fish are over-dried. The meat becomes quite stiff and fibrous, so its taste characteristics are somewhat reduced. In order to be able to produce products with a softer texture, a number of technological problems need to be addressed. One of the most important of these is the oxidation of the subcutaneous fat [2, 3, 24]. One of the possible ways to solve it is the cleavage of lipids by biologically active compounds − enzymes. For economic feasibility, it was decided to use a complex of enzymes extracted from cheap raw materials of plant origin − wheat bran.

Attempts to solve these problems with the help of biotechnological processing method are outlined in this paper.

2.2. Methods of obtaining lipases

Enzymes are biological catalysts of a protein nature, capable of many times accelerating the chemical reactions occurring in a living organism, but they are not themselves part of the end products of the reactions [6].

The role of enzymes in food technology is extremely important. The production of any food product is based on either biochemical (enzymatic) or physico-chemical processes, or these processes are closely interrelated [11].

Unlike inorganic catalysts, enzymes have their own characteristics. Firstly, the rate of enzymatic catalysis is several orders of magnitude higher (103 to 109) than non-biological catalysis. Secondly, the action of each enzyme is highly specific. Each enzyme acts only on its own substrate or group of related substrates. Thirdly, enzymes catalyze chemical reactions under mild conditions, ie at normal pressure, low temperature (20…50 ° C) and at pH values, in most cases close to neutral [6, 11].

Lipases (from the Greek. Lípos − fat), enzymes of the hydrolases class; catalyze the hydrolysis of ester bonds in triglycerides to form fatty acids and glycerol [6].

The methods of obtaining and removing lipases are given special attention by scientists of the world. Yes, Beryozov TT and Korovkin BF proposed a method of

preparative production of wheat germ lipase. They proposed a method of purification and selected the optimal conditions for the release of lipase from wheat germ (Triticum aestivum L.) [16].

Authors such as G. Yu. Nekrashite, I. K. Straykuvene, and others have proposed a method of producing phospholipase D. The invention relates to the microbiological industry, namely the production of enzymes. The aim of the invention is to increase the enzymatic activity in the culture fluid of the target product and reduce its cost. This goal is achieved by the fact that according to methods of producing phospholipase D, including the cultivation of a producing microorganism of the genus *Streptoverticillium* in a nutrient medium containing sources of carbon, nitrogen, mineral salts and water [21].

I. S. Zvyagintseva, V. T. Luka and others received a strain with high lipolytic activity and broad substrate specificity. The invention consists in the fact that by multistage selection the adaptive method was obtained by the yeast strain *Jarrowia lipolytica* VNIIA 304A − an active producer of lipase. High lipolytic activity of the strain and its ability to absorb different substrates is provided by the nutrient medium of a given composition [14].

I. G. Sultanova and K. D. Davranov was proposed the strain of the fungus Rhizopus microsporus − producer of lipase. The invention relates to biotechnology, in particular to obtain the enzyme lipase, hydrolyzing fats. The purpose of the invention is to obtain a strain of the fungus *Rhizopus microsporus*, which has a high ability to form lipase specific for hydrolysis of fish oil. The preparation of lipase obtained from the culture can be used for hydrolysis of fish oils upon receipt of fish products enriched with polyene acids [25].

A rich complex of hydrolytic enzymes can be obtained by *Bacillus subtilis* culture. These are aerobic, gram-positive sticks. The culture is cultured as a method of surface cultivation on bran and in liquid media of special composition by the method of deep cultivation. They can use proteins, carbohydrates, alcohols, organic acids as sources of nutrition.

For a long time in medicines used enzymes of animal origin. However, obtaining these enzymes involves a number of difficulties: the need to use directly the organs of animals, the number of which is limited, in addition, it is a rather time-consuming and expensive process. Plants are a large raw material base, more affordable and cheaper. Therefore, recently enzyme preparations derived from plants are quite widely used.

Plant lipase is found mainly in seeds, fruits, tubers, cereal rhizomes (corn, oats), cruciferous seeds (mustard seeds), especially in legumes (beans, peas), and sunflower seeds.

Wheat flour enzymatic activity (initial rate) is five times higher at 15.1% moisture than at 8.8%. The same behavior is found for lipases of rye, oats and poppy seeds. The temperature optimum of the reaction (for a 24-hour period) for rye was set at 75 ... 90 ° C at 6% moisture, 70 ° C at 15% moisture and 60 ° C at 20% moisture, which reflects the resistance of the enzyme to heating at different humidity levels.

It was found that the highest amount of lipase contains wheat germ. However, the amount of lipase in the wheat germ is less than 5% of the total grain activity.

Earlier works on the purification of wheat lipase indicated that this enzyme acts

on ethers (and soluble) ethers and has a pH optimum of 7.4. Maximum enzyme activity was detected with triacetin. Monobutyrin and ethyl acetate, as well as emulsified monoolein, were easily hydrolyzed by the enzyme [6, 16].

III. OBJECT, SUBJECT MATTER AND METHODS OF RESEARCH

The object of research is the technology of snacks from small Azov-Black Sea fish and from freshwater fish based on a biotechnological method of removing the subcutaneous fat.

The subject of research is small fish of the Azov-Black Sea basin is *Sprattus sprattus*, freshwater fish is silver carp (Hypophthalmichthys nobilis), parameters of technological process of degreasing, organoleptic indicators of the quality of fish snacks.

Research Methods. The experimental studies were carried out in the laboratories of the Department of Meat, Fish and Seafood Technology of the Odessa National Academy of Food Technologies (Odessa) and the Department of of the National University of Life and Environmental Sciences of Ukraine (Kyiv).

Determination of physicochemical indicators of raw materials, as well as at different stages of the technological process and the finished product was carried out experimentally using standard methods of research.

Determination of mass fraction of moisture by drying at 100…105 °C, mass fraction of fat by extraction method in the apparatus of Soxhlet, mass fraction of sodium chloride by the argentometric method according to GOST 7636-85. [10].

Study of snack quality according to GOST 34191-2017 and GOST 33803-2016 [8, 9]. Organoleptic evaluation was performed on the basis of a score scale [20].

IV. WORK RESULTS

4.1. Removal of subcutaneous fat of *Sprattus sprattus* with the help of wheat bran enzyme complex

Pre-dried at 35 ° C to constant weight, wheat bran was ground in a mortar to a powdered state. Next, the bran was poured with water (GM 1: 4) at 35 ° C and kept for 30 minutes, stirring. Then it was filtered through filter paper. Black Sea Sprat fillets were filled with extract and kept for 30… 45 minutes.

Determined the change in mass fraction of fat. The results obtained were compared with the control sample − the mass fraction of fish fat, untreated with the enzyme preparation previously defined.

A graphical representation of the results of the experiment is presented in Figure 4.1.

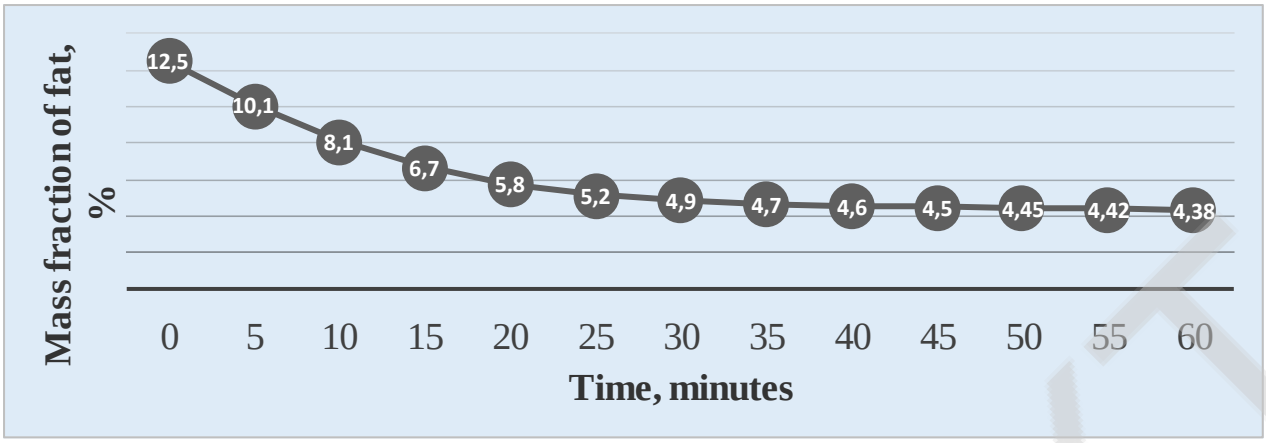


Figure 4.1. Determination of change in mass fraction of Black Sea sprat fat over time.

The results of studies have shown that the mass fraction of fat of the control sample under the action of a complex of wheat bran enzymes decreases from 12 to 4.5%, almost three times. Thus, biotechnological methods based on the use of a complex of enzymes of vegetable raw materials can be used to remove 65% of fat from its original value.

4.1.1. Determination of optimal temperature of action of a complex of lipolytic enzymes of wheat bran. The rate of enzymatic catalysis depends on the temperature of the medium. To determine the optimum temperature of the action of a complex of lipolytic enzymes of wheat bran, the fermentation of fish was carried out at different temperatures for a time equal to 30 ... 45 minutes. A graphical representation of the results of the experiment is presented in Figure 4.2.

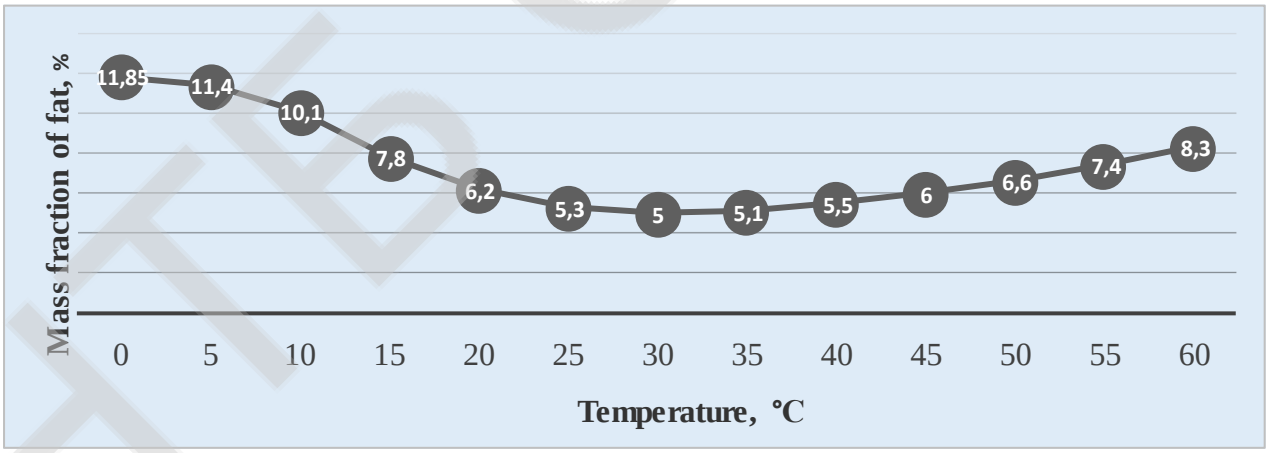


Figure 4.2. The influence of fermentation temperature on the change in the mass fraction of fish fat.

The results of studies have shown that the lipase of wheat bran operates in a sufficiently wide temperature range − from 20 to 45 ° C. In the range from 5 to 20 ° C the rate of hydrolysis increases. In 30 minutes up to 50% of fat is removed from its original value, but the highest activity is observed at 25… 35 ° C and for 30 min. 60-65% of the original fat is removed. In the temperature range from 45 to 60 ° C, the rate of hydrolysis decreases in 30 minutes. removes 33… 50% of the original fat.

4.1.2. Determination of the optimal pH value for enzymatic degreasing. To determine the optimal pH for the complex of lipolytic enzymes of wheat bran, the fermentation of fish was carried out at different pH values for the same time for all samples 30...45 minutes. A graphical representation of the results of the experiment is presented in Fig. 4.3.

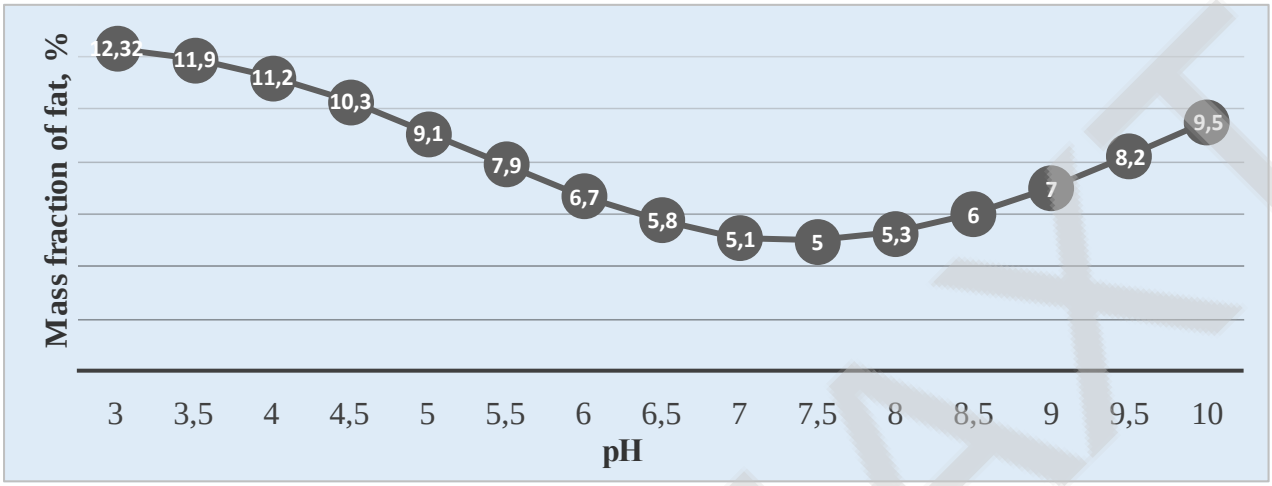


Figure 4.3. Determination of the pH optimum for a complex of lipolytic enzymes of wheat bran.

According to the obtained data, we conclude that in the pH range from 3 to 4 mass fraction of fat is almost unchanged. In the range from 5 to 6, the rate of lipid hydrolysis increases and is 3…5% of fat in 30 minutes, but the fastest cleavage of fat occurs at pH values from 7 to 8 and is 7…8% of fat in 30 minutes. In the range from 9 to 10 the rate of hydrolysis begins to decrease and is 3...5% of fat in 30 minutes.

4.1.3. Vacuum fermentation. If the pressure is below one atmosphere, the air dissolved in the intercellular space of the tissues of the fish will begin to be released and the enzyme solution will be absorbed into its place.

Used enzymes extracted from wheat bran. The fish disassembled into the headless and spinal bone layer, filled with a solution of the enzyme preparation, were placed in a desiccator connected to a vacuum pump. Dilution of 0.8 kgf / cm^2 at 25 °C was created. A graphical representation of the results of the experiment is presented in Figure 4.4.

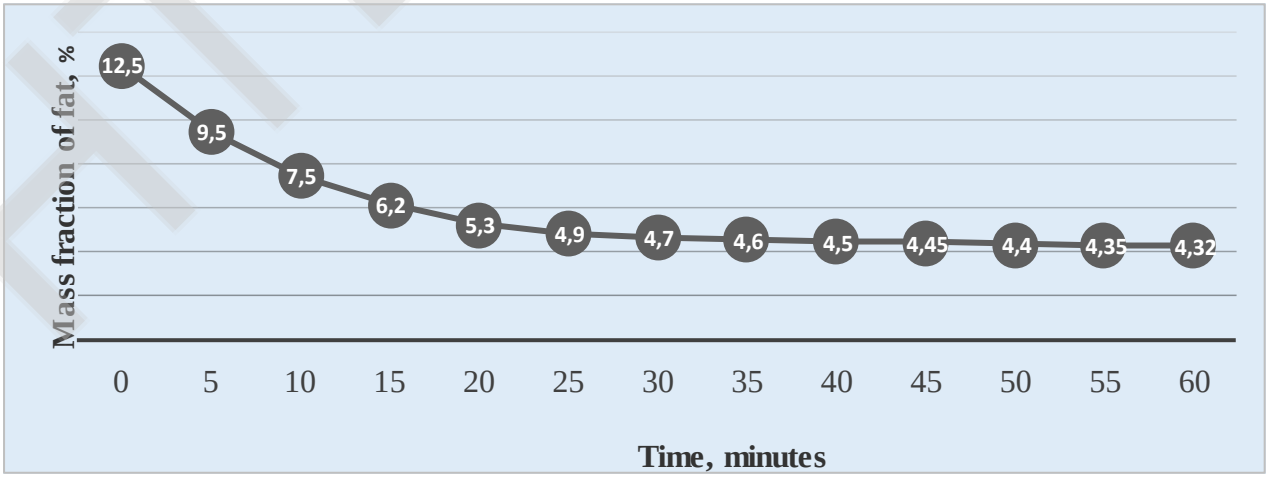


Figure 4.4. The dependence of the effect of fermentation under vacuum on the change in the mass fraction of fat in fish fillets

The obtained data showed that the decrease in mass fraction of fat compared to the treatment at atmospheric pressure is negligible and remained at the level of 4.5…6 %. But at the same time the fermentation time decreased − these results were achieved in 20…30 minutes against 30…45 minutes at normal pressure.

4.2. Investigation of the effect of fish pre-treatment on the drying process

Disassembled into a layer without a head and spinal bone, treated with an enzyme preparation, the fish was dried with a stream of air at a rate of 0.6 m / s, at a temperature of 50 ° C. During the drying process, the fish was weighed and the moisture content was determined.

Drying was stopped after reaching a mass fraction of moisture in fish 25 ... 35%. At the end of the drying did a comparative organoleptic evaluation of fish with pre-enzymatic removal of subcutaneous fat and fish without pre-treatment. Salt treatment and drying time are the same for all samples The results of the studies are shown in Table 4.1.

Table 4.1.

Comparative organoleptic evaluation of dried fish with pre-enzymatic removal of subcutaneous fat and fish without pre-treatment with enzymes

Indicator	Fish without first enzymatic processing	Fish with pre-enzymatic fat removal
Surface color	Light gray	Light gray
Yellowing	Insignificant	None
Humidity	Dry	Dry
Scent	Slight odor of oxidized fat	Odorless oxidized fat
Taste	Peculiar	Peculiar
Hardness	Hard	Hard
Stratification	Fibrous	Fibrous
Oiliness	Significantly oily	Slightly buttery

According to the obtained data, it can be concluded that the fish treated with the enzyme preparation during drying had significantly less fat release to the surface than the fish without enzymatic treatment, which improves the appearance and guarantees a longer storage time.

4.3. Development of technology for the production of snacks using biotechnological method of removing the subcutaneous fat

On the basis of experimental studies, a technological scheme for the production of snacks was developed using a biotechnological method of removing the subcutaneous fat layer shown in Fig. 4.5

Defrosting. The frozen fish should be thawed in defrosting apparatus, baths in running or intermittent water, or in brine at a density of 1.02 g/cm^3 to 1.03 g/cm^3, or in air. The temperature of the water, brine or room air must not be higher than 20 ° C. The ratio of the weight of fish and water or brine in the bath 1:2. Frozen fish washed with water in the air. Do not wash fish thawed in water or brine.

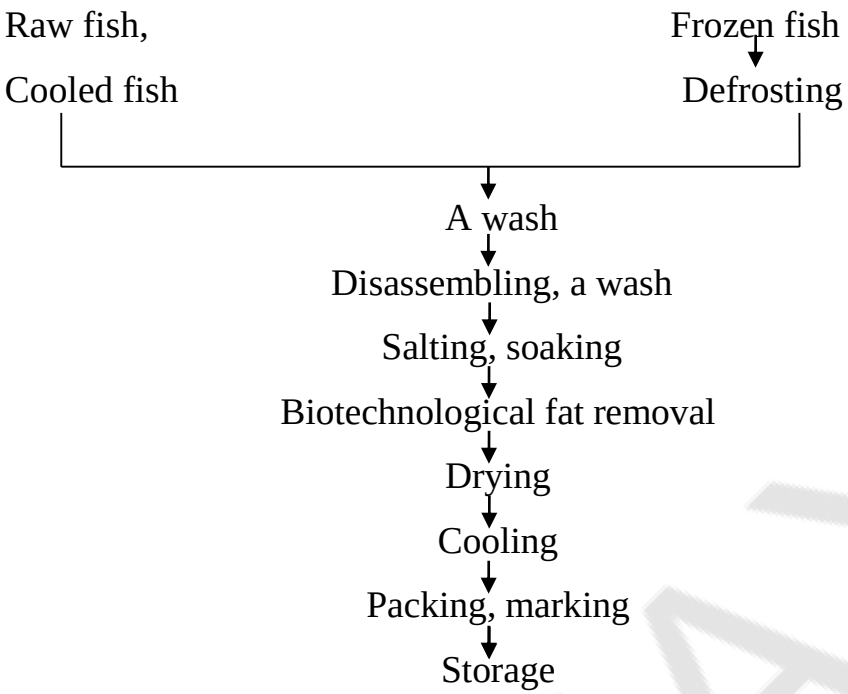


Fig. 4.5. Technological scheme of snack production using biotechnological method of removing subcutaneous fat.

A wash. Raw fish and chilled fish should be rinsed with clean running or replacement water at a fish to water ratio of 1: 2 before being sent for processing. The water temperature should not be higher than 15 ° C. Wash the washed fish from 20 minutes to 30 minutes on waste tables or sieves for water drainage and without delay send for further processing.

Disassembling. The fish is disassembled into fillets. After disassembly, they are washed with a stream of water.

Salting. Salt the fish in saline with a density from 1.12 g / cm^3 to 1.20 g / cm^3, with a temperature not higher than 20 ° C. The ratio of the weight of fish and saline solution in the salting capacity should be 1:2. Finish salted fish after reaching the mass fraction of salt in fish from 3 % to 5 %. Salting duration from 7 minutes to 15 minutes depending on the type and size of the fish. The fish unloaded from the container drains saltinng solution for no more than 0.5 hours on waste tables (sieves) or in perforated decks. Salt fish with a mass fraction of salt over 5 %, before drying, soak in fresh water or a low salt solution with a density of from 1.02 g / cm^3 to 1.04 g / cm^3 and a temperature not exceeding 10 ° C at the ratio of the weight of fish and water (or salt solution) 1:2. After soaking, the fish should be steeped for 1…2 hours on waste tables (sieves) or in perforated decks to drain excess water.

Biotechnological fat removal. The fish is treated with a solution of the enzyme preparation at a concentration of 0.35 g / ml, a temperature of 35… 40 ° C, a pH of a solution of 7… 8 for 30 minutes. Do not reuse the enzyme preparation.

Drying. The fish should be laid in a thin layer on metal perforated nets, which are placed in several rows in a drying chamber so that they are evenly blown by the flow of heated air at a temperature of 50… 60 ° C. During the drying process, the fish is stirred periodically. The first stirring should be carried out in 1 ... 1,5 hours, the second - in 1 ...

1,5 hours after the first. Drying time from 6 hours to 8 hours.

Cooling. Salt-dried fish is transferred to a clean, dry container for cooling (metal containers, wooden boxes or other containers) to the working room temperature and packed.

Packaging. The dried fish is packaged in plastic material bags in accordance with GSTU 15-19 or the applicable regulatory document under vacuum or without vacuum, the maximum mass of the product is 1 kg, followed by their packaging in boxes of corrugated cardboard in accordance with GOST 13516 product weight limit of 10 kg. The dried fish is packaged in plastic bags in accordance with the "Technological Instruction on Packaging of Foods from Fish and Other Water Resources into Plastic Packages".

Marking. Mark containers with fish snacks in accordance with GOST 7630 and regulations.

Storage. Store fish dried at temperatures from 0 ° C to 25 ° C and relative humidity not more than 75% not more than 10 months.

4.5. Development of freshwater fish chips formulations and technology, evaluation of their quality

In order to expand the range of snack products from affordable domestic raw materials, recipes and technology for the production of silver chips with the addition of algae and greens were developed. For the production of fish chips formulations were developed, which are shown in table 4.2.

Table 4.2

Formulations of fish chips samples

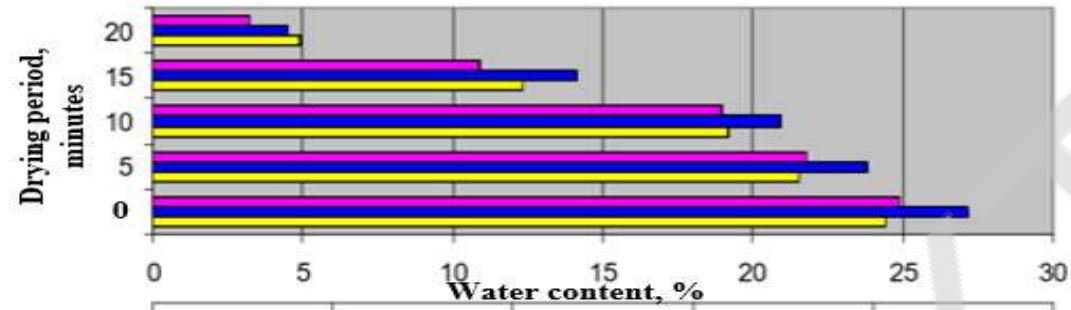
Name of components	Control	Fish chips with dill	Fish chips with kelp
The silver carp	74,4	74,4	74,4
Butter	3	3	3
Chicken eggs	10	10	10
Milk	5	5	5
Wheat flour	6	6	6
Black pepper	0,6	0,6	0,6
Salt	1	1	1
Dill	-	2	-
Seaweed	-	-	2
Total	100	100	100

Chips formulations were selected taking into account the content of their main components: sample 1 - with the addition of dill; sample 2 - with the addition of seaweed, sample 3 - control sample without the addition of dill and seaweed, only on the basis of freshwater fish meat.

The process of production of fish chips consists of the following operations: receiving raw materials, sorting, washing, disassembling, grinding, dough preparation, mixing, molding, drying and baking, packaging in consumer packaging, packaging in transport packaging and sale.

Drying of the chips was carried out at a temperature of 105 ° C, followed by measurement of the moisture content at intervals every 5 minutes. The results of the study are shown in Figure 4.6.

During the research, the time required to dry the finished product was set so that the moisture content did not exceed 5%. Within 20 minutes of drying, the control sample lost - 20.1%, sample 1 - 16.5%, sample 2 - 12.8% moisture.



	0	5	10	15	20
1	24,9	21,8	19	10,9	3,2
2	27,2	23,8	20,9	14,1	4,5
3	24,4	21,5	19,2	12,3	4,9

Figure 4.6. Dependence of moisture loss on drying time: 1- sample 2, 2 - sample - 3, 3 - control sample.

The fish chips were also evaluated according to their own scale 5, where the total number of control points was 19 points, for the dill sample 21 points and for the cabbage 23 points. The results of the study are shown in Figure 4.7.

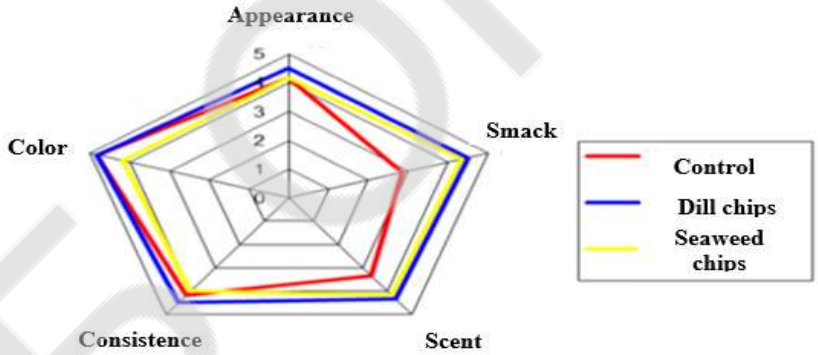


Figure 4.7. Profile of organoleptic evaluation of fish chips.

As a result of organoleptic studies it was found that fish chips in appearance are inherent in this product. The slices are round and almost identical in size. The color of the chips is golden with a brown tinge on the edges. The taste and odor is inherent, with no extraneous odors. Has a taste of additives - dill for 1 sample, and a taste of seaweed for 2 sample. The consistency is brittle and fragile. The overall comparative analysis makes it possible to confirm that all the samples of fish chips have a positive overall impression, a harmonious fish taste.

Positive studies received indicate that this technology is being continued and needs further development.

V. CONCLUSIONS

1. Improvement of the old and the development of new technologies for the production of snacks seem relevant.

2. In today's domestic fish processing industry, most technologies designed to

remove the subcutaneous fat are outdated or ineffective. They are not satisfying in quality and performance. Therefore, the development of an alternative method of removing subcutaneous fat − biotechnological, with enzymes − is relevant today.

3. Based on the results of the studies, it was found that the processing of disassembled fish with a complex of lipolytic enzymes from wheat bran can reduce the mass fraction of subcutaneous fat of *Sprattus sprattus* almost three times. It was found that the time required to remove the fat is 30…45 minutes. Optimal parameters of temperature (35…40 ° C) and pH (7..8) were determined.

4. Studies were carried out to intensify the process of enzymatic removal of the subcutaneous fat − fermentation under vacuum, the results of which were to reduce the fermentation time to 20…30 min.

5. The effect of fish pre-treatment on the drying process is investigated. A comparative organoleptic evaluation of fish pre-treated with enzyme preparation and fish without pre-treatment was performed. Pre-treated fish enzyme preparation in the drying process was observed significantly less release of fat on the surface than fish without enzymatic treatment.

6. The technology of snack production using the biotechnological method of removing the subcutaneous fat was developed. Technological scheme of snack production using biotechnological method of removing subcutaneous fat was developed.

7. The recipe and technology of freshwater fish chips have been developed, which will expand the range of snack products from available domestic raw materials.

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НТБОНАХТ

IMPROVEMENT OF THE TECHNOLOGY OF SUNFLOWER HALVA WITH THE USE GRAPE SEEDS POWDER

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Abstract. *An analytical review of the literature has been conducted and the features of halva technology of different types have been studied. The main problems encountered during halva storage and the existing methods for their prevention are considered. The use of grape seeds powder in the food industry, mainly in fat-containing products has been analyzed. The grape seeds powder was determined to contain a large number of polyphenol compounds that exhibit potent antioxidant and antimicrobial properties.*

According to the results of experiments of acid and peroxide numbers, the addiction of powder in the amount of 5% is notable to lead to slow down the oxidation processes, thereby prolonging the shelf life of the finished product by 1.3 times. The content of dietary fiber prevents the separation of oil, as a result it has a better appearance and the weight of the finished product is nearly unchanged.

The rational dosage of grape seed powder into halva technology, which doesn`t influence the quality has been substantiated. It is 5% to protein mass.

Sunflower halva technology which differs from existing technologies has been developed by using secondary raw materials, lack of synthetic additives, introduction of halva fine grape powders with high content of polyphenolic compounds in the second stage, improved organoleptic properties.

Keywords: *halva technology, sunflower halva, grape seeds powder, antioxidants, storage time, fat oxidation, oil separation.*

INTRODUCTION

Human health is determined by the way of life primarily degree of availability of body with essential nutrients and energy, which come from food.

According to the statistics, confectionery is one of the most prevalent and affordable kind of food in Ukraine. This is due to their wide assortment, good organoleptic characteristics, and affordable. On the other hand, the vast majority of confectionary products contains practically none of biologically active substances, such as vitamins, minerals, food fibres and contain overly high calories. Therefore, the tasks ahead of scientists of the confectionery industry are extending the assortments, developing output, increasing biological and reducing energy values of products.

Halva has a special place in the wide range of confectionery and has been holding a steady position since come to us from Earth, as well as it was differentiated as a separate classification group.

The chief aim of this study is foundation and development the technology of sunflower halva with the addition the grape seeds powder which enrich the finished product with biologically active substances with high antioxidant properties, extend the expiration date, reduce energy value and expand the range.

To achieve this aim, it was necessary to solve the following tasks:

- to study assortments and existing ways to improving halva technology;
- to study the influence of grape seeds powder on the organoleptic and physico-chemical properties of halva sunflower
- to investigate the process of oxidation and hydrolysis of the oil components in the presence of grape seeds powder;
- to consider the process of separation of oil during storage of sunflower halva;
- to improve the technology of sunflower halva, to validate the rational dosing of the choose additive;
- to develop a draft technological documentation for sunflower halva with the addition of grape seeds powder.

1. ANALYTICAL REVIEW OF THE LITERATURE

1.1. Characteristics and features of halva production

Halva is a kind of confectionary product which has a layered fibrous structure. It is obtained by whisking the caramel mass with the foaming agent, followed by the mixing of the whipped mass with the grinded oil seeds. Halva composed of 10…20% protein, 30…35% fat, 40…55% carbohydrates, caloric content 100 g of product is 470…550 kcal [1].

Depending on the type of appearance coating, halva can be glazed and no glazed; by the way treatment method – vacuum or non-vacuum treated; by the way packaging method – packed and weighted. Halvah can be prepared either without additives, as well as with the addition of cocoa powder, milk powder, chocolate, blown cereals (extrusion products), with dried fruits or candied fruits [1, 2]. Depending on the type of raw material used, halva is divided into sunflower, sesame (tahini), peanut, corn, combined. By appointment, halva for general purpose and dietary (for diabetes mellitus patients) are released.

The main ingredients of halva cooking are oil-containing raw materials, sugar, starch syrup and foaming agents. The manufacturing process for halva consists of the following main stages: seeds dehulling; semi-finished products such as tahini and caramel mass) preparation; foaming agent preparation; whipping the caramel mass with the foaming agent; components mixing; packing and packaging [1].

The oilseeds supplied into the manufacture are cleaned of mineral and vegetable impurities. After that, they are crushed and subjected to heat treatment. The technological parameters of these operations depend on the type of raw material.

After dehulling, the sunflower seeds should be calibrated and separation of the whole kernels from husks and unbroken seeds and other fine particles. The kernels are dried to a moisture content by mass of 13…15% and subjected to a heat treatment at a temperature of 130…170° C to a moisture content of not more than 1.0…1.4% (higher moisture can lead to a particulate mass during grinding, as a consequence, deterioration quality of the finished product).

Before calving, sesame seeds are soaked in a salt solution with a concentration of 17…19% NaCl at a temperature of 35 ± 3° C for 30…180 min. During this period, the seeds swell, its mass increases by 30...50%, the shell becomes more elastic and easily separates from the kernels. Drying is carried out to a moisture content of 10…14% by mass, heat treatment to 0,9…1,2% at a temperature of 130…170° C.

Distinctive feature of the peanut kernels is the specific legume taste, which can

be gotten rid by soaking in warm salt solution (35…45° C, concentration 4…6%) with constant mixing for 20 min. The kernels are separated from the brine solution, dried to a moisture content of no more than 10%, fried to a mass fraction of moisture 1…2% at a temperature of 130…170° C.

Corn grits are pre-fried in a deep fryer to a moisture content of 2.5%, fat – 25…26% (due to the absorption of frying fat) [3].

Protein mass is obtained by grinding the roasted seeds of oil or nut kernels to obtain a homogeneous suspension, consisting of a protein fraction and oil content of which is 45...60%. Feature of corn protein mass production is the addition of oil for fat content of 45…49%.

For cooking caramel mass use starch syrup and sugar in the ratio of 188 to 100, which prevents the process of crystallization and gives more plasticity at high temperatures. The finished semi-finished product contains 96…97.5% of dry and 32…34% of reducing substances. It also can be prepared with invert syrup, added instead of part of starch syrup (87 kg of starch syrup is used 100 kg of sugar). The mass is boiled to a moisture content of 3…4% [1, 4].

In the production of dietary halva, fructose or isomalt are used instead of sugar, which decrease the energy value of the finished product and hardly change the organoleptic characteristics set out in the regulatory documents. The use of fructose increases the absorption of the product by the body, and isomalt provides products with low hygroscopicity, don`t increase the level of glucose and insulin in the blood [5, 6].

The foaming agent in the halva production are used as extracts.

The best foaming agent is a soap root, which contains a glucoside saponin. To extraction the root is washed with running water and soaked in warm water (60…80° C) for 10…24 h, then crushed and boiled to a moisture of 90%. The obtained decoction has a dark color, odorless. With the passage of time its foaming capacity deteriorates therefore it should be used immediately after preparation.

The licorice root can be used to replace soap root, which exhibits it's a huge foaming capacity due to the glycerrhizin contained in it (the potassium-calcium salt of glycerixed acid).

The tea seeds are known to use as a foaming argent. It is washed, soaked and boiled extract to a dry matter content of 7% [4].

The production of halva as an easily available foaming agent is albumen at home.

The caramel mass with foaming agent are churned at 105...110° C for 15...20 min until a lush white semi-finished product with a density of 1100...1500 kg/m³ is formed. Whipping the caramel mass at lower temperatures can lead to increase the viscosity and deterioration of the foaming process. The duration of the whipping determines the quality of the product: in the case of long whisking, the caramel semi-finished product is more lush, but the caramel threads are short and easily torn; with insufficient whipping, a coarse fiber of yellow is obtained.

To get a good quality product, it is advisable to follow the optimal ratio 54 of the tahini mass on 45 parts of the caramel mass for sunflower and 60:45 for other types of halva. With such dosages, the texture of halva will be soft, and oil consisting of protein mass is distributed fairly evenly between the caramel layers and is not removed during storage.

When mixing of protein and caramel masses, the temperature of the mass is gradually reduced and the structure of the finished product is formed. At first, the protein mass (40° C) and caramel mass (110° C) are being mixed for 1...1.5 minutes to obtain a heterogeneous structure with large fiber caramel mass (the temperature decreases to 75...80° C); then the caramel threads are being pulled into thinner ones and the protein mass is being evenly distributed between them (the temperature drops to 65…70° C) for 3…4 min; in the next 3…4 min, the final formation of a thin-fiber structure of mass (temperature decreases to 55…60° C) [1, 3].

Halva is known to be a high-caloric product with a large number of biologically active substances. In order to correct its composition, experts from NUFT have been proposed the addition of non-traditional raw materials to the technology of halva sunflower. The use of sunflower and flax seeds, meal of pumpkin seeds made it possible to increase the nutritional value and lower the energy value of the finished product [7].

Halva is stored for 1.5 months and glazed with chocolate or confectionery glaze for 2 months at a temperature of 18 ± 3° C and relative humidity not higher than 70%.

Of all types of halva, sunflower is the most common in our country due to the availability of raw materials for its production. That's why we have chosen sunflower halva for research. The following are problems that may occur during storing this product.

1.2. The main problems of halva storage and their solutions

During the storage of halva processes occur that affect the organoleptic and physicochemical quality indicators and make the finished product unfit for consumption. One of them is oil separate, whose content is up to 35%.

For example, glycerol monostearate, first mentioned in research papers of Damir (1984 and 1990). Its addition to tahini halva has helped to reduce the amount of separated oil from 7.6% to 4.1%, and in sunflower oil – from 11.8% to 6.2% for 90 days of storage [5]. Dietary fiber and emulsifiers [8], hydrogenated palm oil [9] have been effective in halva, as a result of the manifestation of homogenizing properties. These additives are noted not to have significantly affect the organoleptic characteristics of the finished product. At the same time, they increase its viscosity, thereby prevent the separation oil from halva during storage.

The opportunity of solving this problem by adding gelatin, soy protein and $CaCl_2$ was investigated, but as it turns out, these additives interact with sugar and foaming agent during the technological process and lead to change of colloidal state of tahini mass, increase the instability of the emulsion [8].

An important problem is the oxidation of fats during the storage of halva. To solve it, use additives with antioxidant properties or special packaging.

Thus, at the University of Thessaly, pack halva in a modified atmosphere with a CO_2 level of more than 20% was proposed [10]. This makes it possible to reduce the pH of the test samples by dissolving CO_2 in the aqueous fraction, as well as improve the oxidative stability of the halva fat.

It also worth noting that of all types of halve, the most resistant to oxidation is tahini, because of the large number of antioxidants that are formed during the roasting stage of seeds [11, 12].

It would be useful to introduction of antioxidant additives into sunflower halva. But chemical antioxidants, solving the problem of the extension of shelf life of food products, whereas harming our body. Therefore, preference should be given natural addiction. This is due to its availability, low cost by the fact of being a by-product, and rich chemical composition, first of all, the presence of polyphenolic compounds – substances with high antioxidant activity. The properties of this supplement are described below.

1.3. Characteristics and properties of grape seeds powder

Grape seeds powder is a product of the processing of grape pomace that remain after wine production. The essential component is the pomace dietary fiber, including polysaccharides of cell walls and lignin. Their content is 43…75% [13]. Moreover, seeds are a source of calcium, phosphorus, sulfur, magnesium. But the most valuable components of grape pomace are phenolic compounds [14].

Grape powders have been used in food technology due to a rich chemical composition. They were added to dairy [15], flour [16], confectionery [17] products, etc. This has enabled to enrich products with deficient minerals, such as potassium, calcium, magnesium, zinc, copper, manganese and phosphorus, which perform important functions in the body. Moreover, the addition of grape powders allows to extend the shelf life of the food. Antioxidant properties of pomace have been proven by various scientists. For example, the introduction of grape seeds powders in exchange of a portion of cocoa powder in a confectionery glaze has been proved allows to slow down the processes of fat oxidation, which increases the shelf life of the glaze and its glazed products.

Grape seeds components have also been shown to improve the microbiological indices of foods, namely, delay the growth of lactic acid, aerobic mesophilic bacteria, Pseudomonas and psychotrophic populations of microorganisms in food. Grapes extracts have bactericidal action against yeast and mold [18].

Consequently, the use of grape seeds powder will promote the enrichment of halva with dietary fiber, minerals, and prolong its shelf life due to the high content of polyphenolic compounds.

Conclusion of section 1

1. Halva is a popular consumption product that has remained at the center of the main focus of attention for a long time due to its high taste properties.

2. In order to improve the technology of halva, various additives have been used emulsifiers, dietary fibers, hydrogenated palm oil, which help to prevent the processes of oil spillage as well as its oxidation.

3. We have chosen grape seeds powder as an additive, which contains nutrients, minerals, polyphenolic compounds, has antioxidant and antimicrobial properties.

2. OBJECT, SUBJECT, MATERIALS AND METHODS OF RESEARCHES

2.1. Object, subject and material of researches

We have chosen the technology sunflower halva with added grape seeds powder as an object.

Subject of research: Halva quality on the standard recipe and Halva with added grape seeds powder (3.0%, 5.0% and 7.0% of the protein mass) during storage.

The following raw materials have been used to producing samples of halva:

– sunflower seeds – DSTU 7011-2009;
– grape seeds powder – TU U 10.8-34801551-004:2013;
– sugar powder – DSTU 4625:2006;
– soapwort extract – GOST 3448-78;
– starch syrup – DSTU 4498:2005.

Raw and other materials were used to the production of halva have met the requirements of the existing standards and regulations.

The quality indicators and the chemical composition of grape seeds powder was used to studies are shown in Table 2.1 and 2.2.

Table 2.1 – The quality indicators of grape seeds powder

Indicator	Characters
Organoleptic characters	
Appearance	Fine-dispersed and granulated consistency
Color	Brown
Taste	Neutral
Smell	Neutral
Physicochemical characters	
Moisture, %	6.0±0.2
pH	7.0±0.2
Particle size, mkm	20.0…30.0

Table 2.2 – The chemical composition of 100 g of grape seeds powder

Component	Grape seeds powder
Water, g	6.0
Proteins, g	12.4
Fats, g	8.2
Mono-, disaccharides, g	2.3
Dietary fibre, g	
Cellulose	16.4
Hemicellulose	13.2
Pectinaceous substances	0.7
Lignin	30.2
Carotenoids, mg	0.6
Vitamins, mg:	
B_1	0.26
B_2	0.40
B_6	0.20
PP	9.8
Minerals, mg:	
Iron	30.0
Calcium	330.0
Magnesium	360.0
Potassium	1350.0
Phosphorus	260.0
Zinc	5.6
Manganese	1.0
Polyphenols, mg	6111.0

2.2. Methods of researches

Evaluation of organoleptic qualities that are typical for this type of product, namely: appearance, taste, odor, consistency and structure (the structure of faults) were performed according to DSTU 4683:2006.

The physicochemical parameters were determined by the following methods.

Determination of the mass fraction of moisture was carried out by the accelerated method in the oven DEB-3 according to the method DSTU 4910: 2008.

The degree of fat deterioration was determined with acid and peroxide numbers, according to DSTU 4350:2004 and DSTU 4570:2006. Weight of researched sample was poured into 96% ethanol in the ratio of 1 to 2, followed by extraction for 24 hours.

The acid number was established by titrating (in the presence of a phenolphthalein indicator). The solution of weight containig 2…3 g of fat was titrated with 0.1N solution of potassium hydroxide in a neutral mixture (96% ethanol and ethyl ester in a ratio of 1:2). The acid number (AN) was calculated with the formula

$$AN = \frac{\text{a}\times\text{T}_{\text{KOH}}\times 100}{\text{H}}, \quad (2.1)$$

where a – the amount of 0.1N KOH, which went to the titration sample, ml,

H – weight, g.

The peroxide number was measured by titrating. A sample weight (dissolved in 7 ml of chloroform and 14 ml of glacial acetic acid) of about 1 g in the presence of 1 ml of saturated aqueous potassium iodide was titrated a 0.01N sodium hyposulphite solution with. The peroxide number (PN) was calculated by the formula

$$PN = \frac{(\text{V}-\text{V1})\cdot 100\cdot 0{,}001269}{\text{M}}, \quad (2.2)$$

where V – the amount of 0.01N solution of hyposulphite spent on titration, ml,

V_1 – the amount of 0.01N solution of hyposulphite spent on titrating of control, ml,

M – weight, g.

Amount of reducing substances contained was determined by the ferricyanide method, which is based on the visual titration of oxidized reducing agents with an alkaline solution of ferricyanide in the presence of a methylene blue indicator until the blue color disappears by glucose. Samples were prepared according to [19]. Mass fraction of reducing substances in percentage ratio was determined by the formula

$$Z = \frac{0{,}0016\times(V-V_1)\times 100\times K}{m}, \quad (2.3)$$

where Z – mass fraction of reducing substances, %;

V, V_1 – the volume of the standard glucose solution that went to the titration of control and of the test sample, respectively, ml;

K – the correction factor, which is determined by the ratio of the presence of reducing agents and total sugar in the product;

0,0016 – glucose concentration in standard solution;

m – mass of sample, g.

To find out the amount of oil separated while storing halva, each 25 g sample was placed in filter paper and then in foil. All samples were stored for 80 days at 20° C in a desiccator containing absorbent. Samples with a certain frequency were

weighed and the results were calculated by the formula

$$O = \frac{W_1}{W} \times 100, \quad (2.4)$$

where O – amount of separated oil, %;

W_1, W – the weight of the sample at the beginning and after n days of storage, respectively, g.

The energy value of 100 g of sunflower halva and sunflower halva with the addition of grape seeds powder was calculated by the method [20].

Conclusion of section 2

1. The characteristics of the grape seeds powder used in the studies are provided.
2. The methods of conducting experiments for the study of organoleptic parameters, physicochemical properties, determination of acid and peroxide numbers, the amount of separated oil during storage of sunflower halva are defined and described.

3. RESULTS OF THE RESEARCH AND THEIR DISCUSSION

Grape powders were added in an amount of 3.0, 5.0 and 7.0% into the protein mass at the halva mixing stage. The best distribution of grape seeds powder is established to occur at the temperature of 75…80° C during the formation of halva structure with large fibers of caramel mass. Physicochemical characters of halva are shown in Table 3.1.

Table 3.1 – Physicochemical indicators of sunflower halva for different dosage of grape seeds powder

Indicator	Dosage of powder, % to protein mass				According to normative documents
	control	3.0	5.0	7.0	
Moisture, %	3.26	3.19	3.04	3.02	According to approved recipes, but not more than 4
Total sugar, %	39.86	38.24	38.86	34.82	25.0…45.0 limit of deviation from the expected value to decrease no more than 2.0
Redusing sugar, %	19.84	19.06	18.97	17.03	no more than 20.0
Total fat, %	30.65	30.56	30.04	29.89	28.0…34.0

The results of experimental studies provide some evidence for the choose additive to the recipe of sunflower halva doesn`t produce significant changes in the physicochemical properties compared to the control sample. Increasing dosage of grape seeds powder to protein mass can be seen to increase the content of solids in halva slightly, from 96.74% (control) to 96.81%, 96.96%, 96.98% (the test samples containing 3.0, 5.0 and 7.0% of the additive, respectively). At the same time the total mass fraction of sugar and fat of reducing substances slightly reduced by the number of fiber that are made with powder. The grape seeds powder is known to contain a large number of polyphenolic compounds that has exhibited high antioxidant properties. In order to study the effect of choose additive on the state of fat in halva, its acid number was considered. The results obtained are shown in Fig. 3.1.

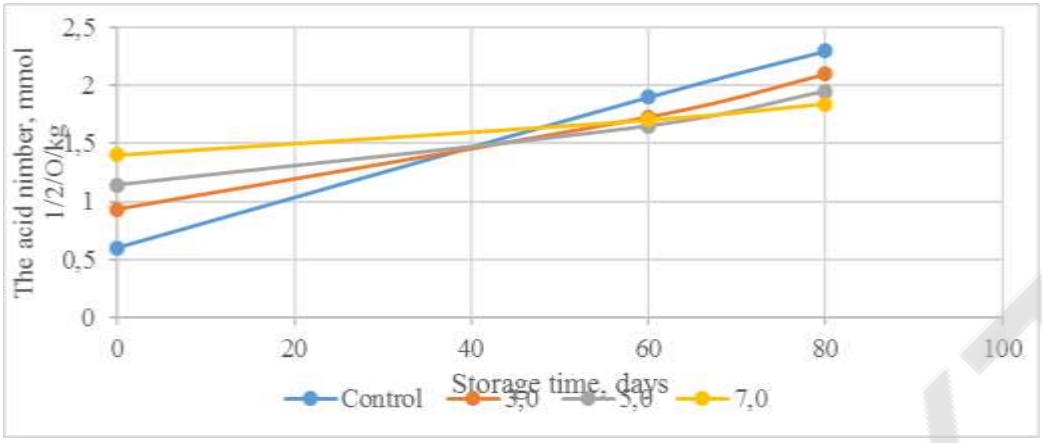

Fig. 3.1 – The dependence of the acid number of fat on the storage time of sunflower halva

From the obtained results it is seen that at the beginning of storage in the test samples, which recipe include grape seeds powder, the acid number is much higher than that of the control one. We can explain this this phenomenon by the presence in the composition of the choose additive of organic acids.

The acid number of the control sample increases rapidly, and in all other samples, the accumulation of acids occurs slowly during storage of halva.

Thus, at the end of the standard storage period (60 days), the acid fat in the control sample is 1.9 mg KOH/g, in the samples with the addition of grape seeds powder in the amount of 3.0, 5.0 and 7.0% – 1.73, 1.65 and 1.7mg KOH/g, respectively. It should point out that the taste sample of sunflower halva which contains 5.0% of grape seeds powder reaches a control value only at 78 days of storage. It prolongs the shelf life by 1.3 times. At 80 days of storage, this figure becomes 2.3 mg KOH/g in the control sample, and in products with the addition of the choose additive in the amount of 3.0, 5.0 and 7.0% – 2.1, 1.95, 1.84 mg KOH/g.

It is concluded that the accumulation of fatty acids has been reducing by the addition of test powder for storage of sunflower halva. However, the acid number hasn`t given a complete description of their degree. The peroxide number is an important indicator, which shows the accumulation of primary oxidation products (peroxides and hydroperoxides) is. The results of his research are shown in Fig. 3.2.

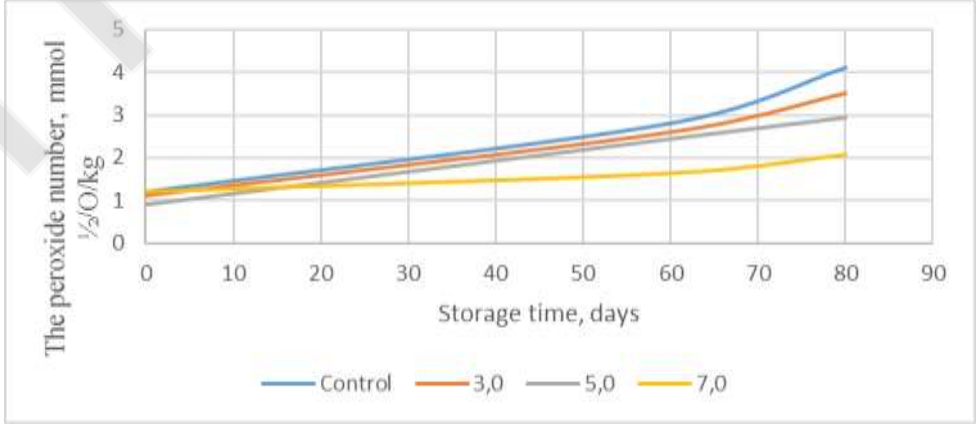

Fig. 3.2 – Dependence of peroxide number on the storage time of sunflower halva

According to the obtained results, in the control sample peroxide number (as well as acid number), acquires significant changes to compare the beginning and the end of storage of the test samples.

The storage time of sunflower halva is known to be 2 months at the necessary conditions. A detailed study revealed that sunflower halva with the addition of 3.0, 5.0 and 7.0% of grape seeds powder to protein mass has had a peroxide value of 80 days of storage of 3.52, 2.94 and 2.06 mmol ½/Okg, respectively, while the control sample for 60 days' storage this value has been 4.1 mmol ½/O kg. The researched additive has been found to retain and improve organoleptic properties, on the other hand, the oxidation processes have been decreased, consequently, the storage time of the rapidly oxidizing product has been increased. The effect of experimental additives on the separation of oil during storage of sunflower halva was investigated. The results obtained are presented in Table 3.2.

Table 3.2 – Influence of test additives on oil separation during storage of sunflower halva

Dosage of grape seeds powder,%	Storage time, days							
	1	10	20	30	40	50	60	80
0 (control)	0.75	2.13	3.78	4.22	5.07	6.02	6.34	7.41
3.0	0.13	0.15	0.15	0.16	0.16	0.18	0.18	0.19
5.0	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
7.0	0	0	0	0.01	0.01	0.01	0.01	0.01

The data obtained indicate that oil is separated in the control sample throughout the shelf life. When adding a test supplement, this rate decreases rapidly and hardly changes during carrying out of the experiment. Thus, for 80 days for 3.0, 5.0 and 7.0% the amount of separated oil is 0.19, 0.03 and 0.01%, while in the control sample – 7.41%. In our opinion, grape seeds powder not only shows its antioxidant properties well, but also firmly holds the oil at its expense. In this way, grape seeds powder not only has good antioxidant properties, but also has a strong oil content. We can explain this by the high content of dietary fiber and the porous structure of the powder, which has been confirmed in [21].

Addition shouldn`t aggravate the organoleptic quality of the finished product. Therefore, it was their basis in determining the rational dosage of grape seeds powder. The results of relevant studies are given in Table 3.3.

According to the data have been obtained, halva with the addition of grape seeds powder in a quantity 3.0 and 5,0% have the similar results, namely sunflower taste and odor, brown shade, retaining a fibrous layered structure, friable texture, as in the control sample. Increasing the dosage of the powder have led to a compaction of the consistency of the product. Therefore, we also think that the rational dosage of the choose additive, which not only improves the organoleptic properties, but also extends the shelf life of sunflower halva, is 5% to protein mass, thereby solving the main problems of the industry.

We calculated the nutritional and energy value of the developed product. The results of the obtained data are shown in Table 3.4.

Table 3.3 – Organoleptic characteristics of sunflower halva with different dosage of powder from grape seeds

Indicator	Dosage of powder, % to protein mass				According to DSTU
	Control	3.0	5.0	7.0	
Odor and taste	Sunflower, no signs of rancidity	Sunflower, no signs of rancidity	Sunflower, no signs of rancidity	Sunflower, no signs of rancidity	Inherent to this type of halva, without signs of rancidity, free of foreign smell and taste
Color	Greyish	Grayish with barely visible light fibers	Grayish with barely visible light fibers	Expressed brown with barely visible light fibers	Inherent to this type of halva
Consistency	Friable, it`s easily cut	Friable, it`s easily cut	Friable, it`s easily cut	Condensed, difficult to cut	Friable, it`s easily cut
Structure in the fault	Fibrous layered	Fibrous layered	Fibrous layered	No fibers	Fibrous layered, fine fibrios

Table 3.4 – Results of calculation of energy and nutritional value of sunflower halva

Sample of sunflower halva	Content in 100 g, g			Energy value, kcal
	Proteins	Fats	Carbohydrates	
Control (no additives)	12.52	30.65	53.77	541.1
With the addition of 5.0% grape seeds powder	12.50	30.04	52.39	530.0

Studies have shown that the choose additives positively influence the chemical composition, while at the same time reduces the energy value of the product, namely the caloric content of 100 g of the control sample is 541.1 kcal, and the halva with grape seeds powder is 530.0 kcal per 100 g.

Referring to our research, we have developed the technology of halva sunflower, which differs from existing halva technologies using natural raw materials, the absence of food additives of synthetic origin, the addiction in the second stage of mixing halva fine powder from grapes with high content polyphenolic compounds, dietary fibers, minerals lead to get a high quality product and an extended shelf life.

The functional and technological scheme of making halva of sunflower with the addition of grape seeds powder is shown in Fig. 3.3

HTP OHAX

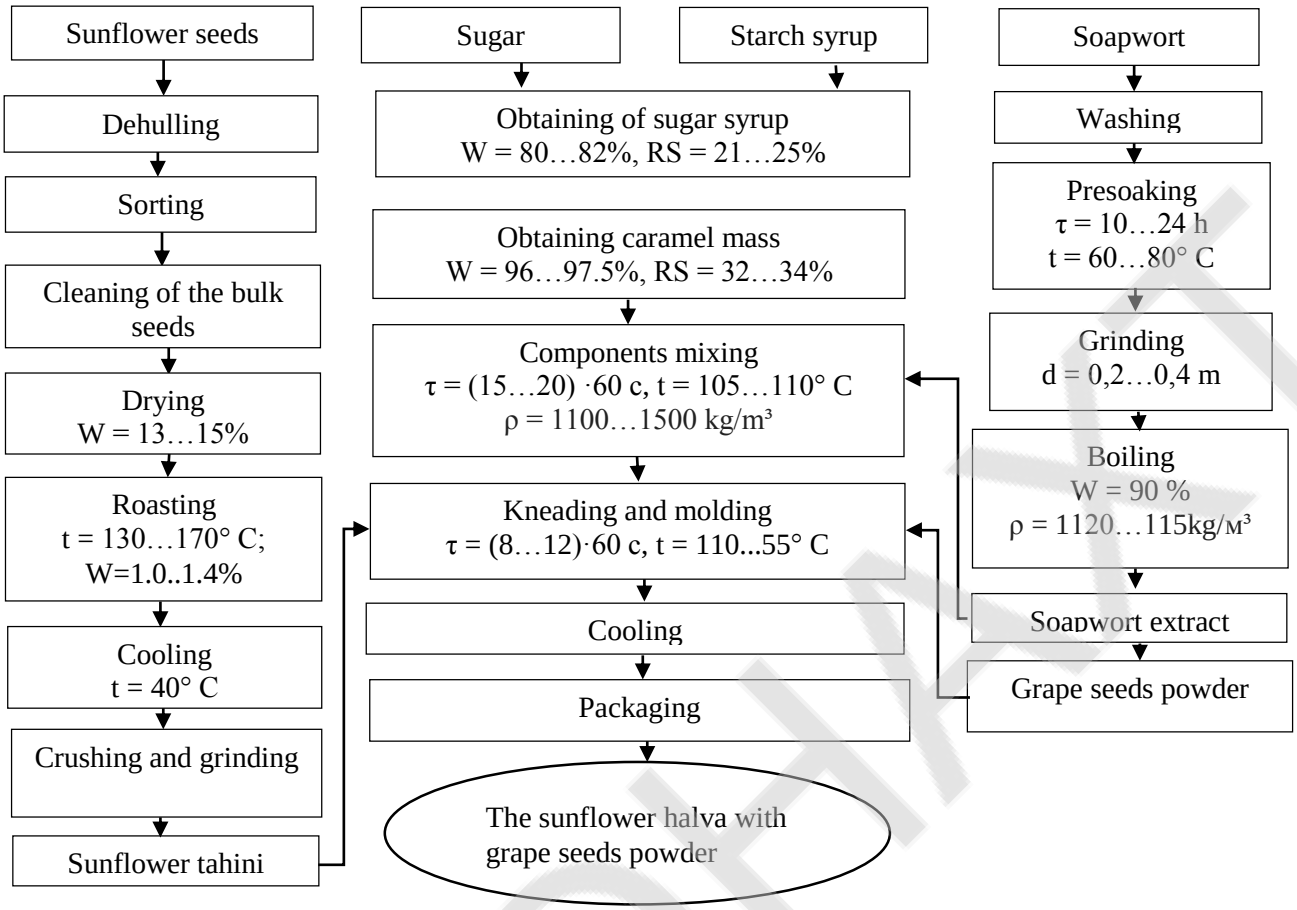

Fig. 3.3 – Functional-technological scheme of manufacturing halva of sunflower with grape seeds powder

Conclusion of section 3

1. Addition of grape seeds powder does not significantly increase the solids content and reduce the mass fraction of total sugars, reducing substances and fat.
2. The addition of grape seed powder leads to slow down the hydrolysis and oxidation of fats
3. Addition of grape seeds powder reduces the separation of oil (80 days) for the samples with the addition of 3.0, 5.0 and 7.0% the amount of separated oil is 0.19, 0.03 and 0.01% while in the control sample – 7.41%.
4. Established rational dosage of the choose additive It is 5% into protein mass this prevents the accumulation of acid number in the finished product
5. The technology of sunflower halva with grape seed powder have been developed by including the introduction of additives with a high content of polyphenolic compounds and dietary fiber in the second stage of kneading

CONCLUSION

1. During of the analytical review of the literature, the features technologies and the main technological stages of the production of different types of halva were studied, as well as the existing problems and methods of their solution.
2. Due to the content of polyphenolic compounds, which have powerful antioxidant and antimicrobial properties, grape seeds powder is used in the production of fat-containing products, which lead to slow down the processes of oxidative and

microbiological spoilage.

3. The results of acid and peroxide numbers, the action of antioxidants contained in grape seeds powder was proved, by analyzing. This made it possible to increase the shelf life of the finished product by 1.3 times and to solve one of the most important problems of spoilage of products.

4. Grape seeds powder is a natural supplement that prevents the separation of fat during storage. As a result, the product has a better appearance and the weight of the finished product remains almost unchanged throughout the life of the product.

5. The optimal percentage of dosage of grape seeds powder – 5% to protein mass has been established that provides a halva with high organoleptic quality.

6. The functional technological scheme of halva of sunflower with grape seeds powder has been developed. The introduction of the experimental additive in the second stage of mixing was determined to provide equal distribution.

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НТБ ОНАХТ

DEVELOPMENT OF COMPOSITIONS AND TECHNOLOGIES OF CULINARY CONFECTIONERY PRODUCTS WITH DETOX PROPERTIES FOR INTRODUCTION IN MODERN ESTABLISHMENTS OF THE RESTAURANT INDUSTRY

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Abstract. *The technologies of preparation of culinary confectionery products (CCP) with pronounced detox properties are presented and the formulations of CCP using collagen hydrolysate and high content of dietary fiber are developed. Such CCP can be positioned as preventative nutrition for people with intellectual work.*

The objective functions in the optimization of the compositions of the CCP was a balanced ratio of the basic macroelements and their amino acid composition.

The chemical composition of CCP was investigated, organoleptic, physico-chemical, microbiological and nutritional and biological values were determined.

The ALST analysis was performed to predict the terms and conditions of storage of CCP, the production and storage of which were carried out under the same conditions, changing the storage parameters according to the established test plan, in conditions similar to modern establishments of the restaurant industry. It is established the created CCP will be competitive in the consumer market of Ukraine.

The results of this work were presented at the XII All-Ukrainian Scientific-Practical Conference of Young Scientists and Students with International Participation "Problems of Forming a Healthy Lifestyle in Youth" (2019). 2 scientific publications have been published. Received 2 patents for utility model and submitted 1 application. The elaborated CCP formulations were introduced into production at the Beer Garden Restaurant in Odessa.

Keywords: *protein; collagen hydrolysate; balanced nutrition; ALST test; competitiveness; culinary product.*

I. Introduction

Nutrition plays a major role in the absorption of basic nutrients of food, their distribution in the human body and accumulation [1].

For the modern man, the main issue is nutrition, especially balanced and healthy. However, the diet contains a high amount of carbohydrate products and contains virtually no sources of complete nutritional protein, fiber, micronutrients.

Low content of easily digestible protein in the diet leads to impaired protein metabolism in the human body and the development of diseases of the pancreas and intestines, reducing the body's resistance to various diseases [2]. All developed countries have raised the issue of healthy nutrition at the level of state policy [3-5]. Today in Ukraine, given the socio-economic conditions, it is becoming urgent as a vital necessity for the formation of state policies in the field of healthy nutrition.

The actual problem today is osteoporosis and osteochondrosis, as well as the slagging of the human body. In Ukraine and in the world, niche products with detoxifying properties are poorly developed. There are dietary supplements with de-

toxifying properties, but no products, so it is important to design and develop recipes for new products with detoxified properties with high protein and dietary fiber con- tent.

Nowadays, CCP are quite popular among different categories of the popula- tion. Particular attention is paid to biologically active substances (BAS) among most of the products and raw materials used for their preparation. This is due to the better transfer of natural compounds compared to synthetic ones, as well as the fact that natural compounds have a more complete effect. Such qualities are absent in the artificial components used for the preparation of CCP.

The purpose of this work is to develop formulations of CCP with detox properties.

II. Analytical review of the literature

The diet of modern man is rich in high-carbohydrate foods, while at the same time characterized by a reduced content of sources of high-grade protein, fiber, micronutrients [2].

All healthy foods contain ingredients that give them functional properties. According to D. Potter's theory, the modern market is effectively utilizing the basic types of functional ingredients: edible fibers (soluble and insoluble); vitamins and minerals, including macro and microelements; polyunsaturated fats (vegetable oils, fish oil, ω3 and ω6 fatty acids); antioxidants: β-carotene, vitamin C, vitamin E; oligosaccharides as substrates for beneficial bacteria [6].

The confectionery market is segmented. By sales, the largest of the segments are flour confectionery, among which muffins and cupcakes are more popular. To ensure the competitiveness of flour confectionery products, it is equally important to expand the range of products by introducing the functional ingredients listed above. [7].

The dietary fibers of beet pulp and wheat germ were considered as food fibers in the production of flour confectionery with functional properties [8].

The dietary fiber has a different granulometric composition and is characterized by a high water- absorbing and fat-holding abilities. Formulations and technologies of cupcakes with functional properties were developed using functional protein raw materials - chicken egg powder, powders of sour milk cheese and yogurt, skimmed milk powder [9].

As an additive with high water absorption properties, we used citrus fiber “Herbacel AQ Plus - type N”, which reduced the energy value of the product. Zucchini puree was used as a source of dietary fiber in the development of flour confectionery for healthy eating [10]. When designing the recipe, the flour was re- placed with an equivalent mass of zucchini puree. The introduction of courgette mashed potatoes has improved such indicators as volume, porosity, shelf life and reduced the time of whipping the dough. Serum was used as a milk base and a protein source for dessert preparation [11].

Vegetable raw materials - dietary fiber Citri-Fi - made it possible to obtain fine oxygen foam for desserts, which increased the stability of the finished product to the destruction of the polydisperse system. The rational quantity of the introduced additive is determined and substantiated, the technological scheme of preparation of the "Sirny" cupcake is developed. The composition of the flour confectionery was made of reconstituted persimmon powder in the amount of 4%, 6%, 8%, 10%. It has been

established that a cupcake made with the addition of 8% persimmon powder is a functional food product in terms of dietary fiber content [12].

Known functional composition CCP containing wheat flour, white sugar, margarine, chicken eggs, kefir or yogurt, salt, baking powder, flavoring, in addition as a source of dietary fiber beet fibers (lighted or unlit), and reduced the amount of white sugar. [13].

The known composition of the ingredients, having a detoxifying effect and as a source of dietary fiber contains activated carbon fiber material and food fiber ce- reals. [14]. Known composition of ingredients for the production of CCP, containing as a source of protein the animal origin collagen drug, as a source of dietary fiber - raisins and candied fruits. [15].

Known composition CCP functional purpose, containing as a dietary supplement for the enrichment of dietary fiber "Meal (Shrot) of wheat germ" [16], which provides increased nutritional value of the product. Ingredients of CCP are known to contain oat bran as a source of dietary fiber [17], which helps to improve the structure and organoleptic characteristics of the product and to increase nutritional value. In addition, it was considered the formulations of gluten-free CCP in which wheat flour (containing gluten) was replaced by corn flour [18] and rice flour, while obtaining a healthy food product with functional properties. From the above data, it follows the relevance of the development of products with balanced chemical composition; with low energy value; with reduced content of sugar and saturated fatty acids; increased content of healthy and healthy ingredients of functional and health-preventive value; be absolutely safe for humans. One of the basic principles of the concept of healthy nutrition is the position that nutrition should not only meet the needs of the human body for nutrients and energy, but also to fulfill preventive and curative goals [19].

Food fibers exhibit a variety of physico-chemical properties: water-holding capacity, water solubility, formation of solutions of different viscosity, ability to create gel, sorption, ion-ex- change and radio-protective properties [19]. Fish raw materials waste are sources of collagen and its hydrolysis products. Fish collagen is hypoallergenic because it is 96% identical to human protein [20-22].

Collagen and its hydrolysis products are widely used in the food industry, including as additives in bread-baking and confectionery industries [23].

Any protein is characterized by biological value, which characterizes its qual- ity, ability to provide plastic processes and synthesis of metabolically active sub- stances, and is conditioned by the presence of essential amino acids in them, their ratio with substitutes and digestibility in the gastrointestinal tract. Collagen is formed by the breakdown of proteins from foods. If at least one essential amino acid is absent, protein production stops. When forming your diet, it is important to con- sume products that enhance collagen synthesis. Although collagen is not a complete protein, its benefit is the presence of two rare amino acids: oxyproline and oxylysine. It acts as a source of glycine (up to 30%) [24].

Due to the absence of tryptophan, collagen is a protein of low biological value. Based on the physiological action of collagen can be attributed it to dietary fibers. It is proved that with optimal combination of muscle proteins and collagen, the rate of pure protein uptake is maximal [20, 23]. Collagen hydrolysis products (glutin, gelatin, etc.)

have a positive effect on the state and function of beneficial intestinal microflora, actively stimulate the secretory and movement functions of the stomach and intestines [23].

In this regard, it is important to develop scientifically sound technologies for products containing collagen hydrolysate and dietary fiber. Given that CCP in the Ukrainian food market among flour confectionery products is in high demand, therefore, it is promising to develop recipes for new types of CCP, enriched with collagen hydrolysate and dietary fiber.

III. Object, subject and methods of research

The object of the study is the technologies of manufacturing new types of CCP with detox properties and high protein content.

The subject of the study was formulations of high-protein CCP and with high content of dietary fiber.

Research methods. Collagen hydrolysate was obtained by alkaline treatment of collagen-containing fish raw materials (fish scales) according to the method de- scribed in the patent of Ukraine for utility model No. 79357 [see patent of Ukraine for utility model No. 79357, publ. 25.04.2013, bul. №8]. Collagen hydrolysate is white in color, odorless and tasteless, allowing it to be used as a biologically active additive to a variety of foods.

Vitamin composition was determined by high-performance liquid chromatography on a column (4 × 150 mm) filled with a 7-μm Separon C-18 sorbent (ZAT Nauchpribor, Russia) with an elution rate of 1.1 cm3 / min.

The mineral composition of the product was determined by annealing the sus- pension. Dry insulation was carried out at a high temperature (about 500 ° C) in the crucible in a muffle furnace under conditions that eliminate the loss of ash elements for 6 hours. The solids content of the solution was determined using an RL-3 refractometer (Poland). Microbiological parameters were determined according to the regulatory documents presented in table 1.

Table 1 - Microbiological indicators for cupcakes

Indicators	Regulatory document
Coliform E. coli bacteria, CFU in 0,1 cm^3	GOST 10444.15
Pathogenic microorganisms, including *Salmonella,* in 25 g of product	Instruction №1138
Number of molds, CFU in 1 g of product, not more	GOST 10444.12
The amount of yeast, CFU in 1 g of product, not more	GOST 10444.12
Staphylococcus aureus, in 0,01 g of product	GOST 10444.2

According to DSTU ISO 6658: 2005, organoleptic analysis was performed by analytical evaluation using a descriptive method (profiling method) and the method of using scales and categories (scoring using a point scale).

The competitiveness of the products was determined as follows. When calculating the future competitiveness of a product, the price and safety of the product are taken into account: Competitiveness is calculated using the formula:

$$K = Б \cdot \frac{\sum m_i \cdot g_i}{Ц}$$

where $\Sigma m_i g_i$ is the total complex indicator of the quality level, expressed in points (m_i is the coefficient of weight and g_i is the indicator of quality of the its property); C - price per unit of product; B - product safety.

Formulas (1) - (2) were used to formulate the complex quality index, where weight coefficients and relative quality indicators were taken into account. Considering the importance of individual indicators, the functional dependence of a comprehensive quality indicator is as follows:

$$K_0 = f(M_i \cdot K_i)$$

where M_i is the importance factor of the individual indicators, the sum of which must be equal to 1; K_i is the coefficient of evaluation of these indicators.

To study the detox properties of collagen hydrolysate, we used IR spectroscopy, which is based on the phenomenon of absorption by chemicals of IR radiation with simultaneous excitation of vibrations of molecules. Spectrophotometers are used for the study, which record oscillation data and as a result we obtain IR spectra.

In the IR spectroscopy use the middle part of the IR region, namely: 4000-200 cm^{-1}. When decrypting the IR spectra, reference materials were used and meant that the IR spectra of the polypeptides and proteins revealed some relatively strong ab- sorption bands, which, as a rule, relate to the vibrations of the –CO – NH– peptide group, as a general structural component of protein molecules.

IV. Research results

3.1 Determination of the detox properties of collagen hydrolysate

To date, scientists in Ukraine and the world are trying to solve the problem of contamination of the human body with heavy metals by creating dietary supplements for adsorption of heavy metals on the surface of the biological matrix and the removal of the formed complex compound from the human body. This is the principle of detoxification of the body.

Often used from natural polymeric carriers for complexing is agar is a polysaccharide consisting of agarose and agaropectin. Immobilization of enzymes on protein carriers can be carried out both in the absence and in the presence of cross-linking agents. In proteins that can be carriers, among the disadvantages are their high immunogenicity (except for collagen, collagen hydrolysate and fibrin). The development of effective matrices for the immobilization of heavy metal ions and their excretion from the human body is an urgent task, which will allow to expand the range of dietary supplements, dishes and culinary products in restaurants.

The most important functional properties of collagen hydrolysate include solubility and swelling, the ability to stabilize dispersed systems (foams, emulsions, suspensions), to form gels, to improve the adhesion and rheological properties of food systems. To confirm the ability of collagen hydrolysate to complex with heavy metals, that is, its detox properties, a corresponding study was conducted, which resulted in a number of IR spectra. Some of them are as follows: collagen hydrolysate, an immobilized form of heavy metal (Pb).

The data obtained showed a broad absorption band in the range 3200-3800 cm^{-1}, which is characteristic of collagen and its hydrolysis products. Analysis of the IR spectra of collagen hydrolysate showed the presence of a peak at 3500 cm^{-1}, indicating

that collagen hydrolysate is a product of collagen hydrolysis (amide A), peaks 1670,24 cm^{-1}, 1550 cm^{-1} characterize the presence of amide I and amide II. The presence of valence vibrations of the C = I group of nonionized and ionized acids is characterized by an absorption band at 1620 cm^{-1}.

In the collagen hydrolysate spectrum, an intense broad band with a maximum absorption at 3400 cm^{-1} is observed, which is shifted to the low-frequency region in comparison with the frequency of free OH- groups, which indicates the presence of hydroxyls in the hydrogen bonding system. The absence of an absorption band at 3650 cm^{-1} indicates that virtually all hydroxyl groups are included in the hydrogen bond. The density and strength of the hydrogen bond network were investigated us- ing a characteristic absorption band of 3400 cm^{-1}, which corresponds to the valence vibrations of the hydroxyl groups. For this purpose, the bandwidth was determined according to the wave numbers of the studied region of the spectrum.

The results of IR spectroscopy make it possible to position the collagen hydrolysate as an enterosorbent and prove that it has detox properties.

Using the results of the study above, as a dietary supplement in the production of CCP used the collagen hydrolysate, which has a high content of oxyproline and oxylysine. The collagen hydrolysate supplies the body with important material to create and strengthen articular cartilage, connective tissue, skin, hair and nails. Its regular intake also promotes skin elasticity and connective tissue strength.

3.2 Development of CCP formulations

Mathematical modeling (optimization) of the formulations of the CCP was performed according to the method described in [11] as follows.

The main task was to build an appropriate mathematical model, which includes the following steps: determining the purpose of the study; choice of optimality criterion; identifying major constraints; mathematical formalization.

A goal function is a research goal written mathematically as a function of variables. The aim of the CCP design was to maximize the nutritional value of the product being designed, which is defined as the sum of the nutritional value of the components of the PI whose mass consists of the formulation.

The nutritional value of the recipe ingredients of the banana CCP «Gluten-free» is presented in Table 1.

Table 1 – The nutritional value of the recipe ingredients of the banana CCP «Gluten-free»

Nutrients	Quantity of nutrients of prescription ingredients, g / 100g					
	Flour buck-wheat	Bananas	Butter	Walnut	Kefir	Chicken eggs
White	13,6	1,5	0,8	16,2	2,9	12,7
Carbohydrates	71,9	21	1,3	11,1	4	0,7
Fat	1,2	0,5	72,5	60,8	2,5	11,5
ω 3	0,071	0,027	0,07	7,1	0,023	0,101
ω 6	0,877	0,046	0,91	33,3	0,078	1,784
Total	87,65	23,07	75,6	128,5	9,5	26,8

To develop CCP, the objective functions are as follows:

- the banana CCP «Gluten-free»: $F(x) = (87,65 \cdot x_1 + 23,09 \cdot x_4 + 75,6 \cdot x_5 + 128,6 \cdot x_6 + 9,5 \cdot x_7 + 26,8 \cdot x_8)/100 \rightarrow \max$;

- CCP «Bubble»: $F(x) = (82,4 \cdot x_1 + 99,8 \cdot x_2 + 75,6 \cdot x_3 + 26,8 \cdot x_4 + 89,0 \cdot x_5 + 74,0 \cdot x_7 + 81,5 \cdot x_8 + 85,0 \cdot x_9 + 98,5 \cdot x_{10} + 70,0 \cdot x_{11} + 99,8 \cdot x_{12})/100 \rightarrow \max$;

- CCP «Snowball»: $F(x) = (30,6 \cdot x_1 + 82,4 \cdot x_2 + 80,3 \cdot x_3 + 99,8 \cdot x_4 + 75,6 \cdot x_5 + 128,5 \cdot x_6 + 74,0 \cdot x_7 + 70,0 \cdot x_9)/100 \rightarrow \max$;

- CCP «Nasinynka»: $F(x) = (82,4 \cdot x_1 + 99,8 \cdot x_2 + 98,5 \cdot x_3 + 26,8 \cdot x_4 + 104,8 \cdot x_5 + 80,3 \cdot x_6 + 128,5 \cdot x_7)/100 \rightarrow \max$

The resulting formulations of all CCP are presented below:

1. Developed recipe composition the banana CCP «Gluten-free»" contains buckwheat flour - 31,0 g; bananas - 40.5 g; chicken eggs - 15,0 g; kefir - 10.6 g; butter - 10.3 g; walnuts kernels - 10,0 g; vanilla sugar - 3.0 g; stevia - 1.6 g; baking soda - 2.0 g; table vinegar - 5.0 g;
2. Developed recipe composition CCP "Bubble" includes wheat flour - 43,9 g; sugar - 14.6 g; butter - 12.6 g; mélange - 4,9g; baker's yeast - 1.0 g; table salt 0.2 g; raisins - 5.8 g; candied fruit - 2.9 g; hazelnuts kernels - 7.7 g; vanilla powder - 0.9 g; collagen hydrolysate - 5.0 g; refined powder - 0.5 g;
3. Developed recipe composition CCP "Snowball" contains skimmed milk cheese - 41,0 g; wheat flour - 27,0 g; sesame black - 3.5 g; sugar - 3.5 g; butter - 7.0 g; walnuts –5,5 g; raisins - 4.8 g; table salt - 0.7g; collagen hydrolysate - 7.0g;
4. Developed recipe composition CCP "Nasinynka" includes wheat flour - 17.5 g; sugar - 27.4 g; vanilla sugar - 0.5 g; chicken eggs - 37.4 g; pumpkin seeds - 5.4 g; black sesame - 5.4 g; walnut kernels –5.4 g.

In the section of the CCP “Bubble”, it is seen that when the collagen hydrolysate is added to the formulation, the structure of the finished product also changes significantly. This increases the size of the pores and the color improves significantly (from light golden to golden). CCP “Bubble” has a glossy surface with a crispy crust. In the control sample, the surface is darker (from dark gold to light brown). The introduction of collagen hydrolysate promotes a uniform distribution of moisture, thereby the weight of the dough when baking is reaches a ready 10 minutes faster than in the control sample.

The analysis of organoleptic indicators of CCP showed their high-quality characteristics. We observe a drier structure of CCP, because of the presence in them of dietary fibers that have a water absorption capacity. The use of vegetable raw materials helps to increase the fiber content.

3.3 Investigation of the nutrient composition of CCP

The use of vegetable raw materials helps to increase the content of monosaccharides and dietary fiber, as well as minerals. The introduction of collagen hydrolysate in the formulations of CCP "Bubble" and "Snowball" allows you to enrich them with rare amino acids oxylysine and oxyproline, which play a major role in the human body in the formation of connective fibers. Created CCP can be called is having

functional properties, due to the content of its functional ingredients, are those whose content in the product meets from 10% to 50% of the daily requirement of the human body.

CCP "Snowball" has a high content of fats, vitamins of group B (B6, B2, B1), A, PP; minerals (P, K, Na, Fe, Mg, Ca), the energy value of the product meets 22.3% of the person's daily energy requirement. CCP "Bubble" is high in protein (however less than in CCP "Snowball"), fats and carbohydrates (mainly starch), as well as vitamin A and mineral P, the energy value of the product satisfies 10.5% of the daily human need for energy. In CCP "Nasinynka" we note the high content of protein, carbohydrates (mostly complex - starch), fiber, minerals (P, Fe and K), vitamins (A, B6 and B2), the energy value of the product satisfies by 12, 4% of a person's energy needs. In the banana CCP «Gluten-free», we note the high content of carbohydrates (mainly complex - starch), fats, fiber, minerals (P, Na, Fe and K), vitamins (A, PP and B1), the energy value of the product satisfies by 10.3% of a person's daily energy requirement. CCP "Nasinynka" and the banana CCP «Gluten-free» contain fiber, which are dietary fiber. Dietary fiber is a prebiotic that is not digested by endogenous secretions of the gastrointestinal tract of humans.

Dietary fiber has numerous physiological effects that determine the normal functioning of the body: stimulate the intestinal motor function; prevent cholesterol absorption; have a positive effect on the normalization of the composition of the gut microflora, slow down putrefactive processes; affect lipid metabolism, the violation of which leads to obesity; adsorb bile acids; contribute to the reduction of the content and removal of toxic substances.

The ratio of basic mineral substances for their highest degree of absorption meets the requirements for healthy nutrition and is: Ca: Mg: P = 2,9: 1: 3,4 - for CCP "Bubble", Ca: Mg: P = 1: 3: 0, 9 for CCP "Snowball". A study on the content of amino acids showed the presence of all essential amino acids, the limiting amino acid is methionine (amino acid score CCP "Bubble", "Snowball", "Nasinynka" and the banana CCP «Gluten-free» is 29.2%; % and 46.7% respectively).

3.4 Investigation of organoleptic and microbiological parameters of CCP during storage

In order to predict the terms and conditions of storage of the CCP, an ALST analysis was performed. Production and storage of CCP was carried out under the same conditions, changing the storage parameters in accordance with the established test plan ALST, in conditions similar to modern establishments of the restaurant industry.

To predict the actual shelf life of the CCP, we used the dependence of the process of changing commodity and CCP security indicators on the time and storage temperature. According to the ALST test, were investigated during storage micro-biological and organoleptic parameters. According to microbiological indicators, the developed CCP meet the requirements of the current sanitary legislation of Ukraine. E. coli bacteria (coliforms), pathogens, including bacteria of the genus Salmonella, S. Aureus were not detected in any specimen during storage. Research of organoleptic parameters. Optimal shelf life in conditions similar to the conditions of modern establishments of the restaurant industry for the banana CCP «Gluten-free» is 3 days, "Bubble" and "Snowball" - 4 days, and "Nasinynka" - 10 days without change of

organoleptic and microbiological parameters.

3.5 Sensory parameters research and competitiveness evaluation of CCP

The conditions of development of economy and society in the modern world make it necessary to assess the competitiveness of new foods. Competitively called products that are in demand by a large number of consumers and have a correspondingly higher level of quality than known counterparts, but different from the latest elements of innovation in the form of intellectual property: patents, etc. The competitiveness of a product can only be determined by comparing its properties with those of competitors or with a hypothetical standard product.

As the consumer first and foremost pays attention to organoleptic characteristics and nutritional value, the above competitiveness criteria were given a higher weighting factor. The competitiveness of CCP "Bubble", "Snowball", "Nasinynka", and the banana CCP "Gluten-free" is 65.5; 58.8; 51.1 and 54.2 points, respectively. From the presented results, it follows that all developed CCP will be competitive in the consumer market of Ukraine due to the improvement of organoleptic characteristics, high content of protein, vitamins and minerals, the presence of preventive properties, which is very important for children, for people with intellectual work and the elderly. In addition to the above the banana CCP "Gluten-free" does not contain gluten, which allows you to recommend this CCP to people with celiac disease.

Conclusions

1. Investigation of the ability of collagen hydrolysate to form a complex with heavy metal, according to the results of IR spectra, confirm its detox properties;
2. Developed compositions and technologies for the production of CCP "Bubble" and "Snowball", which are enriched with collagen hydrolysate; "Nasinynka" and the banana CCP "Gluten-free";
3. Determined the qualitative composition of nutrients (micro- and macronutrients, vitamins);
4. Characterized the qualitative composition of the protein by the balance of amino acids. A limited amino acid is methionine.;
5. Competitiveness studies have shown that CCP developed will be competitive in modern establishments of the restaurant industry;
6. The critical term of realization of the banana CCP «Gluten-free» is 3 days, CCP «Bubble» and «Snowball» - 4 days, CCP «Nasinynka» - 10 days.

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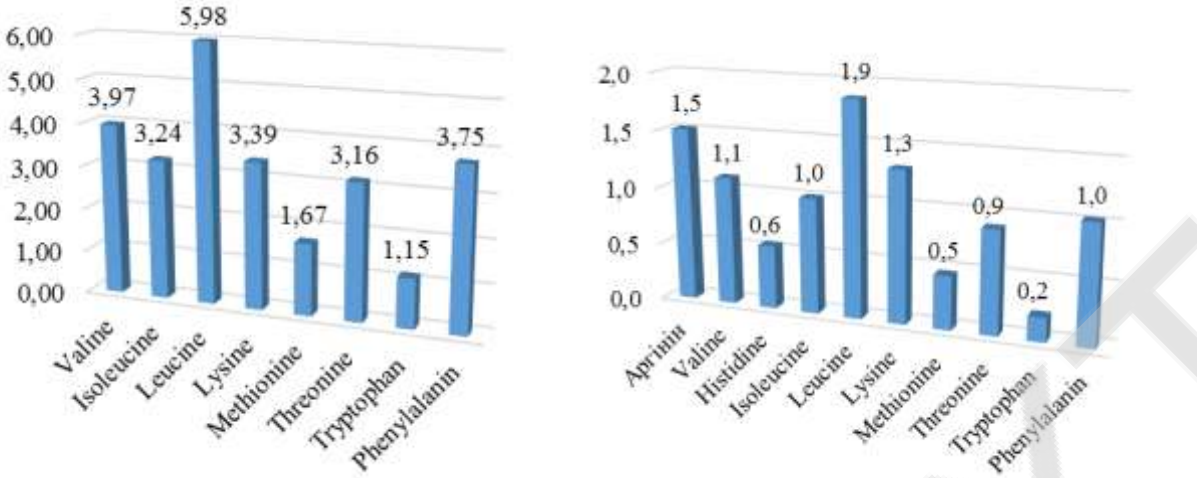
Application A

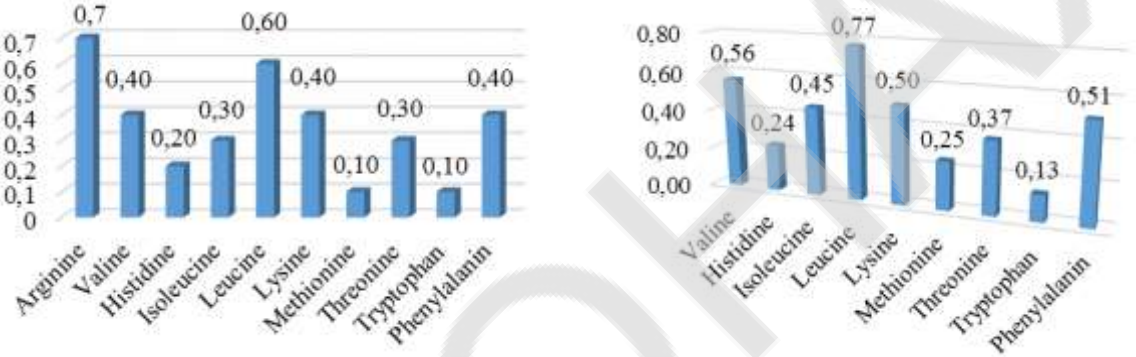
Table 1 - Chemical composition and satisfaction of CCP "Snowball", "Bubble", "Nasinynka" and the banana CCP "Gluten-free" daily requirement in nutrient rents, %

Indicator		CCP "Snowball"		CCP "Bubble"		CCP "Na-sinynka"		the banana CCP "Gluten-free"		Adequate intake of g, mg / day
		100 g content	satisfaction of daily requirement, %	100 g content	satisfaction of daily requirement, %	100 g content	satisfaction of daily requirement, %	100 g content	satisfaction of daily requirement, %	
Water, g		50,4	3,5	41,3	2,8	34,4	2,2	46,3	3,1	1500…2000
Protein, g		22,2	24,7	11,6	12,9	9,6	10,6	6,6	7,3	58…117
Fat, g		13,2	12,0	11,2	10,2	10,8	9,8	14,1	15,7	60…154
Carbohydrates, d. including:		12,2	4,9	35,3	31,4	43,6	25,5	10,09	3,4	257…586
monosaccharides, g		10,8	3,1	14,9	4,3	31,1	8,9	4,7	1,9	207…486
starch, g		1,4	1,8	20,4	27,1	12,5	16,6	6,2	8,9	50…100
Cellulose, g		2,0	13,1	0,6	4,1	1,6	10,4	1,7	13,1	10…15
Mineral substances, mg per 100 g	Na	852,1	21,3	14,0	0,4	61,3	1,5	344,6	6.9	4000…6000
	K	393,0	24,6	142,7	8,9	164,3	10,3	132.2	4.4	2500…5000
	Ca	329,0	11,0	18,9	0,6	97,8	3,3	29.4	3.7	800
	Mg	111,3	13,9	15,4	1,9	65,0	8,1	28.5	7.1	400
	P	377,0	94,3	61,7	15,4	196,1	49,0	76.5	6.4	1200
	Fe	2,8	18,7	0,8	5,0	2,6	17,3	1.2	8	10…18
Vitamins, mg per 100 g	A	0,1	74,9	0,5	74,9	0,1	74,9	0,1	0.02	800…1000
	β-carotene	0,1	1,7	0,1	0,8	0,0	0,2	0,1	1,2	5…10
	B1	0,3	17,3	0,1	5,3	0,1	9,3	0,2	10,0	1.1…2.1
	B2	0,4	20,6	0,1	2,8	0,2	12,8	0,1	7.7	1.3…2.4
	B6	0,4	190,0	-	-	0,2	75,0	-	-	0,1…0,2
	E	1,0	6,5	-	-	1,4	9,5	0,5	3,3	12…15
	PP	6,8	33,9	0,7	3,3	1,6	7,8	1,7	8,5	14…28
	C	1,9	2,4	0,4	0,5	0,3	0,4	2,8	3,5	70…100
Energy value, kcal		558,2	22,3	261,8	10,5	310,7	12,4	198,7	9,9	1800…4200



A B

Fig. 1 - Amino acid profile CCP "Bubble" (A) and "Snowboll" (B), mg / 100 gr



A B

Fig. 3 - Amino acid profile CCP "Nasinynka" and the banana CCP "Gluten-free", mg / 100 gr

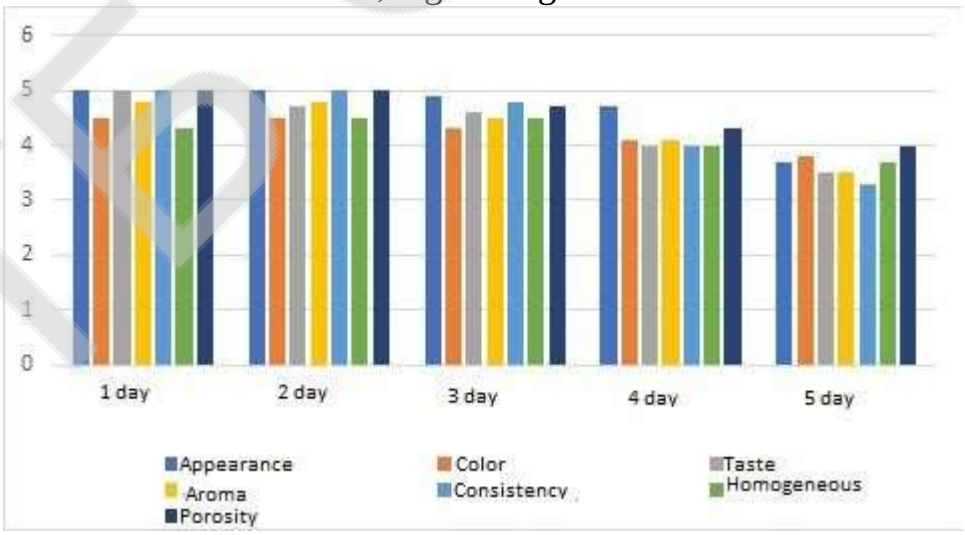


Fig. 5 - Organoleptic profile of CCP "Bubble" during storage

Fig. 6 - Organoleptic profile of CCP "Snowball" during storage

НТБ ОНАХТ

PASTA OF NON-TRADITIONAL POLY-CEREAL RAW MATERIALS

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Abstract. *The object of research is loose grain raw materials, flour from whole grains of various cereals and poly-cereal mixture based on it, which is a valuable source of nutrients and minerals for the production of pasta.*

The purpose of the research is to study the possibility of making pasta of high nutritional and biological value on the basis of non-traditional poly-cereal raw materials.

Method and methodology of the work. The basis for the development of the recipe for making poly-cereal pasta from composite flour mixtures of whole grains of cereals and cereals is based on the methodology for designing their composition, which allows you to regulate the content of nutrients in the product that meet the requirements of rational and adequate nutrition, providing a preventive focus.

Application area. *Pasta production, in particular the production of pasta of high nutritional value based on a combined recipe.*

Economic efficiency and significance of the work. The results obtained help to expand the range of new food products, improve the structure of nutrition, strengthen health, increase the immune protection of the human body, which is due to a positive socio-economic effect.

Keywords: *pasta; grain of grain crops; grain of leguminous crops; grain of cereals; poly-cereal raw materials; non-traditional raw materials.*

I. INTRODUCTION

For the production of traditional pasta, hard wheat varieties are used, which are "poor" in chemical composition with the most important nutrients. In this regard, it is possible to increase the nutritional value of pasta by adding natural ingredients, such as corn, millet, buckwheat, barley or oats, as well as other grains/legumes that differ significantly in chemical composition from traditional raw materials. Therefore, the production of pasta based on non-traditional poly-cereal raw materials is one of the promising areas for creating functional products.

The basis for the development of the recipe for making poly-cereal pasta from homogeneous composite flour mixtures of whole grains of cereals and cereals is based on the methodology for designing its composition, which allows you to regulate the content of nutrients in the product that meet the requirements of rational and adequate nutrition, providing a preventive focus.

Thus, pasta made from non-traditional raw materials, compared with other types of flour products, will have a number of advantages: high digestibility of basic nutrients, high consumer properties (each category of people can meet their taste needs), long shelf life, low cost and availability for all segments of the population. However, in our country, such products are not produced, and manufacturers have to use baking flour from soft wheat, whose protein is deficient in the most important essential amino acids.

The purpose of the research is to study the possibility of making pasta of high nutritional and biological value on the basis of non-traditional poly-cereal raw materials.

II. ANALYTICAL REVIEW OF THE LITERATURE

2.1 Ways of improving the technology of pasta production

There are scientific papers devoted to the balanced introduction of plant raw materials (vegetable or berry crops) in order to enrich pasta with dietary fibers, minerals, organic acids, vitamins and antioxidants. They also use lactic acid leaven or whey for enrichment with biologically active substances; egg shells are used for mineral enrichment; yeast is used to increase the protein content; tomato-based products are enriched to increase the mineral content; a method for enriching pasta to solve problems of iodine deficiency has been developed, using seaweed [1-6].

In addition to increasing the nutritional value of pasta, scientific work is aimed at improving the technological modes of pressing and cooking. Since the introduced components significantly change the structural and mechanical properties of the dough and change the cooking properties of pasta. In this regard, the development of new recipes requires the development of a full cycle of technology from the preparation of raw materials and flour mixture recipes to the production of finished products with an assessment of consumer properties that have undergone heat treatment [3].

Simultaneously with the expansion of the range based on non-traditional raw materials, the production of pasta with the inclusion of coarse flour is becoming more and more interesting. Currently, the production of pasta with the inclusion of bran in the recipe has been established. This direction can be improved without restrictions, because Kazakhstan has a rich grain potential. We need to use the full potential of the grain industry. This area needs to be studied and improved on an ongoing basis.

Thus, further development of pasta production will be aimed at expanding the range of products for the use of new types of raw materials, such as non-traditional poly-cereal raw materials, as well as improving the technological processes of pressing, forming dough, drying and cooking pasta.

2.2 Recommendations for developing a promising range of pasta

The modern pasta industry is developing along the following path: reducing the production cycle and energy costs; reducing the cooking time of pasta and expanding the raw material base of pasta production by using non-traditional raw materials [3, 5].

In the result of the analysis of patent researches it should be noted that at the modern level of development of the pasta industry, the range is regularly updated with new products, characterized by a rich chemical composition and also the ratio of amylase and amylopectin, the gelatinization temperature and granule size. At the same time, a promising direction in the development of pasta production is the use of coarse flour varieties of various cereals and legumes. Different combinations of them will give new varieties of pasta therapeutic and preventive properties, and the consumption of new pasta will give a functional status in the prevention of a number of chronic diseases.

III. OBJECT, SUBJECT AND RESEARCH METHODS

3.1 Object of research

The objects of research are: bulk grain raw materials, flour from whole grains of various cereals and poly-cereal mixture based on it, which is a valuable source of nutrients and minerals for the production of pasta.

3.2 Subject and methods of experimental research

The subject and methodology of the research work included information-analytical and laboratory parts of the study with the use of experiment planning, analytical processing of the results of technological experiments using modern laboratory equipment and computer programs.

Analytical studies were carried out on the basis of Kazakh National Agrarian University, namely in the conditions of research laboratories of the educational research and production Center for processing technology and Agro technological HUB.

3.2.1 Method of developing a poly-cereal mixture recipe

Poly-cereal mixtures for the production of a promising range of pasta based on non-traditional raw materials were made in accordance with the results of automated calculation using software [7], which is intended for compounding composite mixtures based on flour from whole grains of cereals and leguminous crop.

3.2.2 Nutritional value of the flour mixture, rheological properties, duration of kneading and speed of pressing the pasta dough

The chemical composition (mass fraction of protein, starch and fiber content, ash content) was determined using an infrared analyzer.

Study of rheological properties of the dough. The main technological properties that determine the effectiveness of the technological process of pressing pasta dough are elastic-plastic properties: viscosity, elasticity and extensibility of the dough. In this regard, we studied the rheological properties of pasta dough made in accordance with the developed recipe based on poly-cereal raw materials. It is obvious that the prepared mixture will differ not by low values of indicators of the studied properties. In this regard, to give the dough the best elastic-plastic properties, dry wheat gluten was introduced into the recipe, for binding all the components introduced into the mixture recipe.

Determination of the rheological properties of flour using Chopin's Alveograph [8]. The essence of the method consists in kneading dough of constant humidity and a solution of sodium chloride, after which the dough is installed in a special compartment of the Alveograph, where the dough extensibility is determined during the inflating of the dough balls, and automatic plotting with curves showing the rheology of the flour.

Determination of water absorption and rheology of flour using a Farinograph [9]. The study was conducted on a Farinograph from Brabender, Germany. The principle of operation is to mix the dough in a dough mixer, with the addition of the necessary amount of water in order to obtain the desired consistency. The results of the study were recorded in the observation log.

The Farinograph device was used to study water absorption, dough formation time, dough stability, dough dilution rate, and the quality level of the Farinograph.

The production of pasta. Preparation of pasta was carried out on a laboratory screw pasta press.

The dough humidity was 38 %. To prepare the dough (recipe № 1, № 2, № 3), water with a temperature of 35° C was used.

3.2.3 Methods for evaluating the quality of pasta

The quality assessment of consumer properties of pasta was determined in accordance with STST 51865-2002, according to which the assessment is descriptive. It also provides a point-based assessment of the quality of pasta, which in turn

facilitates the comparative assessment of products, more objectively reflects their consumer advantages and changes in quality during their long-term storage.

The evaluation of the developed batch of pasta was made according to the following indicators: appearance, color, smell, taste, consistency, and state of cooking water. Each indicator is characterized by five or six descriptive categories with the assignment of the specified points. The total maximum score is 100 points.

According to the method of evaluating organoleptic indicators of the quality of pasta can be divided into four groups: excellent, good, satisfactory, unsatisfactory.

The "Excellent" category is considered to be pasta products that retain their shape after cooking, are freely separated from each other, and have a smooth surface. The taste and smell are well-defined, characteristic of this product. The color is typical, well-defined, the consistency is elastic, without a powdery core. Cooking water with a small content of suspended particles. The score must be at least 96 points.

For pasta products of the "Good" category, light sticking, more turbid water after cooking, a slight darkening or enlightenment is allowed. The taste and smell are well-defined, typical. The estimated score is 95-84.

Products of the "Satisfactory" category are characterized by a less pronounced taste and smell, noticeable sticking after cooking, a darkish or excessively light color, turbid water, and a softened consistency. The estimated score is 83-75.

Products with a score below 75 are considered "Unsatisfactory" pasta. During cooking, their integrity is violated, they stick together, acquire a faded color, "empty" or very weakly pronounced taste and smell.

IV. RESULT OF WORK

4.1 The recipe of the poly-cereal mixture was developed and the organoleptic properties of the dough for making pasta from non-traditional raw materials were studied

A computer program was used to calculate the nutritional value of poly-cereal flour [7]. As a result of the calculation, three recipes for pasta made from non-traditional raw materials were selected. The calculated values of the selected recipes are shown in table 1.

Table 1 – Pasta recipes from non-traditional raw materials

Name	Recipe 1, %	Recipe 2, %	Recipe 3, %
Wheat	0	0	0
Barley	0	0	16
Corn	33.3333333333333	50	25
Oats	33.3333333333333	16.6666666666667	15
Buckwheat	0	16.6666666666667	27.3
Millet	16.6666666666667	0	0
Peas	0	0	16.7
Soy	16.6666666666667	16.6666666666667	
Protein	18.028	17.824	18.5
Starch	60.256	63.076	56.7
Fiber	8.076	6.684	13.23
Fat	8.61	8.348	7.76
Ash content	3.664	2.946	5.34

4.2 The rheological properties of pasta dough based on non-traditional raw materials are studied

In the course of experimental studies, the elasticity of the dough was studied, which is characterized by the maximum resistance of the dough plate when it inflates into a bubble (P, mm). We studied the dough extensibility, characterized by the maximum volume of the resulting dough bubble (L, mm). Along with indicators of flour strength, it is also necessary to take into account the data of alveogram that characterize the ratio of P/L (elasticity and extensibility) of the dough. We determined the specific work spent on the deformation of the dough (W, a.u.) when the experimental dough sample was inflated into a bubble. We determined the coefficient of elasticity (Ie, %), which is characterized by the dough's resistance to stretching when deformed along two axes.

Experimental data showed that the plates of pasta dough from non-traditional raw materials had the worst rheological properties, which were not just recognized by Chopin's ALVEO-consist graph, which is due to the high content of water-soluble protein fraction, which is not able to bind water. The structure of the dough was crumbly, disintegrating even with small values of deformation. Only the control sample of the dough plate based on first-grade flour had a high characteristic of rheological properties, which is explained by the fact that the protein fraction of cereals is represented mainly by gliadin and gluten, which are insoluble in water, a characteristic feature of which is weak solubility in water and therefore in the dough they are able to bind water, swell The results of experimental studies to determine the rheological properties of the control sample of the dough are shown in table 2.

Table 2 – Rheological properties of first-grade flour dough (control sample)

Name of the indicator	The control (I grade wheat flour)
Dough elasticity, P, mm·H_2O	137
The extensibility of the dough, L, mm	84
Specific work, W, a.u.	455
Elasticity-to-extensibility ratio, P/L	1.63
The coefficient of elasticity, Ie, %	68.9

Further, experimental studies were conducted to improve the rheological properties of pasta dough from non-traditional raw materials. To optimize the rheological properties of the pasta dough and improve the quality of the finished product, dry wheat gluten (hereinafter referred to as DWG) was added to the poly-cereal flour mixture in an amount of 15, 25, 35 %, respectively, according to three selected recipes. The results were compared with a control sample of first-grade flour dough. The results of the research are presented in tables 3-5.

Table 3 – Rheological properties of pasta dough from poly-cereal flour mixture, Recipe No. 1

Name of the indicator	Introduction of the DWG, %		
	15	25	35
Dough elasticity, P, mm·H_2O	181	253	188
The extensibility of the dough, L, mm	81.4	38.5	103.6
Specific work, W, a.u.	132	193	330
Elasticity-to-extensibility ratio, P/L	13.66	17.01	7.09
The coefficient of elasticity, Ie, %	12.4	9.3	29.5
Flour humidity, %	8.47	8.3	8.2

Table 4 – Rheological properties of pasta dough from poly-cereal flour mixture, Recipe No. 2

Name of the indicator	Introduction of the DWG, %		
	15	25	35
Dough elasticity, P, mm·H_2O	121	238	168
The extensibility of the dough, L, mm	40.0	41.01	40.1
Specific work, W, e. a.	79	162	162
Elasticity-to-extensibility ratio, P/L	16.59	22.33	19.81
The coefficient of elasticity, Ie, %	92.9	9.1	36.2
Flour humidity, %	10.38	8.09	8.12

Table 5 – Rheological properties of pasta dough from poly-cereal flour mixture, Recipe No. 3

Name of the indicator	Introduction of the DWG, %		
	15	25	35
Dough elasticity, P, mm·H_2O	96	162	103
The extensibility of the dough, L, mm	92.4	42.2	29.5
Specific work, W, a.u.	129	164	124
Elasticity-to-extensibility ratio, P/L	8.91	8.07	6.01
The coefficient of elasticity, Ie, %	61.6	11.2	40.0
Flour humidity, %	8.05	8.2	7.7

4.3 The chemical composition of the mixtures composed from non-traditional poly-cereal raw materials

The chemical composition of the prepared mixtures with different percentages of DWG (15, 25, 35 %) was studied by near-infrared spectroscopy. The results of the analysis and the results of calculating the nutritional value are presented in table 6.

The analysis of the presented data shows that an increase in the percentage of DWG from 15 % to 35 % in the pasta dough recipe leads to an increase in the calorie content of the flour mixture. At the same time, dry wheat gluten, due to its chemical composition, significantly reduces the calorific value of the original poly-cereal mixture.

Table 6 – Values of the chemical composition of the prepared pasta dough recipe with the DWG entered

Recipe No. 1 +15 % DWG		Recipe No. 1 + 25 % DWG		Recipe No. 1 + 35 % DWG	
Protein, %	16.68	Protein, %	18.31	Protein, %	26.25
Fat, %	3.96	Fat, %	3.96	Fat, %	4.88
Fiber, %	1.35	Fiber, %	1.37	Fiber, %	1.5
Ash content, %	0.51	Ash content, %	0.6	Ash content, %	0.89
Calories, kcal	107.4	Calories, kcal	114.01	Calories, kcal	154.54
Recipe No. 2 + 15 % DWG		Recipe No. 2 + 25 % DWG		Recipe No. 2 + 35 % DWG	
Protein, %	17.12	Protein, %	18.91	Protein, %	22.7
Fat, %	3.10	Fat, %	3.25	Fat, %	3.65
Fiber, %	1.29	Fiber, %	1.4	Fiber, %	1.45
Ash content, %	0.42	Ash content, %	0.48	Ash content, %	0.59
Calories, kcal	101.2	Calories, kcal	110.1	Calories, kcal	129.08
Recipe No. 3 + 15 % DWG		Recipe No. 3 + 25 % DWG		Recipe No. 3 + 35 % DWG	
Protein, %	13.08	Protein, %	15.99	Protein, %	20.29
Fat, %	2.35	Fat, %	2.73	Fat, %	3.13
Fiber, %	1.19	Fiber, %	1.25	Fiber, %	1.34
Ash content, %	0.35	Ash content, %	0.42	Ash content, %	0.55
Calories, kcal	77.93	Calories, kcal	93.21	Calories, kcal	114.35

4.4 The assessment of the organoleptic quality indicators

We studied the effect of the drying agent temperature on the organoleptic quality indicators of pasta products with the addition of 25 % DWG. Organoleptic indicators of pasta quality are presented in table 7.

Table 7 – Results of organoleptic indicators of quality of pasta dried by convective method at different temperatures (40 °C, 50 °C and 60 °C)

Name of the indicator	Temperature of the pasta drying agent		
	40 °C	50 °C	60 °C
Pasta – Recipe No. 1 + 15 % DWG			
Color	Light brown, not transparent	Light brown, not transparent	Light brown, not transparent
The surface	Rough	Rough	Rough
The fracture	Mealy	Mealy	Mealy
Form	in the form of pasta – "horns"	in the form of pasta – "horns"	in the form of pasta – "horns"
Taste, smell	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry
Pasta – Recipe No. 2+ 25 % DWG			
Color	Light brownish, not transparent	Light brownish, not transparent	Light brownish, not transparent
The surface	Rough	Rough	Rough
The fracture	Mealy	Mealy	Mealy

Continuation of Table 7

Name of the indicator	Temperature of the pasta drying agent		
	40 °C	50 °C	60 °C
Form	in the form of pasta – "horns"	in the form of pasta – "horns"	in the form of pasta – "horns"
Taste, smell	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry
Pasta – Recipe No. 3 + 25 % DWG			
Color	Brown, not transparent	Brown, not transparent	Brown, not transparent
The surface	Rough	Rough	Rough
The fracture	Mealy	Mealy	Mealy
Form	In the form of pasta – "horns"	in the form of pasta – "horns"	in the form of pasta – "horns"
Taste, smell	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry	Typical of this type of products, without any shades, sweet flavor, free from foreign smell peculiar to pastry

The results presented in table 7 indicate that the drying temperature does not affect the organoleptic characteristics of pasta. At the same time, the recipe composition of pasta affects the color and condition of the surface of dry products. For example, pasta products with a high content of corn in the recipe color the structure in a light yellow shade, and the presence of buckwheat gives a light brown color. The pasta products had a slight rough surface, which can be explained by the quality of the pasta press matrix.

Figure 1 shows the organoleptic characteristics of samples of poly-cereal pasta (1st row) for three recipes before cooking, pasta after cooking (2nd row) and their cooking water (3rd row). The volume of pasta samples after cooking increased by at least 2 times compared to the volume of pasta samples before cooking. The cooking water has become slightly turbid, with a small amount of suspended particles.

Figure 1 – Pasta from non-traditional poly-cereal raw materials of high nutritional value

The general results of organoleptic evaluation of pasta are presented in table 8.

Table 8 – Results of the General assessment of organoleptic quality indicators of pasta from non-traditional raw materials

No.	Name of the indicator	Brief description	Score	Recipe		
				No. 1	No. 2	No. 3
I	Appearance	The surface is smooth, the shape is correct, the products do not stick together	25			
		The shape is correct, the surface is rough, the edges are slightly loosened, the products do not stick together	23	23	23	23
		The shape is correct, the surface is smooth, the products slightly stick together or a small part of them loses their shape	22			
I	Appearance	The shape is correct, the products noticeably stick together or partially lose their shape, or partially have cracks	15			
		Products stick together to form lumps, or a significant number of them lose their shape, or have cracks	5			
		Most of the products lose their shape, stick together or turn into fragments after cooking	2			
II	The color	Plain, typical for this variety.	15			
		Solid color, slightly darker or lighter	12	12	12	12
		Significantly darker or lighter	10			
		Not plain	5			
		Grey, brown	2			
III	The smell	Typical, very well expressed.	10			10
		Good, but not sufficiently expressed	8	8		
		Weakly expressed	6		6	
		Unspoken, "empty"	4			
		Foreigner	0			
IV	The taste	Typical, very well expressed.	25			
		Typical, well-defined	23	23		23
		Typical, weakly expressed	20		20	
		"Empty"	10			
		Foreigner	0			
V	Consistency	Elastic, without flour core	15	15		15
		Slightly softened	12		12	
		Soft	8			
		Soft, slightly spreading	5			
		Highly sprawling	0			
VI	Cooking water	Slightly muddy	10			10
		Slightly turbid, with a small amount of suspended particles.	9			
VI	Cooking water	Slightly turbid, with a small amount of suspended particles and small fragments	8	8		
		Muddy	7		7	
		Muddy, with a small number of fragments	5			
		Very muddy, with a large number of large and small fragments.	2			
Total score			100	89	80	93

The results of the evaluation of organoleptic indicators of the quality of pasta indicate the high quality of the developed food products.

Thus, the obtained results of the rating evaluation of organoleptic indicators showed that the developed pasta products meet the following categories:

– pasta recipe No. 1-89 points, category "Good". Characteristic: light sticking, more turbid water after cooking, slight darkening or enlightenment is allowed. The taste and smell are well-defined, typical;

– pasta recipe No. 2-80 points, category "Satisfactory". Characteristic: less pronounced taste and smell, noticeable sticking after cooking, dark or excessively light color, cloudy water, softened consistency;

– pasta recipe No. 3-93 points, category "Good". Characteristic: light sticking, more turbid water after cooking, slight darkening or enlightenment is allowed. The taste and smell are well-defined, typical.

V. CONCLUSIONS

1. The analysis of the current state of domestic production showed that the Republic of Kazakhstan has established the production of pasta in a wide range, but their production volumes do not fully meet the domestic demand, there is a high share of imports of pasta.

2. The pasta market is characterized by steady development, there is a tendency to strengthen the positions of domestic producers in the conditions of increasing competition from manufacturers of countries of the near and far abroad.

3. In the production of traditional pasta, hard wheat varieties are used, which are "poor" in chemical composition with the most important nutrients.

4. It is possible to increase the nutritional value of pasta by adding natural ingredients such as corn, millet, buckwheat, barley or oats, as well as other grains/legumes that differ significantly in chemical composition from traditional raw materials. Therefore, the production of pasta based on non-traditional poly-cereal raw materials is one of the promising areas for creating functional products.

5. We have developed 3 (three) recipes for a poly-cereal mixture with the addition of dry wheat gluten for the preparation of pasta dough.

6. The rheological properties of the dough for making pasta from non-traditional raw materials with the use of modern laboratory equipment were studied.

7. The results of the evaluation of organoleptic indicators of the quality of pasta indicate the high quality of the developed food products.

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НТБ ОНАХТ

TECHNOLOGY OF EDIBLE BIODEGRADABLE COATING FOR CONFECTIONERY PRODUCTS

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Abstract. *The confectionery market in Ukraine has changed significantly in recent years, it was caused by negative and positive factors. Negtive factors include a decrease in the purchasing power of the population, an increase in the price of goods. Positive factors include a introduction of the modern technologies and the use of new equipment have contributed to this, which contributes to the great demand of domestic products both among the population of Ukraine and beyond.*

An important aspect that characterizes the quality of confectionery products is the preservation of their freshness during storage. The use of polymer materials partially contributes to the solution of this problem, however, the current environmental situation requires reducing the use of polymer packaging.

The relevance of the work is to replace traditional types of packaging made of polymeric materials with a new one – edible biodegradable packaging from renewable raw materials, which will allow to maintain high quality products during storage.

The purpose of the work is the development of an edible biodegradable coating for confectionery products in order to prevent their staling (marshmallows and cookies) and to slow down the oxidation of fat (cookies).

The objective of the scientific work is the selection of film-forming substances for the development of an edible coating that protects confectionery products from stale and oxidation of fat.

Research methods – analytical, standard organoleptic, physico-chemical and structural-mechanical.

Key words: *biodegradable coatings, edible coating, confectionery products, marshmallows, cookies, starch, gelatin, plasticizer.*

I. INTRODUCTION

The development of edible packaging for food products is a relatively new achievement, contributing to the reliable protection of the food product from the course of oxidative and microbiological processes. Preservation of quantitative and qualitative indicators of food quality due to the absence of an air layer between the food product and the film makes the packaging technology more rational and modern.

In modern conditions relevant is the creation of a covering which is formed on the food product in the form of a sheath or film, to remove that before using is not necessary. The main advantage of such packaging is the use of eco-friendly and safe substances based on natural renewable raw materials, among which the most promising is using of starch.

Through the use of edible coatings enriched composition of a possible extension of the range of daily consumer products, in particular confectionery, because this coating is able to retain biologically active substances, and, accordingly, enrich the foods with the necessary nutrients [1].

The object of research is technology biodegradable edible coatings; properties of the developed coatings based on natural polymers; modification of the organoleptic and physico-chemical properties of marshmallows and butter biscuit coated with edible film during storage.

The subject of research – biodegradable edible coatings based on natural polymers for marshmallows and butter cookies.

The work purpose – development of manufacturing technology biodegradable edible coatings for confectionery, to prevent their hardening and slowing the oxidation of fat. The work provides for the investigation of physicochemical regularities and development of chemical and analytical support of processes of creation of new materials.

II. ANALYTICAL REVIEW OF THE LITERATURE

The confectionery industry is one of the leading branches of food industry of Ukraine is more than 16 % of the gross output accounted for its share. During storage of confectionery products there is the shrinkage and hardening, but these slow the process and increases the duration of their storage.

One of the main factors determining the competitiveness of confectionery products is the increase in shelf life of finished products. Packing is the most economical event prolongation of maintaining their freshness, reducing losses from shrinkage, improvement of sanitary conditions of storage and transportation. For confectionery packaging, use paper, cardboard boxes and various polymeric compositions. To extend the shelf life of confectionery products with a high content of fat in their composition contribute antioxidants and synergists of antioxidants [2].

Marshmallow is a sugar confectionery obtained by whipping fruit and berry puree with sugar and egg white, are added into this mixture of any of the formative (tagliatelli) fillers. As additives in the production of marshmallows used food acids, essences, dyes and ect. Due to the content of carbohydrates, marshmallows, in limited quantities, promotes mental activity and dietary fiber help digestion, the method of preparation allows to preserve most of the nutrients intact [3].

In terms of production of cookies and wafers in second place (19,6 %) after bakery products (70,9 %) [4]. Slowing oxidation of fats to prolong shelf life and avoid reducing the quality of flour confectionery products [2].

A promising direction in the food industry is the use of edible coatings (film), with the aim of preserving the nutritional value of foods. Back in the old days, in Ancient China in the XII century used food packaging (wax) to maintain moisture and elasticity of the product. In the XV century in Europe, this technology has received a special name – lang (covering fruits and vegetables with a layer of wax or fat that operationala shrinkage of food products). In Japan they used film, which was called Yuba – received by boiling soy milk to improve the appearance and preserve the quality of food. The first patent on a food packaging was published in the USA in the XIX century, when it was suggested to wrap meat products in a gelatin shell [5].

Each film biodegradable material contains the following components:

1. Primary: film-forming substance (polymer) that forms a matrix; the solvent (water, alcohols, acetone, gasoline etc.); plasticizer (glycerin, sorbitol, sucrose etc.).

2. Additional: stabilizers; fillers (mineral powders); inhibitors, retarders ect.

Edible film among the various types biodegrading packaging are subject to relatively new areas of research. This kind of biodegrading film has an alternative natural mechanism baronceanca – under the influence of intracellular, endo - and ectoenzymes contained in the stomach and human intestines, a polymeric material subjected to chemical reactions, which is oxidation and hydrolysis [6].

Nutritional value of edible coatings conventionally are divided into digestible (based on proteins, fats, carbohydrates) and not absorbed (based on waxes, paraffins, water-soluble natural and synthetic gums, water soluble cellulose derivatives, polyvinyl alcohol, polyvinylpyrrolidone, etc.) [7].

Most confectionery products, example, candy require the application of edible coatings to prevent adhesion, absorption of moisture, and for chocolate and other confectionery products lipidosterolic – loss of oil. Candy is often covered with confectionery glaze, shellac or wax. Candy, covered with a coating based on corn starch and plasticizer remain dry even in conditions that cause surface stickiness [8].

To improve water resistance and mechanical properties of edible packaging are administered in various non-toxic additives, mostly plasticizers, conduct processing of film and coatings «stitching» components that increase strength for reduce water vapor permeability in the composition of the film added fatty acids. It reduce the water vapor permeability and some reduction in the solubility of film in water [9].

Known technology for the production of cake, which is covered by a thin layer of cling film (based on potato starch, sugar and apple juice), to protect from contact with the environment, the preservation of biologically valuable substances and impart gloss. The disadvantage of this design is the high sugar content in the film [10].

Developed biodegradable film containing the film-former, plasticizer, water and optionally a biologically active additive for increasing the biological value of confectionery products. The disadvantage of this coating composition is that biological additive in the composition of the film will prevent oxidation of fats, which are found in confectionery in large quantities (up to 20%) [11].

The application of edible coatings based on inulin, gelatin, whey and glycerol with addition of probiotic *Lactobacillus casei Shirota (LBC)* for the cracker significantly increased moisture content, reduced resistance to rupture. It is established that the coating consisting of: inulin 4 %, glycerol 3,5 % and 2 % *LBC* – preserve the quality of the cracker and will lead to better to improvement of the functioning of the digestive system due to the composition of the probiotic [12].

N. C. Brake and O. R. Fennema have developed an edible coating containing high-methoxyl pectin, acacia gum, corn syrup, to inhibit lipid migration for confectionery [13]. The best moisture retention effect on crumb moisture during storage was established using polymyxane and xanthan films [14].

A promising direction is the use of the film-forming solution basis of which are natural polymers – polysaccharides. Polysaccharide-based films protect the food product from weight loss and create a barrier to the penetration of oxygen and other substances from the outside. We have developed a technology of edible biodegradable coating for confectionery products, which contains vitamin E, which prevents fat oxidation in confectionery products during long-term storage.

The main advantages of edible packaging coatings include: simplicity of technological solutions of application of the product; the possibility of increasing the nutritional value of the product; environmental friendliness; the relatively low cost and availability of raw materials; reducing product losses [15].

The disadvantages include: increased humidity of the film-forming solution; high vapor permeability; lower mechanical, protective and barrier properties than traditional packaging materials.

III. OBJECT, SUBJECT AND METHODS OF RESEARCH

III.I. Object and subject of study

The subject of the study is an edible biodegradable coating based on natural polymers for marshmallows and cookies.

Raw materials used in the production of edible coating: corn and potato starch; gelatin; glycerin (E 422); sorbitol (E 420); sucrose; fruit powders; Vitamin E; water.

In the experimental studies used marshmallows «Shkolyarik» TM «Jaco» without packaging (control sample 1) and in polymeric packaging (control sample 2), marshmallows with developed edible coating without additives and with fruit powders: lemon, strawberries and blueberries. A cookies made according to DSTU 3781: 2014: without packaging – sample 1, in a plastic bag – sample 2 and with a developed edible coating with vitamin E (sample 3) were studied. The samples were stored at room temperature (18-20 °C) and relative humidity not higher than 75%.

Object of study – technology of edible coating; properties of the developed coating based on natural polymers; changes of organoleptic and physicochemical properties of marshmallows and cookies with edible film during storage.

The technology of edible film is shown on fig.3.1.

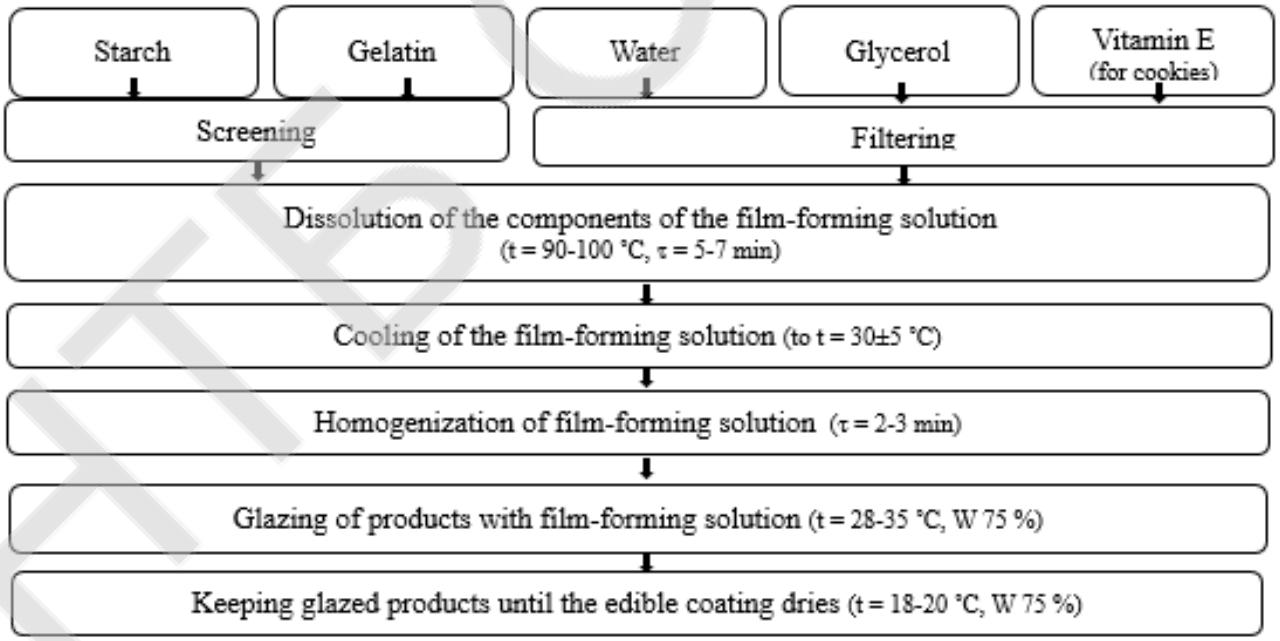

Fig. 3.1. Technology of edible coating

III. II. Research Methods

III. II. I. Methods of film study

A 5-point scale was developed to evaluate the organoleptic quality of edible film (Table 3.1) [15].

Table 3.1. – Score of the quality of edible films

Metric name	Point				
	«5»	«4»	«3»	«2»	«1»
Taste (0,5)	Neutral, sweet taste allowed	Sweet taste that does not spoil	The taste is not peculiar, bitter	Foreign taste	Not typical
Scent (0,2)	The inherent odor of raw materials used	Neutral	Abrupt	Hardly a foreign smell	Foreign smell
Surface (0,1)	Smooth, glossy or matte	Smooth	Minor roughness	Rough	Very rough
Color (0,1)	Colorless	Colorless with grayish tint	Gray, white	White	Very white
Transparency (0,1)	Transparent	Transparent	Transparent with little opacity	It's cloudy	Very cloudy

The weight coefficients adopted in the studies for the calculation of the complex film quality index are presented in the Table 3.2 [16].

The determination of the elongation and tensile strength of the tear film was performed according on the F-1000 tensile machine at a temperature (23 ± 2) ºC and relative humidity (50 ± 2)%.

The viscosity characteristics of the prescription coating mixtures were determined on a Rototest-2 rotational viscometer.

III. II. II. Methods for the study of the quality of edible marshmallows

Organoleptic quality of marshmallows was investigated according to DSTU GOST 6441-2003; physicochemical parameters (mass fraction of moisture) by refractometric method according to DSTU 4910:2008; as well as the change in weight of the food during storage, by weighing the samples during the month [17, 18].

To evaluate of the organoleptic properties of edible coated marshmallows, a 5-point scale was developed and the weighting coefficients of each indicator were determined using the ranking method (Table 3.2) [19].

Table 3.2. – Score quality of marshmallows with edible coating

Indicator	Weighting factor	Point	Characteristic
Appearance: Form	0,1	5	The correct product is not minted for this product
		4	Proper with lightweight clamps
		3	Slightly primate and vague
		2	Blurry, with lateral effusions
		1	Irregularly shaped, blurry, trashy
Surface	0,1	5	Without rough curing on the side faces, smooth or slightly rough
		4	Smooth, rough
		3	Smooth with slight wrinkling
		2	Wrinkled, noticeable hardening on the edges
		1	Very firm on the side faces
Color	0,1	5	Uniform, white with a rudder
		4	Completely white
		3	Uneven color with steering tint
		2	Uneven color with steering tint
		1	Uneven color with a grayish tinge

Continuation of table 3.2.

Indicator	Weighting factor	Point	Characteristic
Structure	0,1	5	Uniform, elastic, non-sticky, fine-porous
		4	Uniform, elastic, finely porous
		3	Uniform, inelastic, finely porous
		2	Uniform, with large pores
		1	Uniform, inelastic, slightly sticky to the touch
Taste and smell	0,2	5	Characteristic marshmallows, well expressed
		4	A pronounced, characteristic marshmallow
		3	Not pronounced, characteristic marshmallows
		2	Unspoken
		1	Not peculiar, unpleasant, extraneous
Consistence	0,1	5	Soft, easy to break
		4	Slightly protracted, breakable
		3	Slightly protracted, barely susceptible to breaking
		2	Soft when breaking the middle of the product is wet
		1	Too soft, middle when wet
Chewiness	0,3	5	Well chewed
		4	Chews with little effort
		3	Tough when chewed
		2	Hard
		1	Hard to chew

III. II. III. Methods of research of quality of cookie with edible coating

Organoleptic indicators of cookie quality were investigated according to DSTU 3781:2014. To evaluate the organoleptic properties of a cookie with edible coating, we developed a 5-point scale. The ranking method determined the weight coefficients of each indicator in the overall organoleptic evaluation, which is shown in Table 3.3.

Table 3.3. – Score of quality of cookies with edible coating

Indicator	Weighting factor	Point	Characteristic
Appearance: Form	0,1	5	The product, inherent in this type of product, is correct, even edges
		4	Correct, with slight dents
		3	Uneven, edges curved
		2	Cracks and fractures
		1	Irregularly shaped, deformed
Surface	0,15	5	Not burnt, without swellings, bursting bubbles and crumbs
		4	Not burned, without tears and splashes
		3	Not burned, the presence of crumbs
		2	The presence of burns
		1	The burned surface
Color	0,15	5	Uniform, light yellow, bright
		4	Uniform, light yellow
		3	Less pronounced
		2	Slightly pronounced
		1	Uneven, dull

Continuation of table 3.3.

Indicator	Weighting factor	Point	Characteristic
Taste and smell	0,2	5	Even
		4	Yellow-brown
		3	Not typical
		2	Dark brown
		1	White
The view in the fault	0,1	5	Well-baked, with no trace of non-tampering, easily broken
		4	Roasted, without traces of non-tampering, crumble
		3	With traces of non-mining, it crumbles heavily
		2	Signs of worming, badly broken
		1	A stale product that does not break
Chewiness	0,3	5	Easy, well chewed
		4	Moderate
		3	The complexity of the bite
		2	It's cruel
		1	Does not chew

Physico-chemical indicators of quality of cookies (mass fraction of moisture) were determined by drying according to DSTU 4910: 2008, the ability to get wet according to DSTU 5023:2008. The change in mass of the test specimens during storage was determined by weighing them during the month.

IV. RESULTS OF WORK

IV. I. Investigation of new types of edible materials based on natural polymers for marshmallows

IV. I. I. Determination of the influence of different types of starch on film quality

Organoleptic quality assessment of edible films based on different types of starch (potato and corn) was determined by the complex quality index in conventional units from 0 to 1. It was found that films based on corn starch had the highest complex quality index.

The physico-mechanical properties of starch-based films depend on the ratio of its amorphous and crystalline structure. Factors such as the content of amylose in starch, the type of starch, the content of mineral additives, the pH of the solution, and the temperature of the crystallization influence the nature of the rheological curves [20]. The results of changing the viscosity of the solution depending on the type of film-forming agent are shown in Fig. 4.1.

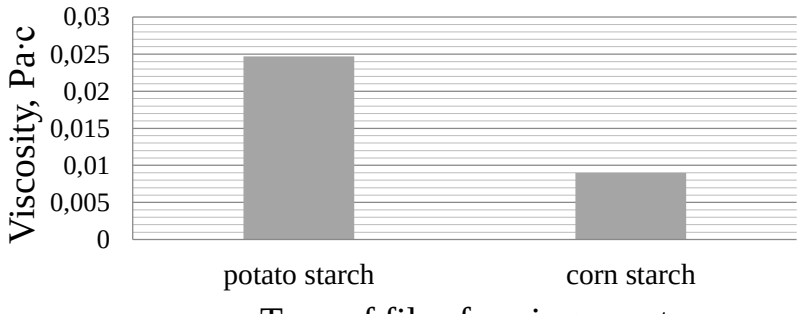

Fig. 4.1. Change in viscosity of starch-gelatin-glycerol solution

The highest viscosity has a film solution with potato starch, which is quite reasonable, since the starch contains a large amount of amylopectin 77 %, whereas in corn starch, its content is within 72 % [21].

The characteristics of the physical-mechanical properties of films with different film-forming agents are shown in Fig. 4.2.

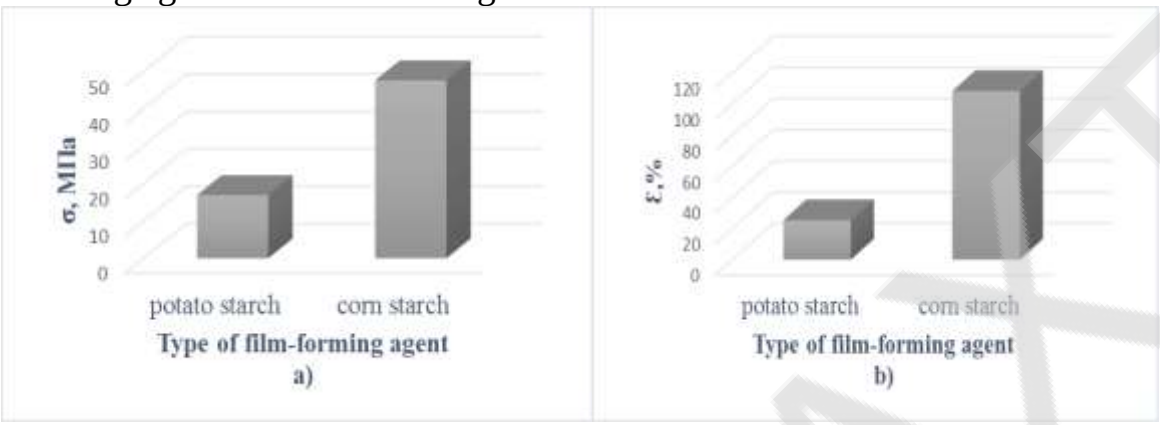

Fig. 4.2. Effect of film-forming agent on: a) film strength (σ) and b) elongation (Ɛ)

Corn starch films have better strength (47,6 MPa) and elongation (108,1 %). The integrity of the coating must not be compromised during consumption, storage and transportation. According to organoleptic and structural-mechanical parameters, corn starch is selected as the optimal film-forming agent.

IV. I. II. Determination of the effect of gelatin on film quality

Gelatin is a powder that swells in water and dissolves when heated above 50°C, forming a viscous liquid. During cooling, the gelatin forms jewels and, when heated, returns to the liquid state. The determination of the effect of different concentrations of gelatin on physico-mechanical quality of film is given in Table 4.1.

Table 4.1. – Physico-mechanical properties of gelatin films

№	Ingredients, g / 100 g of solution			Physico-mechanical indicators		
	Corn starch	Gelatin	Glycerol	Thickness μm	Strength MPa	Lengthening %
1	1	1,0	0,5	0,03	2,5	34
2	3	3,0	1,5	0,13	10,7	44
3	3	6,0	3,0	0,11	17,6	80
4	5	3,5	2,5	0,23	13,2	60
5	3	-	2	0,17	9,4	64
6	5	-	2	0,12	10,4	24

Increasing the content of the ingredients (sample № 4) leads to a thickness of the film by 0,23 μm, whereas with their smaller content (sample № 1). The thinnest film is formed with a thickness of 0,03 μm. The elongation rate of the films varies depending on the concentration of the glycerol plasticizer in it: min concentration – 34 % (sample № 1), max concentration – 80 % (sample № 3). The concentration of starch and glycerol does not affect on the thickness of the films. Two samples without gelatin (№ 5 and № 6) were investigated to confirm the effect of the gelatin fraction in the film composition. It is established that gelatin in the composition of the film increases its

strength: the sample of film without gelatin (sample № 5) has a strength 9,4 MPa, and the sample № 3 of the same composition, but with gelatin – 17,6 MPa. Sample № 6 has a strength of 10,4 MPa, while sample № 4 with gelatin is 13,2 MPa.

IV. I. III. Effect of different plasticizers on the quality of films

Starch-based films have low mechanical properties [22], so plasticizers are added to the solution for improving the flexibility, elongation, strength, and resistance of film breakage [23, 24]. The plasticizer should be compatible with the polymer, well soluble in the solvent and close to the polymer structure [25].

We have selected the most common plasticizers: glycerol (E 422) and sorbitol (E 420) for corn starch films. It is advisable to perform a comparative analysis to determine the optimum of the most common and inexpensive plasticizers. The films studied by us on organoleptic indicators are colorless, transparent and odorless. For plasticizer film The integrated quality index for plasticizer film was 1.

The results of change of strength and elongation of films depending on the type of plasticizer are shown in Fig. 4.3.

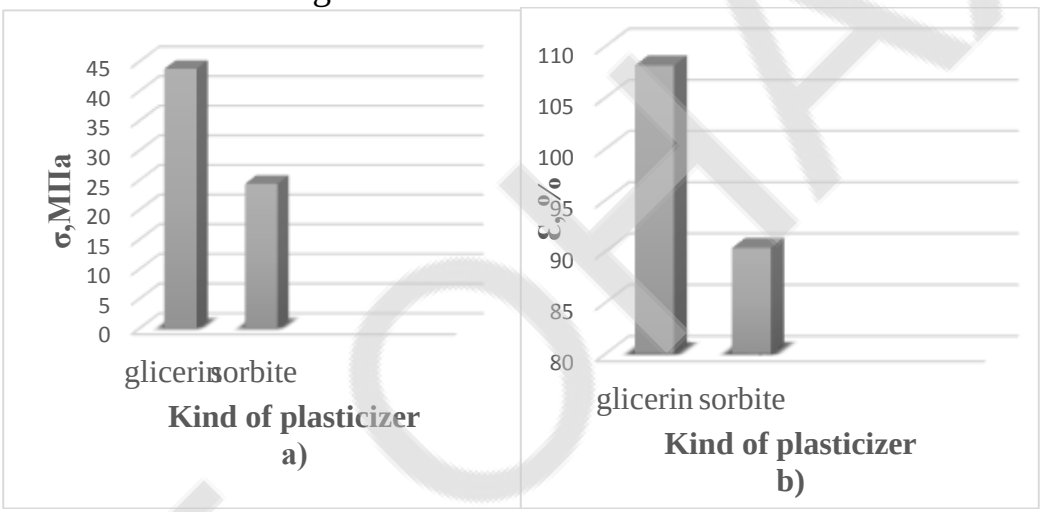

Fig. 4.3. Physico-mechanical characteristics of films with different plasticizers: a – tensile strength; b – elongation

The values for the sucrose plasticizer are not shown on the graph because the films were fragile. The films with the plasticizer glycerin (43,7 MPa) have the highest strength and the sorbitol (24,3 MPa) have the lowest strength. The highest elongation was observed for films with glycerol (108,1 %) and the lowest for sorbitol (90,3 %). Thereby, glycerol was chosen as the optimal plasticizer.

IV. II. Effect of edible biodegradable coating on marshmallow quality

An edible coating consisting of starch, gelatin and glycerol has been developed. The gelatin in the coating retains better moisture than starch, which is able to undergo retrogradation. The combination of gelatin and starch in the recipe composition of the edible coating, due to the fact that gelatin during cooling forms jelly, which makes it impossible to further apply such coating on confectionery. All selected components of the food coating are accessible and safe.

Edible coating should not alter the organoleptic characteristics of marshmallows. The results of the summary tasting assessments and the calculation of the total quality of edible coatings are given in Table 4.2.

Table 4.2. – Tasting assessments of organoleptic evaluation of marshmallows

Sample	Form	Surface	Color	Structure	Taste and smell	Consistence	Chewiness	Generalized Quality Score
	Weighting factor							
	0,1	0,1	0,1	0,1	0,2	0,1	0,3	
The sample in the package	4,8±0,1	4,8±0,1	4,9± 0,1	5,0±0,2	5,0±0,2	4,8±0,1	4,8±0,1	4,87
Sample without powder	4,8±0,1	4,8±0,1	4,9± 0,1	5,0±0,2	5,0±0,2	4,8±0,1	4,9±0,1	4,90
Sample 1	4,8±0,1	4,9±0,1	5,0± 0,1	5,0±0,2	5,0±0,2	4,8±0,1	4,9±0,1	4,92
Sample 2	4,8±0,1	4,9±0,1	4,9± 0,1	5,0±0,2	5,0±0,2	4,8±0,2	4,9±0,1	4,91
Sample 3	4,8±0,1	4,8±0,1	5,0± 0,1	5,0±0,2	5,0±0,2	4,8±0,2	4,9±0,1	4,91

Note: Sample 1 – marshmallow with blueberry powder, Sample 2 – marshmallow with strawberry powder, Sample 3 – marshmallows with lemon powder

The edible coating developed has a neutral taste, transparency and chewiness. An organoleptic evaluation of the quality of the marshmallow samples tested showed that the edible coating developed did not alter the organoleptic characteristics.

Changes in physico-chemical parameters have been investigated by determining the change in the mass fraction of moisture in marshmallows during storage. The results of changing the mass fraction of moisture of marshmallows during storage are shown in Fig. 4.4.

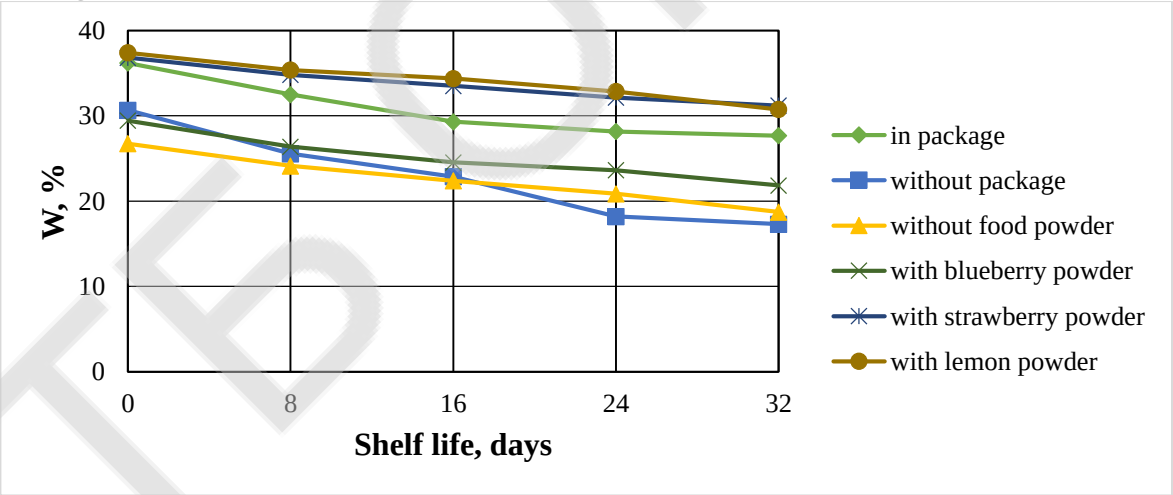

Fig. 4.4. Changing the mass fraction of moisture of marshmallows

According to Fig. 4.4 the moisture content of marshmallows in the packaging and edible coating is almost the same. After a month of sample storage, the moisture content of marshmallows without packaging decreased by 44 % and marshmallows with edible coating by 30 %. Therefore, the edible coating has barrier properties, which contributes to the longer conservation of marshmallows.

The change in mass of marshmallow samples during storage was investigated. The results are shown in Fig. 4. 5.

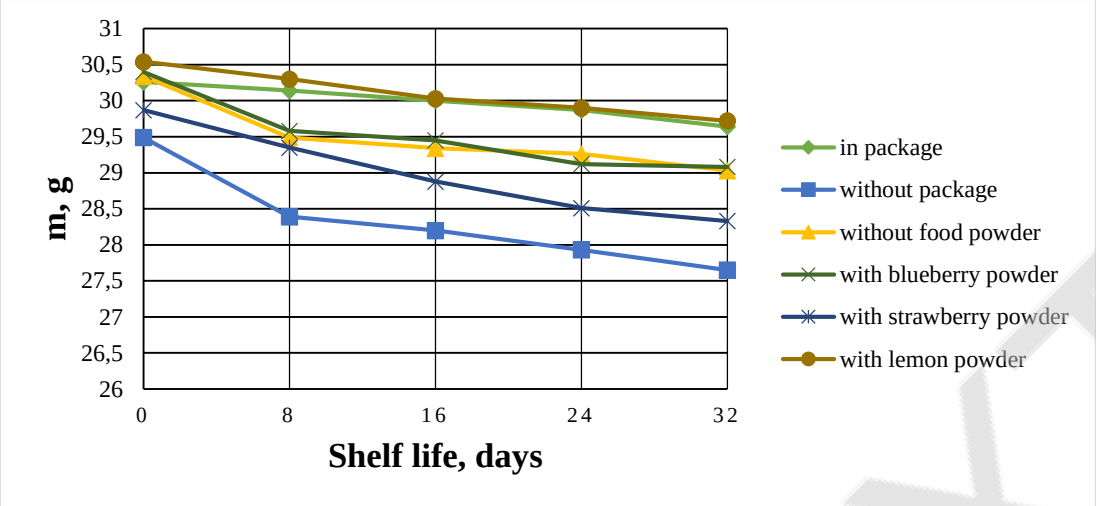

Fig. 4.5. Changing the mass of marshmallows during storage

It was found that during storage of marshmallows during the month, the weight of the product without packaging decreases by 6,3 %, the edible marshmallow reduced its weight by 4,3 %. The worst is that it retains its marshmallow properties without packaging, which is caused by the open access of the air to the foodstuff. The edible coating and storage of the product in the package are identical in value, and marshmallows with edible coating without the addition of powder and blueberry powder have similar results of mass deviations. However, marshmallows with strawberry powder did not provide conditions for long-term preservation of the food.

IV. III. The effect of edible film on the quality of the cookies

Edible coating should not alter the organoleptic characteristics of cookies. The results of the summary tasting assessments and the calculation of the total quality of edible coatings are given in Table 4.3.

Table 4.3. – Organoleptic evaluation of the quality of the cookie samples

Sample	Form	Surface	Color	Taste and smell	Fracture view	Chewiness	Generalized Quality Score
	Weighting factor						
	0,1	0,15	0,15	0,2	0,1	0,3	
The sample is uncoated	4,8±0,1	4,8±0,1	4,9± 0,1	5,0±0,2	4,8±0,1	4,8±0,1	4,87
Sample in PE package	4,8±0,1	4,8±0,1	4,9± 0,1	5,0±0,2	4,8±0,1	4,9±0,1	4,90
The sample is film-coated	4,8±0,1	4,9±0,1	5,0± 0,1	5,0±0,2	4,8±0,1	4,9±0,1	4,92

The organoleptic evaluation of the quality of the cookies showed that the developed edible coating does not affect the taste properties and improves the appearance.

Changes in physico-chemical parameters have been investigated by determining the change in the mass fraction of moisture in a cookie during storage, since desorption processes are processes that lead to the release of moisture and cause a stale of cookies. The results of changing the moisture content of the cookie samples during storage are shown in Fig. 4.6.

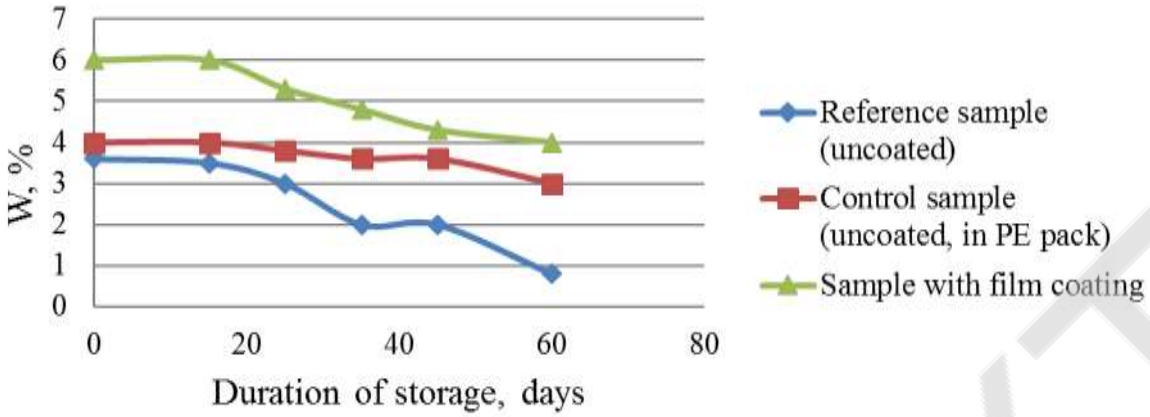

Fig. 4.6. Changing the moisture content of cookies during storage

Cookies are stored at a relative humidity of 70-75 %, under these conditions, moisture is absorbed and the cookie gradually loses its fragility. To prevent this, cookies should be packaged in a moisture-proof package [26]. According to the researches and the processed data the following results were obtained: in the cookies without packaging the mass fraction of moisture decreased by 78 %, in PE – 25 %, in the coating – 33 %. Therefore, the edible coating has barrier properties, which prevents moisture from being absorbed and the cookie fragility.

A change in the ability of cookies to get wet is shown in Fig. 4.7.

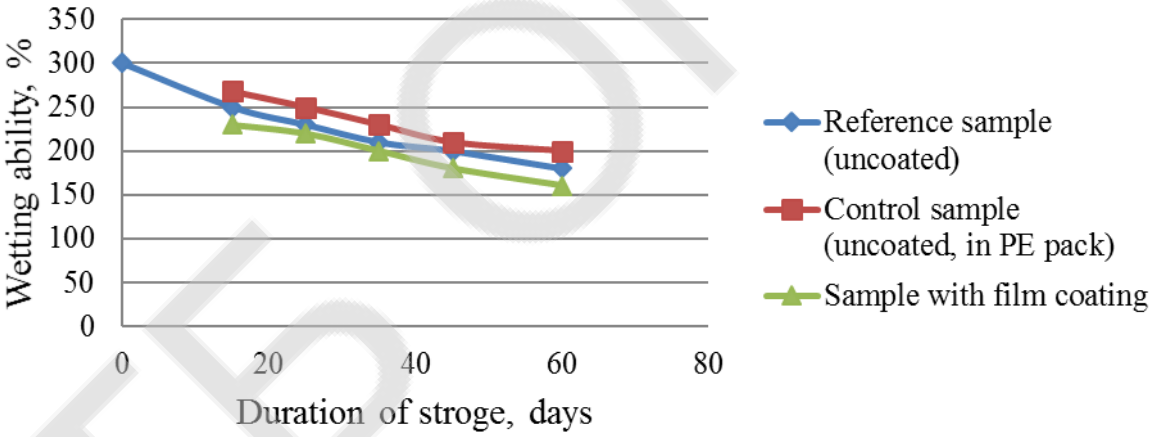

Fig. 4.7. A change in the ability of cookies to get wet

When conducting cookies on the ability to get wet, there is a dynamic decrease in performance in all three samples. The ability of cookies without packaging decreased by 40 %, in PE – 33 %, in the coating – 53 %. Therefore, the edible coating, due to the content of vitamin E, prevents the rapid oxidation of fat, strengthens the porosity of the structure and reduces the ability to get wet.

The change in the weight of the cookies during storage is shown in fig. 4.8.

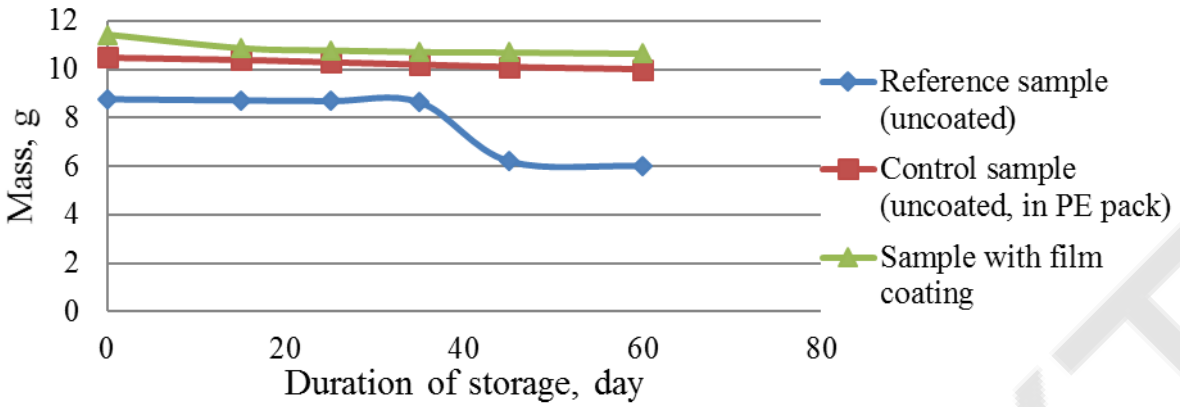

Fig. 4.8. Changing the weight of cookies during storage

It was found that during storage of cookies for 60 days, the weight of the product without packaging decreases by 31,7 %, in plastic packaging – 5 %, the cookies in the edible coating reduced its weight by 7 %. Worst of all, it retains its properties of cookies without packaging, which is caused by open air access to the food and oxidation of fat.

IV. IV. Marketing researches

As a tool for conducting marketing research, we used a developed questionnaire consisting of 9 questions. Consumers are less likely to buy pastry in paper based packaging than in PE. According to the ranking of respondents by various factors by importance, they can be divided as follows: taste preferences > appearance > packaging > brand > price. The survey showed that environmental and packaging safety were important factors for most respondents.

A large part of the population of different age categories is interested in new types of food packaging, which should meet the following requirements: not affect the taste properties of the product; not change its shape; high quality and safe; ergonomic; price. The competitiveness of cookie in edible packaging with respect to polyethylene has been proved based on the integral index [27, 28].

V. CONCLUSIONS

An analytical review of the literature shows that the use of edible films is a relatively new but promising packaging for confectionery, which not only extends shelf life, but also improves organoleptic characteristics (such as luster) and enhances their biological value through components films.

The technology of preparation of edible biodegradable coating was developed and the basic and additional raw materials for the manufacture of edible coatings, the method of determining the properties of the developed films and the change in the quality of marshmallows and cookie during storage were determined.

The organoleptic parameters of the quality of the edible film were determined according to the developed score scale, the elongation and the tensile strength of the film, the viscosity characteristics of the prescription coating mixtures.

A number of experiments were conducted, such as the study of organoleptic indicators of marshmallows and cookie using the developed score, determined changes in physicochemical parameters during the month shelf life.

The composition of the edible coating used allows the confectionery product to be stored for a certain period of storage without deterioration of organoleptic and

physico-chemical parameters.

In edible film-forming coatings, the most important properties are their microbiological stability, adhesion, cohesion, wettability, solubility, transparency, mechanical properties, permeability to water vapor and gases. It is established that the most appropriate edible coating to use for products where the determining factor for their storage are desorption processes.

Therefore, edible films and coatings used for food are effective materials for increasing the shelf life of products, while preserving their microbiological, organoleptic, physicochemical characteristics and consumption characteristics.

Thus, the developed edible coating for marshmallows and biscuits may have its segment in retail chains as an alternative to the replacement of synthetic packaging in the food industry.

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RESEARCH ON THE GOAT MILK YOGURT WITH FRUITS OBTAINING AND QUALITY INDEX CHARACTERISTICS OF IT

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Abstract. *In recent years increasing trend to guide consumers to the yogurt with high biological value. Interest presents both raw materials with a special chemical composition such as goat's milk, as well as the emphasis on non-lactic ingredients / additives, in the case of the fruit-flavored fruits, raspberries, strawberries, peaches, apples marked by the vitamin content, fibers and mineral substances, which increase the nutritional and biological value of raw materials.*

The current study was conducted to produce by thermostat method a goat's milk yoghurt with the use of fruits and evaluated for 15 days with a physicochemical, organoleptic, microbiological, antioxidant capacity, polyphenol content, anthocyanins, vitamin C and β-carotene. The added fruit type also had a strong impact on the titratable acidity and pH values respectively. During storage the pH was slightly reduced, the peach yogurt had a pH of 4.68. Higher acidity were obtained for raspberry yogurt, 103°T. The amount of dry substance indicates 20.8% in yogurt with aronia. After the yogurt samples organoleptic properties examination it was found that yogurt with strawberries and raspberries preserved their characteristics best. The results obtained for the determination of yogurt total number of germs are satisfactory, the values being between 2.2 x 10^7 and 3.1 x 10^7. Aronia yogurt has the highest total content of polyphenols (187.1 mg GAE / 100g), raspberry yogurt has the highest anthocyanin content (48.34 mg / 100g), antioxidant activity is the highest, 0.007 %, in raspberry and strawberries yogurts, the maximum content of β-carotene (0.50 mg / 100 g) in raspberry yogurt and the ascorbic acid content (25.77 mg/100g) in strawberry yogurt. Based on the analysis of all the results, it was determined that yoghurt with strawberries, raspberries and aronia was appreciated among the potential consumers with the highest ratings with a practical period of storage of 10-12 days.

Keywords: *goat milk, fruit, nutritional value, quality characteristics.*

I. Introduction

Enlargement of the fermented dairy products assortment at the end of the 20th century and the beginning of the 21th century, has contributed to the intensification of different technological processes for improving the rheological characteristics, extending the term of preservation of the products. Milk is a very important and accessible source of animal protein, which is necessary and indispensable for the vital activity of the human body, [1].

Goat milk and dairy products present excellent nutritional qualities and high biological value with high degree of assimilation and play an important role in the nutrition of the population, especially of developing countries. In developed countries, where there is a tendency to consume healthy food, there is a particular interest in goat's milk. Goat milk production is well developed in Europe (France, Spain, Holland, Norway). In most countries, goat's milk is processed at farms or small businesses. In

Russia there are only a few dairy farms. Goat milk and goat milk products are launched in comparatively small volume on the Russian markets, but the popularity of this product is increasing.

In the last years in the Republic of Moldova we can see the tendency to increase the herd of goats and increase the volume of milk obtained, in order to use it on the industrial scale.

Several authors consider that after its composition goat milk is superior to the cow milk due to the nutritional, toning, anti-anemic and anti-infectious effects. Due to the fat globules fineness goat milk is easily absorbed by the intestinal villi and thus has a higher digestibility. Under the action of gastric juice the proteins coagulate into fine flakes, are easily digested by the proteolytic enzymes of the small intestine and are therefore easily assimilated.

Yogurt is considered to be the healthy dairy product. Its beneficial effects in the healing of various intestinal diseases made it quickly known and its process could not remain secret. But although today 30% of the world's population consumes yogurt regularly and it is a great food due to its taste, [2, 3].

Fruits are some of the healthiest foods for the human body. They have a high water content and a very low fat and calorie content so they can be consumed in larger quantities. Fruit gives flavor and variety to dairy products. Consumers are increasingly interested in the consumption of nutrient-rich yoghurt, as it is known that not all plant sources have the same chemical composition or the same biological properties. The use of the bioactive potential of biologically active compounds in fruits with health benefits is continuously expanding, the main purpose being the rational use of these compounds in yogurt, [4, 5].

Purpose of the thesis: Obtaining goat milk yogurt with high biological value and analyzing the quality indices of the manufactured product.

The objectives of the thesis:

• Bibliographic analysis of the quality of goat's milk compared to other milk varieties;

• Analysis of the quality indicators of the raw materials, auxiliaries and methods of analyzing the quality of the finished product;

• Elaboration of the technological scheme for the production of yogurt with fruits from goat's milk;

• Analysis of the quality indices of goat milk yogurt samples with bleached fruits.

II. Literature review

Analysis of the dynamics regarding the production and processing of goat milk in the Republic of Moldova

According to the National Bureau of Statistics in recent years, there is an increase in the quantity of goat milk produced and processed in the Republic of Moldova.

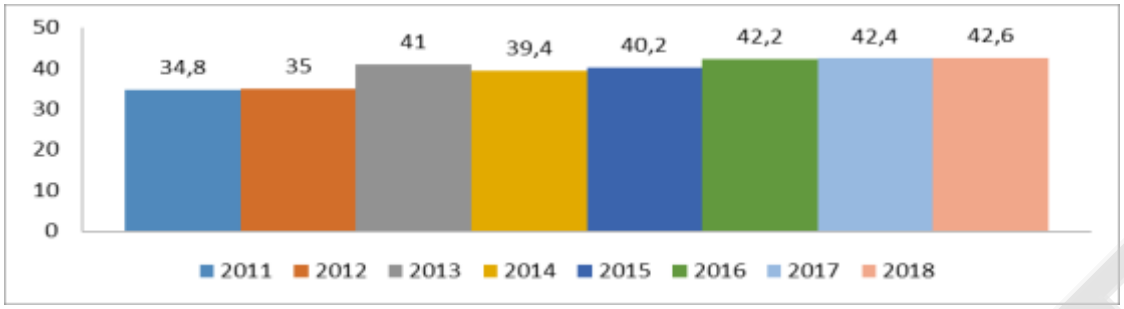

Figure 1. Graph of goat's milk production and processing, thousands of tonnes

Composition of goat milk

The goat's milk composition is comparable to that of cow's milk. Both types of milk have about 13% dry matter. Proteins, lipids and lactose are found in equivalent quantities and therefore provide similar amounts of energy

Table 1. Characteristics of goat milk and cow's milk, [1, 6]

Content,%	**Milk**	
	caw	**goat**
Water	87,3	86,3
Energetic value, kcal	71	65
Fat	3,8	4,4
Protein	3,3	4,1
Casein	2,7	3,3
Lactoze	4,7	4,4
Mineral solts	0,7	0,8
Acidity, °T	16-18	15-19
Density, °A	1,03	1,83
Dry metter	12,7	13,7

Goat's milk is fatter. Studies show greater variability. This difference has a small impact on the consumer, because the milk distributed and sold on the market is standardized, like cow's milk, goat's milk is sold at 2.5% and 3.5%.

Table 2. Similarities and differences in the chemical composition of goat milk and cow's milk, [2]

Goat's milk vis-à-vis cow's milk	
Similarities	Differences
1. There is no major difference in energy value	1. Proteins are differently distributed: the casein micelle of goat milk has more β-lactoglobulin than α-lactalbumin.
2. They have about the same amount of lactose	2. Fat globules are smaller and evenly distributed in goat milk.
3. Both goat and cow's milk have a high protein content.	3. Vitamin A in goat milk is in the form of retinol, which is the most assimilable form in the human organism.
4. Both types of milk have a low iron content.	4. Goat's milk has a higher vitamin D content.
5. Goat's and cow's milk have about the same amount of vitamin B_1,B_2, B_6, and PP.	5. In goat milk the fatty acids are in short and medium chains.
	6. Goat's milk contains more vitamins and mineral salts than goat's milk
	7. Goat milk contains twice as much calcium, phosphorus, potassium, sodium.
	8. Laptele de capră are un conținut mai mic de acid folic, vitamina B_{12}, E și C decît laptele de vacă.

The advantages of consuming goat's milk are:

• *Digestibility of proteins and lipids* - Protein digestibility in goat milk is facilitated by its less binder feature. The proteins contained in goat's milk are less agglomerated than in cow's milk. The curd formed during digestion is therefore smaller and more friable, [7]. Acids in gastric juice have a greater contact surface with proteins. This accelerates the action of the enzymes and ensures an accelerated gastric transit. The United Nations has studied the processing of all types of milk (including cow's and goat's milk) in yogurt and concluded: «Recent and accurate work, few in number, tend to show important differences in protein digestion according to technology to which the milk is subjected. So if we consume milk, a casein forms curd quickly in the stomach, which is slowly digested as peptides. But if we consume yogurt, the shell does not form and, very quickly, the casein is evacuated in degraded form and even in non-degraded form ", [8].

The fat globules in goat milk are smaller than the fat globules in cow milk, [9,10]. The action of lipases increases with increasing contact area between lipases and fat globules. In addition, goat milk fat globules contain several short and medium triglycerides chain. These short and medium triglycerides chain have the particularity of being water soluble. Solubility in water allows the immediate action of lipase and fatty acid absorption without the use of bile acid micelles. Therefore, they can be used immediately as a source of energy. In the case of consumption, goat milk fat may increase triglyceride levels in the blood, [3, 7, 9, 10, 11].

• *Protein intolerance* - According to a document issued by health professionals at the Canadian Dairy Bureau, "only about a quarter of adverse reactions to food can be confirmed by diagnostic tests, suggesting that the incidence of" true "food allergies is overestimated, [12]. Therefore, there may be non-immunological reactions to cow's milk proteins, [3] Goat's milk contains more deproteinized nitrogen, the proteins are of higher quality, higher in thiamine content and practically do not cause allergic reactions and digestive disorders It is known that α_{s1} - casein - the main protein of cow's milk - is a powerful allergen for humans, in the casein of goat's milk casein contains more the β-casein fraction, [13]. Goat's milk are more easily assimilated and rich in amino acids such as: histidine, lysine, aspargic acid, tyrosine, tryptophan; contains several serum proteins, namely, immune globulin, has high lactalbumin and lactglobulin content. Due to the pronounced dietary-curative properties it is a valuable product in the nutrition of children, the sick, and elderly, [2].

• *Lactose intolerance* - Despite the absence of scientific studies, there is evidence that some people who are lactose intolerant in cow's milk do not respond to lactose when they eat goat's milk. However, the amounts of lactose in the two types of milk are not quite comparable. Lactose intolerance occurs for two reasons:

1. The intestine does not produce lactase

On the one hand, irritation of the intestinal mucosa can literally destroy lactase secreting cells. This situation is usually resolved after the disappearance of irritable factors and the reconstruction of the intestinal mucosa, [13, 14]. On the other hand, suppression of the secretory potency of lactase by changes in genetic precursors may be involved [14]. This explanation is poorly documented and requires further research.

In any case, intestinal irritation or changes in genetic precursors do not suggest any difference in lactose tolerance of cow's or goat's milk, [2].

2. Lactase is present, but it cannot exert its action

According to the literature, a difficulty may be involved in neutralizing the pH of the product when entering the duodenum. This explanation supports the importance of mineral administration in the human body. Certain conditions associated with aging or certain pathological conditions can interfere with the assimilation of minerals by the human body. Malnutrition, in both adults and children, is caused by lactose intolerance, [14].

Biologically active product - Goat milk contains vitamins, minerals, trace elements, electrolytes, enzymes, proteins and fatty acids that are easily assimilated by the body, [15]. Goat's milk has therapeutic benefits for people with certain dietary problems, so doctors have recommended goat's milk for infants and other people allergic to cow's milk. Similarly, it has been used in the treatment of ulcers, [8,15]. The variation of milk compositions and total milk production depends on different factors. Some of these factors are physiological, genetic and climatic factors. Some physiological factors are lactation stage, age, health of the udder and type of diet. Daily variations and seasonal changes can be considered climatic factors, [16]. Lactation periods, as well as climatic conditions are generally called seasonal changes that have a great influence on milk constituents.

Use of fruit filling in the manufacture of dairy products

Fruits are sources of glucose and fructose, vitamins, minerals, phenolic compounds, dietary fiber. Considering their compatibility with milk, apple, apricot, raspberry, strawberry, cherry are considered most acceptable. To give the yogurt a fruity taste and aroma as well as an attractive appearance, the fruits are used in the form of syrups, concentrates or dried mixtures. Thanks to these fillings, the content of vitamins, carbohydrates, minerals in fermented dairy products is regulated. A special role in the formation of functional properties belongs to dietary fiber, [17, 18, 19].

Fruits: Aronia, Apples, Peaches, Raspberries, Strawberries

To blanche fruits involves placing the produce in boiling water. The main purpose of protecting fruits and vegetables is to inactivate all the enzymes present and especially the oxidative enzymes, which are the most heat resistant. Among the beneficial effects, besides those related to the inactivation of enzymes, it is mentioned the destruction of the vegetative forms of the microorganisms and the elimination of air from the tissues, which consequently fixes, maintains and even accentuates the color of the finished products, as well as fixing and preserving the vitamin C during the following processes. In general, the microorganisms that survive to the blanche process are highly heat resistant. Regarding the adverse effects of blanching process is the loss of soluble substances (sugars, mineral salts, vitamins, etc.) in the boiled water. These losses vary depending on the blanching conditions and especially on the duration, temperature and the ratio between the amount of water and the amount of material subjected to be blanched. Any increase in time and temperature results in a considerable increase in the loss of soluble extract, including vitamin C, while causing excessive tissue softening, [20].

III. Materials and methods of research

Materials

Goat milk was carried out at a local farm, which was labeled and transported at 4 ° C to the laboratory, to analyze the following physico-chemical parameters: fat, protein, total dry substance, pH, density using for comparison Moldovan standard: 2015 Goat and sheep raw milk. Specifications. This standard establishes technical conditions for the raw goat milk quality collected for industrial processing.

Starter culture for the dairy products manufacture: Lyofast YAB 352. Dosage: 10 UC / 1000 liters. The composition: Streptococcus thermophilus, Lactobacillus delbrueckii subsp. Bulgaricus, Lactococcus lactis subsp Lactis biovar diacetylactis, sucrose and maltodextrin.

Fruit has been added to the yoghurt as a pulp in order to maintain the viable form of the bioactive components. Fruit was added at a concentration of 10%.

Methods

- Determination of titratable acidity (ISO/TS 11869 and IDF/RM 150).
- Determination of pH. It was carried out using a Hanna Instruments pH meter which was previously calibrated with buffer solutions having pH 4.0 and pH 7.0 respectively. (ISO/TS 11869 and IDF/RM 150).
- Determination of fat content by acid-butyrometric method (GOST 5867).
- Determination of milk protein content. The principle of the method consists in blocking the amyl groups of proteins with formaldehyde and liberating the carboxylic groups, which are neutralized with 0.1N NaOH solution.
- Determination of the viscosity of the fermented milk products on the BROOKFIELD DV-III Ultra rotary viscometer.
- Determination of the total dry substance content (MAC Humidity Analyzer, Radwag).
- Determination of water activity aw,% (Novasina, LabSwift-aw)
- Assessment of sensory quality based on the score scale. Method principle: Evaluation of each organoleptic characteristic by comparison with scoring ranges of 0 ... 5 points and obtaining the average score of the group of tasters, (ISO 6658: 2005).
- Determination of yeasts and molds according to (SM EN ISO 4833-1:2014)
- Determination of vitamin C according to GOST 30627.2-98.
- Determination of β-carotene according to GOST 8756.22-80.
- Determination of total polyphenols by Folin-Ciocâlteu method. Expressed in gallic acid equivalents, mg GAE / 100 g FW (Sconta, 2012) to the spectrophotometer SF-46, $\lambda = 750$ nm.
- Determination of anthocyanin content. It was determined by the spectrophotometric method at $\lambda = 540$ nm, modified at the Food Technology Department, TUM, extracted with a 95% C_2H_5OH solution and 1.5N HCl (85:15 to sample discoloration)
- Determination of antioxidant capacity by potentiometric method. (SM EN 12857:2014).

IV. Results and discussions

Milk quality - raw material used in the yoghurt manufacture

Goat's milk was subjected to a lot of physico-chemical and organoleptic analyzes before being processed, because the yogurt quality depends on the quality of the raw milk. The results obtained in the TUM laboratory were studied in comparison with the indicators presented in the Moldovan standard: 2015 Goat and sheep raw milk. Specifications.

The results of the sensory analysis of goat milk and cow's milk are listed in table 3.

Table 3. Organoleptic indices of goat milk - raw material.

Parametres	Goat's milk
Appearance and consistency	Homogeneous liquid, with a matte, specific appearance. No sediment, watery, filamentous appearance
Color	White
Taste and smell	Pleasant, sweet, characteristic of milk

Table 4. Physical-chemical indices of raw goat's milk.

Parametres	Goat's milk
Temperature, °C	20,4
Fat content, %	3,1
Density, g/cm^3	1,030
Acidity, °T	18
Dry metter	12,15
Protein	3,34
pH	6,8

It has been proposed to make 6 varieties of yoghurt. The assortment of yoghurt is shown in table 5:

Table 5. Assortment of manufactured yogurt

Raw material	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Goat milk	Classic yogurt	Yogurt with aronia	Yogurt with apple	Yogurt with peach	Yogurt with raspberries	Yogurt with strawberry

Yogurt has been manufactured using the thermostat method because it is an effective method to study the formed coagulum and its firmness. [21, 22]

The raw material mixture was pasteurized at 85-90° C for 2-3 min, after which it was cooled to the sowing temperature and subsequently inoculated with Lyofast YAB 352. The samples were thermo stated at 38-40°C for 6 hours. The end of coagulation time was determined by the pH value, and visually by the firmness of the coagulum. The yogurt samples were packed in 180 g containers and stored at 4±2 °C.

Table 2 shows the yoghurt quality indices. Values obtained for titrable acidity range within insignificant limits for yogurt samples depending on the content of acidic biologically active substances. From the data of table 2 it can be seen that according to the physico-chemical, microbiological and organoleptic qualities, the obtained yogurt corresponds to the technical conditions stipulated in the Government Decision nr. 158 - Milk and dairy products. Yogurt have a fine and soft consistency, due to the fact that the fat globules of goat's milk are smaller and evenly distributed.

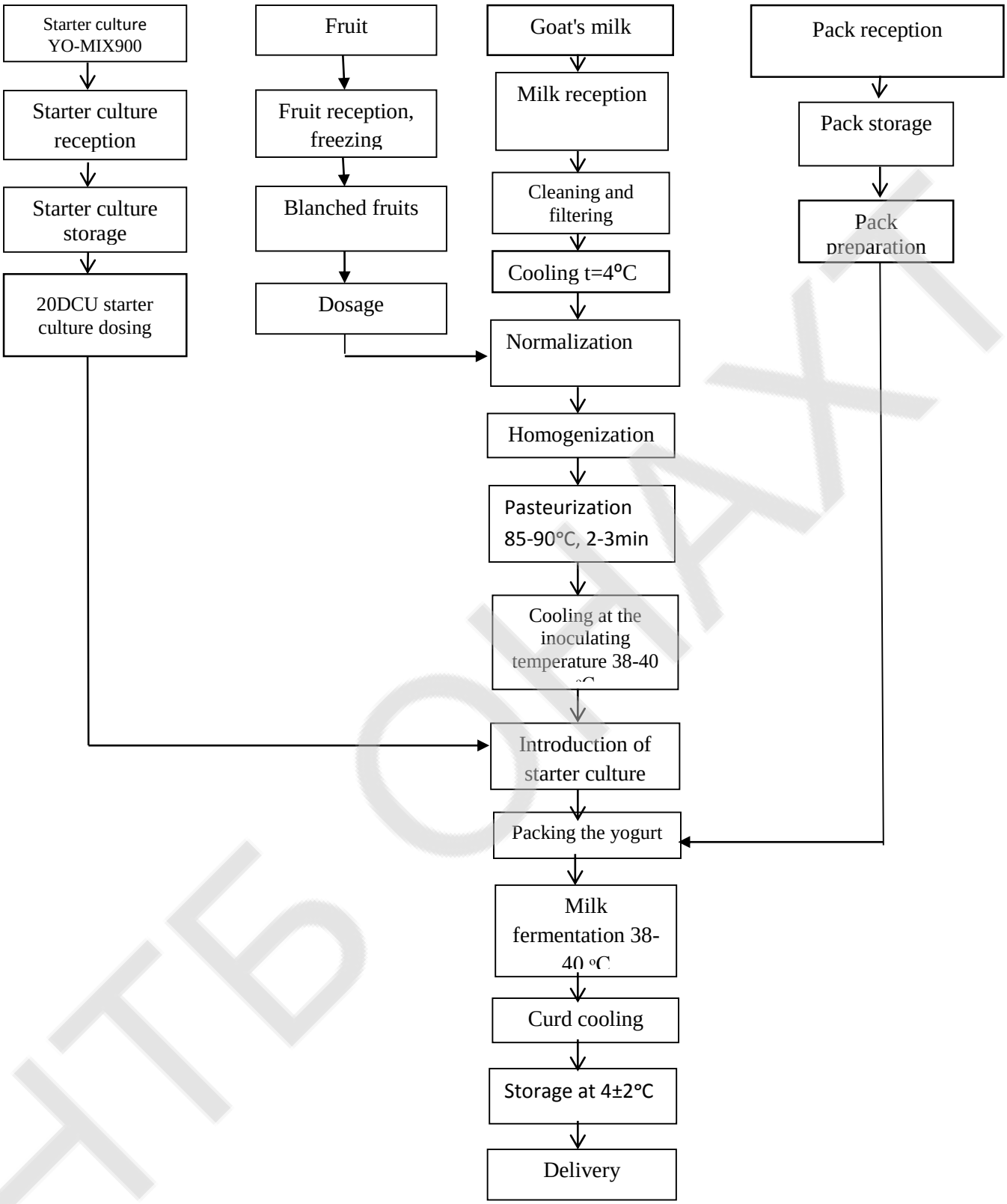

Figura 2. Scheme of goat's milk yogurt production with blanched fruits by the thermostat method.

The type of added fruit had an impact on the titrable acidity and pH values respectively. Higher titers of acidity (103°T) were obtained for raspberry yoghurt, the high acidity being converted by fruit acidity. The smallest values were obtained for peach yoghurt, 90 ^{0}T.

The dry matter quantity indicates different values ranging from 17,83% for apple yoghurt to the maximum of 28,03% obtained for the control sample. The dry matter

content is inversely proportional to the water activity value, for which minimum values of 0.895% for the control sample and 0.904% for yogurt with apple, peach, raspberry were obtained. This two parametres were influensed by the fruit add.

The fat and protein content were slightly influenced by the addition of fruits. That parameters are lower in fruit yoghurt compared to control samples due to the low fruits fat content and due to increasing of water content because of fruit blanched process in the yoghurt manufacturing.

Rheological properties are important indicators of the yogurt quality during processing. The samples were investigated at a temperature of 20˚C. This behavior is typical for non-newtonian fluids and is clearly highlighted for fruit yogurt samples. Minimum viscosity values were obtained for the control yogurt $5,09*10^2$ mPa·s, followed by yogurt with aronia, apple, peach, raspberry, strawberry.

Table 6. Yogurt quality's indices

Nr.	Characteristics		The experimental value				
		Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**
		Classic yogurt	Yogurt with aronia	Yogurt with apple	Yogurt with peach	Yogurt with raspberries	Yogurt with strawberry
1.	**Titrable acidity, °T**	98	94	95	90	103	98
2.	**pH**	5,06	4,65	4,62	4,68	4,61	4,67
3.	**Dry metter, %**	28,03	20,80	17,83	18,73	19,11	20,40
4.	**a_w, %**	0,895	0,901	0,904	0,904	0,904	0,903
5.	**Protein content, %**	6,03	5,31	5,14	5,43	5,62	6,01
6.	**Fat content, %**	3,4	2,0	2,6	2,4	2,3	2,0
7.	**Viscosity, mPa·s**	$5,09*10^2$	$5,45*10^2$	$7,65*10^2$	$8,50*10^2$	$8,64*10^2$	$8,96*10^2$
			Microbiological characteristics				
8.	**The total number of microorganisms, cfu/ml**	$2,1*10^7$	$1,5*10^7$	$1,7*10^7$	$1,8*10^7$	$1,7*10^7$	$1,6*10^7$
9.	**Yeast and mold**	absence	absence	absence	absence	absence	absence
			Sensory characteristics				
10	**Appearance and consistency**	Soft curd moderately viscous					
11	**Taste and smell**	Acid lactate	Sweet taste and characteristic aroma of the introduced fruit				
12	**Color**	White with cream shade	Corresponding to the color of the introduced fruit, uniform throughout the yoghurt				

The sensory characteristics show that strawberry and raspberry yogurt samples best preserved their organoleptic characteristics, having a fine shell, uniform color throughout the mass, sweet taste and characteristic aroma of the added fruits.

Yogurt in combination with fruits play a functional role in the human body, due to the supply of fiber, vitamins, minerals, phytonutrients, polyphenols, anthocyanins, [23, 24]. Yogurt with aronia had the highest polyphenol content (187.10 mg EAG/100 g). Peach and apple yogurt recorded the following values for total polyphenol content: 184.15 mg EAG/100 g., respectively 173.93 mg EAG/100g. The lowest values of total polyphenol content were recorded by control yogurt sample 52.3 mg EAG / 100 g.

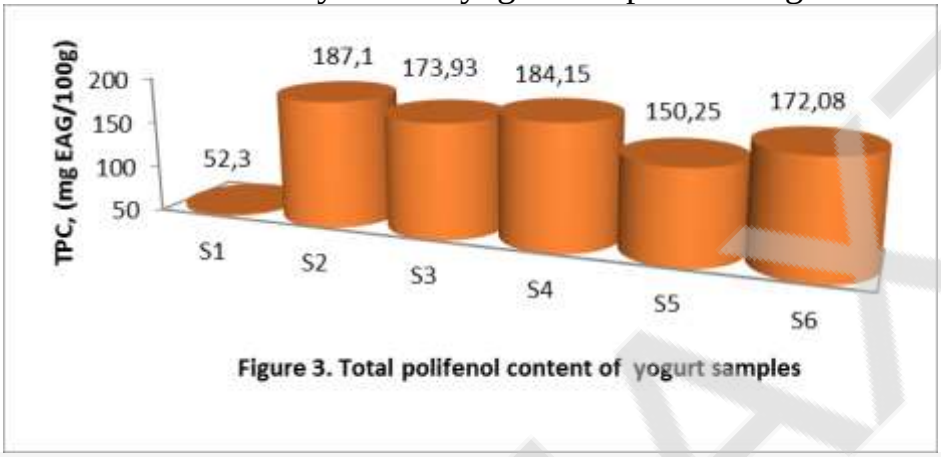

Figure 3. Total polifenol content of yogurt samples

Anthocyanins play an important role in the quality of the color of the yogurt made with fruits and differ from other compounds due to their ability to form different structures depending on the pH of the environment. Due to this property, anthocyanins can provide the body, first and foremost, with protection against the intense harmful reactions of free radicals and can be used in the manufacture of yogurt as natural colorants, [25].

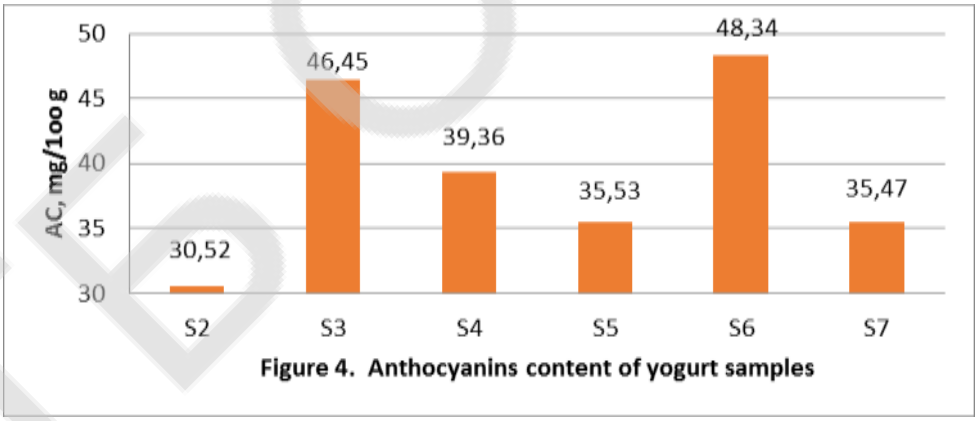

Figure 4. Anthocyanins content of yogurt samples

Using a simple method for quantifying total monomeric anthocyanins, the anthocyanin content of the five yogurt samples with fruits was determined. Values ranged from 35.53 - 48.34 / 100g (Figure 4). The highest anthocyanin content was determined in raspberry yogurt (48.34 mg/100g), followed by aronia yogurt (46.45 mg/100g), apple yogurt (39.36 mg/100g), yogurt with peach (35.53 mg/100g). The lowest value was determined for strawberry yogurt (35.47 mg/100g).

Antioxidants are bioactive substances that prevent oxidation or inhibition of reactions promoted by oxygen or peroxides and thus protect cells from the effect caused by oxidative stress. Fruits are a natural source of antioxidants and therefore their effectiveness in protecting against oxidative stress has been demonstrated by some researchers, [26].

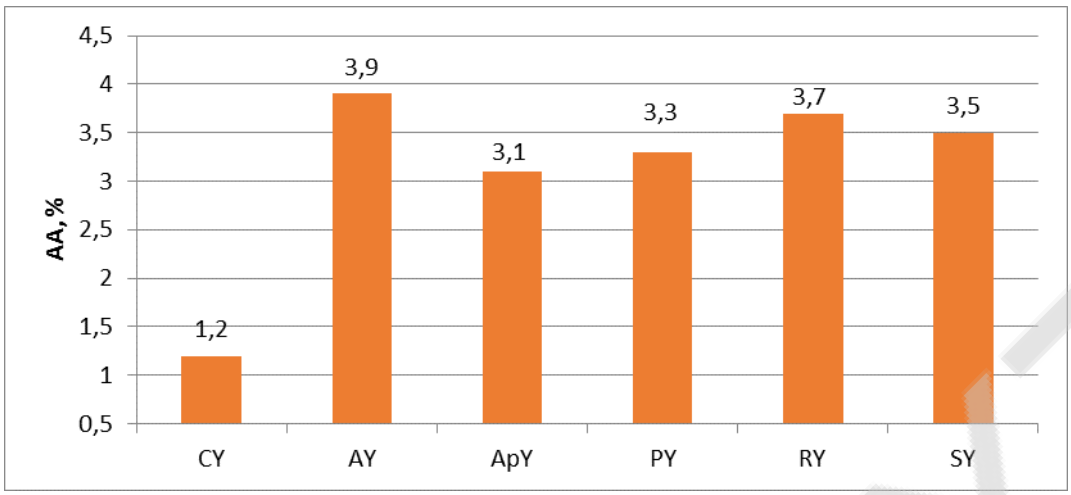

Figure 5. Antioxidant activity of yogurt samples

Natural antioxidants with effect on oxidative stability have the role of preventing rancidity, an undesirable fact in the obtained yogurt samples. Yogurt with aronia registered the highest antioxidant activity of 3.9%, followed by raspberries and strawberries, with values of 3.7% and 3.5%, respectively.

The vitamin content in yogurt can be significantly reduced due to their destruction during the technological process of milk pasteurization. β-carotene and vitamin C are important components in describing the nutritional value of yogurt, [27, 28, 29].

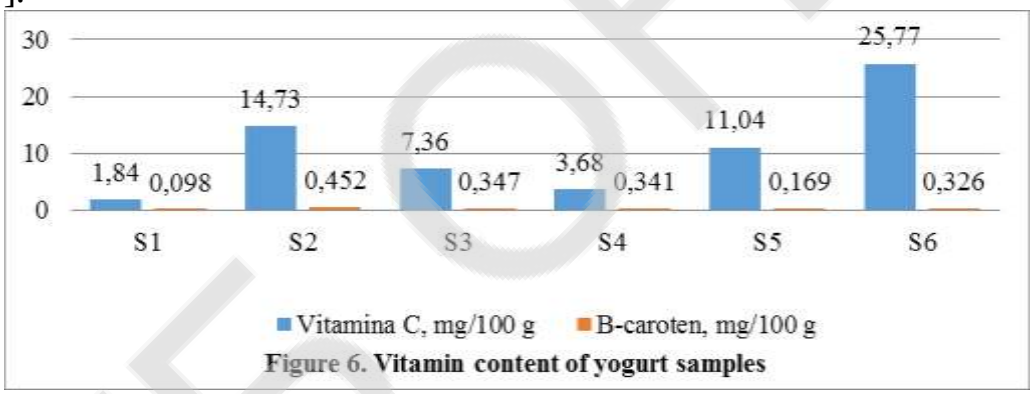

Figure 6. Vitamin content of yogurt samples

The ascorbic acid content of the yogurt fruit samples varies from 1.84 to 25.77 mg/100g. The strawberry yogurt had the highest value (25.77 mg/100 g). The content of β-carotene varied between (0.098-0.452 mg/100 g), yogurt with aronia had a major value, 0.452 mg/100 g.

Evolution of the quality indexes of goat's milk yogurt with blanched fruits during the storage period.

Sensory indices of goat milk yogurt were rated according to the score scale, presented in the sensory analysis sheet: 5 = very good, 4 = good, 3 = satisfactory, 2 = unsatisfactory, 1 = bad, 0 = very bad.

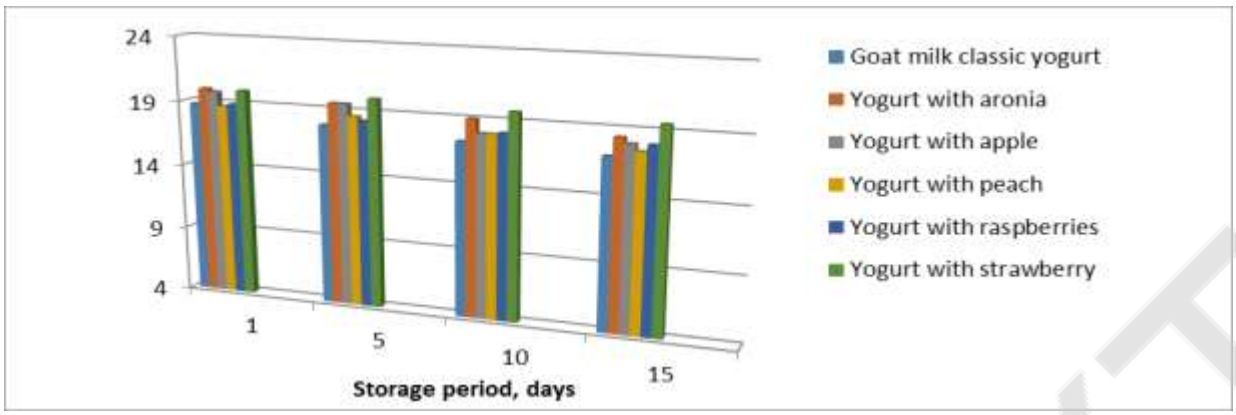

Figura 7. Total average score for goat milk yogurt.

After the sensory examination of the yogurt samples it was found that the goat's milk yogurt with strawberry and raspberries best preserved their organoleptic characteristics such as: appearance, color, consistency, smell and taste.

Physico-chemical indices

Acidification of milk leads to the destruction of the internal structure of casein mycelia due to solubilization of K-casein (Lee W., Lucey J., 2010), as a result of acid coagulation, resulting in the formation of lactic gel.

The evolution of pH (Fig. 8) and titrable acidity (Fig. 9) is correlated with the intensity of lactic fermentation. Active and titratable acidity was determined over 15 days. During storage the pH values decrease on the first day being 4.7. At 5 days -4.6, at 10 days-4.3, at 15 days - 4.2. Results with decreasing tendency were obtained by other authors, Ahmet Ayar, 2014, Kailasapathy, 2008.

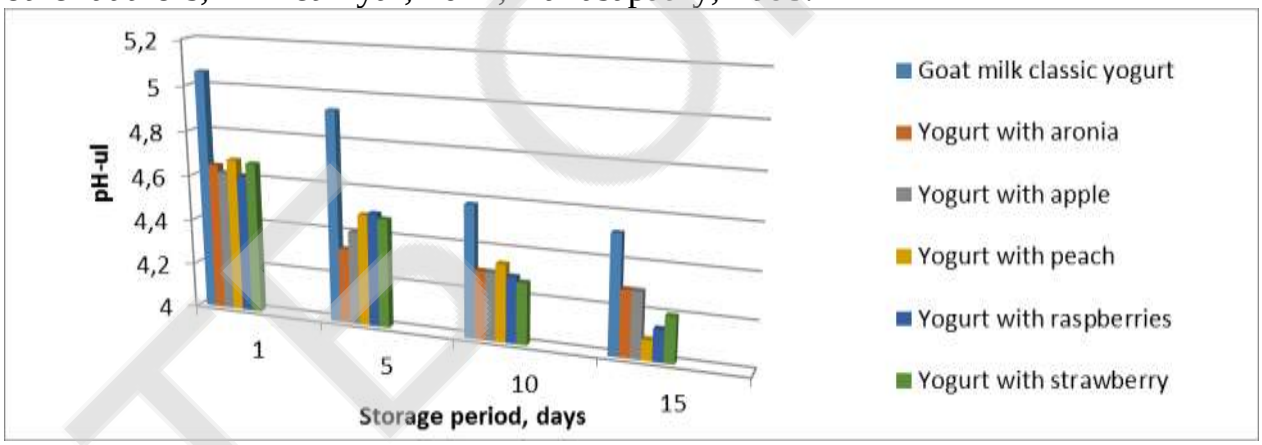

Figura 8. pH evolution of goat milk yogurt with blanched fruits during storage period

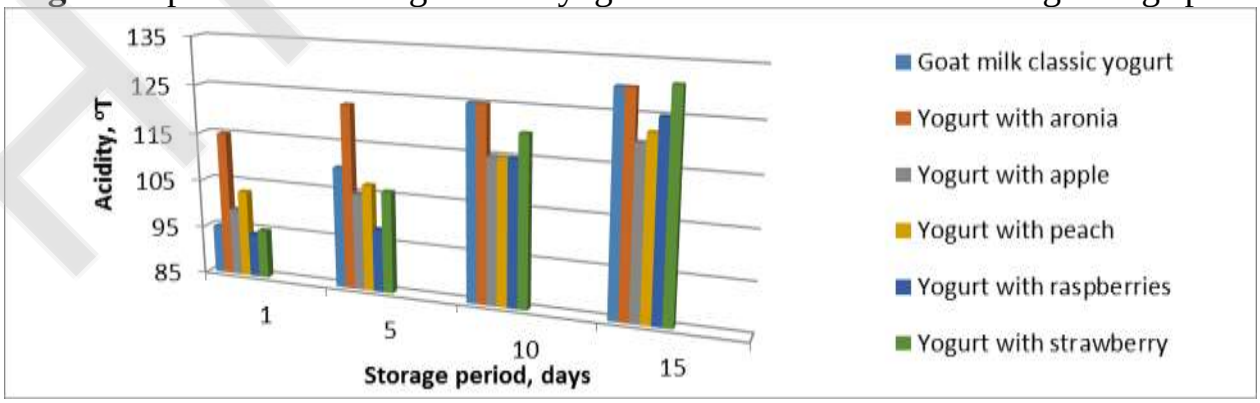

Figura 9. Titrable acidity evolution of goat milk yogurt with blanched fruits during storage period

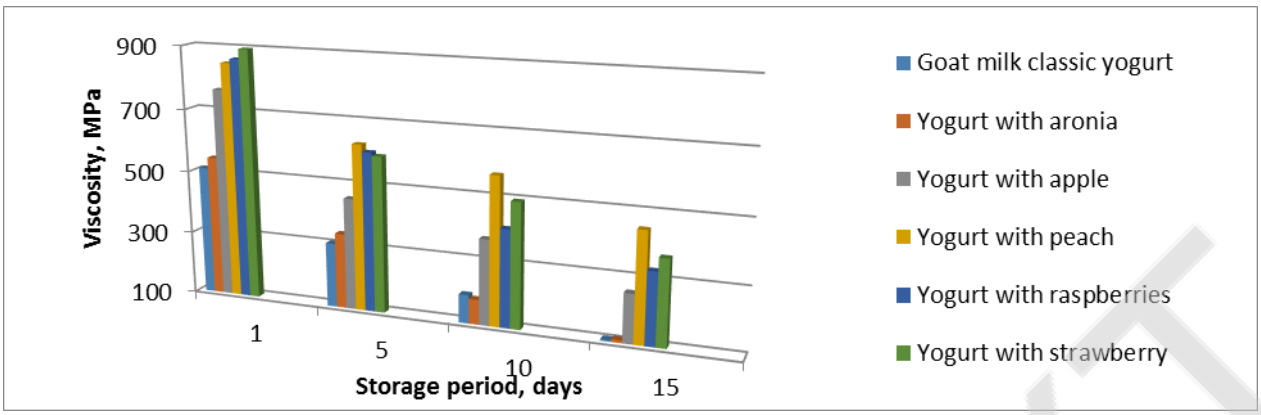

Figura 10. Viscosity evolution of goat milk yogurt with blanched fruits during storage period.

Yogurt gel is a type of soft solid product, and its network is a relative dynamic system, inclined towards rearrangement. The physical properties of yogurt can be explained using the model of interactions in casein micelle that includes the balance between attraction and rejection forces, [30]. The textural properties of the yogurt are influenced by several factors, some of the most important being the temperature and the duration of the heat treatment the fermentation temperature as well as the mass part of the total dry substance.

Minimum viscosity values were obtained for goat milk yogurt, followed by goat milk yogurt with blanched fruit. Goat milk due to its higher β-casein content forms a gel with a weaker network.

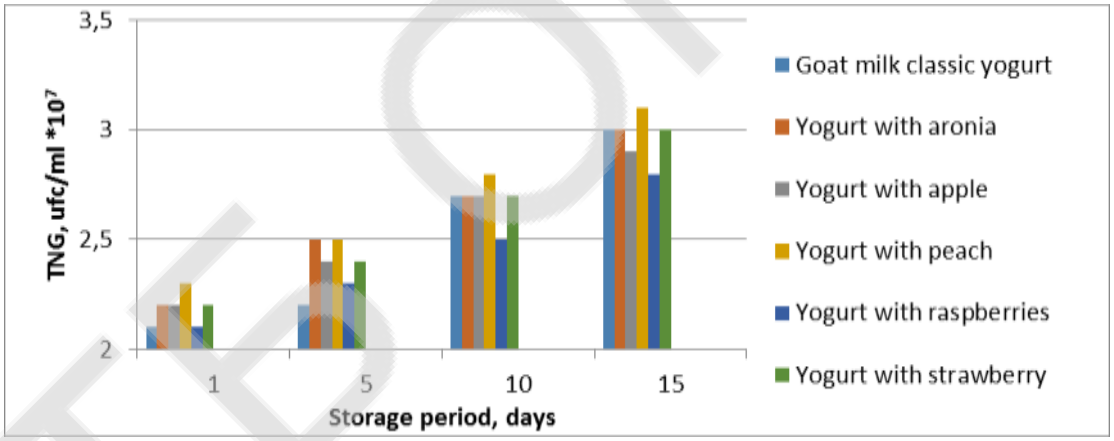

Figura 11. The total number of germs evolution of goat milk yogurt with blanched fruits during storage period.

The results obtained for the determination of the total number of germs for the yogurt samples with blanched fruits are satisfactory during the storage period of 10-12 days and fall within the values stipulated in the normative documents (GD 158, annex 4). While retaining NTG it started to grow above the allowable norms, the values being between 2.2 x 10^7 and 3.1x10^7.

V. Conclusion

Goat's milk yogurt with strawberries and raspberries have best preserved their organoleptic characteristics such as appearance, color, consistency, smell and taste.

Goat milk yogurt, the control sample, was found to have a minimum polyphenol content, and the maximum value was obtained for goat milk yogurt with aronia (187.1 mg / 100g) and 184 mg / 100g respectively for yogurt with blanched peach. The value

of the antioxidant capacity was higher for all yogurt samples with the addition of blanched fruits, the maximum value having the product with the addition of raspberries and strawberries (0.007 mg / 100g).

The physico-chemical and microbiological indices presented values that fall within the limits stipulated in the normative documents for this category of products, while retaining TNG began to grow above the allowable norms, the values being between 2.2 x 10^7 and 3.1x10^7.

The goat milk yogurt samples were kept at a temperature of 4 ± 2 ° C, in order to determine the practical period of storage. Organoleptic indices, pH and viscosity of the yogurt were determined during storage, which presented acceptable results over 15 days. The results of the microbiological indices presented satisfactory values for 10-12 days.

The practical period of storing of goat milk yogurt with the blenched fruit is estimated at 10-12 days.

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MAP OF DEFECTS AND DISEASES OF FRESH APPLES OF LATE MATURATION

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Abstract. *The map of defects and diseases is a method of regulating the quality of fresh apples of late ripening, depending on defects and diseases, their characteristics. The research paper analyzes the requirements for commercial varieties of fresh apples of late ripening in accordance with the requirements of technical regulatory legal acts (hereinafter TNLA) in force on the territory of the Republic of Belarus. The classification is considered in accordance with TNLA, dividing apples into several groups depending on the quality, size and color of the fruit.*

The aim of this work is to develop a map of defects and diseases with illustrations and explanations for identifying permissible and unacceptable defects that occur during the transportation and storage of fresh apples.

The result of this work is visualization of defects and diseases of fresh apples and presentation of results in the form of a map of defects, as well as classification of defects into permissible defects within the commercial class and unacceptable defects.

Key words: *apples, defects, diseases, commercial grade, appearance, quality.*

I. Introduction

In the modern world, the quality of products is very important. But consumers are not always able to determine for themselves with commercial grade this or that batch belongs, which defects occur in apples and which of them are acceptable. Map of defects and diseases in apples is an easy-to-use tool to recognize, understand and solve this problem.

Apples are used both in fresh form and for industrial processing: for making jam, juices, compotes, marmalade, also for drying, souring and freezing. The nutritional value of apples is based on the content of easily digestible sugars, vitamins, mineral salts, organic acids and other substances necessary for the human body. Storage of fresh apples can be carried out in warehouses, including RGS, up to 9-12 months. Depending on the variety of apples storage temperature should be from minus 2 °C to 4 °C. Relative air humidity during storage of apples is 85-95%. During storage of apples, in addition to the main process of metabolism (breathing), maturation and aging, because of incorrect or prolonged storage conditions there is bitter pit, browning of pulp and skin.

The expiration date and storage conditions for fresh apples are set by the manufacturer. There are two TNLA in Belarus, according to which apples are fresh for sale must comply with the requirements of the quality indicators.

II. Analytical review

The chemical composition of apples depends on the variety, growing conditions and degree of maturity. The nutritional value of apples is due to the content of easily digestible carbohydrates (11,3%), mono - and disaccharides (9%), starch (0,8%), proteins (0,4%), fiber (0,6%), ash (0,5%), vitamins (β-carotene 0,03 mg, B1 0,01 mg,

B2 0,03 mg, PP 0,30 mg, C 13 mg), minerals (Na 26 mg, K 100 mg, Ca 16 mg, Mg 9 mg, P 11 mg, Fe 2,2 mg) and organic acids (in terms of malic acid 0,7%) [1]. In the laboratory, several indicators of the quality of fresh apples were studied and it was found that apples mainly contain 7-12 % of sugars, 0,2-1,1 % of organic acids (in terms of malic acid), and vitamin C (up to 20 mg/100 g).

On the territory of the Republic of Belarus there are two TNLAs: GOST 34314-2017 "Fresh apples sold in retail trade. Technical conditions" [2] and STB 2288-2012 "Fresh apples of late maturation. Technical conditions" [3], according to which apples must comply with the requirements of the quality indicators.

According to GOST 34314-2017 "Fresh apples sold in retail trade. Technical conditions" fresh apples are divided into three commodity grades depending on quality: the highest, first, second. Depending on the color of the whole surface or part of it, they are divided into four color groups:

- group A – red color (¾ or ½ of the total surface area of the red color);
- group B – non-uniform red color (½ or 1/3 of the total surface area of non-uniform red color);
- group C – pinkish color, non-uniform red color or with red stripes (1/3 or 1/10 of the total surface area of pinkish color, non-uniform red color or with red stripes);
- group D – no color requirements.

Fresh apples are calibrated by the largest transverse diameter (not less than 60 mm) or weight of the fruit (not less than 90 g).

Table 1 – Permissible deviations by weight of fruit

Quantity (pcs.)	**For all grades of apples, arranged in rows and layers**	**For apples of the first grade, packed in bulk or in a single consumer package**
Over 70 to 90 incl.	15,0 g.	35,0 g.
Over 90 to 135 incl.	20,0 g.	35,0 g.
Over 135 to 200 incl.	30,0 g.	70,0 g.
Over 200 to 300 incl.	40,0 g.	70,0 g.
Over 300	50,0 g.	100,0 g.

In STB 2288-2012 "Fresh apples of late maturation. Technical conditions" classification of pomological varieties of apples of late maturation, zoned in the Republic of Belarus, is made depending on the quality: the highest, first and second commercial grades.

Table 2 – Classification by fruit size

Fruit shape	**Group I (large fruit grades)**	**Group II (medium and small fruits)**
Round	not less than 60-70 mm	not less than 50-60 mm
Oval	not less than 55-65 mm	not less than 45-55 mm

The commercial grade of fresh apples of late maturation is established taking into account the following indicators:

- Appearance: the fruits are whole, clean, without excessive external humidity, for the highest and first grade - with the typical form and color of the pomological variety, with a stalk.

- defects: for the highest grade - very insignificant skin defects are allowed, for the first grade - minor defects of form, development, skin, for the second grade - defects of form, development, coloring, skin.

Apples of the highest grade must be clean and intact, with the whole stalk. The batch must consist of fruits of the same pomological variety, uniform in shape and color. Apples of the first and second grades may be heterogeneous, without a stalk.

The presence of spoiled, rotten, overripe and damaged apples, signs of withering, browning the pulp and the presence of a weed impurity are not allowed.

III. Object, subject and research methods

The object of research is fresh apples of late maturation.

The subject of research is the quality of fresh apples.

Research methods: observation, comparison, measurement, analogy, generalization and analysis. The appearance, maturity of the fruit, and damage within the fruit are determined organoleptically; the size, mechanical, and other damages are measured.

IV. Work results

The requirements of the TNLA have been analyzed and a comparative characteristic of the descriptors described in GOST 34314-2017 “Fresh apples sold in retail trade. Technical conditions” and STB 2288-2012 “Fresh apples of late maturation. Technical conditions” has been carried out.

Table 3 Characteristic of descriptors

Characteristic and norm for commercial grade	GOST 34314-2017	STB 2288-2012
Appearance		
Highest grade:	Fruits of the same pomological variety with typical shape and color, whole, clean, with a stalk and without excess moisture.	Fruits of one pomological variety, typical in shape and color, dry, clean, with a whole stalk, without excessive external humidity.
First grade:		Fruits of the same pomological variety, typical in shape and color or with slight deviations, dry, clean, with or without a whole stalk, but without damage to the skin and excessive external humidity.
Second grade:	The shape, the color of the fruit, the presence of a pedicel is not normalized.	Fruits of one or more pomological varieties, typical and atypical in shape and color, but not ugly, dry, clean, with or without the whole fruit stalk, but without damage to the skin of the fruit and excessive external humidity.
Defects		
Highest grade:	Very minor skin defects are allowed.	Mechanical damage: - at places of shipment: not allowed; - at the destination: light pressure with a total area of not more than 20 mm^2 is allowed; - a weak grid is allowed, a strong grid is not; The absence of a stalk is permissible when selling fruit after storage (December-June).

Continuation of table 3.

Characteristic and norm for commercial grade	GOST 34314-2017	STB 2288-2012
First grade:	Allowed: - Minor defect in shape and development; - Minor skin defects not exceeding 2 cm in length for oblong shaped defects and 1 cm^2 of total surface area, except for apple scab (not exceeding 0,25 cm^2).	Allowed: - no more than two hailstones, light pressure and abrasion (total area not exceeding 40 mm^2); - weak, strong mesh (not more than 1/4 on the surface area of the fruit).
Second grade:	Allowed: - defects in shape, development, coloring; - slight damage not exceeding 1,5 cm^2 with a slightly changed color; - skin defects not exceeding 4 cm in length for oblong shaped defects and 2,5 cm2 for other defects, except for apple scab (total area not exceeding 1 cm^2).	Allowed: - At the destination: no more than five hailstones, pressure and abrasion of the total area of no more than 1/4 of the fruit, no more than two fresh punctures of the skin; - weak and strong mesh are allowed.
Browning of the skin		
Highest grade:	Brown spots are allowed that do not extend beyond the cavity of the stem, slight isolated signs of browning.	Not allowed: browning of the skin (tan), bitter pit and withering.
First grade:	Allowed: - not rough brown spots slightly beyond the cavity of the stem; - weak browning, not exceeding 1/5 of the total surface area of the fruit and not sharply contrasting with the general color; - strong browning, not exceeding 1/20 of the total surface area of the fruit, weak netting and strong browning together not exceeding 1/5 of the total surface area of the fruit.	Allowed: - slight skin browning in the area not exceeding 1/4 of the fetal surface; - bitter pit with the total area not exceeding 3 mm^2; - mild withering without signs of wrinkles;
Second grade:	Allowed: - rough brown spots that may extend beyond the cavity of the stem; - weak browning, not exceeding 1/2 of the total surface area of the fetus and not in sharp contrast to the overall colouring; - strong browning, not exceeding 1/3 of the total surface area of the fruit, weak netting and strong browning together, not exceeding 1/2 of the total surface area of the fruit.	Allows: - slight skin browning on the area of no more than 1/3 of the fruit; - bitter pit with the total area not exceeding 10 mm^2; - withering with slight wrinkling;

Continuation of table 3.

Characteristic and norm for commercial grade	GOST 34314-2017	STB 2288-2012
Smell and taste		
Highest grade:	Must be typical for the pomological variety, without foreign smells and flavors.	The flavor should be sour-sweet, sweet-sour or sweet, the aroma is light. No foreign smell or flavor.
First grade:		
Second grade:		
Degree of maturity and condition of the fruit		
Highest grade:	Fruits are removed at a removable degree of maturity, capable of withstanding loading, transportation, unloading and delivery to their destination.	The condition should be homogeneous, removable - at workpiece, at realization - a consumer degree of maturity. Green and overripe fruits are not allowed.
First grade:		
Second grade:		Homogeneous, removable state is acceptable at the workpiece, consumer maturity - at realization. Green and overripe fruits are not allowed.
State of the pulp		
Highest grade:	The pulp is benign.	Browning of the pulp is not allowed.
First grade:		
Second grade:	Without significant defects.	Browning 1/4 of the cross-section surface is allowed.
Mass fraction of fruits that do not meet the requirements of this variety, but meet the requirements of lower varieties, %, not more than		
Highest grade:	5,0 %	10%
First grade:	10 %	15%
Second grade:	10 %	15%
Presence of agricultural pests, apples, damaged by agricultural pests		
Highest grade:	Not allowed.	Not allowed.
First grade:		Fruits with 1-2 healed injuries not exceeding 20 mm^2 are allowed.
Second grade:		Fruits with 1-2 healed injuries not exceeding 40 mm^2 are allowed.

All fruits, regardless of the variety of fruit, have the following requirements: the apples must be whole, healthy, without a foreign smell and free of excessive moisture; the degree of maturity must be removable (in which the fruit is fully developed and formed, able after harvesting to ripen and reach consumer maturity), to withstand transportation, loading and unloading and ensure delivery to the destination in a satisfactory condition. Immature apples are those which, after harvesting, are not able to acquire the appearance and taste typical of this pomological variety under optimal conditions.

V. Conclusions

At the analysis of TNLA it is established that the requirements to fresh apples differ in terms of defects, mass fraction of fruit that do not meet the requirements of a certain commercial variety, the presence of agricultural pests and damage from them.

While selling fresh apples on the price tag, in addition to information about a pomological variety, it is necessary to specify a commercial grade or information about non-standard products [4], which affects the price, as well as the choice of consumers and ensures food safety of the population of the Republic of Belarus.

While researching the quality of fresh apples sold in retail networks in Minsk, it was found that the marking of fresh apples contains only information about the pomological variety and does not contain information about the commercial grade. The following defects were also found: bitter pit, Jonathan spot, puffiness (browning pulp from over-ripe), sunburn (tan), withering, sunburn (tan), withering, beatings with darkened pulp, hailstones, rough cracks and rubbing, apple scab. The most common mechanical defects are pressures, beatings, hailstones and apple scab.

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НТБ ОНАТ

SUBSTANTIATION OF WHOLE-GRAIN FLOUR PRODUCTION TECHNOLOGY

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Abstract. *Current work is devoted to the research of wheat and spelta grain technological properties, development of grain processing scheme for obtaining whole-grain flour (WGF) and determining its quality. The technological and baking properties of WGF are substantinated.*

Keywords: *WGF, wheat flour, spelta flour, baking properties, ash content, gluten, grain size, flour quality, rheological properties.*

I. Introduction

Grain processing is one of the leading branches of the food industry. It provides the population with flour and cereals; its waste is used for the feed industry. Technological processes of grain processing into flour result with complex structural and mechanical, physical and biochemical changes in grain and also in finished products. Thus, knowing of these changes regularities is not only the essence of studying the flour milling technology, but also is the source for further technological improvement of grain processing into flour.

Compliance violation of rational nutrition principles nowadays is the main reason for rapid non-contagious diseases development. The most common consequences of unbalanced diet in Ukraine is different metabolic disorders. Being overweight and fattiness is the fifth largest risk factor for death in the world, as it is the leading cause of diseases such as diabetes, cardiovascular disease, musculoskeletal disorders, and some cancers. The main treatment and prevention of metabolic diseases is diet therapy with the inclusion in the diet of high-fiber products, vitamins and minerals. Under these conditions, it is urgent to manufacture bakery products with healthy and preventive purposes with reduced energy and increased nutritional value [1].

II. Analytical literature overview

The traditional cereal grinding is based on the gradual grain milling and the mechanical distribution of its three main parts (endosperm, embryo and shells), which are significantly different in their physical and mechanical properties and chemical composition.

This is achieved while using of a large number of crushing systems, which leads to high energy costs for the high-quality flour production [1]. Separating from the endosperm shells, aleurone layer and embryo results in removing most of the vitamins, proteins and minerals (table 1). This reduces the biological value of flour comparing to grain reduces the nutritional value of bread.

Compared to wheat flour of the highest grade, WGF contains 12.5 times more fiber, 2.1 times more calcium, 5.8 times magnesium, 3.9 times - phosphorus, 3.4 times - iron, 3.7 times - vitamin PP, 2.3 times - vitamin B1, B2. In addition, WGF contains vitamin E, which is completely absent in premium flour. [2].

Table 1. Some nutritional values of wheat flour

Indicator	High-grade wheat flour	Wheat WGF
Fiber content, %	0,15	1,90
Mineral content, mg/100g		
Ca	18	39
Mg	16	94
P	86	336
Fe	1,2	4,1
Vitamin content, mg/100g		
B_1	0,41	0,98
B_2	0,08	0,19
PP	1,2	4,5
E	0,0	5,7

There is high interest to spelta grain nowadays. However, the cultivation and use of spelta is hampered by hard threshing of the grain due to the tight coverage of the flower scales of the grain. This requires equipment and additional energy costs to manufacture grain without films [3].

The content of the anatomical parts varies significantly depending on the variety. According to Egorov and Kazakov [4], the shells content in wheat grain floats from 5.6 to 11.2%, aleurone layer - from 5.2 to 8.8, embryo - from 1 , 4 to 4.2, endosperm - from 78.7 to 84.3%.

Increasing the Protein content increasing of spelta grains adversely affects the baking quality of the flour. This is due to the fact that with increasing protein content increases the proportion of gluten-forming proteins (gliadin and glutenin), and the proportion of albumins and globulins decreases. For wheat spelta, carbohydrates are a major component (50-70%) of grain, and sugar content is 2-3%. The dietary fiber content of spelta wheat varies from 10.5 to 14.9%. The rich vitamin and mineral composition of spelta wheat can be explained by its specific ability — to absorb nutrients from the soil better than bare wheat.

More proteins and lipids content in spelta wheat, along with the reduced carbohydrate content, makes the bread-baking properties of these crops different. It is indicated (in Table 2) that spelta wheat has a lower sugar content than wheat, since it contains less starch than wheat, whose grains are smaller but better protein-bound [5].

Table 2. Quality indicators of wheat and spelta WGF

Indicator	WGF	
	Wheat	Spelta
Gluten content, %	24	32
Gluten extensibility, cm	14	18
Elasticity, IDG units	74	90
Hydration capability, %	174	151
Flour acidity, Degrees	4,8	5,2
Water absorption capability, %	65	61

As a result, the spelta flour dough ferments less intensively, which is confirmed by a 21% lesser release of carbon dioxide during its fermentation. Acidity of spelled

flour is higher by 0.4 deg. It was found that spelta flour releases gluten by 8% more than wheat flour. Spelta flour gluten is less plastic, more elastic, has less than 15% hydration capacity and 28% - elasticity.

There are several technologies for processing grain into WGF. Rolling mills, crushers or millstones can be used as crushing equipment (Fig. 1).

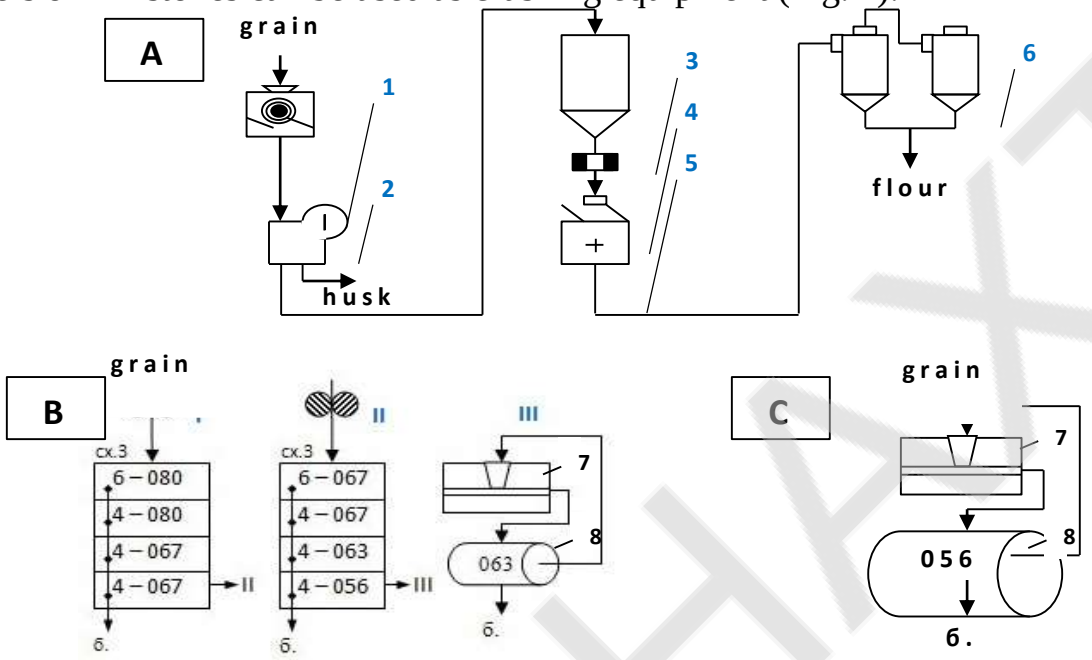


Fig. 1. Structural scheme of wheat grain processing in WGF: A — with crusher using; B — with roller mills and millstones using; C — with millstones using: 1 – the peeler; 2 – aspiration column; 3 – operational bunker; 4 – magnetic separator; 5 – hammer crusher; 6 – cyclone; 7 – millstone; 8 – burate

There is also the practice of using flow charts, where roller machines are used as the main grinding equipment, and millstones or crushers are installed on the latter grinding systems [2].

WGF obtained by different manufacture technology, differs significantly in quality.

In the most world countries, the moisture content of the flour should not exceed 14.5-15.0% (except France, where moisture content is limited to be not more than 16.0%). In some countries, cereal flour standards have upper and lower ash limits, such as the United States (1.6 - 1.8%), the United Kingdom (1.6-2.2%) and Canada (1.07-1.94%). In Germany, the production of three types of flour with a high content of ballast substances with an ash content of 1.60 to 1.85% is allowed.

The highest ash content of flour is regulated in:

- Bulgaria (flour of coarse flour with an ash content of not more than 1.85%);
- Poland (‘Greham’ flour with an ash content of not more than 1.85%);
- UK (WGF with an ash content of 1.60 — 2.20%);
- Canada (coarse flour with an ash content of 1.07 - 1.94%).

The standards of some countries regulate gluten content in wheat WGF:

- Bulgaria - at least 26.5% of coarse flour;

- Poland - at least 24.0% of flour;
- Czech Republic - at least 23.0% of flour, in flour of coarse grinding not less than 22,0%;
- the USA - in flour of whole grain grain not less than 14,0%.

Ukraine's standards for WGF are absent today. GSTC 46.004-99 «Wheat flour. Specifications» apply only to high-quality flour and upholstery. The production of WGF from cereals and legumes, on the contrary, allows to preserve all the natural nutritional value of the grain. Therefore, the purpose of the study was to examine the quality indicators of WGF.

III. Object, subject and methods of research

Literature analysis allowed to formulate the purpose and tasks of research.

The purpose of the work is to substantiate technological scheme and optimal modes of wheat WGF production.

Objectives are:

- To carry out the analysis of technologies and quality indicators of ukrainian and foreign WGF;
- Investigate technological and baking indicators of quality for WGF obtained by different technological schemes;
- To substantiate the technological scheme of WGF production;
- To justify the requirements for WGF quality indicators.

Object of study: Wheat WGF production technology.

Subject of study: Wheat and spelta WGF obtained in manufacture conditions and in the laboratory under various technological schemes.

In the first stage of the study, organoleptic parameters of flour quality, moisture, whiteness, size, gluten quantity and quality were determined.

The main indicators of quality in flour were determined by standard methods:

- GSTC 27558-87. Flour and bran. Methods for determining color, odor, taste and crunch;
- GSTC 9404-88. Flour and bran. Method of determination of humidity;
- GSTC 26361-84. Flour. Method of determining whiteness;
- GSTC 27560-87. Flour and bran. Size determination method;
- GSTC 27839-88. Wheat flour. Methods for determining the quantity and quality of gluten.

The study of the baking properties of flour was carried out using the direct method: the evaluation of the quality of flour by trial baking.

The standard for the method of trial laboratory baking of bread [6] provides a clear method of preparation of dough from flour, water, baker's yeast and salt. Bread quality assessment was carried out according to physic-chemical parameters according to GSTC 27669-88 “Wheat flour bakery. Method of trial laboratory baking of bread.”

Sensor evaluation of bread was performed by the method of describing and evaluating flavors.

Descriptors were developed for the objective evaluation of bread, showing its main characteristics. Each indicator was evaluated according to a number of descriptors, indicating its intensity on a 5-point scale. The following scale was used to

evaluate the intensity of the characteristics:

Intensity scale

Weak intensity → Strong intensity

□0 □1 □2 □3 □4 □5

The following evaluation sequence was selected. First, the descriptors that characterize the appearance (the appearance of the crust, the appearance of the crumb, the color of the crumb) were evaluated to determine the sensory profile of the bread.

Wheat grain was used for laboratory grinding, which, according to the quality indicators, belongs to class 4 (group B) and spelta grain (Table 3).

Table 3. Wheat grain quality indicators.

Quality indicator		Sample 1 wheat grain	Sample 2 spelta grain
Bulk density, g/L		780	668
Vitreous, %		53	79
Test weight, g		43	42
Moisture, %		13,2	12,9
Protein, %		10,4	-
Gluten	content, %	16,3	44
	quality, units	82	105,0

The experimental base of the Department of Grain Processing Technology and the base of the ONAFT Sensor Analysis Laboratory were used for the research.

To implement the scheme of laboratory grinding of grain into WGF, “Nagema” laboratory mill and “KoMo Fidibus XL” mill were used.

IV. Results

The ukrainian market offers to the consumer various types of flour (Table 4): milled wheat WGF, varietal wheat flour, milled spelta WGF, varietal spelta flour, coarse grinded wheat flour.

Table 4. Product packing and marking

N	Product name	Storage period	Normative document	Weight, g
1	milled wheat WGF	10 months	GSTU 46.004-99	1000 ±2%
2	wheat flour “whole-grain”	12 months	GSTU 46.004-99	2000 ±2%
3	milled spelta WGF	10 months	GSTU 46.004-99	1000г±2%
4	milled spelta WGF	10 months	GSTU 46.004-99	1000 ±1%
5	coarse-grinded wheat flour “organic”	12 months	GSTU 46.004-99	1000 ±15г
6	wheat WGF	12 months	TCU15.6-36594696-001:2009	1000 ±1%
7	coarse-grinded wheat flour “special”	12 months	TCU10.6-36580577-001:2012	1000 ±1%
8	milled wheat WGF	12 months	TCU15.6-24582550-002:2004	1000 ±1%
9	wheat WGF	8 months	TCU 15.6-00952737-006:2002	1000 ±15г

Analysis of the package and labeling of the product (according to the manufacturer) showed that the flour samples No. 1-5 were manufactured according to GSTU 46.004-99, the quality of the flour samples No. 6-9 is controlled by the manufacturer's own specifications. There are no Ukrainian standards for wheat WGF.

Flour quality studies usually begin with the determination of organoleptic characteristics, moisture, whiteness, size, quantity and quality of gluten (table. 5).

The moisture of all samples of WGF did not exceed 15.0%.

Ash content of WGF of domestic production ranges from 1.12-1.26% (for samples No. 6-9) to 1.37-1.58% (for samples No. 1-5).

The size of coarse flour (padded wheat flour) according to the standards is controlled by two sieves: residue on sieve No. 067 and passage of sieve No. 38. The size of the studied flour samples differed greatly, so for samples No. 1, 3 the residue on sieve No. 067 was within 3-6%, samples No. 2, 4, 5, 6, 7, 9 - 0,4-1,0%, sample No. 8 - 16%. The highest content of fine fraction of flour (passage of sieve No. 38) in the range of 50-60% was observed in samples No. 1, 2, 3, 6, 7 and 9. In samples No. 5, 8, the content of the corresponding fraction of flour is 30%, which is less, than recommended by GSTU 46.004-99.

Table 5. Quality indicators of flour samples.

Sample No.	Product name	Moisture, %	Ash, %	Whiteness, convent. units	Size, %	
					Sieve N067 residue	Sieve N38 pass
1	milled wheat WGF	12,0	1,58	-29,0	6,0	60
2	wheat flour “whole-grain”	10,6	1,37	-9,5	0,2	49
3	milled spelta WGF	10,8	1,46	-2,7	3,0	56
4	milled spelta WGF	11,4	1,41	-0,5	1,0	50
5	coarse-grinded wheat flour “organic”	11,3	1,39	-0,5	--	30
6	wheat WGF	12,2	1,12	30,4	0,4	51
7	coarse-grinded wheat flour “special”	12,3	1,15	6,1	--	50
8	milled wheat WGF	10,9	1,26	-15,9	16	30
9	wheat WGF	12,8	1,13	19,7	0,6	62
GSTU 46.004-99 requirements for quality indicators of upholstery flour		< 15,0	< 2,0	Not limited	< 2,0	> 35

Judging from the ash and grain size indicators, several manufacturers in their production adhere to the principle of almost 100% of all anatomical components of the grain getting into WGF, but the grain size may be at or equal to the size of the size of the upholstered flour.

One of the main indicators characterizing the baking properties of flour is the amount and quality of crude gluten. The amount of gluten, as well as its quality depends on both the varietal characteristics of the grain, the conditions of its growth, and the size of the flour. In terms of grain quality, the approach to the selection of raw materials

from different suppliers is also heterogeneous. Some manufacturers get whole wheat flour from high quality wheat, which results in higher baking properties and the higher cost of such flour, while others follow the approach of using cheaper but weaker wheat. In addition to wheat, some manufacturers use expensive spelta wheat, which increases the nutritional value of bread and also affects the baking properties of flour.

According to the requirements of GSTU 46.004-99, the gluten content is limited to at least 18% (Fig. 2).

Fig. 2. Content and quality of raw gluten in studied flour samples.

The highest gluten content was observed in samples No. 3, 4 (spelta flour) – 32 and 34% respectively, in samples No. 1, 5, 6, 7 gluten content was 25-27%, the lowest crude gluten content was observed in samples No. 2 and 9 - 21%. In sample No. 8, gluten is not washed out.

The standard for the laboratory test baking method of bread (GSTU 27669-88) provides a non-hazardous way of preparing dough from flour, water, yeast and salt. The quality analysis of the finished products was performed according to organoleptic and physic-chemical indicators of quality. The results of the trial baking of bread from the samples of flour are shown in table 6.

Table 6. Physic-chemical indicators of bread from WGF

No.	Product name	Bread vol., cm^3	Porosity, %	Specific vol., cm^3/g
1	milled wheat WGF	375	64	1,7
2	Wheat flour “whole-grain”	434	66	2,0
3	milled spelta WGF	500	69	2,2
4	milled spelta WGF	520	70	2,4
5	coarse-grinded wheat flour “organic”	455	70	2,1
6	Wheat WGF	590	75	2,8
7	coarse-grinded wheat flour “special”	475	70	2,1
8	milled wheat WGF	255	47	1,2
9	wheat WGF	430	68	2,0

The baked bread had a developed, uniform porosity, smooth, with no lateral detonations on the crust surface, had a pleasant taste and aroma. The largest volume of bread is observed in flour samples No. 3, 4, 6, 7. This is due primarily to the high content and quality of gluten (more than 24%) and the size of flour of the specified samples (passage of sieve No. 38 is 50-56%) . Bread porosity is in the range of 66-75%.

Sample flour No. 8 has the lowest volume of bread among the samples tested because it has the weakest protein complex that does not form a gluten framework. This bread has a low porosity of 47%.

WGF was obtained from two variants of technological schemes with different modes of grinding systems. The technological scheme according to option No. 1 (grinding No. 1.1-1.4) included four break grinding systems (B1, B2, B3, B4) on roller machines and one grinding system (St1) on a millstone. The technological scheme according to option No. 2 (grinding No. 2.1-2.3) included three break grinding systems (B1, B2, B3) on roller machines (whereby I and II break grinding systems were carried out without intermediate sieving) and two grinding systems (St1, St2) on a millstone.

According to the scheme option No. 1 at each of technological system the WGF was obtained by the using of sieves No. 1,0; 090; 080; 067; 063; 056. The overtail products, after the sieving of the flour, were directed for further grinding at subsequent systems. The final grinding of the brans obtained at the last roller mill system (B4) took place on a millstone (St1). Tables 7-10 show the balances of wheat WGF laboratory grindings according to scheme option No. 1.

In laboratory grinding No. 1.1 the following operative system modes (sieve release) were maintained: SR_I = 34 %, SR_{II} = 58 %, SR_{III} = 57 %. At the final grinding system the maximum amount of flour was selected. During the laboratory grinding No. 1.2 the operative modes at B3 and B4 were slightly higher than at the previous grinding: SR_{III} = 41 %, SR_{IV} = 21%. The load on millstone system (St1) at grinding No. 1.2 was 13.8 %.

During laboratory grinding No. 1.3 low operating modes of the systems were maintained: SR_I = 36 %, SR_{II} = 76 %, SR_{III} = 74%, SR_{IV} = 86 %. The load at St1 at this grinding was the lowest and equal 0.6 %. Laboratory grinding No. 1.4 is characterized by the following operation modes of the grinding systems: SR_I = 26 %, SR_{II} = 53%, SR_{III} = 36 %, SR_{IV} = 23 %. In this grinding operation mode of B1 was the highest comparing to other grindings. The load on St1 at grinding No. 1.4 was the highest comparing to other similar laboratory grindings and equal 17,3 %.

Table 7 – Balance of laboratory grinding No. 1.1, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	66,0				34,0
B2	66,0		28,0			38,0
B3	28,0			12,0		16,0
B4	12,0				3,0	9,1
St1	3,0					3,0
Total		66,0	28,0	12,0	3,0	100

Table 8 – Balance of laboratory grinding No. 1.2, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	67,9				32,1
B2	67,9		29,8			38,1
B3	29,8			17,5		12,4
B4	17,5				13,8	3,7
St1	13,8					13,8
Total		67,9	29,8	17,5	13,8	100

Table 9 – Balance of laboratory grinding No. 1.3, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	63,6				36,4
B2	63,6		15,5			48,2
B3	15,5			4,0		11,5
B4	4,0				0,6	3,5
St1	0,6					0,6
Total		63,6	15,5	4,0	0,6	100

Table 10 – Balance of laboratory grinding No. 1.4, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	74,1				25,9
B2	74,1		34,8			39,4
B3	34,8			22,4		12,4
B4	22,4				17,3	5,2
St1	17,3					17,3
Total		74,1	34,8	22,4	17,3	100

In the next stage, the laboratory grinding of common wheat and spelta wheat grains into WGF according to the scheme option No. 2. It consisted of three roller mill grinding systems and two millstone grinding systems, and based on gradual-parallel grain grinding. On the roller mill grinding systems, WGF was selected by passage of flour sieves No. 38, which provided separation of pure flour. Larger fraction with brans in its composition was sent for further grinding. Balances of laboratory grinding of common wheat grain are given in Table 11-12, and for spelta wheat grain – in Table 13.

For laboratory grindings the sieve release on the first two systems SRI+II was gradually reduced: 54.6%, 48.8%, and 39.8% for grindings No. 2.1, 2.2, 2.3, respectively. As a result, the load on the millstone systems increased and the amount of flour obtained from the abrasion deformation also increased.

Table 11 – Balance of laboratory grinding No. 2.1, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	45,4		13,4	41,2
B3	45,4		10,1	2,7	32,6
St1	10,1			10,1	
St2	26,2				26,2
Total		45,4	10,1	26,2	100

Table 12 – Balance of laboratory grinding No. 2.2, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	51,2		13,4	35,4
B3	51,2		10,8	7,8	32,6
St1	10,8			10,8	
St2	32,0				32,0
Total		51,2	10,8	32,0	100

Table 13 – Balance of laboratory grinding No. 2.3, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	60,2		12,4	27,4
B3	60,2		16,6	10,5	33,1
St1	16,6			16,6	-
St2	39,5			-	39,5
Total		60,2	28,6	39,5	100

There were no significant difference in moisture content, ash content and gluten content between the obtained WGF samples (Table 14). Analyzing the obtained data it can be noted that the best sample for quality indicators and baking properties in the grinding scheme option No. 1 was a sample of whole grain flour from laboratory grinding No. 1.3. This is connected directly to the particle size of the flour: passage through the sieve No. 38 was 55 %, and the top of sieve No. 067 – 1.5 %, which indicates a more balanced particle size distribution. Bread volume for samples No. 1.1-1.4 fluctuated within 330-360 cm3, the porosity of the studied bread samples varied within 76-77 %. The worst quality had the sample of flour obtained as a result of laboratory grinding No 1.4, which is also related to its particle size.

Table 14 – Quality indicators of WGF

No. grindings	Moisture, W %	Ash content, Z %	Crude gluten		Granulatory, %		Physiochemical indicators of bread		
			content, %	gluten deformation index, units	top on sieve No. 067, %	passage through sieve No. 38, %	bread volume, cm^3	porosity, %	specific bread volume, cm^3/g
1.1	12,9	1,68	17,1	71	4,3	44,3	350	75	1,5
1.2	12,5	1,68	17,0	70	4,9	40,8	350	75	1,5
1.3	12,8	1,67	17,1	71	1,5	55,0	360	77	1,6
1.4	13,0	1,68	17,2	72	11,0	36,0	330	75	1,4
2.1	12,8	1,68	17,4	70	1,3	64,3	430	79	2,0
2.2	12,6	1,68	17,2	68	3,4	60,1	400	79	1,9
2.3	11,3	1,81	39,6	106	1,6	50,3	380	67	1,8

The quality indicators of the common wheat whole grain flour obtained according to the scheme option No. 2 (grinding No. 2.1 and No. 2.2) differed with a smaller particle size of the flour: the top on sieve No. 067 was 1.3 and 3.4 %, respectively. The passage through sieve No. 38 had 64.3 % and 60.1 %, respectively. The obtained bread from these samples was characterized by good baking properties, a larger bread volume of 430 and 400 cm3, and a high porosity that corresponds with similar indicator from bread made of high-grade flours.

Particle size of spelta WGF was characterized by top on sieve No. 067 – 1.56 % and sieve No. 38 passage – 50.3 %. The content of crude gluten in the sample was 39.6 %, gluten deformation index (GDI) = 106 units. The high value of GDI resulted in worse baking properties compared to wheat flour obtained in the same scheme.

In the next phase of research, we investigated the rheological properties of WGF.

The set of obtained indicators allows to create a specific graphical profile for a particular flour or grain sample and describe its rheological characteristics in the way of consecutive 6 product quality indicators for easy comparison and use.

Flour samples selected for the study of rheological properties are presented in Table 15 and Figure. 3.

Mixolab profilers for industrial-grade flours and laboratory-grade flour indicate that the WAC index (1) varies over a wide range, from 1 to 8, due to fluctuations in the protein content of the grain, the number of damaged starch grains, and the number of shell particles. The degree of hydration influences all technological processes,

especially the mechanical mixing, the weight yield of dough and bread, the quality of the final product.

Table 15. Samples of flour that were examined on Mixolab

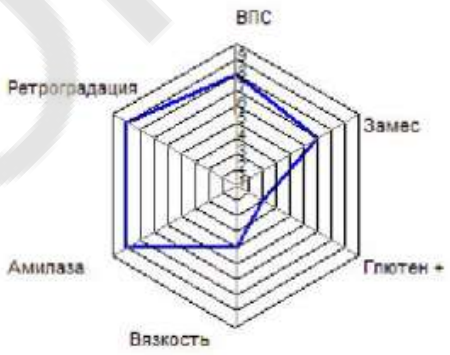
Sample No.	Product name	Trademark
1	Milled spelta WGF (upholstery)	Green Mill (TM)
2	Milled spelta WGF	Traditions bench (TM)
3	Coarse-grinded wheat flour organic	Eco-family (TM)
4	Wheat WGF	Alta-Vista (TM)
5	Coarse-grinded wheat WGF	Health formula (TM)
6	Wheat WGF	Laboratory grinding (No.1)
7	Wheat WGF	Laboratory grinding (No.3)
8	Wheat WGF	Laboratory grinding (No.4)
9	Wheat WGF	Laboratory grinding (No.5)
10	Spelta WGF	Laboratory grinding (No.7)

The highest value of the index 2 was noted in samples № 5, № 7-8. Interpreting the results of the analysis of the sample of flour on the mixolab chart, we can assume that the higher the water absorption index, the better the technological value of the sample. The kneading index (2) depends on the kneading behavior of the dough, especially the stability. The higher the index, the more stable the dough is during kneading. For baked bread, it is preferable to use flour with an index of 4-6. The smallest batch index 2 in samples № 1 and № 3.

Sample №1

Profile 1-24-278

Sample №2

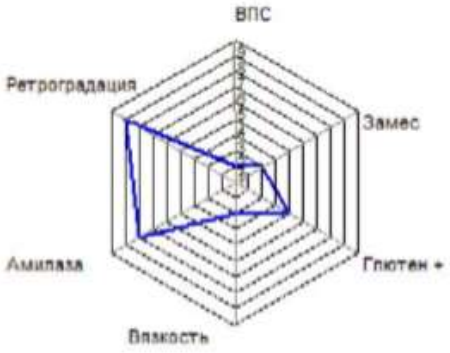


Profile 7-62-488

Sample №3

Profile 2-67-596

Sample №4



Profile 1-58-898

Sample № 5

Profile 8-75-275

Sample № 6

Profile 4-58-698

Fig. 3. Mixolab profiles of samples

Sample № 7

Profile 7-58-788

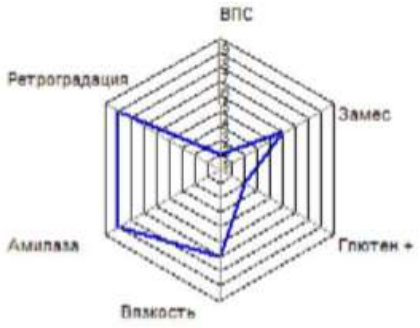
Sample № 8

Profile 7-57-745

Sample № 9

Profile 6-57-645

Sample № 10



Profile 1-52-688

Fig. 3. Mixolab profiles of samples

The Gluten + index (№) depends on the links between the gluten molecules and has a significant impact on the volume of the final product. The higher the index on the initial phase of gluten + heating, the more stable the dough behaves when it is initially heated. The gluten + index in most samples was 7-8, exceptions are samples № 1, № 2 and № 10.

The viscosity index (4) depends on the structure and degree of damage to the starch. The lower the index, the higher the resistance of the test against attack by amylases. The low viscosity index of the dough is caused not by the high amylase

activity but by the features of the starch structure. In the above samples, the index ranges from 2 to 8.

The amylase index (5) mainly depends on the amount of α and β amylase. This index is based on the same interpretation as the traditional method for the analysis of amylolytic activity, the number of falls, namely: a high index of amylolytic activity of Mixolab will correspond to a high value of the number of falls, therefore, a weak activity of alpha-amylase (hypodiastasis) and vice versa (hyper). Samples № 8 and № 9 have an index value above 4, other index values for other samples range from 7 to 8, and the samples have low amylase activity.

The Retrogradation Index (6) indicates how fast the bread stems, the hardness of the bread crumb, and the softness of the crust. Samples №№. 5, 8, 9 have index values of 5, which indicates a longer shelf life and freshness of whole grain bread.

V. Conclusions

Wheat and spelta WGF is popular among the population of many countries in the world. Ukrainian state standards for wheat WGF are absent for this moment. DSTU 46.004-99 «Wheat flour. Specifications» apply only to high-grade flour and dark flour. The research of technological, baking quality indicators of wheat and spelta WGF and the indicators of baked bread showed completely different end-results, due to different technological approaches for its production and lack of general normative documentation.

For the production of WGF, it is most appropriate to use combined technological schemes with the usage of roller machines as grinding equipment on the main systems of the technological process and millstones at the ending systems for the final grinding of intermediate products.

Based on the conducted researches it is advisable to use the scheme, which consists of 3-4 roller mill grinding systems and 1-2 millstone grinding systems with sequentially grinding. The following operative modes of systems (passage through sieve No. 067) are recommended: SR_{II} = 30-40 %, SR_{III} = 60-70 %. The operation mode of other systems must be such as to ensure maximum extraction of WGF.

It was found that the particle size of wheat WGF, which is controlled by the top on sieve No. 067, must be not more than 2.0 %, while the passage through sieve No. 38 must be not less than 50 %.

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НТБ ОНАХТ

RECEIVING DESSERTS WITHOUT SUGAR ON THE BASIS OF VEGETABLE RAW MATERIALS

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Abstract. *Desserts form an important and integral part of South East Asian cuisines and are often associated with festive eating and celebrations. Since most desserts are high in caloric content and contain refined carbohydrates and saturated or trans-fats, their consumption poses obvious challenges in diabetic individuals. Meals should not only meet the biological needs of an individual but should also be palatable, appealing and retain their hedonistic aspects of taste, smell and visual appeal. While remaining within the principles of medical nutrition therapy, desserts can be incorporated into meals with use of whole grains, low fat dairy or yoghurt, fruits, vegetables and pulses as their primary ingredients. Intake of free sugars can be minimized by using non-nutritive sweeteners, soluble fiber, condiments and spices. In this article, we focus on ways to encourage healthy eating among diabetics while still retaining pleasurable foods such as desserts.*

Key words: *dessert, biological value, energy value, microbiological indicators, pectin, carbohydrates.*

I. Introduction

The problem of quality and food safety is one of the most important in the modern world. Food is necessary not only as a nutrient and energy, but also for physiological value. Specialists in the food industry pay great attention to the creation of technology for the production of therapeutic and preventive products, improving their quality and safety in order to prevent various diseases and strengthen the body's protective functions. The problem can be solved by developing innovative food technologies aimed at increasing the efficiency of using various ingredients as the most important and biologically active sources [1].

The aim of the work is to obtain sugar-free desserts based on vegetable raw materials, namely pumpkin, beetroot, and carrot, and to study their value.

To achieve this goal, the following tasks are set:

1. improving the technology of making pastilles from vegetable raw materials
2. research of physical and chemical properties of products
3. Evaluation of microbiological safety of products

II. Analytical review of the literature

Currently, confectionery products are popular all over the world. However, their excessive use leads not only to irreversible consequences in the body, but also to the acceleration of existing diseases. The result of a mixture of fast carbohydrates and fats is a metabolic disorder that leads to obesity and diabetes. Therefore, the problem of developing new types of dessert products based on the principles of functional nutrition is currently very urgent [2].

There is a growing demand of consumers who lead a healthy lifestyle for low-calorie desserts with a pleasant taste, aromatic and refreshing properties. For the

development of these products, vegetables and fruits are used as the main raw materials.

Desserts on a vegetable and fruit-berry basis are rich in high biological and nutritional properties, abundant vitamin composition, minerals and simple carbohydrates.

Hearing the word "Dessert", first of all, in our opinion, comes a delicious and sweet dish. But in fact, dessert is a very broad concept that originated from the ancient French word desservir. As desserts, all light products that are issued after the main course can be used. For example: cheese, fruit, berries, nuts, juices, confectionery. The history of the origin of desserts appeared several thousand years ago. Traditionally, desserts include cakes, pies, cookies, jam, candy, chocolate, and many Oriental sweets. The name and period of the main dessert originated in the 19th century with the development of sugar production in Europe. Until this time, sweet desserts were only on the table of rich families and on the table of ordinary families on a holiday. Sweet fruits and honey are the main available type of desserts. Many sweet dishes are made on the basis of natural sweeteners, and later they are replaced with sugar. The taste of desserts that are currently consumed by our original dishes, the taste, nutritional value and vitamin composition were far away [3].

Currently, many desserts are rich in glucose sources. They are good at fighting glucose deficiency with hunger to increase strength and improve mood and brain stimulation. If a person follows an active lifestyle, you do not need to use this product anymore [4].

III. Object, subject and research methods

The object of the study was a pastille developed on the basis of vegetable raw materials (pumpkin, carrots, beets).

Production technology for sugar-free dessert products

Pastille-light and voluminous confectionery products. During the experiment, the pastille was made from three different vegetables-carrots, pumpkins, and beets. The main difference between cooking this pastille is not the use of sugar. For the production of pastilles, add vegetable purees, a lot of orange juice and orange pulp to sweeten the taste [5].

First of all, 500g of vegetables were cooked in steam (water) at a temperature of 100ºC and pureed through blenders. The resulting puree in the 1st case is 200g of orange juice, in the 2nd case with the pulp, and in the third case, the orange juice is well mixed with the pulp and peel. Hot pastille coating

dry. After the Pastille has slightly hardened the mass, the orange applies the pulp to the surface. It will take 2-3 days for the paste to dry completely. Pastille is stored in clean, well-ventilated areas at a temperature of 20 ° C and a relative humidity of 75% [6].

Determination of the quality of pastilles by organoleptic method

The study of the quality of the obtained products was carried out by the method of organoleptics.

The organoleptic method is a method for determining product quality indicators based on vision, sniffing, sensation, hearing, and taste. The accuracy and accuracy of

such an assessment depends on the employee's qualifications and competence, as well as on the conditions for conducting the analysis [7-8].

Methods for determining the physical and chemical properties of products

In the course of determining the physical and chemical properties of products, the total protein, total fat content, total amount of sugar, humidity, acidity, and ash content are determined. The content of fructose and glucose in sugars and the amount of pectin were also studied [9-10].

IV. Result of work

The results of organoleptic evaluation of pastille samples are shown in tables 1

Indicators	According to GOST standards	Pumpkin pastilla	Beets pastilla	Carrot pastille
Surface layer	It is characteristic that there is no solid solidification and release of syrup on the side faces.	According to the recipe, the orange pulp is filled in, without hardening and completely dried.	According to the recipe, the orange is sprinkled with pulp, slightly stiff, the syrup is not released.	According to the recipe, the orange pulp is filled in, without solidification, the syrup is not released.
Color	Different product names that are specific to this product.	beige brown	vinous	Orange
Smell	the flavorings of products taken for research should not contain any other substance. If there is a sharp taste and smell, research is not allowed	There is a pleasant smell of dry pumpkin and orange	The smell of dry, pleasant beets prevails.	A pleasant aroma, the aroma of orange prevails in contrast to carrots
Taste	The flavorings of products taken for research should not contain any other substance. If there is a sharp taste and smell, research is not allowed	Pleasant, sweet and sour taste, without foreign taste	Pleasant, sweet and sour taste, without foreign taste	Pleasant, sweet and sour taste, without foreign taste
Structure and consistency	homogeneous small porous, soft, light, characteristic of this product name	Evenly, finely porous, soft, light.	The surface and middle are inho-mogeneous, and small porosities are observed. Soft, light.	Evenly, finely porous, soft, light.

HTOHAT

The use of orange pulp and orange seeds with juice made it possible to obtain raw materials of the necessary consistency that meets the requirements of the technology. The resulting products meet the requirements of GOST.

Determination of physical and chemical properties of vegetable pastilles

To assess the quality and properties of dietary pastes, studies were conducted to determine the total proteins, fats, carbohydrates, acidity, humidity, and ash content in the product (table 2).

Table 2 physical and chemical properties of pastilles

	Total protein, g/100г	Fats, g/100г	Carbohydrates, g/100г	Acidity, °T (norm-not less than 5,0)	Humidity, % (according to the TU norm no more than 9128-001-61664-456 14-25)	Ash content (According to the norm of TU no more than 9128-001-61664-456, 1)
Pumpkin pastilla	2,2	0,3	31,71±0,6	7,5	15,5	0,08
Beets pastilla	4,5	0,1	24,96±0,5	6,9	18,2	0,09
Carrot pastilla	2,5	0,09	19,3±0,04	7,2	16,3	0,075

When calculating the energy value, the amount of energy of pumpkin pastille was 289 kcal, beet paste-113 kcal, carrot paste-83.4 kcal. Thus, from these indicators, you can see that the pastille has a high calorie content.

More detailed studies have been carried out to determine the biological value and vitamin C contained in the raw material and the finished product (Table 3).

Table-3 vitamin C content, mg / 100g

	Source material	Final product
Pumpkin pastilla	8,7	185,3
Beets pastilla	4,5	168,3
Carrot pastilla	4,8	170,5
Orange juice	47,3	-
Orange pulp	52,1	-
orange peel	130,3	-

In the analysis, the orange cheese showed a significant part of vitamin C. If you are using juicy and cortical mixtures increases the vitamin content in the finished product, which is an indicator of biological value of products with a low energy content, which is crucial for a healthy diet.

Many people suffer from obesity and endocrine diseases, and people are forced to take sugar from their diets and replace it with fructose. The difference between sucrose (sugar) and fructose is due to different absorption of the body. The structure of fructose is very important, especially for people with diabetes. Unlike other fructose carbohydrates, they can function without the participation of insulin in internal cellular metabolism. For a short period of time, it is absorbed into the blood, so the increase in blood sugar is very reduced, compared to taking glucose. Fructose does not cause intestinal hormones that stimulate insulin production, so it is widely used in dietary products for people with diabetes [11-12]

Useful properties of glucose occur only when it is used in its own quantity. In our studies, the content of glucose and fructose in the pastille was established [13].

Qualitative indicators of carbohydrates are presented in table-4 .

Table-4 analysis of vegetable pastille carbohydrates

	Glucose,%	Fructose, %
Pumpkin pastilla	31,71	10,98
Beets pastilla	3,93	2,64
Carrot pastilla	24,96	7,13

As a result of table 4, the glucose content in pumpkin is 60% higher than fructose. Glucose 10.98 %, fructose 3.87 %. The composition of beet paste contains fructose four times more than glucose. Fructose 4,05 %, glucose of 0.64 %. Carrot paste contains a glucose content of more than 40%. Glucose 7.13 %, fructose 4.68 %. Therefore, we noticed that the amount of carbohydrates in the composition of pumpkin is much higher compared to three different pastilles.

Pectin is a medicinal food fiber that can form a gel-forming mass that collects toxic substances from the intestinal walls and removes them naturally. The use of pectin-containing products normalizes metabolism by restoring intestinal motility. The uniqueness of natural pectin is the ability to preserve the bacteriological balance of the human body [14-15].

In the course of the study, an analysis was carried out on vegetable raw materials and pectin composition in pastilles. The results are shown in table 5.

Table-5 pectin composition, %

	Raw material composition	Final product
Pumpkin pastilla	2,1	3,87
Beets pastilla	1,3	4,05
Carrot pastilla	0,9	4,68
Orange juice, pulp, shell	1,2	

Determination of the probability of growth and reproduction of microorganisms, including pathogens and microorganisms that cause harm to the product (for example, mold), is indicated in the following table. The results of the study are presented in table 6.

Table 6 microbiological indicators of pastilles

Microbiological indicators	Standards	Pumpkin pastilla	Beets pastilla	Carrot pastilla	Compliance with regulatory documents for test methods
Kmafanm, CFU / g (cm3)	$10^3 \div 10^4, \leq 10^5$ - Storage graphs, benign $> 10^5 \div 10^{6-}$ - Manufactured or stored in violation of technological or sanitary conditions $> 10^6 \div 10^{7-}$ Potentially dangerous as a source of pathogenic microorganisms and their toxins $> 10^7 \div 10^8$ – Damaged, which is confirmed visually (color, change in smell, appearance of mold)	$3*10^3$	$2*10^3$	$3*10^3$	Respond
Molds	No more than 100 CFU / g of product	0	0	0	Respond
Yeast	No more than 50 CFU / g of product	0	0	0	Respond

Studies have shown that the resulting paste samples are microbiologically safe and meet quality indicators.

V. Conclusions

The study resulted in sugar-free desserts based on vegetable raw materials, namely pumpkin, beetroot, carrot, and studied their composition, identified organoleptic, physical and chemical indicators of products and vitamin C content. The "research laboratory for assessing the quality and safety of food products" was also sent to determine the content and pectin composition of carbohydrates and indicators of mold and yeast.

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2. ECONOMICS AND ADMINISTRATION

НТБ ОНАХТ

COMPREHENSIVE ASSESSMENT OF EFFICIENCY IN USING HUMAN RESOURCES OF THE ENTERPRISE

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Abstract. *In the paper was proposed a methodological toolkit for assessing the efficiency in using human resource as a source of competitive advantage of companies, based on a dynamic standard (in the author's interpretation), formed by the economical justification of its key HR-metrics, cause and effect comparison with their further ranking in the dynamics and calculation methods of mathematical statistics. This will allow informatively, adequately to the inversion type of market transformations, that observed today and taking into account the time factor, to analyze all substantive aspects of the object of research that cannot be estimated by classical methods, which traditionally boil down to the analysis of a certain set of labor indicators in statistics and / or comparison their magnitudes over a number of periods, and do not imply the identification of mutual influence, significant relationships, and the dynamic subordination between them. The scientific novelty lies in devising a matrix model for selecting strategies for improving the efficiency in using human resources, which combines its integral indicator with the rating position of the enterprise in terms of labor productivity indicator in the industry, which allows comprehensively approach to the issues of evaluation of such efficiency, obtain economic benefits from synergy and can claim to versatility as an analytical tool. According to the results of the research the estimation of the efficiency in using human resources of the enterprises-leaders of the sauce and seasonings market in Ukraine with corresponding recommendations on the options of strategic development in this direction.*

Keys words: *an efficiency in using human resources, a dynamic standard, a graph, an integral indicator and a matrix.*

I. Introduction

Human resources are the key asset of the company, whose value in the context of global personnel default, that are projected and the innovation of the economy, drives which they are, is growing. Accordingly, for Ukrainian business bring new challenges, that complicate the management process and, in particular, the role of human resources in it, which means that there is an urgent need to obtain comprehensive and fully information about the efficiency of their using for making the reasonable management decisions, which in turn, leads to the need to improve methodological approaches to measurement. At the same time, the dynamism of the market environment and the internal business processes of companies requires to extrapolate it to a methodological toolkit of such an assessment, which should be based on a system of dynamic HR metrics, tracking which will allow companies to control the efficiency in using human resources, and most importantly - to determine the strategic directions of its enhancement. The majority HR executives of Ukrainian companies approach to this issue intuitively and situationally, or by using established

techniques that do not take into account the realities of time. Instead, it is traditional among scientists to note the assessment of efficiency in using human resource to the separation of different combinations of its partial indicators, with rare attempts to aggregate them into the integral indicator, which also updates the theme of further research.

II. Literature overview

The research experiments were based on the idea of normative (reference) ordering of economic systems indicators in dynamics, what has been called "the theory (method, model) of dynamic standard", first formulated in the work of Professor Syroiezhyn I.M. [1], and developed in the writings of his followers – Motyshyna M.S. [2], Pohostynska N.M., Pohostynskyi Yu.A. [3] and Tonkykh A.S. [4], who devised methodological rules and procedures for their statistical evaluation. Nowadays, the method of dynamic standard is actively discussed in the scientific community and is widely practiced in completely different aspects of analysis: the socio-economic efficiency of banking activities [5], the liquidity of the banking system [6], the balance of development of enterprises [7], the investment activity of non-state pension funds [8], performance of corporate finance management [4] and others, however, there is lack of scientific development on how to build a dynamic standard for assess the efficiency in using human resource of enterprise. The paper presents its author's version, which contains a system of indicators for the directions of their using, theoretically substantiated by domestic economists: Bahrii K.L. [9], Lashkun H.A., Shakhno Yu.A. [10] and Cherep A.V. [11]. Industry specificities in the calculations were provided by data and information from official statistical observations and marketing analysis [12, 13].

III. Object, subject and methods of research

The object of research is the process of ensuring the efficiency in using human resources of enterprises. *The subject of research* – is a set of theoretical and methodological approaches and applied aspects of the implementation of the comprehensive methodology of assessment of efficiency in using human resources of PJSC «Volynholding» (Nestlé S.A. Corporation) and PJSC «Chumak» (Delta Wilmar International) based on normative-index diagnostic model and matrix technologies of strategy formation. *Methods of research.* In the paper were found the traditional general scientific and special methods, which allowed to examination the objects and phenomena in close relationship and to solve the list of tasks set before the researcher: *the theoretical generalization, system analysis and synthesis* – for clarification the subject-object scope of research; *the statistical grouping and method of relative values* – for formation the system of key indicators of efficiency in using human resources of enterprises; *the method of reference dynamics of the indicators* – for construction the linear and nonlinear dynamic standard of such efficiency, and for calculation of its integral indicator (EF) – *the non-parametric method of statistic*; *methods of strategic diagnostics* – with the purpose of positioning the enterprise in the strategic matrix «EF – the rating indicator of labor productivity»; *method of logical generalization* – in formulating conclusions of investigations.

IV. Results

Disparate indicators in the statistic are matched in dynamics and, moreover, have a distinct cause and effect relationships, so they can be ranked and subordinate the relative to each other – this observation became the basis for the development of the theory about dynamic standard, founded by a famous scientist Syroiezhyn I.M. [1], was awarded by the author's certificate, which he also validated during his work as a part of the United Nations Expert Group on Planning Methodology. In general, under the term of a dynamic standard is understood a set of indicators, which organized in terms of growth rate, so that maintaining this order for a long time interval provides the best mode of the economic system operation [2, p. 210]. The completed methodology of its estimation by the methods of nonparametric statistics and the mathematical apparatus of the theory of matrices, which are used now, is phased formed and brought to practical capacity in papers [2 – 4].

The construction of a dynamic standard begins with the selection of key indicators of the phenomenon, which is being analyzed. Some authors are betting on absolute indicators [5, 8], others [6, 7] – on relative ones, which, in our view, more comprehensive characterize the concept of «efficiency», as opposed to absolute, which are measures of «effect». The recommended optimal number indicators of dynamic standard is in the range up to 10 [1, p. 85] and from 6 to 25 [3, p. 55]: both too few and too many can lead to errors in further integral assessment and loss of its information content.

By scientists, who consider the evaluation of efficiency in using human resources of enterprise theoretical platform for research [9 – 11 and many others] have established its basic directions, notably: the analysis of productivity and profitability of labor; the availability of workforce in the enterprise (its number, composition and movement); the working time fund. Consequently in table 1, we have submitted metrics of efficiency in using human resources of enterprise with a breakdown on groups of indicators, which appropriate to each of these directions.

The relative indicators from the table 1 will be used to form a dynamic standard by establishing the ratio of their tempo values, which will be economically interpretable and have high diagnostic informativeness to evaluate the efficiency in using human resource. An ordinal scale of growth rate (T) labor productivity indicators and personnel profitability would be as follows:

$$T(P_p) > T(LP) > T(CL_r) > T(C_w) > 100\% > T(C_{dfem-e}) \qquad (12)$$

The initial element of a dynamic standard $T(P_p)$ guarantees the maximum efficiency in using human resources for the enterprise through the operating revenue indicator per employee, because, in our opinion, this kind of profit is directly influenced by the production personnel, since profits from other operating, financial and investment activities, mainly, the result of management influence and unregulated factors of diverse nature. The benchmarking $T(P_p)$ і $T(LP)$ in favor of the former indicates the available cost savings of production and marketing of enterprise commodities, because, there is a more intensive profit growth in comparison with growth of production volumes and further sales.

Table 1 – Metrics of efficiency in using human resources of the enterprise

№	Indicators	Formula of calculation	
1	**Labor productivity and personnel profitability**		
1.1	Profitableness of personnel	$P_p = P_{oper} \div N_{av}$	(1)
1.2	Labor productivity	$LP = PV \div N_{av}$	(2)
1.3	Capital-labor ratio	$CL_r = BPF \div N_{av}$	(3)
1.4	The coefficient of ratio the average wage on the enterprise to the average industry wage	$C_w = W_{int} \div W_{ind}$	(4)
1.5	Defect coefficient due to fault of employee	$C_{dfem-e} = V_{dfem-e} \div PV$	(5)
2	**Stability of personnel and their qualitative composition**		
2.1	Coefficient of personnel stability	$C_{stab} = N_{stab} \div N_{av}$	(6)
2.2	Coefficient of qualified employees stability	$C_{stabq} = N_{stabq} \div N_{av}$	(7)
2.3	Coefficient of prospective employees turnover	$C_{turnpr} = N_{turnpr} \div N_{av}$	(8)
2.4	Coefficient of personnel turnover	$C_{turn} = N_{disturn} \div N_{av}$	(9)
3	**Efficiency in using work time**		
3.1	Coefficient of efficiency in using work time	$C_{ewt} = WT_{act} \div CF_{wt}$	(10)
3.2	Coefficient of breach labor discipline	$C_{bld} = \frac{L_{ishld}}{EF_{wt(per.-hours)}} + \frac{L_{rounld}}{EF_{wt(per.-days)}}$	(11)

Notation keys: P_{oper} – the operating revenue; N_{av} – the average number of employees; PV – the production volume; BPF – the basic production funds; W_{int}, W_{ind} – the average monthly wage for the year, accordingly by enterprise and by industry; V_{dfem-e} – the value of the defect due to fault of employee; N_{stab} – the number of stable employees with more than 3 years of experience in the enterprise; N_{stabq} – the number of qualified employees who have advanced training, have undergone retraining and / or vocational training and have been on the company lists for the last 3 years; N_{turnpr} – the number of prospective employees whose development the company has invested for the last 3 years; $N_{disturn}$ – the number of employees, dismissed for reasons of personnel turnover; WT_{act} – the actual time worked (person-hours); CF_{wt} – the calendar fund of work time; L_{ishld} – the intra-shift losses of work time related to a breach labor discipline, (person-hours); L_{rounld} – the round-the-clock losses of work time related to a breach labor discipline (person-days); $EF_{wt(per.-hours)}$; $EF_{wt(per.-days)}$ – the effective fund of work time accordingly in person-hours and person-days.

The dependence of indicators $T(LP) > T(CL_r)$ explains the enhance in production capacity of the enterprise through progressive rates of results of output growth over labor financial security, and indicators $T(CL_r) > T(C_w)$ – more dynamic using the means by the personnel, which were invested by the enterprise in basic production funds as a driver of productive capital rather than aimed at labor remuneration which determines its motivational environment.

The ratio $T(LP) > T(W_{av})$ is a classic and a determined for assessment of efficiency in using human resources: with productivity growth are created the real prerequisites for increasing level its remuneration, which, in turn, enhances employee motivation for more productive work. Comparison of average wage by enterprise and by industry will give a more objective picture of satisfying the level of material requirements of employees of a particular enterprise and assessing the prestige of labor.

Defects of goods causes additional losses for the enterprise and increases the cost price of its production, and defects due to fault of employee is also attest to lack of

competence (qualification) or the level of practical training of such employees, which should be minimized: $100\% > T(C_{dfem-e})$.

In relation to personnel stability indicators and their qualitative composition (table 1) we present their dynamically ordering in the following way:

$$T(C_{stabq}) > T(C_{stab}) > 100\% > T(C_{turn}) > T(C_{turnpr}) \quad (13)$$

Inequality $T(C_{stab}) > 100\%$ – is a positive trend towards building employee loyalty to the employer, who is satisfied with wage and working conditions for at least the last three years, and $T(C_{stabq}) > T(C_{stab})$ – on the increment of loyalty of qualified personnel, who actively involved in the process of professional development. As is custom, indicators of personnel turnover should decline in dynamics in order to eliminate threats to the personnel security of the enterprise due to staff leakage. Moreover, the rate of decrease in the coefficient of personnel turnover as a whole $T(C_{turn})$ should be lower than the rate of decline prospective employees $T(C_{turnpr})$ because the latter are costly for enterprise (in addition to the salary, a sufficiently long time in professional and personal development, career advancement of prospective employees are invested money, which, if they are fired, will not receive a financial return in the form of productive labor results) and strategically important to close key positions by internal candidates.

The efficiency in using work time, which is determined by the self-titled indicator and is another component of assessment of efficiency in using human resource (table 1), should increase, and the coefficient of breach labor discipline, in reverse:

$$T(C_{ewt}) > 100\% > T(C_{bld}) \quad (14)$$

An ascending dynamic C_{ewt} means that on the enterprise is reducing unproductive losses of working time, and a downward trajectory of movement C_{bld} describes an effective system of prevention and control over the employees' compliance with the rules of internal labor arrangements, work regulations and self-organization.

The formed above dynamic standards (12) – (14) are linear, means such, where the temporal pairwise ordering of the indicators has an unambiguous interpretation of the economic relations between them, and can be used autonomously as partial evaluation indicators of efficiency in using human resource. However, from a systemic approach point of view, they should be combined. As a result, we obtain a nonlinear dynamic standard (fig. 1), when interdependence between some pairs of tempo indicators is not obvious, but in the aggregate compliance with their reference dynamic will ensure to any enterprise the high efficiency in using of human resources.

Nonlinear dynamic standard of efficiency in using human resources of the enterprise, except the graph of the reference ordering (fig. 1), can be represented with the assistance the mathematical apparatus of matrix theory, and to be analyzed by methods of nonparametric statistics according to the methodological recommendations shown in figure 2.

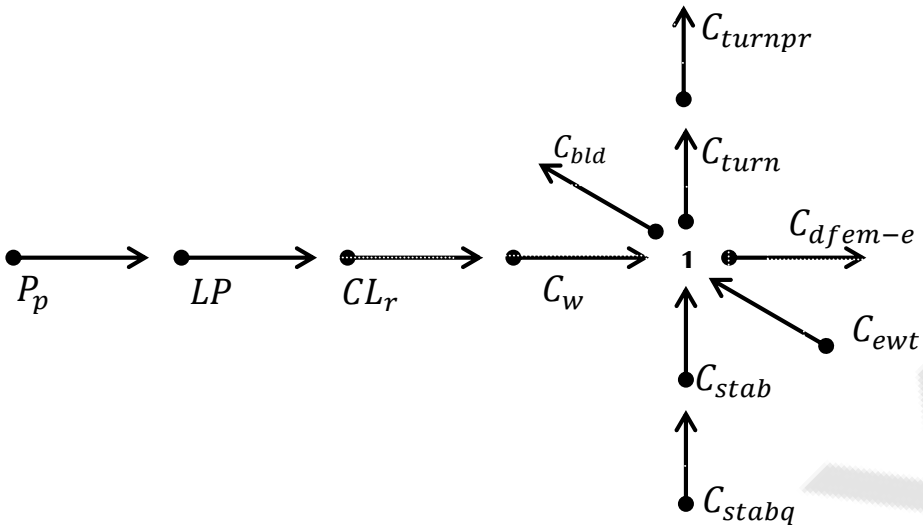

Fig. 1. Graph of the reference ordering the indicators of efficiency in using human resources in the enterprise

* Compiled by the author on indicators, the notation keys of which are given in table 1

** The elements of the graph are not the relative indicators but indexes

On the fig. 2 notation keys are as follows:

$I(b_i)$ – the index changes in the i-the indicator b;

b_i^1, b_i^0 – an absolute amount of the indicator b in the reporting and base periods, respectively;

i, j – sequence number of indicator b in dynamic standard that matches the i-th row and the j-th column;

e_{ij}, f_{ij}, d_{ij} – according to the matrix of reference, actual, incidence of reference and actual ordering of indexes changes in indicators of dynamic standard;

EF – the efficiency integral indicator, range of the assessment those lies within [0;1].

The closer the value of EF gets to 1, the more normative (reference) ratios of indexes change in indicators are actually being applied. About the efficiency in using human resources should talk subject to $0{,}5 \le EF \le 1$.

For the purpose of building the comprehensive methodology for assessing the efficiency in using human resource, is created by us, a strategic matrix, that allows the enterprise to be placed in a two-dimensional coordinate system, where the horizontal vector is its integral indicator, and as a landmark on vertical vector was elected a central indicator of efficiency as labor productivity as the ratio of its actual value of the enterprise to the mid-industry, which allows to get a rating:

$$R_{LP} = LP_i^1 \div LP_{mid-in}^1 \quad (20)$$

where R_{LP} – the rating indicator of labor productivity; LP_i^1 – the labor productivity of the i-th enterprise in the reporting year; LP_{mid-in}^1 – mid-industry meaning of the labor productivity in the reporting year according to the State Statistics Service of Ukraine.

1. Indices calculation of change of indicators as a part of a dynamic standard:

$$I(b_i) = b_i^1 \div b_i^0 \quad (15)$$

2. Constructing a matrix of reference ratios of indexes changes in indicators on the basis of the matrix of preferences and guided by the principle of their transitivity:

$$e_{ij} = \begin{cases} 1, \ if \ I(b_i) > I(b_j) \\ -1, \ if \ I(b_i) < I(b_j) \\ 0, \ if \ between \ I(b_i) \ and \ I(b_j) \ absent \ reference \ ratio \end{cases} \quad (16)$$

3. Constructing the matrix of actual ratios of indices change in the indicators of the dynamic standard:

$$f_{ij} = \begin{cases} 1, \ if \ I(b_i) > I(b_j) \\ -1, \ if \ I(b_i) < I(b_j) \\ 0, \ if \ I(b_i) = I(b_j) \end{cases} \quad (17)$$

4. Constructing the incidence matrix of the reference and actual ordering of indexes change in indicators of dynamic standard:

$$d_{ij} = \begin{cases} 1, \ if \ e_{ij} = 1 \ simul\tan eously \ with \ f_{ij} \geq 0, \\ or \ if \ e_{ij} = -1 \ simul\tan eously \ with \ f_{ij} \leq 0 \\ 0, \ in \ another \ cases \end{cases} \quad (18)$$

5. Calculation of efficiency integral indicator:

$$EF = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij} \div \sum_{i=1}^{n}\sum_{j=1}^{n} |e_{ij}| \quad (19)$$

Fig. 2. Structurally-logical scheme of assessment the efficiency in using human resources of the enterprise on the nonlinear dynamic standard

* Compiled by author based on sources [3, c. 66; 5, c. 255]

The developed matrix of efficiency estimation in using human resources of the enterprise will have four quadrants, each of which contain a corresponding strategy in this field, which is summarized in the figure 3. The value of the horizontal scale of the matrix «EF-R_{LP}» 0,5 is consistent with the boundary mark, after its crossing will begin progressive-regressive changes of the integral indicator of the efficiency in using human resources, which will become exceptionally progressive when in proximity to 1.

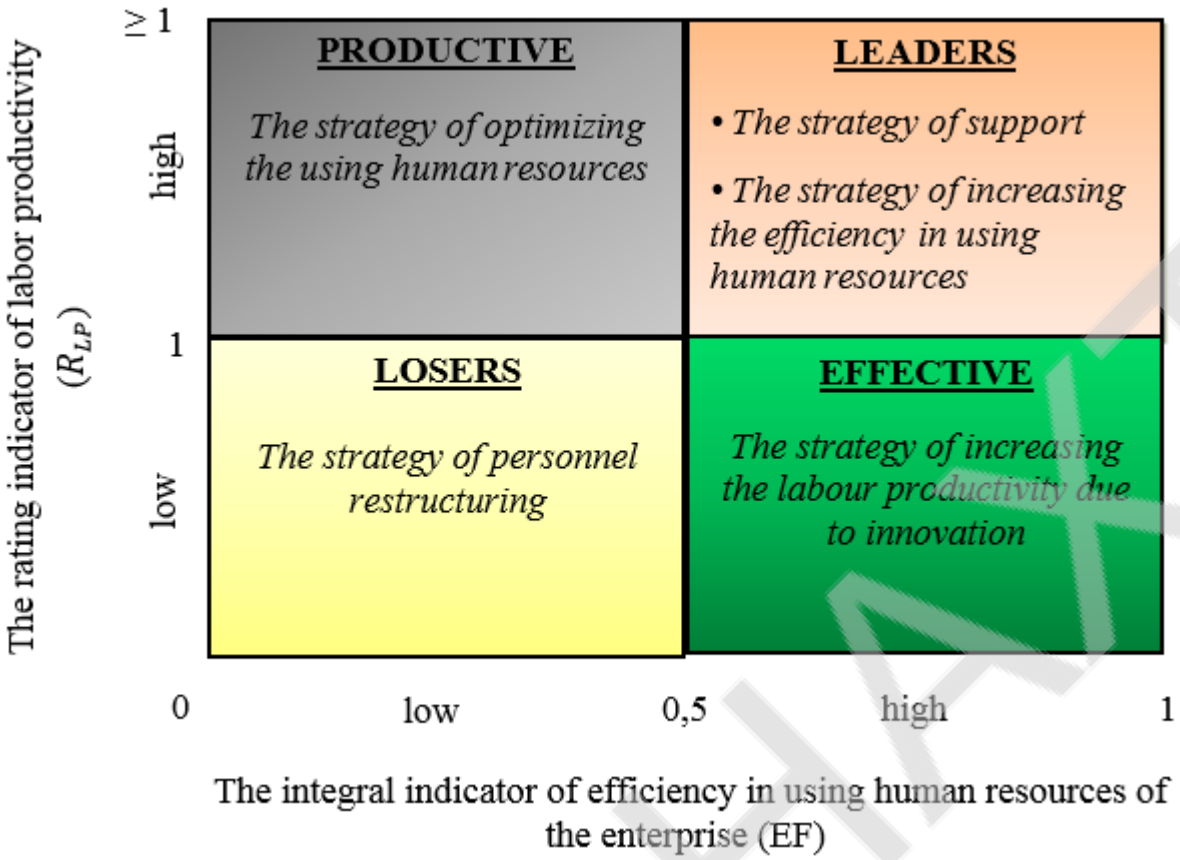

Fig. 3. The matrix of the strategic positioning the enterprise in the coordinate system «the efficiency in using human resources - the rating indicator of labor productivity»

*Compiled by the author

The interval of the vertical scale of the matrix [0;1] means that the personnel labor productivity of the enterprise is below than its mid-industry level, and, accordingly, exceeding the mark 1 is regarded as a significant benefit in a competition.

Every strategic position in the matrix on fig.3 requires an economic justification (table. 2).

The described above, comprehensive methodology for assessing the efficiency in using human resource will be tested on the example of manufacturers whose activities are in class 10.84 Manufacture of spices and condiments (section C10 «Production of food products» of group 10.8 «Production of other food products»).

Activity in the sauce market, including ketchup, and seasonings in Ukraine is detected by more than 30 enterprises, among which there is fierce competition, mainly in the economical and middle price category, since the share of imports is small – 5,9% [12], and, in basically, it is an elite segment of products under the exclusive recipe. In the coming years, is expected the increasing intensification of competition, due to the offensive development of Private Label, the demand for certain types of products by HoReCa companies, as well as the increasing emergence of number of craft sauce producers, who making this products in small batches and at high prices and do not will be able to compete with the giants of the industry, but their presence is a positive signal for it.

Table 2 – The characteristic of strategic capabilities of improvement the efficiency in using human resources of the enterprise in the matrix «EF-R_{LP}»

The matrix coordinates	Linguistic evaluation of the scale	The content of the strategy
1	*2*	*3*
The strategy of personnel restructuring (quadrant «LOSERS»)		
EF [0;0,5] R_{LP} [0;1]	EF, R_{LP}: low	Continuous audit of all directions of using human resources, implementation of a complex of anti-crisis and preventive measures, such as: scientifically substantiated normalization of labor and revision of its norms; optimization of personnel composition, taking account of the real personnel needs; eliminating the imbalance between remuneration and labor productivity; improving the qualitative composition of personnel; system in saving of costs on personnel; critical revision of HR-policy
The strategy of optimizing the using of human resources (quadrant «PRODUCTIVE»)		
EF [0;0,5] R_{LP} [0;1]	EF: low R_{LP}: high	Here, the emphasis should be on the indicators-perpetrators of the nonlinear dynamic standard of efficiency in using human resources in order to overcome their negative dynamics and stabilize positive changes in time
The strategy of increasing the labor productivity due to innovation (quadrant «EFFECTIVE»)		
EF [0,5;1] R_{LP} [0;1]	EF: high R_{LP}: low	Searching and mobilizing innovative reserves of labor productivity improvement: reengineering of personnel processes, corporate informative HR-systems, digital-recruiting, developing of command and management structure, kaizen-management and others. This is exactly about innovations, because the high level of EF in this quadrant means that the enterprise has already formed favorable conditions for improving labor productivity, there are not enough new approaches to strengthen its industry position
The strategy of support (quadrant «LEADERS»)		
EF [0,5;1] R_{LP} [1; ∞]	EF, R_{LP}: high	Maintaining the status quo of acquired positions through the establishment on the enterprise monitoring system of efficiency in using human resources and benchmarking of competitive-companies' positions
The strategy of increasing the efficiency in using human resources (quadrant «LEADERS»)		
EF [0,5;1] R_{LP} [1; ∞]	EF, R_{LP}: high	Rising investment in human resources development, improving the labor motivation mechanism, stimulating employees to innovations, strengthening the corporate culture and promoting a positive image of the employer in the labor market

* Compiled by the author

The main producers of ketchup and tomato sauces in the country are PJSC «Chumak» (TM Chumak) and PJSC «Volynholding» (TM Torchyn), which account for 60% volumes of output. In the table 3 according to their reporting and based on official statistics [13] on the average industry wage level, have been calculated the indicators of the efficiency in using human resources of these enterprises and their averages for the period, included in the dynamic standard.

Table 3

Table 3 – Metric of efficiency in using human resources of the investigated sauces and seasonings producers-enterprises of PJSC «Volynholding» and PJSC «Chumak»

№	Indicators	Units of measurement	Volynholding (E_1)			Chumak (E_2)			Average indices	
			Years			Years				
			2016	2017	2018	2016	2017	2018	E_1	E_2
1	**Labor productivity and personnel profitability**									
1.1	Profitableness of personnel	thousand UAH/person	124,6	118,2	134,0	-210,8	37,5	127,8	1,04	1,61
1.2	Labor productivity	thousand UAH/person	1514,1	1608,0	1578,9	1378,6	1214,6	1276,4	1,02	0,97
1.3	Capital-labor ratio	thousand UAH/person	294,4	324,3	316,9	177,3	168,0	182,0	1,04	1,02
1.4	The coefficient of ratio the average wage on the enterprise to the average industry wage	%	90,0	92,4	95,4	112,2	105,3	104,0	1,03	0,96
1.5	Defect coefficient due to fault of employee	%	0,95	0,9	1,2	1,0	1,4	1,6	1,14	1,26
2	**Stability of personnel and their qualitative composition**									
2.1	Coefficient of personnel stability	%	79,7	73,3	72,1	83,2	81,4	83,0	0,95	1,00
2.2	Coefficient of qualified employees stability	%	41,0	44,3	41,0	38,0	39,2	40,0	1,00	1,03
2.3	Coefficient of prospective employees turnover	%	1,1	0,5	1,3	2,0	2,3	2,9	1,53	1,21
2.4	Coefficient of personnel turnover	%	2,8	6,4	9,5	10,4	10,0	10,1	1,89	0,99
3	**Efficiency in using work time**									
3.1	Coefficient of efficiency in using work time	%	93,4	94,5	94,6	92,4	94,0	94,1	1,01	1,01
3.2	Coefficient of breach labor discipline	%	3,2	2,8	2,4	4,0	2,8	2,7	0,87	0,83

*Calculated according to Form №1 Balance Sheet (Statement of Financial Position), Form №2 Statement of Financial Results «Statement of comprehensive income», Form 1-PV Work report, internal personnel documentation on the quantitative and qualitative composition of the personnel of the enterprise

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It is difficult to give an unambiguous answer as to which enterprise has more efficient human resources, bearing in mind the multi-vector trajectory of the movement of indicators over time and their value.

Express review shows that PJSC «Volynholding» has difficulties in the direction of fluctuations in labor productivity and its capita-labor ratio in the direction of decrease, increase of the share of defects, due to fault of employees, as well as disturbance of personnel stability and its qualitative composition by all indicators. In doing so, the enterprise offers candidates and pays employees a non-competitive salary, the level of which is below the industry average for three years. This may be a reason for the increasing personnel turnover of PJSC «Volynholding» and the relatively low but existing destabilization of its staff. PJSC «Chumak» problems also lie in the turnover of staff, including prospective staff, negative wage trends, despite the outperformance of the average market wage, and the loss due to human factors-related product shortages.

For the purpose of integral assessment of efficiency in using human resources of PJSC «Volynholding» and PJSC «Chumak» in table 4 was compiled a matrix of graph of reference ordering of its indicators (formula 16 fig. 2), which is based on the theory of matrices and the principle of transitivity, the matrix of their actual ordering for each enterprise (formula 17 fig. 2) and the matrix of their incidence (formula 18 fig. 2), are presented in table 5. Next, using the methods of nonparametric statistics according to the formula 19 (fig. 2), we calculated the integral index of the dynamic standard EF, which comes down to determining the degree of similarity of the matrices of the reference and actual ordering of indicators, that were constructed in the previous stages. As a result, Chumak's EF turned out be higher $(EF = 60 \div 94 = 0{,}64)$, than Volynholding's $(EF = 38 \div 94 = 0{,}4)$.

Finally, let us find out the value of the rating indicator of enterprise labor productivity, for which we use the data of the State Statistics Service [13] regarding its sectoral trends and the formula 20.

Table 4 – Matrix of a graph of reference ordering indicators of efficiency in using human resources of the enterprise

	1	P_p	LP	CL_r	C_w	C_{stabq}	C_{stab}	C_{ewt}	C_{turnpr}	C_{turn}	C_{bld}	C_{dfem-e}
1	X	-1	-1	-1	-1	-1	-1	-1	1	1	1	1
P_p	1	X	1	1	1	0	0	0	1	1	1	1
LP	1	-1	X	1	1	0	0	0	1	1	1	1
CL_r	1	-1	-1	X	1	0	0	0	1	1	1	1
C_w	1	-1	-1	-1	X	0	0	0	1	1	1	1
C_{stabq}	1	0	0	0	0	X	1	0	1	1	1	1
C_{stab}	1	0	0	0	0	-1	X	0	1	1	1	1
C_{ewt}	1	0	0	0	0	0	0	X	1	1	1	1
C_{turnpr}	-1	-1	-1	-1	-1	-1	-1	-1	X	1	0	0
C_{turn}	-1	-1	-1	-1	-1	-1	-1	-1	1	X	0	0
C_{bld}	-1	-1	-1	-1	-1	-1	-1	-1	0	0	X	0
C_{dfem-e}	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	X

* Compiled in accordance with the graph in Fig.1

Table 5 – The matrix of the ratios of reference and actual ordering indicators of efficiency in using human resources in PJSC «Volynholding» and PJSC «Chumak»

	1	P_p	LP	CL_r	C_w	C_{stabq}	C_{stab}	C_{ewt}	C_{turnpr}	C_{turn}	C_{bld}	C_{dfem-e}
1	X	1 (1)	1 (0)	1 (1)	1 (1)	1 (1)	0 (0)	1 (1)	0 (1)	0 (1)	1 (1)	0 (0)
P_p	1 (1)	X	1 (1)	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)	0 (1)
LP	1 (0)	1 (1)	X	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	1 (1)	0 (0)
CL_r	1 (1)	1 (1)	0 (0)	X	1 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)	0 (0)
C_w	1 (0)	1 (1)	0 (1)	1 (1)	X	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	1 (1)	0 (0)
C_{stabq}	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	X	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)	0 (0)
C_{stab}	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	X	0 (0)	0 (1)	0 (1)	1 (1)	0 (0)
C_{ewt}	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X	0 (1)	0 (1)	1 (1)	0 (0)
C_{turnpr}	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X	0 (1)	0 (0)	0 (0)
C_{turn}	0 (1)	0 (1)	0 (0)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	1 (1)	X	0 (0)	0 (0)
C_{bld}	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	0 (0)	0 (0)	X	0 (0)
C_{dfem-e}	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X

*Compiled in accordance with the data table 3

** Figures in brackets () indicate the data about PJSC «Chumak»

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In 2018, the labor productivity in the sauce and seasoning market is slightly higher than in the food industry as a whole. At the same time, its level in PJSC «Volynholding» is higher, and in PJSC «Chumak» it is lower than the average market mark, which influenced on the places of enterprises in the rating and, as a consequence, their location in the strategic matrix (fig. 4).

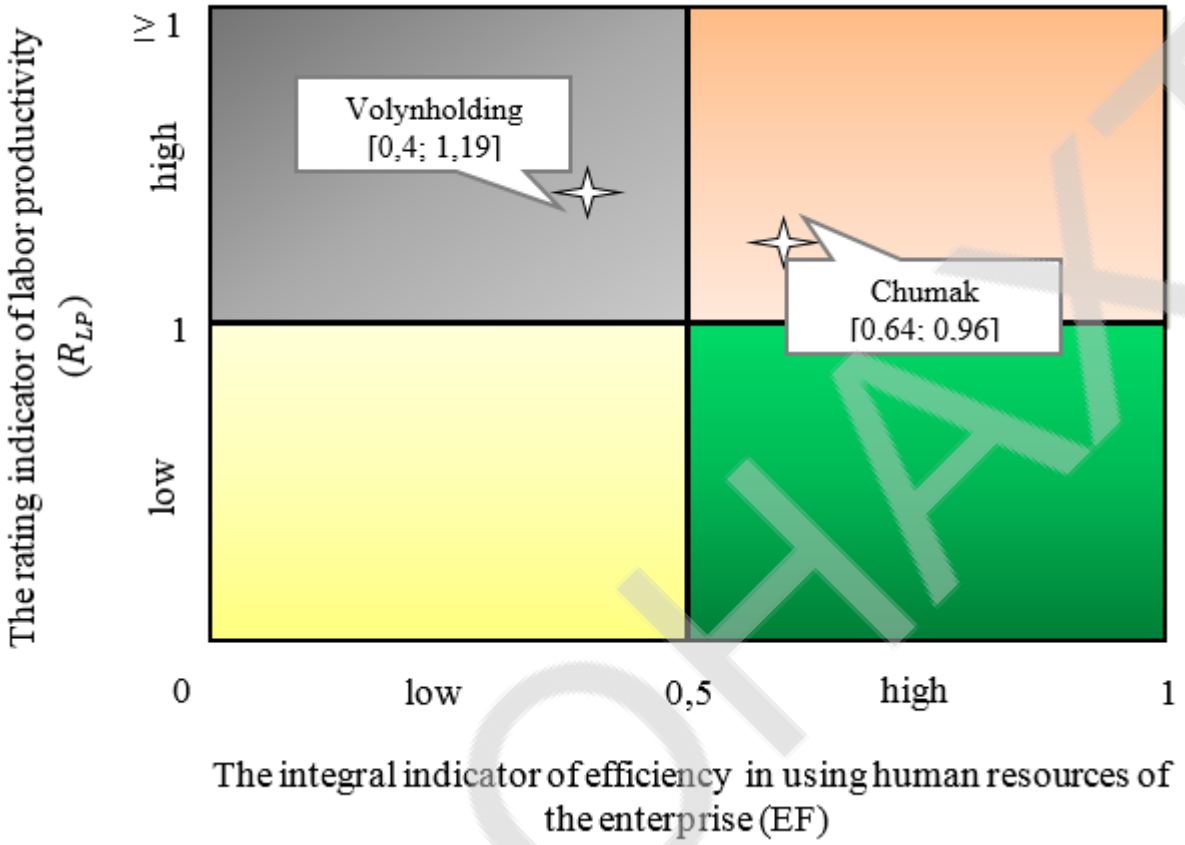

Fig. 4. Strategic position of surveyed enterprises in the matrix «the efficiency in using human resources – the rating indicator of labor productivity»

*The names and locations of the strategies in the quadrants correspond to fig. 3, the contents are specified in table 2

PJSC «Volynholding» get into the «Productive» quadrant. As the labor productivity indicator of the enterprise for several years exceeds its industry average value, thus providing a significant competitive advantage for the movement to the quadrant «Leaders», it is recommended to eliminate the weaknesses, identified during the assessment of the components of the dynamic standard of efficiency in using human resources, by paying the special attention to optimization personnel movement and reviewing the current system of work motivation. Instead, PJSC «Chumak», primarily, needs the reorientation to an innovative path of development: from the modifications to the product nomenclature, the technological upgrades, the implementation of Lean-management to re-engineering of HR processes – all that will allow it to identify and uncover potential reserves of labor productivity improvement, rising in the ranking to the leader position.

V. Conclusions

Dynamics of the market environment from outside the enterprise and permanent organizational transformations inside are reflected in the pace priorities of changes in

economical indicators of their activity, in particular, indicators of using human resources as a strategic asset and a source of future benefits from investments. With this in mind, the constructed dynamic framework can serve as a universal tool for integrated assessment and comparison of the efficiency in their using for manufacturing enterprises, regardless of industry, size, scale of production and ownership. Comprehensiveness of such estimation provides its combination with the rating, the symbiosis of which takes the form of a matrix of choice the strategy of efficient in using human resources, where as the vector lines are chosen its integral indicator, according to the normative-index model (nonlinear dynamic standard) and the rating indicator of labor productivity, weighted on the branch specificity. Each of the five strategies proposed is a program of basic recommendations that will allow to uncover potential reserves for improving efficiency in usng human resource and labor productivity at the enterprise. Logically, arises the question of determining the degree of difficulty individual indicators of the dynamic standard, which will signal to the executives on priorities in their decision (an opportunity for them not to waste efforts, but to concentrate on specific processes of personnel using), which determines the directions of further scientific research.

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НТБ ОНАХТ

MODELS OF ANALYSIS AND FORECASTING OF MONETARY POLICY PARAMETERS

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Abstract. *An important prerequisite for the implementation of effective monetary policy under the regime of inflation targeting is the ability of the central bank to predict the basic parameters and to simulate different scenarios of monetary policy development adequately. The study shows the results of the analysis conducted of the advantages and disadvantages of existing approaches that solve the task of modeling and forecasting monetary policy parameters. The results of this analysis testify to the inability of the dominant approach to modeling and forecasting monetary policy settings effectively to solve the set tasks. On the basis of quarterly information for 24 reporting periods (since 2014), a methodology for modeling the dynamics of the main parameters of the NBU's monetary policy, which allows to identify the direction and lag of cause and effect relationships between them were proposed. The developed model includes 10 equations and 2 identities, which has 24 variables, including 12 endogenous, 8 exogenous and 4 auxiliary variables: trend and seasonal dummy variables. Based on the model developed, calculated indicators of the tightness connection factor of the variable with the result in each equation, namely the coefficients of elasticity, the beta-coefficients and indirect beta-coefficients. Forecast for the next six periods of such endogenous variables of the model developed as: NBU discount rate, absolute increase of the consumer price index, real GDP per thousand people, real exchange rate was calculated. The proposed methodology can form the basis for supplementing the existing system of analysis, stress testing and forecasting of the state regulatory center as well as interested organizations.*

Keywords*: analysis, monetary policy, the discount rate, simultaneous model, macroeconomic model.*

INTRODUCTION

Crisis events of 2008 demonstrated the inability to solve effectively the problem of predicting the onset of the crisis, but also reflect the destructive effects of the crisis with the basic tools of macroeconomic modeling in the central banks of many countries, such as class of DSGE-models (dynamic stochastic general equilibrium). This forces the scientific community to revise the feasibility of further application of these models. For the most part, scientists agree that, along with research on improving DSGE models, one should also pay attention to the use of other classes of models, in particular structural econometric models. So, now it’s necessary to conduct a study of the use of SEM (structural econometric model) in the realities of the domestic economy regarding the available statistical framework and formation of scientific and methodological recommendations regarding the implementation of such models.

An important contribution to research tends on the development of approaches to macroeconomic modeling of various levels of complexity, including and modeling of monetary policy parameters are devoted in research works of such domestic and

foreign scientists: V. Vitlinsky, I. Lukyanenko, O. Ulanovsky, S. Kozlovsky, V. Kozlovsky, O. Sharapov, V. Derbentsev, S. Mishchenko, S. Naumenkova , V. Mishchenko, V. Ivanov, R. Lysenko, J. Taylor, J. Wayne, R. Clarida, D. Brasch, L. Bol, B. Krushkovich, A. Neukovich and others.

The purpose of the study is to improve existing and develop new theoretical foundations and scientific and methodological approaches to solving the problem of forecasting monetary policy parameters.

According to the goal, the following *tasks* were formulated and solved:

– characterized the role and place of monetary policy and the central bank in achieving macroeconomic stabilization;

– analysis of existing classes of macroeconomic models aimed at analysis and forecasting of monetary policy parameters;

– the methodology of modeling and forecasting of macroeconomic indicators, the dynamics of which determines the main parameters of monetary policy;

– the results of the structural model analysis and forecasting, and results of the neural network prediction were compared.

The scientific novelty of the obtained results lies in the development of the existing scientific methodological tools of macroeconometric modeling and approaches to forecasting the parameters of monetary policy. In particular, according to the results of the Granger test for identifying the direction of causality between the studied indicators, the use of the corrected Akaike criterion to determine the lag values of factor endogenous and exogenous variables, the use of auxiliary trend variables and dummy seasonal variables on which to evaluate the effectiveness of monetary policy.

Further research in this area will allow to expand the set of endogenous and managed exogenous indicators included in the model and to use a wider range of applied econometric tools for their analysis.

ANALYTICAL REVIEW OF LITERATURE

The results of the analysis presented in scientific papers [1; 2] considerations of both domestic and foreign scientists make it possible to summarize the definitions of the essence of monetary policy as a set of regulatory measures by the central bank or with its participation with the aim of macroeconomic stabilization and the formation of confidence in the national currency.

In our study, we share the views presented in [3, p. 29], according to which macroeconomic stability is a complex concept defined as the internal non-susceptibility of the economic system to the action of destabilizing factors in time and its ability to overcome imbalances that arise.

In recent years, in Ukraine a significant relationship between the parameters of monetary policy and the state of the economy [4] could be observed. Therefore, in the context of macroeconomic stabilization and in the context of the inflation targeting regime, under the effectiveness of monetary policy, we will consider the approximation of the inflation rate to the target value determined by the central bank [5].

After taking into account that at beginning of 2014, the NBU made the transition to a floating exchange rate regime of the national currency due to a current account deficit on the balance of payments ($ 16.5 billion), with a decrease in foreign exchange reserves and the requirements of IMF cooperation on reform [6, p. 12], it should be

noted that the difference between effective monetary policy during the floating exchange rate and effective monetary policy during the fixed exchange rate. Therefore, in the current conditions of the floating exchange rate, it is more advisable to consider NBU monetary policy precisely from the moment of transition to this regime.

Resolution of the NBU Board of Ministers from August 18, 2015 No. 541 "On the Fundamental Principles of Monetary Policy for 2016-2020" defines the main directions of monetary policy of Ukraine for the specified period. This resolution [5] provides for the transition to the inflation targeting regime, according to which it is determined that low and stable inflation is one of the main contributions to sustainable economic growth that can be provided by the central bank.

The benchmark for the annual change in the price index is currently set to 5 % +/- 1 pp. The main tool for achieving this goal is to change the key interest rate of the monetary policy, especially the discount rate. According to the Law of Ukraine "About the National Bank" [12], the NBU discount rate is one of the monetary instruments by which the National Bank of Ukraine sets a benchmark for banks and other entities of the monetary market of the value of attracted and placed funds.

The decision-making process on monetary policy in central banks with inflation-targeting is based on FPAS monetary policy (Forecasting and Policy Analysis System) [7, p. 59]. FPAS provides the use of a set of models of various classes and complexity, each of which is used to study a particular problem. In general, a theoretically substantiated basic model is distinguished, which is used as the main tool for forecasting and simulation experiments, and the auxiliary models that are necessary to supplement the base model by solving the problems of current state estimation, short-term forecasting, analysis of specific issues.

Various models may be used as the basic model, however, models with several equations or a system of simultaneous equations are better than models with one regression equation, since the first one allow us to provide a broader analysis of the dynamic relationships that exist between macroeconomic variables. Having analyzed the literature [7; 8; 9; 10], in general, the following classes of macroeconomic models can be distinguished and used as basic ones:

- structural econometric model;
- vector autoregression;
- dynamic stochastic general equilibrium.

Structural econometric models are associated with simultaneous equations models, as well as large-scale macroeconometric models. The basis of such models is a system of regression equations between time series that reflects empirical relationships based on econometric estimates, that is, they use large samples to calculate forecasts based largely on historical correlations rather than theoretical relationships. Examples of such models are the US macroeconometric models: Klein, Klein-Goldberger, Wharton, MPS, Brooking model, DRI, FRB/US [8, p. 117].

Vector autoregressive models are dynamic models of several time series, which are a generalization of the one-dimensional autoregression model (AR model). This allows more than one variable to be used in such a way that in the model each variable is defined by its own lag values, lag values of other variables and residuals. Unlike

SEM, VAR models are devoid of structural constraints, but as the number of VAR time series and lags increases, the number of model parameters increases sharp.

VAR models, like SEM, have two major drawbacks: lack of microeconomic justification and Lucas's criticism. Attempts to overcome these shortcomings have led to the formation of DSGE models as the core model of central banks of many developed countries, in particular, NAWM of the European Central Bank, TOTEM II - Bank of Canada, BEQM and COMPASS - Bank of England, NEMO - Bank of Norway, RAMSES II - Bank of Sweden, Aino - Bank of Finland, G3 of the Czech National Bank.

Dynamic stochastic general equilibrium models can be viewed as a macroeconomic modeling method that attempts to analyze and justify economic phenomena such as economic growth and business cycles, as well as the impact of economic policy, including monetary policy, using econometric models based on using the theory of general equilibrium and the principles of microeconomics.

As noted [11, p. 50], DSGE models are based on microeconomic foundations, which are then aggregated to a macro level, which allows to provide modeling of expectations the best way. DSGE models are also able to model various policy regimes by including various monetary policy rules in the models, for example, the Taylor discount rate rule.

The limitations imposed by the theory and complexity of DSGE models cause central banks to use simplified or incomplete dynamic stochastic models as the base models of their FPAS. The specificity of such simplification leads to some difficulties, in particular when determining the impact of the financial sector on the real economy [7, p. 63]. An example of this model are the Quarterly Forecast Model of the Czech National Bank, which was used as the basis for its own similar models by the central banks of many countries, including Ukraine, Russia, Turkey, Serbia, Armenia, Georgia, Romania, Chile and others.

As mentioned in the NBU Board Decision of January 1, 2019 No. 1-rd “On Methods and Forms of Forecasting Macroeconomic Indicators of Economic and Social Development of Ukraine, as well as Monetary Policy ” [13], the quarterly forecast model of the NBU (QPM) is the basic semi-structural New Keynesian model for long- and medium-term forecasts and complemented variables that allow you to analyze a small open economy, "dollarized" economy and so on.

The global financial crisis contributed to the formation of active criticism of the use of DSGE - models [8; 14]. A number of scientists, in particular Simon Wren-Lewis in the article "Ending the microfoundations hegemony" [14], proposed to use structural econometric models (SEM). According to the author, SEM are intermediate between DSGE and VAR-models in their ability to reproduce the dynamics of macroeconomic indicators [10, p. 29]. Also, David Hendry and John Mulbauer in the article “The future of macroeconomics: macro theory and models at the Bank of England” analyze Lucas’s criticism that the interest of the scientific community has moved away from SEM, and which contributed to the creation of DSGE models [15]. One of the conclusions made by the authors is that the crisis events demonstrated the need for the existence of models that are assembled on empirical modeling, and not on a simplified and unrealistic theory [10, p. 30].

In addition, there are studies that demonstrate the limitations of the effective use of such classic monetary policy rules, typically J. Taylor's and its modifications for the NBU monetary policy [8]. Given this, it is appropriate to investigate the use of the SEM tools as addition to the existing basic NBU model.

In accordance with this, one can propose the following version of the problem statement: to propose such an approach to macroeconomic modeling, in which it is possible to identify the direction and nature of causal relationships between the macroeconomic indicators available in the statistical databases of the State Statistics Service and the NBU, determine the lag value of the influence between the available indicators in the resulting structure. And than develop a model based on the result with the goal of both assessing and analyzing the effectiveness of the current monetary policy, and designing scenarios of macroeconomic development in the short and medium term, which will expand the existing tools for macroeconomic modeling and forecasting. Moreover, this approach should open prospects for the inclusion in the final model of new blocks that can characterize critical sectors of the economy, in particular banking and financial, and serve as the foundation for their further research in this area.

OBJECT, SUBJECT MATTER AND METHODS OF RESEARCH

The object of the research is the processes of formation of monetary policy parameters.

The subject of the research is theoretical and methodological provisions, economic and mathematical methods and models of analysis and forecasting of monetary policy parameters.

The achievement of this goal in the conducted research, as well as the maintenance of scientifically sound results and the formation of the proposed methodology became possible through the use of the following *research methods*:

– collecting, normalizing, analyzing and comparing information;
– analysis of existing statistical framework;
– use of the Granger test to identify the direction of causality between the studied indicators;
– use of the corrected Akaike criterion to determine the magnitude of the lag of factor endogenous and exogenous changes in them;
– analysis of distributions of values of variables and values of Pearson correlation coefficients between variables;
– use of auxiliary trend variables and dummy seasonal variables to account for the relevant effects in the model;
– construction of structural econometric model and its estimation by means of 2SLS with fulfillment of its preconditions;
– analysis of coefficients of determination, F-test, dynamics, autocorrelograms and residual distribution in order to determine the adequacy of the estimated equations of the developed model;
– calculation of indicators of the close relationship of the factor variable with the resultant in each equation, namely elasticity coefficients, beta-coefficients and indirect beta-coefficients and analysis of the obtained results.

WORK RESULTS

According to earlier statement of the problem and taking into account of criticism, the advantages and disadvantages of each class of models, we decided to chose instruments of structural econometric models for solving the problem of forecasting the key macroeconomic indicators that characterize monetary policy. The practical implementation of the calculations presented in this paper involves the use of the statistical computing environment R (RStudio) [16; 17], in particular packages «systemfit», «forecast», «lmtest», «mctest», «GGally».

For the development of the model of analysis and forecasting, a set of indicators, which have been presented by the State Statistics Service [18] and the NBU [19], was selected from the existing static base, reflecting the macroeconomic situation in the country and available since 2014. As a result, the following endogenous, exogenous as well as ancillary variables are identified:

Endogenous variables:

RTE – NBU discount rate,%;

INF – absolute increase in consumer price index up to December of previous year, base - 1 sq. M. 2014,%;

GDP – real GDP per thousands of persons, million UAH;

ER – real official hryvnia exchange rate against the dollar average for the quarter, UAH;

BAL – consolidated balance sheet, USD million;

UNP – unemployment rate in Ukraine, thousand;

ARR – real wage arrears at the end of the quarter, UAH million;

WGE – real average quarterly wage, UAH;

INV^d – direct investment, millions of dollars;

INV^p – portfolio investments, millions of dollars;

ΔB – difference between consolidated revenues and consolidated expenses, million UAH;

ΔE – net exports, USD million;

Exogenous variables:

INF^{exp} – inflationary expectations of banks and enterprises for the next 12 months,%;

TRN – money transfers to Ukraine from abroad, millions of dollars;

NDS – volume of sales of industrial products, real, million UAH;

RTL – volume of retail trade turnover, real, million UAH;

XPN – actual consolidated budget expenditures, UAH million;

INC – real consolidated budget revenues, UAH million;

IMP – import of goods and services, millions of dollars;

EXP – export of goods and services, millions of dollars;

Auxiliary variables:

T – trend;

S – seasonal dummy variables that reflect the difference between the first quarter and the following.

On the basis of the Granger test, the direction of causality between the selected indicators was identified. The lag duration was determined by the method of all

possible regressions by corrected Akaike information criterion (AICc), which is adapted for small samples [20, p. 164]. The result is the following system of simultaneous structural equations:

$RTE_t = a_{12} * INF_t + a_{13} * GDP_t + b_{10} + b_{11} * INF_t^{exp} + d_{11} * T_{(1,t)} + \sum_{i=2}^{4} d_{1i} * S_{(1i,t)} + u_1;$

$INF_t = a_{21} * RTE_{t-4} + a_{26} * UNP_{t-3} + b_{20} + b_{21} * INF_{t-4}^{exp} + d_{21} * T_{(2,t)} + \sum_{i=2}^{4} d_{2i} * S_{(2i,t)} + u_2;$

$GDP_t = a_{34} * ER_{t-2} + a_{35} * BAL_{t-2} + a_{311} * \Delta B_{t-2} + b_{30} + b_{33} * NDS_t + b_{34} * RTL_t + d_{31} * T_{(3,t)} + \sum_{i=2}^{4} d_{3i} * S_{(3i,t)} + u_3;$

$ER_t = a_{42} * INF_{t-4} + a_{45} * BAL_{t-3} + b_{40} + d_{41} * T_{(4,t)} + \sum_{i=2}^{4} d_{4i} * S_{(4i,t)} + u_4;$

$BAL_t = a_{54} * ER_t + a_{59} * INV_t^d + a_{510} * INV_t^p + a_{512} * \Delta E_t + b_{50} + d_{51} * T_{(5,t)} + \sum_{i=2}^{4} d_{5i} * S_{(5i,t)} + u_5;$

$UNP_t = a_{67} * ARR_t + b_{60} + b_{61} * TRN_t + b_{65} * XPN_{t-2} + d_{61} * T_{(6,t)} + \sum_{i=2}^{4} d_{6i} * S_{(6i,t)} + u_6;$

$ARR_t = a_{78} * WGE_{t-2} + b_{70} + b_{75} * XPN_{t-1} + d_{71} * T_{(7,t)} + \sum_{i=2}^{4} d_{7i} * S_{(7i,t)} + u_7;$

$WGE_t = a_{83} * GDP_t + b_{80} + b_{85} * XPN_{t-1} + d_{81} * T_{(8,t)} + \sum_{i=2}^{4} d_{8i} * S_{(8i,t)} + u_8;$

$INV_t^d = a_{92} * INF_{t-3} + b_{90} + b_{91} * INF_{t-3}^{exp} + d_{91} * T_{(9,t)} + \sum_{i=2}^{4} d_{9i} * S_{(9i,t)} + u_9;$

$INV_t^p = a_{103} * GDP_t + a_{104} * ER_t + a_{106} * UNP_t + b_{100} + d_{101} * T_{(10,t)} + \sum_{i=2}^{4} d_{10i} * S_{(10i,t)} + u_{10}; \quad \Delta B_t = INC_t - XNP_t; \Delta E_t = EXP_t - IMP_t.$

The presented system was evaluated by 2SLS after preliminary analysis of the fulfillment of its preconditions and has the following form:

$RTE_t = 0.116 * INF_t - 1.537 * GDP_t - 0.118 + 1.442 * INF_t^{exp} + 1.362 * T_{(1,t)} - 5.720 * S_{(12,t)} - 6.035 * S_{(13,t)} - 9.207 * S_{(14,t)}, R^2 = 0.97, F = 39.86;$

$INF_t = -0.76 * RTE_{t-4} + 0.02 * UNP_{t-3} - 18.795 - 0.08 * INF_{t-4}^{exp} - 0.19 * T_{(2,t)} + 23.25 * S_{(22,t)} + 16.366 * S_{(23,t)} + 18.957 * S_{(24,t)}, R^2 = 0.86, F = 3.17;$

$GDP_t = -0.087 * ER_{t-2} - 5.4\text{E}-06 * BAL_{t-2} - 4{,}8\text{E}-05 * \Delta B_{t-2} + 1.889 + 6\text{E}-05 * NDS_t + 3.8\text{E}-06 * RTL_t + 0.152 * T_{(3,t)} + 0.335 * S_{(32,t)} + 2.506 * S_{(33,t)} - 0.965 * S_{(34,t)}, R^2 = 0.99, F = 62.562;$

$ER_t = 0.031 * INF_{t-4} + 0.003 * BAL_{t-3} + 20.104 - 0.079 * T_{(4,t)} - 5.735 * S_{(42,t)} - 5.710 * S_{(43,t)} - 7.425 * S_{(44,t)}, R^2 = 0.97, F = 56.855;$

$BAL_t = -273.16 * ER_t + 1.13 * INV_t^d + 1.9 * INV_t^p + 1.56 * \Delta E_t + 2379.46 + 303.9 * T_{(5,t)} - 127.9 * S_{(52,t)} - 239.7 * S_{(53,t)} - 293.5 * S_{(54,t)}, R^2 = 0.85, F = 3.71;$

$UNP_t = 0.044 * ARR_t + 1813.79 - 0.084 * TRN_t + 0.001 * XPN_{t-2} - 4.286 * T_{(6,t)} - 60.028 * S_{(62,t)} - 68.425 * S_{(63,t)} - 14.376 * S_{(64,t)}, R^2 = 0.77, F = 2.048;$

$ARR_t = 0.1 * WGE_{t-2} + 863.29 + 0.005 * XPN_{t-1} - 14.409 * T_{(7,t)} - 264.07 * S_{(72,t)} - 155.15 * S_{(73,t)} - 397.82 * S_{(74,t)}, R^2 = 0.86, F = 5{,}424;$

$WGE_t = 531.82 * GDP_t - 1215.3 + 0.004 * XPN_{t-1} - 7.025 * T_{(8,t)} - 127.47 * S_{(82,t)} - 857.01 * S_{(83,t)} - 604.97 * S_{(84,t)}, R^2 = 0.99, F = 113.94;$

$INV_t^d = 10.625 * INF_{t-3} - 180.71 + 39.431 * INF_{t-3}^{exp} + 19.491 * T_{(9,t)} + 188.61 * S_{(92,t)} - 21.736 * S_{(93,t)} + 115.814 * S_{(94,t)}, R^2 = 0.67, F = 1.389;$

$INV_t^p = -141.73 * GDP_t - 53.19 * ER_t - 4.440 * UNP_t + 9321.58 + 74.182 * T_{(10,t)} - 615.14 * S_{(102,t)} - 173.91 * S_{(103,t)} - 1019.3 * S_{(104,t)}, R^2 = 0.76, F = 2.37.$

Fisher's F-criteria proved to be adequate except for the UNP (unemployment rate in Ukraine) and INV^d (direct investment) equations.

For the purpose of exploring the model's forecasting capabilities, it is first proposed to make a 2014-2018 study-based forecast on the 2019 test sample and compare it with the actual data. Limitations on the availability of statistical information determine the forecast framework for 2 quarters.

Analysis of values of prediction accuracy indicators [20, p. 79-81] in the training and test samples, namely root mean squared error (RMSE), mean absolute error (MAE), mean absolute percentage error (MARE), mean absolute scaled error (MASE) showed that not all models are the same well solve the forecasting problem. The equations of ARR (arrears of salary) was the worst in solving the problem of forecasting and best - RTE (discount rate of NBU).

The results of the test sample of the developed methodology provide the basis for calculating the predicted values of endogenous variables based on available data for 2014-2019. In order to compare the results obtained, it is proposed to use a neural network modeling tools. The structure of artificial neural networks allows to better reproduce the dynamics of socio-economic indicators, whose nature is characterized by uncertainty, unpredictability and the presence of nonlinear relationships [21; 22, p. 324]. That is why we proposed method NNAR (Neural network autoregression), which has enough good prognostic features [22, p. 325]. The disadvantage of using NNAR is the lack of structural links and exogenous variables, but the existence of differences between the predicted values obtained through neural networks and SEM may reflect the effect of the relationships between the variables included in the structural model. Model NNAR provided in the package «forecast» [23].

Predicted values of exogenous variables for the next 6 quarters, that is, up to 4 quarter of 2020, were obtained using trend models using seasonal dummy variables.

According to the table. 3.1 forecast quality indicators of the main macroeconomic indicators, we can conclude that the NNAR model mainly has the best predictive properties. Anyway, structural model is better coped with forecasting real GDP.

Table 3.1

The value of the forecast quality indicators

	RTE		INF		GDP		ER	
	SEM	NNAR	SEM	NNAR	SEM	NNAR	SEM	NNAR
RMSE	1,1562	0,6183	6,4081	1,9622	0,1813	0,425	0,5548	0,5532
MAE	0,7837	0,4776	4,8445	1,467	0,1598	0,3235	0,4498	0,4706
MAPE	5,0647	2,931	180,95	46,944	1,7425	3,6216	3,1207	3,3113
MASE	0,1077	0,0656	0,6398	0,1938	0,1374	0,2782	0,5118	0,5354

In the table. 3.2 highlights the importance projections of key macroeconomic indicators, such as the discount rate of the NBU, the increase in consumer prices, the real GDP for 1000 people and the real exchange rate, where the real figures are based on the price in December 2013.

Table 3.2

Forecasts of SEM and NNAR macroeconomic indicators

	RTE		INF		GDP		ER	
	SEM	NNAR	SEM	NNAR	SEM	NNAR	SEM	NNAR
2019 Q3	14,778	16,404	0,4765	2,7884	12,555	13,246	13,866	12,871
2019 Q4	12,462	15,273	1,3989	3,1824	11,918	10,756	11,501	8,9232
2020 Q1	11,389	14,15	-4,023	-14,2	13,415	14,312	18,198	16,384
2020 Q2	9,22	13,497	1,0773	1,763	12,346	13,173	13,719	14,335
2020 Q3	8,135	13,497	0,93	3,2192	13,647	13,741	13,296	13,304
2020 Q4	6,954	13,616	2,1189	3,2286	12,871	12,225	11,526	5,3667

The predicted value of the consumer price index indicator according to the obtained structural model for the last quarter of 2020 will be 5.5784 % (fig. 3.1), which corresponds to the NBU inflation target and is indicative of the effectiveness of monetary policy, while maintaining existing trends and the absence of shocks. However, the NBU's estimated quarterly interest rate for the 4th quarter of 2020 may be somewhat inaccurate, since the model does not account for the neutral rate and possible shocks.

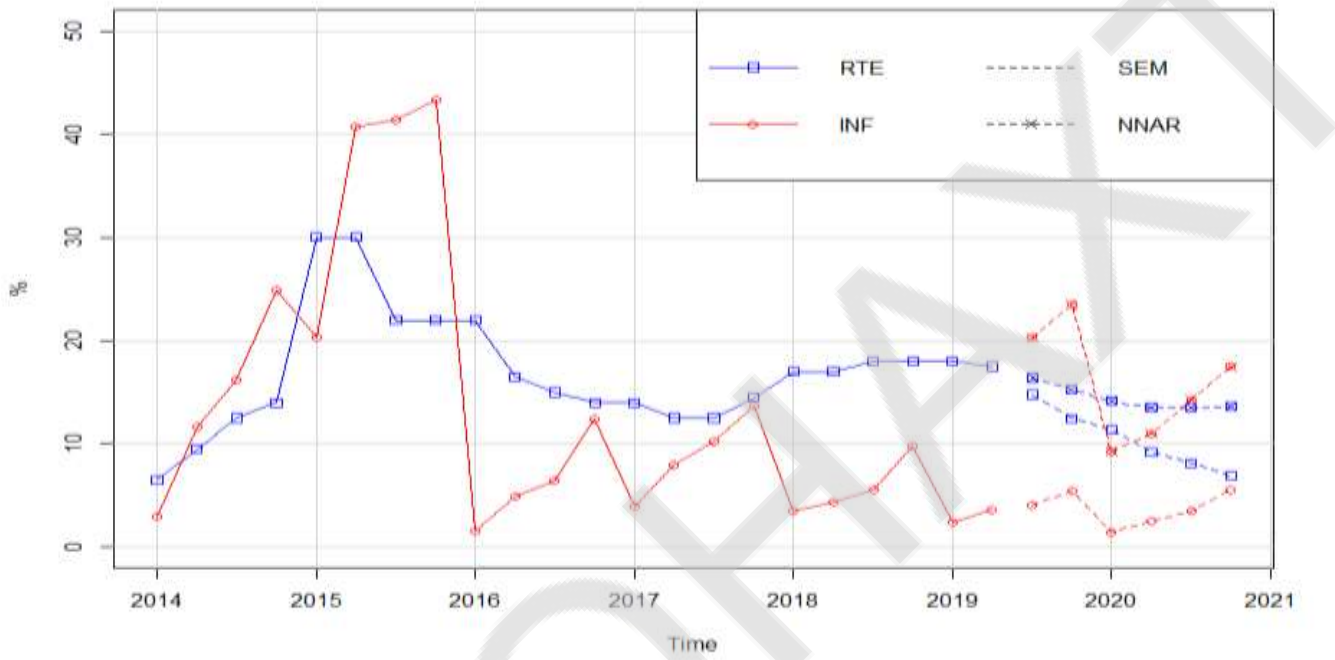

Figure 3.1. NBU interest rate and CPI dynamics and forecasts by SEM and NNAR

To study the influence between the variables in the structural equation system, the calculated values of the elasticity coefficients, beta-coefficients, and indirect beta-coefficients were analyzed.

The elasticity coefficients reflect how much of the average the resulting variable in a single equation will change as one factor variable grows by 1% of its average over the fixed values of the other exogenous variables [24, p. 89].

Beta-coefficients reflect the magnitude of the mean deviation of the resulting variable with increasing the corresponding value of the factor variable by the magnitude of its standard deviation with a fixed value of the remaining factor variables. Indirect beta-coefficients correspond to the magnitude of the indirect effect, that is, the influence through other factor variables of the equation [24, p. 90-91].

Before starting interpretation of the results obtained from the estimated parameters of the model, we should pay attention to their statistical significance, as the relevant conclusions can be made only on the basis of statistically significant estimates:

RTE – all estimates but the intersection is statistically significant;
INF – statistically significant estimate of S_2;
GDP – statistically significant estimates of ER, NDS, T, S_3, S_4;
ER – statistically significant all estimates except T;
BAL – all estimates are insignificant;
UNP – statistically significant intersection estimate;

ARR – statistically significant intersection estimates, S_2, S_4, and XPN;
WGE – statistically significant intersection estimates, S_3, S_4, and GDP;
INV^d – statistically significant estimate of INF^{exp};
INV^p – all estimates are insignificant.

The biggest impact on the NBU discount rate by the coefficients of elasticity and beta coefficients is the real GDP per 1000 people (-0.8 % and -0.493) and inflation expectations (1.2 % and 1.408). At the same time, the inflation indicator is the largest indirect influence due to the inflation expectations index (0.377) and real GDP per capita through the inflation expectations index (-1.011).

The approach proposed makes it possible to identify the direction of causality between macroeconomic indicators and to build and evaluate a system of simultaneous equations. Because the relationships based on empirical data are unstable, we recommend to follow all steps of the proposed methodology each time new data emerges.

CONCLUSIONS

In the framework of this work, an analysis of the existing approaches to macroeconomic modeling of the dynamics of monetary policy indicators is carried out, a methodology for constructing a macroeconometric model of the formation of the monetary policy parameters of the domestic economy is proposed taking into account the dynamics of the main available macroeconomic indicators. The calculated predicted values of the endogenous variables of the developed model are compared with the predicted values of the NNAR - model of the corresponding variables. Comparison of approaches makes it possible to identify possible effects of the existing relationships between indicators in the structural model. To interpret the results of the structural model, elasticity coefficients, beta coefficients, and indirect beta coefficients are calculated.

Thus, the use of the capabilities of applied econometric tools, in particular, systems of simultaneous structural equations to solve the problem of macroeconomic modeling, allowed to obtain competitive scientific results. Further development of this area of research towards inclusion in the model of a larger range of endogenous and managed exogenous indicators , use of autoregressive values of endogenous variables , use of dummy variables to describe such qualitative changes as change of political power, economic institutions and other qualitative changes, the block structure of critical sectors of the economy today, in particular the banking and financial sectors and the broader range of modern econometric applications This tool will be complemented by the NBU macroeconomic modeling toolkit. In addition, the emergence of new data will help to improve the methodology presented.

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НТБ ОНАХТ

MODELING OF SUSTAINABILITY OF COMPETITIVE POSITION OF AGRARIAN SECTOR OF THE REGION

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Abstract*. Purpose: The aim of the study is the analysis of theoretical concepts for the formation of sustainable competitive advantages, assessment and modeling of the stability of the competitive positions of the agricultural sector in the region.*

Results: It is revealed that in modern conditions, the concept of providing sustainable competitive advantages based on the resource approach is more adequate for the agrarian sector. To evaluate the stability of the competitive position of the agricultural sector of the region, a method of comparing the rate of change of the main economic indicators of the region and the industry as a whole is proposed. The assessment of the competitiveness of the competitive position of the agrarian sector of the region based on the proposed methodology has shown that, in order to ensure sustainable competitive advantage, it is first necessary to pay attention to cost reduction and innovation implementation. Carried out by the method of exponential smoothing with the use of the Brown-Meier model, the calculation of the predicted values of the integral index and its components allowed us to estimate the dynamics and tendencies of development of the agrarian sector of the Sumy region's economy, which are generally positive. The proposed model of dynamic assessment of competitive position stability allows simulating in the near future the situation on the market, gives the necessary information to the relevant state and local authorities for making sound management decisions.

The practical significance of the results obtained. Proposals have been taken into account by specialists of the Department of Agro-Industrial Development of Sumy Regional State Administration (reference # 01-18 / 202 of 30/01/2020). [Annex A].

Key words: *agrarian sector of the region, sustainable competitive advantages, competitive position stability, modeling of competitive position stability.*

I. Introduction

Relevance of the research topic. Sustainable development of the agrarian sector in the conditions of aggravation of competition is possible only in the presence of competitive advantages. Attention to the problem of their provision is increasing and new features of the study are emphasized, especially the focus of research on such a sign of competitive advantage as sustainability [1; 2]. Reliable diagnostics and modeling of the further situation are the bases for ensuring sustainable competitive advantages of the region.

Problems of diagnostics and providing of competitive advantages of enterprises in general, and agricultural, in particular, were dealt with by domestic and foreign scientists: I. Boryshkevych, Zh.S. Ptashnik, N. Stelmashchuk, N. Tkachova, O. Tridid, I. Shapovalova, V. Yatsenko, Barney J., Wang H., Hart S., Mugera A, Grant R., Hamel G., Wernerfelt B., Porter M. etc.

Scientists have made a significant contribution to the study of this problem, but some aspects require additional research. In particular, the issues of assessment and modeling of the competitive position of the agrarian sector of the region as a result of

expressing competitive advantages are insufficiently researched. In this regard, the search for methods of assessing and modeling the sustainability of the competitive position of the agricultural sector of the region is of particular relevance.

The purpose of the study is to evaluate the competitiveness of the competitive position of the agricultural sector in the region and to simulate scenarios for the development of the competitive position of the region.

Based on the goals in the process of the study were set the *following tasks*:

• clarify the conceptual apparatus of the process of ensuring sustainable competitive advantages;

• to assess the stability of the competitive position of the agricultural sector of the region;

• on the basis of the assessment, to predict trends in the stability of the competitive position of the agricultural sector in the region.

II. Analytical review of the literature

In terms of sustainable competitive advantage, there are two opposing concepts in the scientific literature: the Resource-Based Approach [1] and models based on research on the environmental impact of competitive position [4].

According to Porter [4], the competitive position of the subject depends on the particular industry in which he belongs. M. Porter's «Five Forces» model explains the influence of external factors on the industry's competitive environment. M. Porter identifies two types of competitive advantage: low costs and product differentiation. According to Porter, a potential source of competitive advantage is a successful combination of different activities. The small number of activities creates the conditions for copying and imitation of behavior by other competitors [4]. The instability and uncertainty of the industry structure due to the transformation processes caused by the rapid technological development have led to a weakening of the dominance of this concept. Wang notes that Porter's five-force model has limitations because it implies the existence of a perfectly competitive market that is virtually non-existent in our current environment [5].

Critics of this concept, the founders of the resource approach [1; 3; 6-9], believe that it does not pay enough attention to the impact on the competitive advantages of internal features. From the point of view of proponents of the resource approach, the source of sustainable competitive advantage is resources that are endowed with a certain set of attributes, such as rarity, immaturity and uniqueness. The presence of these special features is reflected in the immensity of resources, which protects the company from copying competitors. Barney [1; 3] believes that barriers to entry do not provide sustainable competitive advantage. Barriers are only possible if there are differences in resources. If competitive advantages can be copied by other firms, they are unsustainable. That is, the source of competitive advantage is a unique combination of available resources. If the production of the resource itself and its component is monopolized, it will reduce the income of other producers who do not have such a resource. [6].

Grant R.M. Resources are also considered to be a major source of competitive advantage. But in his view, resources alone are not a source of concrete benefits. Resource characteristics such as poor mobility and complexity of reproduction are the cause of long-term success [8; 9].

To date, the agrarian sector is quite labor intensive and benefits from natural resources. But it has a negative impact on the environment and cannot be a source of sustainable competitive advantage. Hart explored the environmental impact of competitive advantage. Establishing certain environmental requirements by the state may be an external barrier to entry into the industry. Only environmentally oriented resources will be a source of sustainable competitive advantage in the future [12].

Unique resources, combined with a set of appropriate management actions, create sustainable competitive advantages [2]. This is evidenced by the fact that, under the same conditions of functioning within the same branch, the subjects provide different results.

Competitive advantages are the unique strengths of an entity with respect to competitors, which combine the best elements of doing business while ensuring competitiveness [13]. Consequently, the search for sources of sustainable competitive advantage should focus on the heterogeneity and inferiority of resources [14].

Sustained competitive advantage ensures a stable competitive position. An entity's competitive position is its place in specific segments of the external market relative to competitors [15]. Competitive advantages can be of both external and internal origin [16]. Thus, a stable competitive position is to a large extent ensured by a set of internal factors, taking into account the possible impact of which and taking appropriate measures will ensure the development of both individual entities and a certain region (Fig. 1).

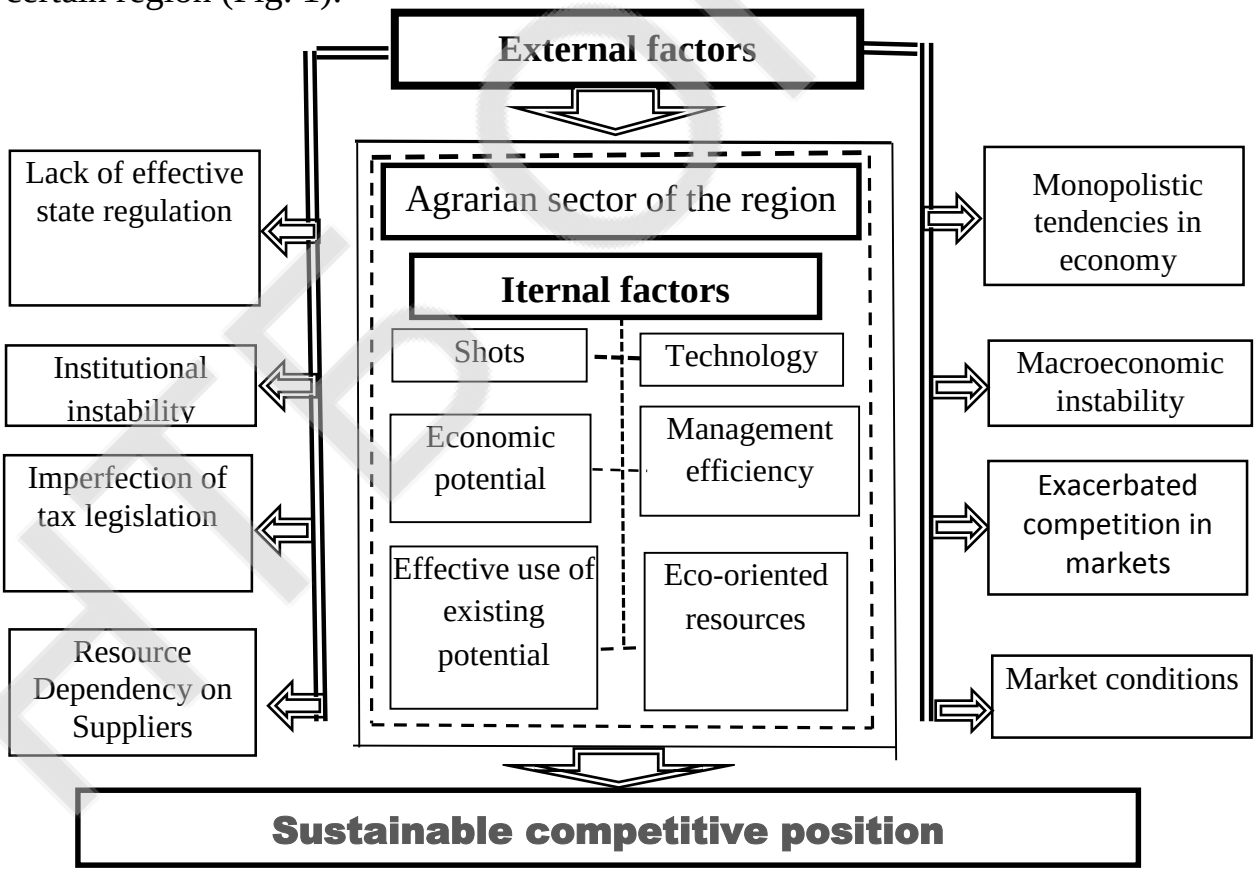

Figure 1. Impact of external and internal environment factors on the competitive position of the agricultural sector of the region

Source: Developed by the author.

The success of management decisions to secure the trajectory of competitive development depends directly on a reliable assessment of the sustainability of the competitive position. There are different approaches to assessing the competitive advantages of agricultural enterprises [17; 18; 19; 20; 21; 22]. When choosing the valuation method, we proceeded from the fact that the agricultural enterprises of the agrarian sector of the region are competing in the industry that, by its characteristics, is the closest to absolute competition, since each producer is a producer of homogeneous products.

III. Object, subject and methods of research.

The subject of the study is the peculiarities of the process of ensuring the sustainable competitive advantages of the agricultural sector of the region in the conditions of increased competition.

The subject of the study is a set of theoretical, methodological and practical bases for ensuring sustainable competitive advantages of the agrarian sector of the region based on evaluation and modeling of the stability of competitive position.

Research methods. In the course of scientific work, the following methods of economic research were used: abstract-logical (in studying and clarifying the essence of the concept of «sustainable competitive advantage» and «sustainability of competitive position»); the method of theoretical generalization (when formulating theoretical generalizations and conclusions, conducting a critical analysis of research results of domestic and foreign authors); economic and statistical (when assessing the competitive position of the agrarian sector of the region on the basis of their sustainability); forecasting using the Brown-Meier economic-mathematical function (to model the stability of competitive positions of the agrarian sector of the region).

IV. Results of work.

IV.I. Analysis of the stability of the competitive position of the agrarian sector of the region.

In assessing the stability of the competitive position of the agrarian sector of the region, we consider it necessary to take into account not so much the absolute values of certain indicators (productivity, cost, product quality and others), or their comparison with competitors (average industry), but rather the dynamic tendencies of changes of relevant indicators in comparison among ourselves.

In our opinion, the analysis of the competitive position should include an integrated assessment using indices of change of individual indicators in the comparison of industry and regional values. We propose to determine the agricultural competitiveness indexes of Sumy region in comparison with the values in Ukraine according to the following indicators: production level (gross production at comparable prices per 100 hectares of agricultural land), level of labor productivity (gross production at comparable prices in per 1 year average employee), level of efficiency (pre-tax financial result per 100 ha of farmland), level of production costs (unit cost), and level of market benefits (average selling prices).

The analysis for 2013-218 was conducted according to the above indicators, with the values for 2013 being taken as the base (index = 1.00). The values of the respective indices for the following years were defined as the ratio of the absolute values of a given year to the value of the indicator for the previous year. Comparative dynamics

of agricultural production indices of agricultural sector of Sumy region and Ukraine are shown in Fig. 2.

The analysis shows that since 2016 production growth rates in the region have fallen below the industry average, although in 2017-2018 they were already higher.

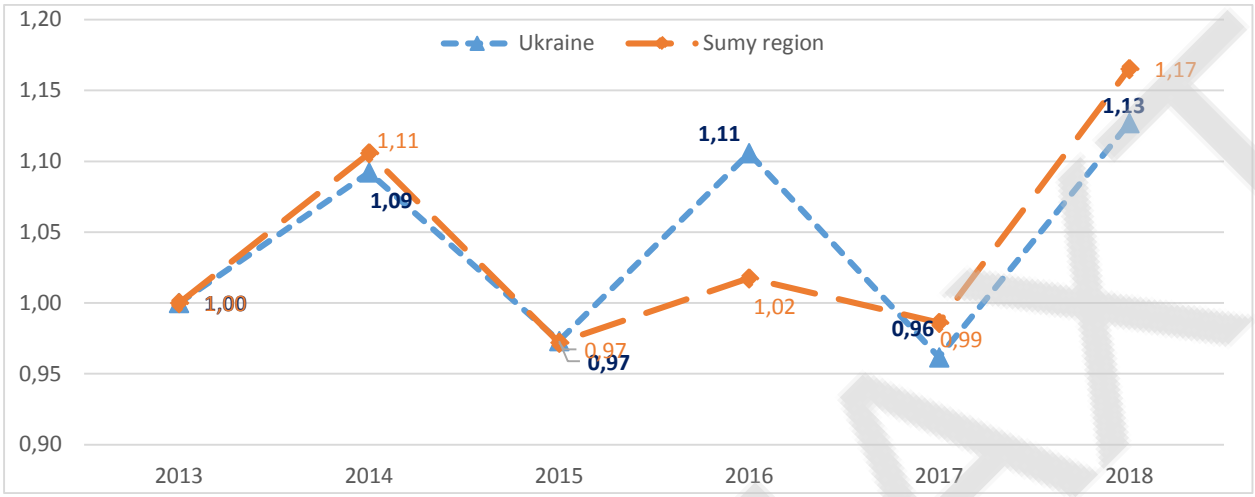

Figure 2 - Indices of change in the level of production (gross production per 100 hectares of farmland) for 2013-2018.

Source: Based on the State Statistics Committee of Ukraine [23-25].

The lower growth rates of the production level in 2016 also led to a lag with the growth rates of labor productivity (Fig. 3).

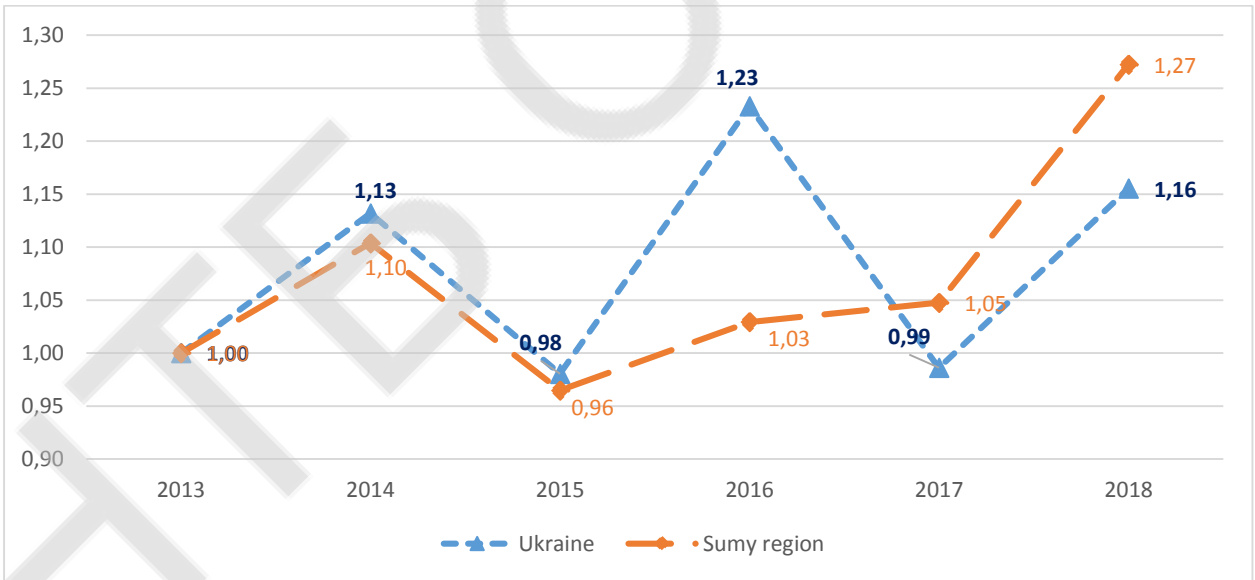

Figure 3 - Indices of change in labor productivity (gross output per 1 average worker) for 2013-2018.

Source: Based on the State Statistics Committee of Ukraine [23-25].

Comparison of agricultural efficiency indices production is shown in Fig. 4.

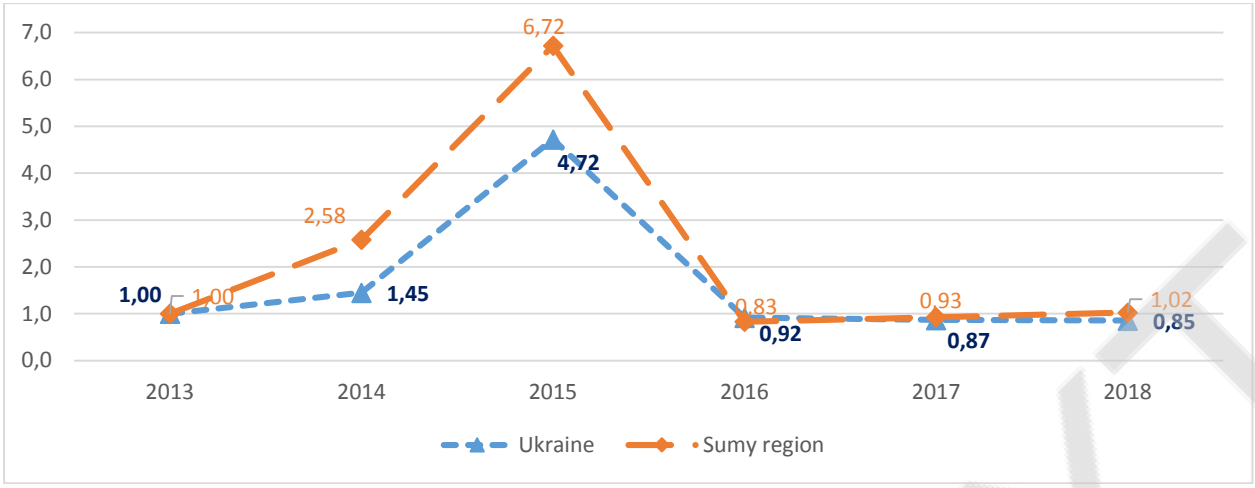

Figure 4 - Indices of change in production efficiency (financial result per 100 hectares of farmland) for 2013-2018.

Source: Based on the State Statistics Committee of Ukraine [23-25].

The analysis of the growth rates of the efficiency indices shows that starting in 2016, the growth rates of the production efficiency index in the region were lower than in the industry, which is confirmed by previous findings (Figures 2 and 3).

Analyzing the dynamics of growth rates of production cost indices and the level of market advantages, it should be noted that considering that different types of products may have different dynamics, we calculated complex indices of the level of costs and the level of market advantages on the basis of geometric values (formula 1).

$I_{інтегр} = \sqrt[n]{I_1 * I_2 * ... * In}$, where (1)

In - the corresponding cost indices (selling prices) of the n-th type of production.

The dynamics of the complex cost level index are shown in Fig. 5.

The analysis shows that the growth rate of the level of expenditures in Sumy region is slowing down since 2016, which has led to an increase in the sustainability of existing competitive advantages in 2018.

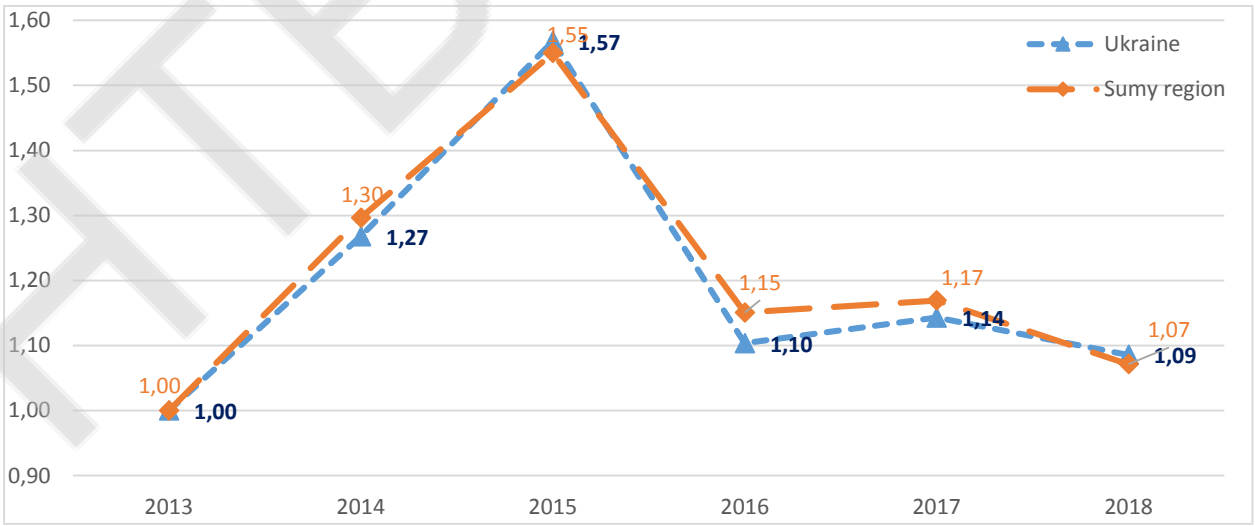

Figure 5 - Complex indexes of changes in the level of production costs (1c cost) for 2013-2018.

Source: Based on the State Statistics Committee of Ukraine [23-25].

Another trend is observed in the analysis of the level of market advantages (average selling prices). In this aspect, agricultural Sumy region enterprises in 2018 slightly reduced their competitive advantages (Fig. 6).

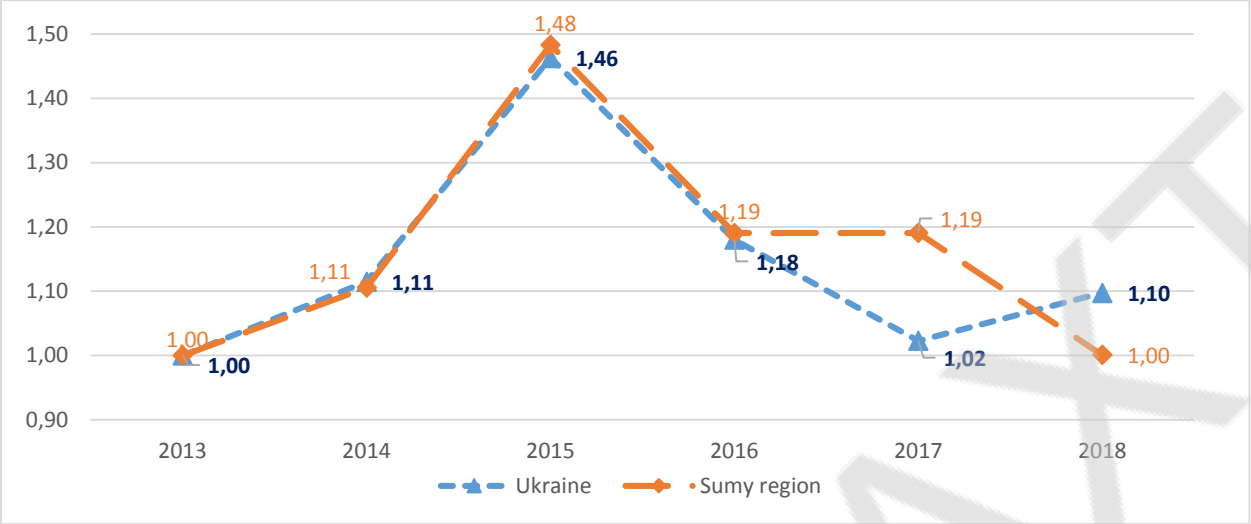

Figure 6 - Complex indexes of change in the level of average selling prices 1t) for 2013-2018.

Source: Based on the State Statistics Committee of Ukraine [23-25].

To better understand the overall trend of changes in competitive positions, we propose to use the integral index of changes in competitive position, as the geometric mean of the above calculated indices (Fig. 7), while taking into account that when evaluating the level of spending less value is better, we used the inverse of the cost level index.

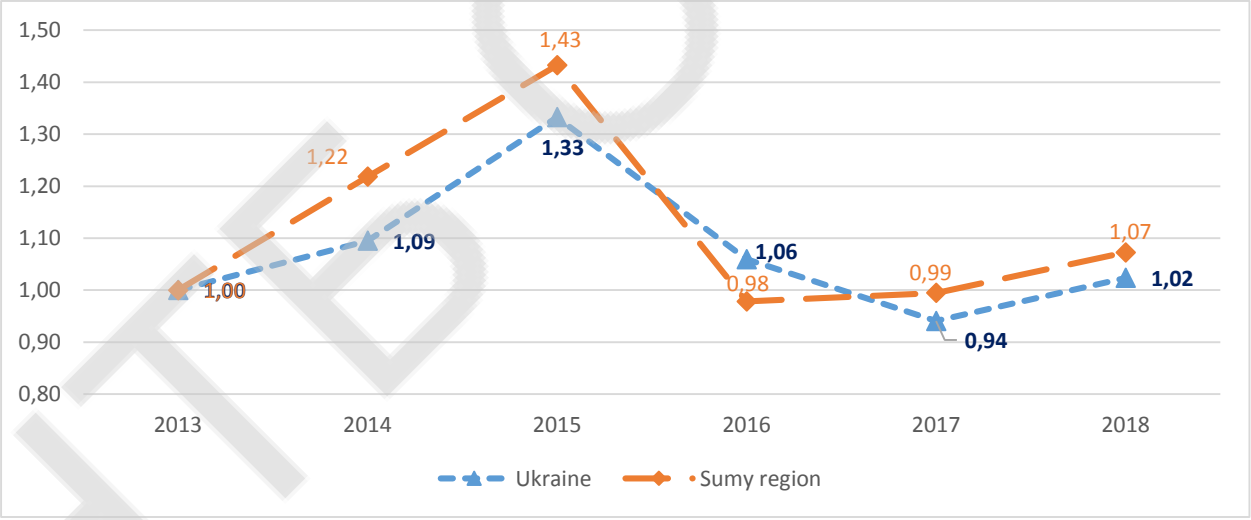

Figure 7 - Integral indices of change of competitive position for 2013-2018.

Source: calculated by the authors.

As the graph in Fig. 7 shows, Sumy Region in its dynamics strengthens its competitive position (except for 2016, when in almost all parameters the region was inferior to industry indicators). Moreover, the analysis of the components revealed that this was due both to a higher level of financial result per unit of agricultural land and a slightly higher level of selling prices (which also affects the financial result to a certain extent) and due to internal competitive factors (production and efficient use of material and labor resources), which in the future contributes to the strengthening of competitive positions.

IV.II. Predicting the stability of the competitive position of the agricultural sector in the region.

Development of the forecast of stability of the competitive position of the Sumy region involves the integrated estimation using indices of change of separate indicators in comparison of the average industry and regional values.

After calculating change indices: production level ($I_{ВП}$), level of labor productivity ($I_{ППП}$), level of efficiency ($I_{ФР}$), level of production costs ($I_{СВ}$) and level of market advantage ($I_{ЦР}$), the integral index of competitive position is calculated as the geometric mean of the product of the above indices (formula 2).

$I_{КР} = \sqrt[5]{I_{ВП} * I_{ППП} * I_{ФР} * I_{СВ} * I_{ЦР}}$, where (2)

$I_{КР}$ is an integral index of the competitive position of the agrarian sector of the region; $I_{ВП}$ - the index of change in the level of production; $I_{ППП}$ - index of change in labor productivity; $I_{ФР}$ - production efficiency change index; $I_{СВ}$ - Production Cost Change Index; $I_{ЦР}$ is an index of change in market preferences.

At the same time, as noted above, that the increase in the level of costs is a negative factor, WIS recognized as the inverse of the index of change in costs

The corresponding indices for the period 2013-2018 for the Sumy region and for Ukraine as a whole were calculated (Table 1).

Table 1 - Dynamics of the index of competitive position of the agrarian sector of Sumy region for 2013-2018.

Indexes		Years					
		2013	2014	2015	2016	2017	2018
Production level index	Sumy region	1,00	1,11	0,97	1,02	0,99	1,17
	Ukraine	1,00	1,09	0,97	1,11	0,96	1,13
Labor productivity index	Sumy region	1,00	1,10	0,96	1,03	1,05	1,27
	Ukraine	1,00	1,13	0,98	1,23	0,99	1,16
Production efficiency index	Sumy region	1,00	2,58	6,72	0,83	0,93	1,02
	Ukraine	1,00	1,45	4,72	0,92	0,87	0,85
Inverse production cost index	Sumy region	1,00	0,77	0,65	0,87	0,86	0,93
	Ukraine	1,00	0,79	0,64	0,91	0,87	0,92
Market Advantage Index	Sumy region	1,00	1,11	1,48	1,19	1,19	1,00
	Ukraine	1,00	1,11	1,46	1,18	1,02	1,10
Integral index of competitive advantages	Sumy region	**1,00**	**1,22**	**1,43**	**0,98**	**0,99**	**1,07**
	Ukraine	**1,00**	**1,09**	**1,33**	**1,06**	**0,94**	**1,02**

Source: calculated based on the State Statistics Committee of Ukraine [23-25].

The following methodology was used to determine the predicted values of the above indices.

First, the values of the baseline indices for the calculation of indices were predicted - corresponding indicators for Sumy region and Ukraine by applying the Brown-Mayer method based on the second-order parabola [26].

If a series of dynamics is described by a second-order parabola:

$$Y_t = A_0 + A_1 t + \frac{1}{2} A_2 t^2, \quad (3)$$

then the main exponential smoothing indices are calculated by the following formulas:

Initial conditions:

$$\begin{cases} S_0^1(Y) = A_0 - \frac{1-\alpha}{\alpha} A_1 + \frac{(1-\alpha)(2-\alpha)}{2\alpha^2} A_2; \\ S_0^2(Y) = A_0 - \frac{2(1-\alpha)}{\alpha} A_1 + \frac{(1-\alpha)(3-2\alpha)}{2\alpha^2} A_2; \\ S_0^3(Y) = A_0 - \frac{3(1-\alpha)}{\alpha} A_1 + \frac{(1-\alpha)(4-3\alpha)}{2\alpha^2} A_2. \end{cases} \quad (4)$$

Exponential averages:

$$\begin{cases} S_t^1(Y) = \alpha Y_t + (1-\alpha) S_0^1(Y); \\ S_t^2(Y) = \alpha S_t^1(Y) + (1-\alpha) S_0^2(Y); \\ S_t^3(Y) = \alpha S_t^2(Y) + (1-\alpha) S_0^3(Y). \end{cases} \quad (5)$$

Estimates of trend coefficients:

$$\begin{cases} A_0^\beta = 3\left[S_t^1(Y) - S_t^2(Y)\right] + S_t^3(Y); \\ A_1^\beta = \frac{\alpha}{(1-\alpha)^2}\left[(6-5\alpha) S_t^1(Y) - 2(5-4\alpha) S_t^2(Y) + (4-3\alpha) S_t^3(Y)\right]; \\ A_2^\beta = \frac{\alpha^2}{(1-\alpha)^2}\left[S_t^1(Y) - 2S_t^2(Y) + S_t^3(Y)\right] \end{cases} \quad (6)$$

Model according to which the forecast is made:

$$Y_{t+l}^\beta = A_0^\beta + A_1^\beta l + \frac{1}{2} A_2^\beta l^2 \quad (7)$$

As a result, the corresponding values of indicators for the period 2019-2021 (Annexes A,B) were projected

Secondly, the indexes of change were calculated on the basis of the projected values: production level ($I_{ВП}$), level of labor productivity ($I_{ПП}$), level of efficiency ($I_{ФР}$), level of production costs ($I_{СВ}$) and level of market advantages ($I_{ЦР}$).

The final stage was the calculation of the integral index of competitive position on the basis of formula 2. The results of the calculation are shown in table 2.

Table 2 - Forecast values of the index of competitive position of the agrarian sector of Sumy region and Ukraine for 2019-2021.

Indexes		Years		
		2019	2020	2021
Production level index	Sumy region	1,13	1,13	1,12
	Ukraine	1,10	1,10	1,11
Labor productivity index	Sumy region	1,22	1,22	1,22
	Ukraine	1,13	1,14	1,16
Production efficiency index	Sumy region	1,24	1,61	1,99
	Ukraine	1,02	1,27	1,53
Inverse production cost index	Sumy region	0,91	0,88	0,85
	Ukraine	0,91	0,88	0,85
Market Advantage Index	Sumy region	1,05	1,10	1,14
	Ukraine	1,11	1,15	1,20
Integral index of competitive position	Sumy region	**1,10**	**1,16**	**1,21**
	Ukraine	**1,06**	**1,11**	**1,15**

Source: calculated by the authors.

Therefore, the stability of the competitive position of the agrarian sector of Sumy region, which is clearly shown in Figure 8, is increasing in the future.

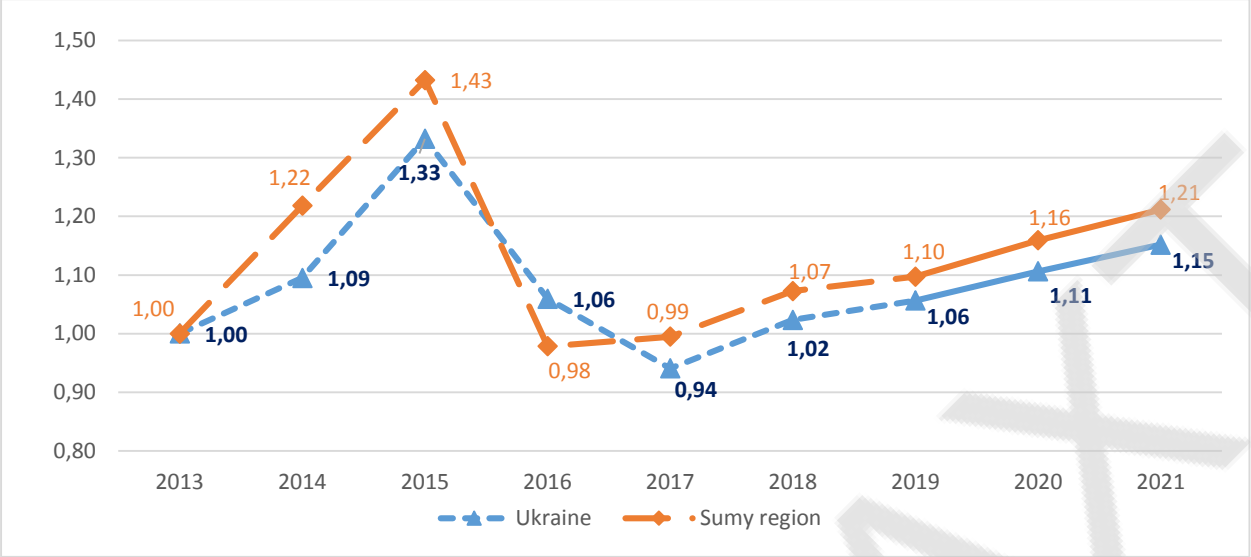

Figure 8 - Integral indices of change of competitive position for 2013-2018

Source: calculated by the authors.

Of course, this forecast, like all other forecasts, does not take into account all the factors that influence the stability of the competitive position, but it allows to simulate in the short term the situation on the market, which provides the necessary information to the relevant state and local authorities for making sound management decisions.

V. Conclusions

1. Sustainable development of the agrarian sector of the region depends on its competitive advantages. Generalization of approaches in the literature to determine the essence of the category «sustainable competitive advantages» has made it possible to define it as a set of features of the economic system, which provide it with a stable competitive position.

2. An important prerequisite for achieving competitive advantage is to assess the sustainability of the competitive position. We were asked to evaluate the stability of the competitive position of the agrarian sector of the region on the basis of indices of change of individual indicators in the comparison of industry and regional values. We propose to determine the agricultural competitiveness indices of the region's agriculture (for example, Sumy region) in comparison with the values in Ukraine according to the following indicators: level of production (gross production at comparable prices per 100 ha of agricultural land), level of labor productivity (gross production at comparable prices per employee per year (average per employee), level of efficiency (pre-tax financial result per 100 ha of farmland), production costs (unit cost) and level of market benefits (average selling prices).

3. To better understand the overall trend of changes in competitive positions, we propose to use the integral index of changes in competitive advantages, as the geometric mean value of the above indices, while considering that the cost level less value is better, we used the inverse cost level index.

4. Analysis of data for 2013-2018 showed that Sumy region in dynamics strengthens its competitive position (except for 2016, when in almost all parameters the region was inferior to industry indicators). Moreover, this was due both to a higher

level of financial result per unit of agricultural land and a slightly higher level of selling prices (which also has a certain effect on the financial result), and due to internal factors (production level and the efficiency of material and monetary use manpower), which in the future contributes to the strengthening of competitive position.

5. To determine the predictive values of the indices characterizing the stability of the competitive position, a method using the Brown-Mayer method based on the second-order parabola was used. As a result, the corresponding values of the indicators for the period 2019-2021 were initially projected. Then, on the basis of the projected values, indices of change were calculated: production level ($I_{ВП}$), level of labor productivity ($I_{ПП}$), level of efficiency ($I_{ФР}$), level of production costs ($I_{СВ}$) and level of market advantage ($I_{ЦР}$). The final stage was the calculation of the integral index of competitive position based on the geometric mean of the above indices, which showed that the stability of competitive advantages of the agrarian sector of Sumy region is increasing for the future.

The implementation of the proposed measures will help to ensure the competitive development of the agricultural sector and, on this basis, to ensure the sustainable development of Ukrainian agriculture.

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Annex A

Intermediate calculations for calculating the regression forecast trend of competitive advantage indicators

Indicators	Options											
	A_0	A_1	A_2	S_0^1	S_0^2	S_0^3	S_t^1	S_t^2	S_t^3	A_0^β	A_1^β	A_2^β
Production level index in Sumy region	0,9837	0,0091	0,0233	1,2008	1,2782	1,3556	0,2500	1,1919	1,2566	1,3309	1,1367	-0,0055
Production level index in Ukraine	1,0227	0,0052	0,0081	1,0918	1,1125	1,1332	0,2500	1,1006	1,1095	1,1273	1,1005	0,0013
Labor productivity index in Sumy region	0,9690	0,0258	0,0395	1,3061	1,4065	1,5068	0,2500	1,2976	1,3792	1,4749	1,2301	-0,0064
Labor productivity index in Ukraine	1,0880	0,0077	-0,0040	1,0224	0,9811	0,9398	0,2500	1,0556	0,9997	0,9548	1,1224	0,0099
Production efficiency index in Sumy region	3,7733	-0,0914	-0,6704	-2,9916	-5,7342	-8,4767	0,2500	-1,9876	-4,7975	-7,5569	0,8729	0,3649
Production efficiency index in Ukraine	2,6732	-0,0312	-0,4409	-1,8625	-3,7530	-5,6435	0,2500	-1,1836	-3,1107	-5,0103	0,7708	0,2483
Inverse production cost index in Sumy region	0,7217	-0,0005	0,0532	1,2821	1,5232	1,7642	0,2500	1,1950	1,4411	1,6834	0,9451	-0,0318
Inverse production cost index in Ukraine	0,7455	-0,0021	0,0471	1,2466	1,4649	1,6832	0,2500	1,1653	1,3900	1,6099	0,9357	-0,0294
Market advantage index in Sumy region	1,3447	0,0085	-0,0796	0,4833	0,0996	-0,2841	0,2500	0,6127	0,2279	-0,1561	0,9983	0,0483
Market advantage index in Ukraine	1,2838	0,0087	-0,0602	0,6262	0,3294	0,0327	0,2500	0,7439	0,4330	0,1328	1,0654	0,0417

НТБ ОНАХТ

Annex B

The results of the statistical analysis of the dependence of the production level index in the Sumy region on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,9837	0,0594	16,5590	0,0005	0,7947	1,1728
X Variable 1	0,0091	0,0159	0,5742	0,6060	-0,0414	0,0597
X Variable 2	0,0116	0,0103	1,1331	0,3395	-0,0211	0,0443

$$\text{Ipв}_t^{\text{C}} = 0{,}9837 + 0{,}0091 \cdot t + 0{,}0116 \cdot t^2$$

$$\text{Ipв}_{t+l}^{\text{C}} = 1{,}1367 - 0{,}0055 \cdot l + \frac{1}{2} \cdot 0{,}0011 \cdot l^2$$

The results of the statistical analysis of the dependence of the production level index in Ukraine on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1,0227	0,0666	15,3462	0,0006	0,8107	1,2348
X Variable 1	0,0052	0,0178	0,2910	0,7900	-0,0515	0,0619
X Variable 2	0,0040	0,0115	0,3495	0,7498	-0,0326	0,0407

$$\text{Ipв}_t^{\text{y}} = 1{,}0227 + 0{,}0052 \cdot t + 0{,}0040 \cdot t^2$$

$$\text{Ipв}_{t+l}^{\text{y}} = 1{,}1005 + 0{,}0013 \cdot l + \frac{1}{2} \cdot 0{,}0010 \cdot l^2$$

The results of the statistical analysis of the dependence of the labor productivity index in the Sumy region on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,9690	0,0650	14,8974	0,0007	0,7620	1,1759
X Variable 1	0,0258	0,0174	1,4811	0,2352	-0,0296	0,0811
X Variable 2	0,0197	0,0112	1,7545	0,1776	-0,0161	0,0555

$$\text{Iпп}_t^{\text{C}} = 0{,}9690 + 0{,}0258 \cdot t + 0{,}0197 \cdot t^2$$

$$\text{Iпп}_{t+l}^{\text{C}} = 1{,}2301 - 0{,}0064 \cdot l + \frac{1}{2} \cdot 0{,}0016 \cdot l^2$$

The results of the statistical analysis of the dependence of the labor productivity index in Ukraine on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1,0880	0,0981	11,0892	0,0016	0,7757	1,4002
X Variable 1	0,0077	0,0262	0,2935	0,7883	-0,0758	0,0912
X Variable 2	-0,0020	0,0170	-0,1191	0,9127	-0,0560	0,0520

$$\text{Iпп}_t^{\text{y}} = 1{,}0880 + 0{,}0077 \cdot t - 0{,}0020 \cdot t^2$$

$$\text{Iпп}_{t+l}^{\text{y}} = 1{,}1224 + 0{,}0099 \cdot l + \frac{1}{2} \cdot 0{,}0012 \cdot l^2$$

The results of the statistical analysis of the dependence of the production efficiency index in the Sumy region on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3,7733	1,8644	2,0239	0,1361	-2,1600	9,7066
X Variable 1	-0,0914	0,4985	-0,1834	0,8662	-1,6777	1,4949
X Variable 2	-0,3352	0,3224	-1,0397	0,3749	-1,3612	0,6909

$$\text{Ie}\phi_t^{\text{C}} = 3{,}7733 - 0{,}0914 \cdot t - 0{,}3352 \cdot t^2$$

$$\text{Ie}\phi_{t+l}^{\text{C}} = 0{,}8729 + 0{,}3649 \cdot l + \frac{1}{2} \cdot 0{,}0056 \cdot l^2$$

The results of the statistical analysis of the dependence of the production efficiency index in Ukraine on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2,6732	1,2275	2,1779	0,1176	-1,2331	6,5795
X Variable 1	-0,0312	0,3282	-0,0950	0,9303	-1,0756	1,0132
X Variable 2	-0,2204	0,2123	-1,0385	0,3754	-0,8960	0,4551

$$\text{Ie}\phi_t^{\text{y}} = 2{,}6732 - 0{,}0312 \cdot t - 0{,}2204 \cdot t^2$$

$$\text{Ie}\phi_{t+l}^{\text{y}} = 0{,}7708 + 0{,}2483 \cdot l + \frac{1}{2} \cdot 0{,}0030 \cdot l^2$$

The results of the statistical analysis of the dependence of the inverse production cost index in the Sumy region on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,7217	0,0744	9,7064	0,0023	0,4851	0,9583
X Variable 1	-0,0005	0,0199	-0,0247	0,9819	-0,0638	0,0628
X Variable 2	0,0266	0,0129	2,0701	0,1302	-0,0143	0,0675

$$\text{Iвв}_t^{\text{C}} = 0{,}7217 - 0{,}0055 \cdot t + 0{,}0266 \cdot t^2$$

$$\text{Iвв}_{t+l}^{\text{C}} = 0{,}9451 - 0{,}0318 \cdot l - \frac{1}{2} \cdot 0{,}0004 \cdot l^2$$

The results of the statistical analysis of the dependence of the inverse production cost index in Ukraine on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,7455	0,0869	8,5791	0,0033	0,4690	1,0221
X Variable 1	-0,0021	0,0232	-0,0889	0,9348	-0,0760	0,0719
X Variable 2	0,0236	0,0150	1,5682	0,2148	-0,0243	0,0714

$$\text{Iвв}_t^{\text{y}} = 0{,}7455 - 0{,}0021 \cdot t + 0{,}0236 \cdot t^2$$

$$\text{Iвв}_{t+l}^{\text{y}} = 0{,}9357 - 0{,}0294 \cdot l - \frac{1}{2} \cdot 0{,}0005 \cdot l^2$$

The results of the statistical analysis of the dependence of the market advantage index in the Sumy region on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1,3447	0,0935	14,3755	0,0007	1,0470	1,6424
X Variable 1	0,0085	0,0250	0,3380	0,7577	-0,0711	0,0880
X Variable 2	-0,0398	0,0162	-2,4612	0,0908	-0,0913	0,0117

$$\text{Іпп}_t^{\text{С}} = 1{,}3447 + 0{,}0085 \cdot t - 0{,}0398 \cdot t^2$$

$$\text{Іпп}_{t+l}^{\text{С}} = 0{,}9983 + 0{,}0483 \cdot l + \frac{1}{2} \cdot 0{,}0001 \cdot l^2$$

The results of the statistical analysis of the dependence of the market advantage index in Ukraine on the index of the forecast value

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1,2838	0,1160	11,0684	0,0016	0,9147	1,6529
X Variable 1	0,0087	0,0310	0,2800	0,7977	-0,0900	0,1074
X Variable 2	-0,0301	0,0201	-1,4995	0,2307	-0,0939	0,0338

$$\text{Іпп}_t^{\text{У}} = 1{,}2838 + 0{,}0087 \cdot t - 0{,}0301 \cdot t^2$$

$$\text{Іпп}_{t+l}^{\text{У}} = 1{,}0654 + 0{,}0417 \cdot l + \frac{1}{2} \cdot 0{,}0012 \cdot l^2$$

НТБ ОНАХТ

DISTRIBUTION ACTIVITY MANAGEMENT OF CORPORATION

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Abstract*. Theoretical aspects of distribution activity organization were considered in the research work. distribution activity of corporation «Zeus Ceramica» as an example was observed and mechanism of modernization was proposed. The implementation of optimization tasks with the help of MS Excel and the new storage opening is proposed as one of the main direction to improve the organization of distribution activity.*

Basic thesis and results of the scientific work were made public by the author on the scientific-practical conference: on the 24-25th of April 2019, Kramatorsk city: Donbas National Academy of Civil Engineering and Architecture;on the 30th of November, 2019., Kherson city: Kherson State Agrarian University.

According to the theme of research work the article and thesis were published:

1. Karasyova M.O., Dolgalyova O.V. Modern problems of distribution activity in Ukraine. Electronic scientific and practical journal «Collection of scientific works of DonNACEA». Kramatorsk. 2019. №. 2 -2019 (16). C. 111-116.

2. Karasyova M.O., Dolgalyova O.V., Gryzuk Y.V. Optimization of the enterprise transportation plan with the use of MS Excel. Modern computer systems and networks in control: materials of the second all-Ukrainian scientific-practical Internet conference of students, graduate students and young scientists (Kherson, the 30th of November, 2019.). Kherson: FOP Vyshemyrskyi V.S.., 2019. C. 325-328.

Key words*: distribution, distribution activity, management distribution system, mechanism of modernization, optimization, optimisation tasks.*

Introduction.

In terms of market economy every corporation was immersed into new conditions and has got an opportunity to carry out and regulate its activity by itself. Today, in terms of unstable economical situation in the country, work conditions became worse for every corporation, the level of competition at the market has increased, demand for products has diminished because of the considerable increase in prices, the price of purchasing accessories and transportation cost has also increased. All these factors have caused an essential influence on the worsening the conditions of corporation's distribution activity. That is why, nowadays the question of searching for the ways to improve supplying and distribution has become actual.

Misunderstanding of the importance of distribution activity in a practical work of the management subjects leads to the worsening of the work efficiency in any corporation. Beforehand the cleared negative distribution factors and the reasons of their creation or the ways of optimization and improvement give an opportunity to the corporation not just to save the part of income, but also to diminish essentially the amount of expenses and to get necessary level of income for the further development of corporation. So, today the question of organizational improvement of supplying and distribution the production arises for every corporation, thanks to that, the general efficiency of functioning and profitableness increases.

Analytical outlook.

Learning the problems and developing the ways of the improvement of corporation's organization of supplying and distribution can be referred to the narrow circle of native and foreign researchers which searched different aspects in supplying and distribution organization of the enterprises.

The problems of organization of supplying and distribution goods was searched by these researchers: G.J. Bolt, O.O.Bruch, L.E. Vardanyan, V. M. Vlasova, S. S. Garkovenko, J.S.Zavadsky, V.Y.Kardash, A. Kus, I.Y. Kutlina, T. I. Lukyanets, S. S. Nesterenko, A. O. Starostina, N. V.Terenteva, V. P. Khlusov.

But the subject distribution activity improvement is very actual nowadays, in spite of that, the industrial programme and results of management activity depends on the efficiency of distribution organization.

The object, subject and methods of research.

The purpose of this work is to research the theoretical approaches to the indication of the essence and management of corporation's activity and improvement on the base of the knowledge in distribution activity, which we've got from «Zeus Ceramica». According to the purpose of research the following tasks were put and solved: to research the meaning «corporation's distribution activity»; to open up the essence of the process of distribution management; to give common characteristic of the corporation «Zeus Ceramica»; to fulfil the analyse of supplying- distribution activity of «Zeus Ceramica»; to propose the ways to improve distribution activity of «Zeus Ceramica».

The object of research is distribution activity of the corporation.

The subject of research is theoretical, methodical and practical questions of improvement of distribution activity of the corporation.

The following methods of research were used: the method of abstraction (for specification the meaning of the term «distribution» and «distribution activity»), the method of optimization modeling (for fulfilment of optimization tasks with the help of MS Excel on the «Zeus Ceramica» and others.

The informational ground of research includes the monographs, articles, educational textbooks of native and foreign researchers on the corporation's management and marketing, legislative acts, posts of practices in management and marketing, statistic and practical materials.

The results of the work.

The majority considers that the determination of the word «distribution» is obvious. But searching of the special literature, it is easy to mention that it doesn't exist the only description of «distribution». Moreover, a lot of such descriptions sometimes principally differ from each other. Distribution is often identified with such terms as sales, goods' movement, division, implementation. That's why for the further research it is necessary to analyse existing descriptions and give all-round exhausted formulation. Only in such a way we can determine the meaning of the given concept in the corporation's management system. The determination of the right term «distribution» would promote the further planning of corporation's activity including the strategy of distribution.

Let's consider the different approaches to the term «distribution» of different researchers (t.1.1) [14].

Table 1.1 – Approaches to the term «distribution» [14]

Author	Term	Determination
1	2	3
Bolt G.J.	selling	Personal two-sided communication which is directed on achievement the concrete aims on receiving the profit from distribution that demands certain knowledge, skills and level of competence
Bruch O.O.	distribution	Gradual movement, promotion of goods (ready production) to the further element of distribution circle on the base of the marketing strategy and establishment of relationships with consumers and goods sales on the base of satisfaction of people's needs
Vardanyan L.E.	distribution	Personalised direct two-sided process of accomplishment the contacts and conviction with the aim of sales increase on the market
Vlasova V.M.	distribution	Transportation, warehousing, saving, refinement and promotion to wholesale and retail points pre-sale preparation and exact selling the goods
Garkavenko S.S.	distribution	The organization of the web for effective selling of made production
Zavadsky J.S.	distribution activity	Promotion of the goods from the place of production to the place of consumption and distribution operations (warehousing, saving, refinement, packing, completing of consignment of goods, transportation and so on)
Kardash V.Y.	distribution	Directly connected to the promotion of goods from manufacturer to the consumer, there is a totality of organization-technological and commercial activities for direct realization of goods and services
Kus A.	distribution	The totality of marketing activities and selling goods activities
Lukyanets T.I.	distribution	The movement of goods from the manufacturer to customer
Staristina A.O.	distribution (marketing)	Different activity that provides the movement of goods to the consumers which is connected to the offset of producing process and consumption according to the place, time and shapes
Khlusov V. P.	distribution	Different activity which helps the seller to communicate with the consumer

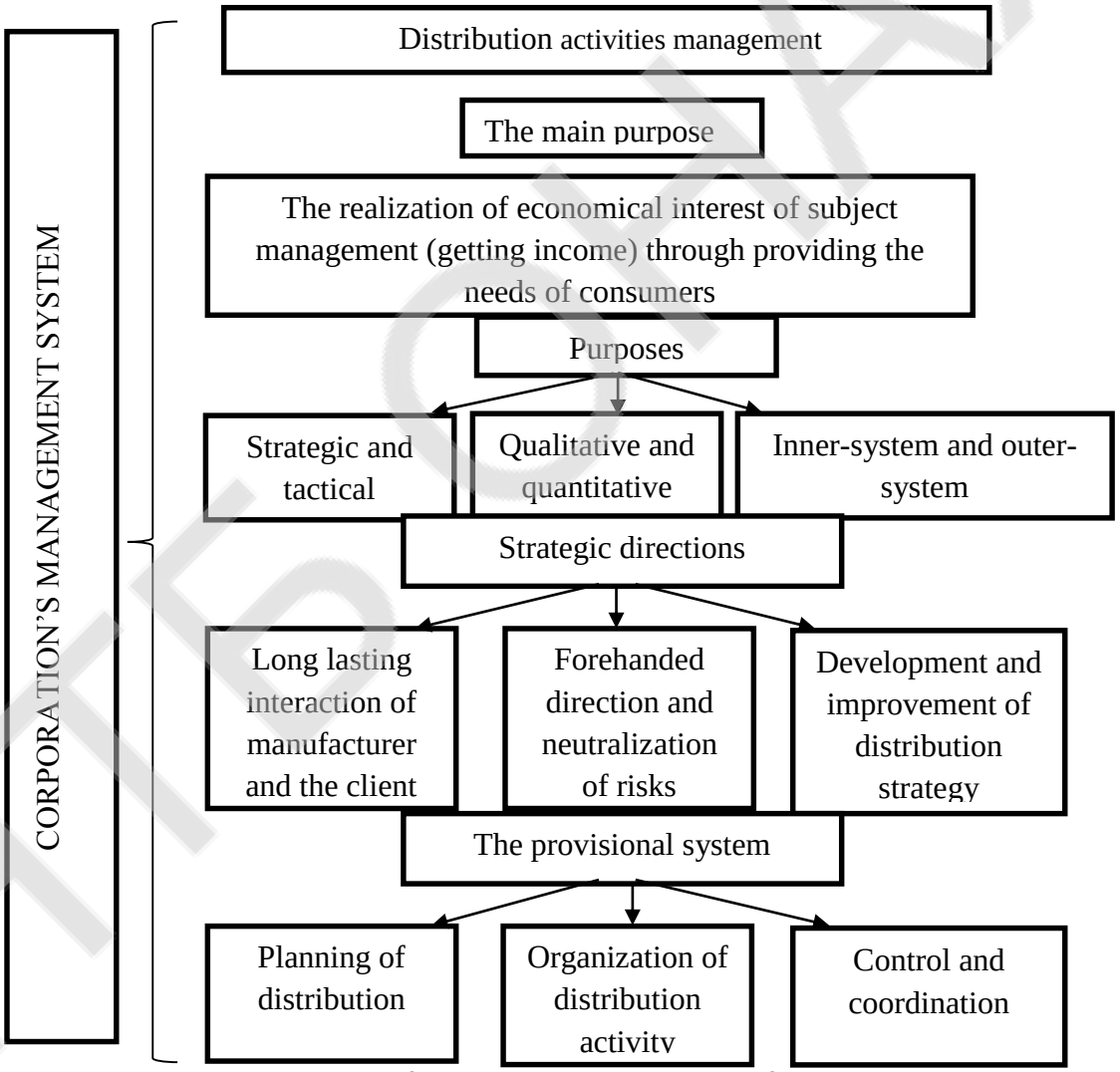
Have searched the different thoughts about interpreting the meaning «distribution» we've got the conclusion that «distribution» considers the transfer of production from manufacturer to consumer according to the orders and contracts.

To the distribution operations belong: the development of the prediction of the market conjuncture and of production realization, calculation and justification of financial distribution costs and approval of marketing distribution standards, the choice of alternative ways of distribution, creating distribution communications, development of distribution reporting, modelling the selling processes and final results of distribution operations.

We consider the distribution is a complete aspect of corporation's activity along with the finance, accounting, stuff, manufacturing and supplying. So, it is time to move to the definition of the place of distribution activity in the system of corporation's management.

The system of corporation's management include the main purposes, aims of activity (that means the division on strategic and tactical, qualitative and quantitative, inner-system and outer-system), strategic focus (which denotes long lasting interaction of the manufacturer and the client, forehead detection and neutralization of risks, development and improvement of distribution strategy) and system provision (distribution planning, distribution activity organization, control and coordination) depicted in details on the pict.1.1

To achieve the efficiency in management of corporation's distribution activity is necessary to create the distribution system which is directed on the gaining the aims and strategies of sales oriented the needs of final consumer.



Picture 1.1 – The place of management process of distribution activity in the system of corporation's management [developed by the author]

It should be mentioned that, as a rule, the purposes of distribution flow from the corporation's purposes, among them there is the aim of maximization of the income

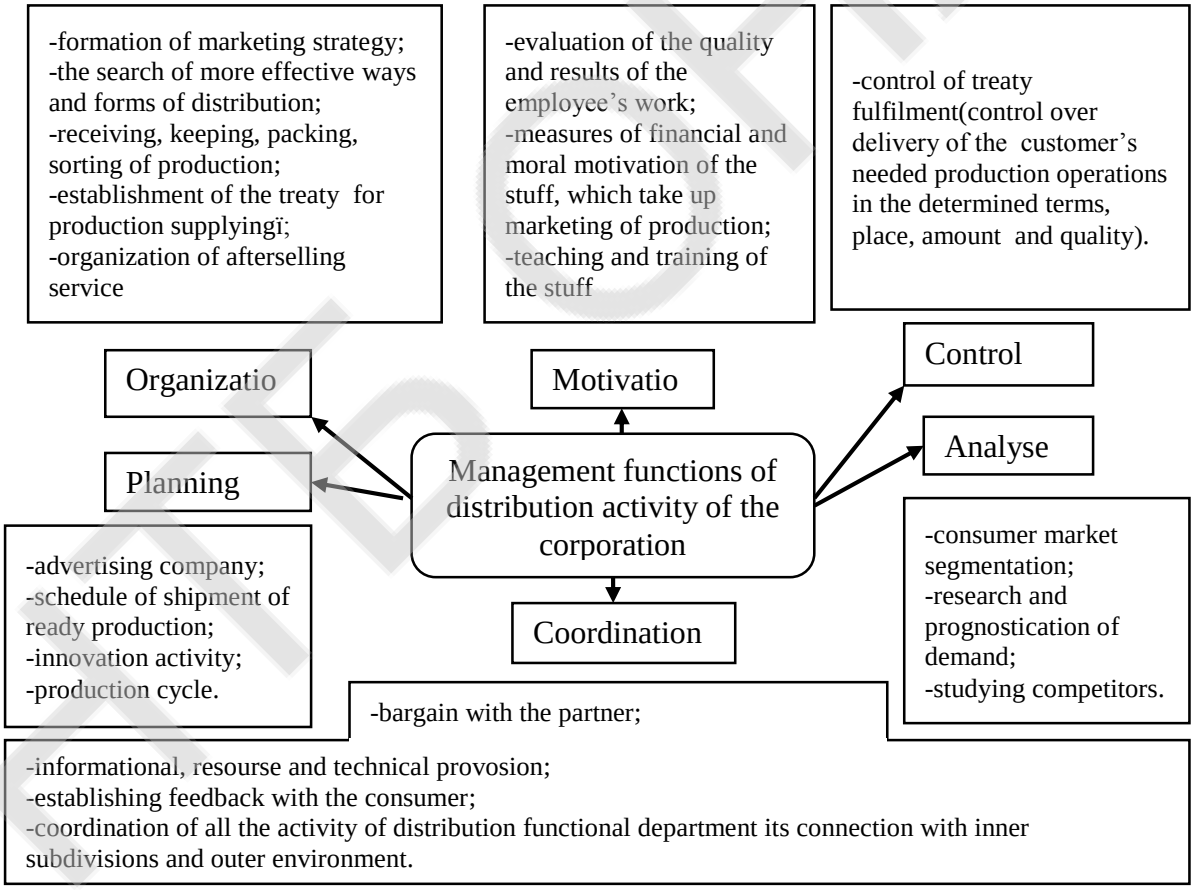
first of all. To achieve the aims is possible through successful fulfilment of the following tasks in the sphere of distribution activity:

- Optimal download of manufacturing power with the needs of consumers;
- The rational choice of the distribution ways;
- Minimization of the amount of joined costs in the life cycle of goods that includes the costs of self-service.

The key-elements of distribution are system, form and route of selling. The combination of these elements in different distribution situations gives an opportunity to the manufacturer to realise efficiency according to the aims of selling.

The distribution management system represents the totality of elements which are connected and subordinated the one goal – optimization of supplying management. The special attention in its activity should be paid to the evaluation of efficiency because the back connection between economical streams of the management supplying system and the strategy of corporation's development fulfils.

So, we consider, the formation of effective management decisions about distribution activity predict systematized and planned usage of certain management functions – planning, organization, motivation, control, analyse and coordination. More detailed management functions of distribution activity are depicted in the pict. 1.2.



Picture 1.2 – The management functions of distribution activity of the corporation [17, c. 131]

Represented functions create the base of systematic provision of corporation's distribution management and competitiveness of the corporation.

The organization of distribution activity should be a part of the management strategy of the corporation. It provides the development of optimal partner relationships, marketing analyse, quality management and advertisement policy of the corporation.

The organization process of distribution activity would be appropriate to consider as the one formed in two directions:

- First of all, it must provide optimal connection and effective usage of all kinds of economical resources for gaining financial results from producing-distribution activity;
- Secondly, the process of organization through realizations of management functions must coordinate and control distribution activity.

Based on the laws and regularity of market development and denoting the direction of activity of all competitors of manufacturing as agreeable process, we'll make the following principles of distribution activity management of the corporations:

- The principle of justified choice of strategy of goods politics according to the main strategy of corporation development;
- The principle of orientation on the achievement of the final result of distribution which means the provision of needed level of corporation's profitability;
- The principle of adaptation to the demands of internal and external environment with the aim to provide the needs, to renovate close connection between the elements of distribution system and distribution conditions;
- The principle of systematic provision of resources of distribution activity anticipates the formation of close internal corporation effective connections of management activity of structural units, that take up distribution activity;
- The principle of monitoring of the market predicts constant research of the changes of the marketing conjuncture and needs of consumers;
- The principle of innovation predicts usage of leading innovation mechanisms not just in producing goods, increasing their demands and consumptive cost, but also the usage of innovation approach in formation of mechanisms of distribution activity [17, c. 135].

So that, as we think, distribution system of the corporation is the totality of subjects of distribution activity with some functional authorities, duties and indicated official and legislative connections and relations.

We suggest toobserve distribution system of «Zeus Ceramica», which is a private corporation, as an example. It was created according the constituent agreement on the 17.09.2002 and registered by the executive committee of Slovyansk city council on the 06.03.2003, registration number 10716. The basic document of corporation is Regulations. According to it the corporation acts followed the principles of full economic calculations and self-funding, responds its duties before partners, banks and budget according to the made agreements.

The founder of the corporation is: «Emilceramica S.P.A.», legal entity which is created and exists according to the legislation of Italy, certificate of registration № 01016070367 on the 25th of November, 1980, which is situated at Fiorano Modenese (MO) – Via Ghiarola Nuova n.29 – Italy, (further - Emilceramica).

Private Corporation was created according to the civil and economic code of Ukraine, the Law of Ukraine «About private corporations» and other legislative documents of Ukraine.

According to the classification of kinds of economical activity «Zeus Ceramica» takes up the producing of building materials out of clay that is production of ceramic tile and flagstone [10].

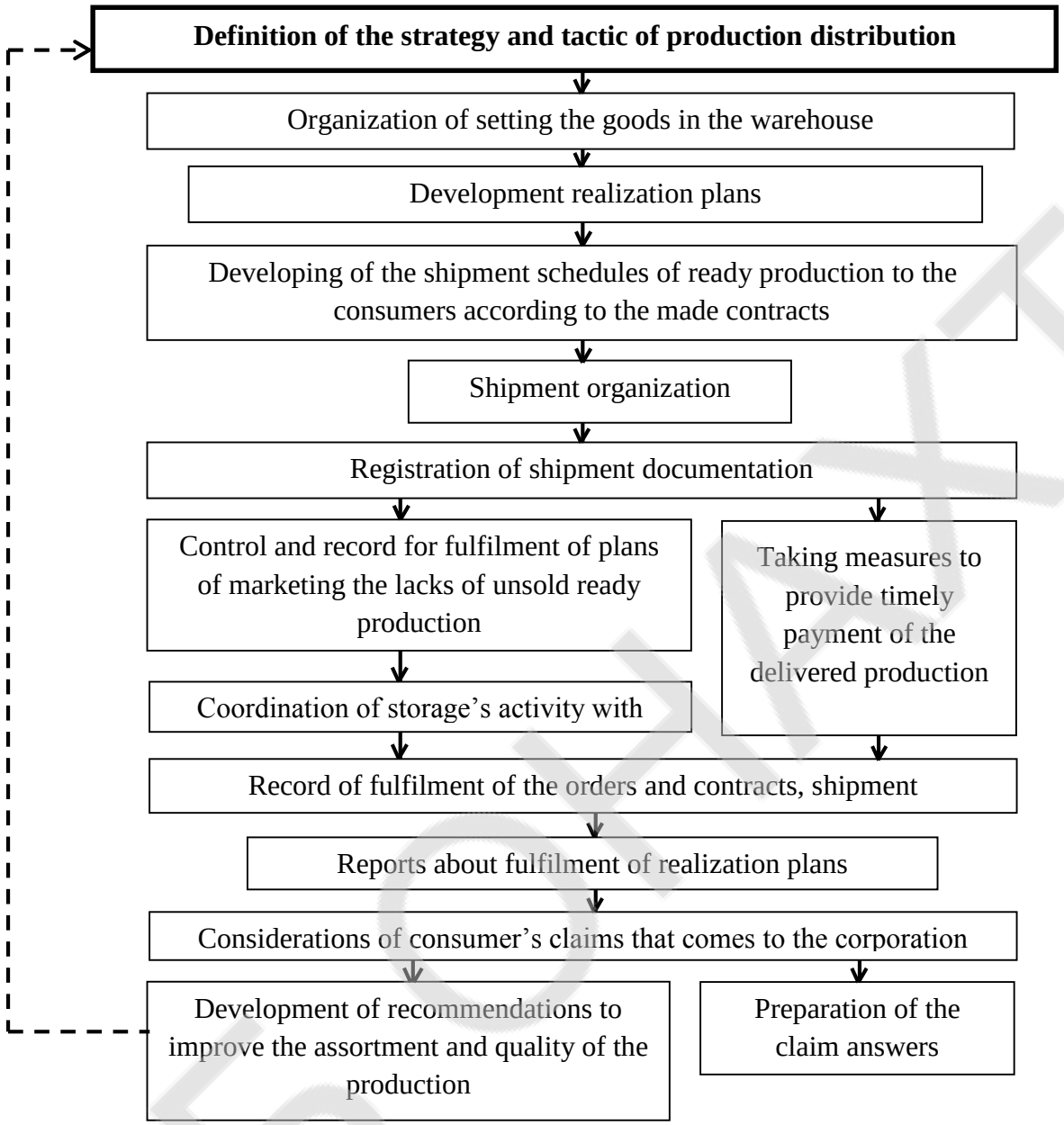
The corporation has being existed for 17 years on the Ukrainian market that gives a lot of advantages: availability of the circle of loyal consumers (long lasting base), the popularity of corporation because every design project is developed by leading Italian specialists, great experience of work in Ukraine and abroad, transaction external economical activity, availability of strong relationships with partners and organizations, availability of personal approach to every client, the system of personal managers, informational openness and transparency.

The process of management on the corporation is fulfilled thanks to the availability of line-functional organizational structure. Direct management accomplished by the line ruler, the structure of which consists of subdivisions and teams of workers. There also exists functional subdivisions in the corporation, which directly carry out the put questions, prepare the projects and plans, meanwhile helping the leading ruler.

All decisions come either through the leading ruler or through rulers of certain subdivisions within the authority.

The ruler of distribution department denotes the strategy and tactics of distribution the goods, develops recommendations about improving the assortment and quality of production, watching the goods are shipped to the consumers in time in demanded amount, provides the participation of the department in preparing the projects, perspective and annual plans of production and realization of production, search the demands on the production of corporation, watches the supplying of ready production to the consumers and denotes the needs in transport means, mechanized loading means, containers, working hands and shipment of ready production. [15].

Distribution managers take up organization and control shipment of ready production in time according to the concluded contracts, provide control for the fulfilment of consumer's order according to contract responsibilities in an established terms, for the amount of realized production, assortment, completeness and quality, the condition of supplying of ready production in the storages, accomplish the registration of conducting documents for shipment of the production to the consumers. The system of distribution activity of «Zeus Ceramica» is represented on the picture 1.3.



Picture 1.3 – The system of distribution activity of «Zeus Ceramica» [developed by the author]

The corporation «Zeus Ceramica» has wide net of distribution but nowadays has jut one storage in Slavyansk city in the Goncharna street, 7. Production is transported from this storage to the rest of the sales points in the other regions in Ukraine which are situated far from.

We've prepared the scheme with the logistic ways of distribution on the map of Ukraine. (pict. 1.4).

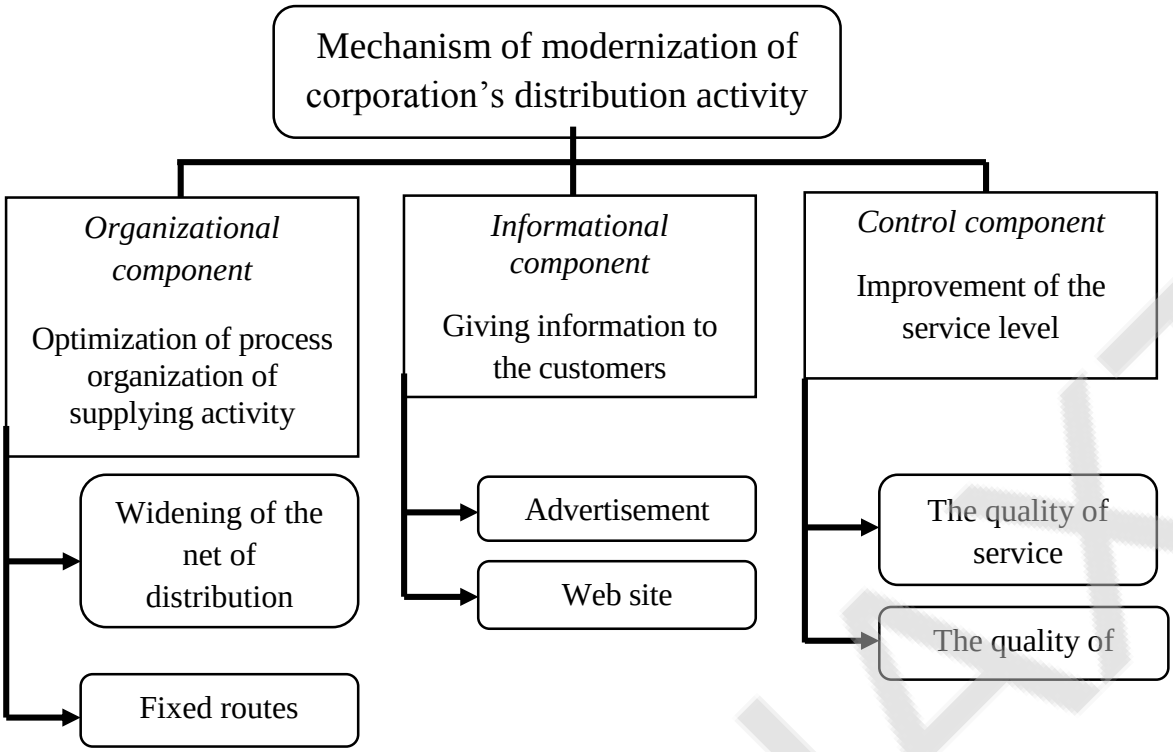
This scheme was made with the help of data from the table 1.2, which consists of the names of consumer-cities, their needs and transport costs.

Picture 1.4 – Logistic ways of distribution of corporation «Zeus Ceramica» in Slavyansk city [developed by the author]

Table 1.2 – The names of customer-cities, their needs and transport costs

	Customer	Needs, K. t	S, Km	Transport costs, K.UAH/t
1	2	3	4	5
1	Kharkiv	1 992	174	4 735,62
2	Vinnitsa	1 594	837	687,12
3	Dnipo	797	240	3 338,80
4	Zhytomyr	1 132	808	1 157,29
5	Zaporizhzhia	996	287	1 209,71
6	Kiev	2 988	675	5 782,42
7	Kropyvnytskyi	1 195	487	1 872,63
8	Lutsk	796	1 087	2 793,63
9	Lviv	2 386	1 209	2 487,17
10	Mykolaiv	1 195	701	2 690,40
11	Odessa	1 394	833	4 691,26
12	Poltava	1 129	337	682,28
13	Sumy	996	279	766,15
14	Kherson	598	629	1 393,59
15	Cherkasy	996	571	1 693,60
16	Chernihiv	1 394	733	3 432,35
Total:	**16**	**21 578**	**9 887**	**39 414,00**

After we've got acquainted and analysed distribution activity of «Zeus Ceramica», we proposed common scheme of modernization of corporation's distribution activity (pict. 1.5). It consists of organizational, informational and control component. Thanks to its successful functioning, the corporation will successfully develop and broaden the borders of distribution activity.



Picture 1.5 – Mechanism of modernization of corporation's distribution activity [developed be the author]

Instead, one of the key-indexes of success of distribution activity in the process of satisfaction of manufacturing and consumer demands, is the usage of transport logistics, which is irreplaceable component of logistical chain.

Major part of corporation's costs make transport costs which are needed to organize the delivery of goods, so the main attention should be paid to the question of lowing costs for transport-expeditionary services.

We think that all the corporations which are connected with transport-logistical ways should pay much more attention to solve questions of optimization. As well as the corporation can fulfil the put tasks more effectively with its help for less time and with less transportation costs.

As a rule, mathematical model of such tasks can be observed as a model of transport tasks of lineal programming. Transport tasks are the tasks of choice of optimal variant of goods logistics from the producer's point to the distribution point considering all real opportunities. Using of the calculation lets to diminish transport costs in many cases for 10-30%.

To solve typical tasks of optimization the use of electronic tables MS Excel. The advantage of this method is universality, flexibility and convenience in the process of calculation of the task of optimization that can make the work easy and save the time.

That's why, proceeding the analyse of activity and problems of «Zeus Ceramica», we consider reasonable to solve the optimization tasks with the help of MS Excel. We suggest looking over two variants of logistical task solving in details which are actual for the given corporation.

The first variant is the task that can be lead to solvation by the method of minimal cost. As the origin data we should set specific value to the parameters of corporation «Zeus Ceramica» (look table 1.3).

Table 1.3 – Volumes of supplying and usage and transportation cost of the goods between the storage and places of consumption

Place and volume of consumption/ place and volume of production	Kharkiv 1992 t	Poltava 1129 t	Dnipro 797 t	Zaporizhzhia 996 t
Storage №1 1359 t	4 735,00	728,00	3 228,00	1 210,00
Storage №2 1893 t	4 610,00	682,00	3 400,00	1 197,00
Storage №3 1665 t	4 800,00	650,00	3 338,00	1 253,00

According to the purpose-oriented function of this very transport task in a mathematical setting can be written in the following way:

$$4735x_{11} + 728x_{12} + 3228x_{13} + 1210x_{14} + 4610x_{21} + 682x_{22} + 3400x_{23} + 1197x_{24} + 4800x_{31} + 650x_{32} + 3338x_{33} + 1253x_{34} \rightarrow \min_{x \in \Delta\beta}, \quad (1.1)$$

where great number of admissible alternatives form the following system of limitations of the type of equality:

$$\begin{cases} x_{11} + x_{12} + x_{13} + x_{14} = 1359 \\ x_{21} + x_{22} + x_{23} + x_{23} = 1890 \\ x_{31} + x_{32} + x_{33} + x_{34} = 1665 \\ x_{11} + x_{21} + x_{31} = 1992 \\ x_{12} + x_{22} + x_{32} = 1129 \\ x_{13} + x_{23} + x_{33} = 797 \\ x_{14} + x_{24} + x_{34} = 996 \\ x_{ij} \geq 0, \forall i \in \{1,2,3\}, \forall j \in \{1,2,3,4\} \end{cases} \quad (1.2)$$

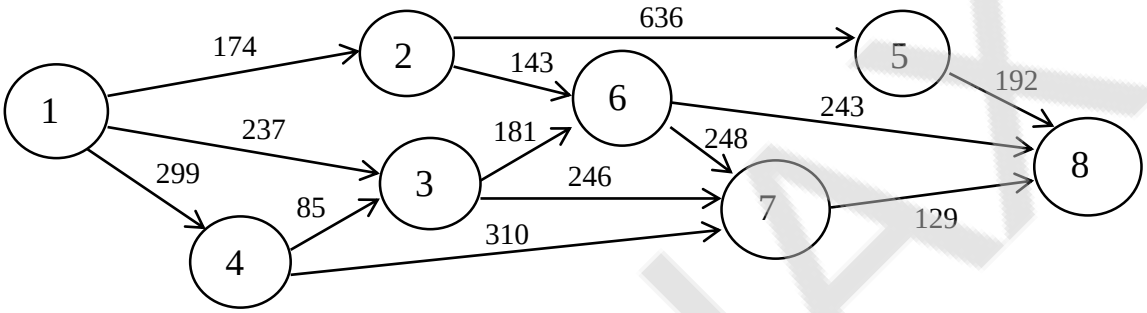
We should mention that the first three limitations of the given task respond to the common limitation according to which it is impossible to export more then they have, the next four limitations respond the common limitation according to which city-consumer cannot get more then needs. The last limitation tells about the fact we cannot get negative number of quantity of goods but otherwise total volume of consumption equals the sum of needs. Common limitations correspond the demands of balanced transport task because the existing quality of goods equals the needs of city-customers – 4914 t.

After calculation of MS Excel we'll get the qualitative solution which has the following view picture A. 1 (appendix A).

As the result of transport task solvation, optimal values by variable are found: x_{11} = 102, x_{12} = 0, x_{13}= 797, x_{14} = 660, x_{21} = 1890, x_{22} = 0, x_{23} = 0, x_{24} = 0, x_{31} = 0, x_{32} = 1129, x_{33} = 0, x_{34} = 536, to which the objective function values correspond: 13730644 UAH.

Analyse of founded solution shows us that we have to transport 102t of production from the first storage and 1890t from the second storage to fulfil the needs of Kharkiv, we have to transport 1129t of production from the third storage to fulfil the needs of Poltava, we have to transport 797t of production from the first storage to fulfil the needs of Dnipro, we have to transport 460t of production from the first storage and 536t from the third storage to fulfil the needs of Zaporizhzhia. The total cost of this very plan of transportation equals 13730644 UAH.

The second variant that is represented as the sum about minimal way in the graph [1; 6; 12], where we should choose the shortest route of movement passing different intermediate places. Let's observe the solvation of this task using the existing data of corporation «Zeus Ceramica» (Slovyansk). The corporation covers almost all the Ukraine with logistical ways, but, as an example we'll take a part of ways which unite 8 settlements. This district is represented as a scheme which is formally oriented connected graph, which is consists of 8 tops and 13 arcs (pict.1.6). Relevant settlements are represented on the scheme in the following way: Slovyansk – 1, Kharkiv – 2, Dnipro – 3, Zaporozhzhia – 4, Kyiv – 5, Poltava – 6, Kropyvnytskyi – 7 and Tcherkassy – 8.



Picture 1.6 – The scheme of logistic ways [developed by the author]

The length of the road between two settlements is represented in km and equals the value of the weight function for every arc which is showed next to the picture of corresponding arc in the graph. We have to find the route connecting the beginning point 1 – Slovyansk which is corresponded the top $1 = v_s$, with the ending point 8 – Tcherkassy which is corresponded the top $8 = v_t$, in such a way that the common length of the road was minimal.

Mathematical model variables of data of individual task about minimal way in an oriented graph are 13 variables: v_{12}, v_{13}, v_{14}, v_{25}, v_{26}, v_{36}, v_{37}, v_{43}, v_{47}, v_{58}, v_{67}, v_{68}, v_{78}. We attach to the review Boolean variable x_{ij}, which are interpreted in the following way. The variable x_{ij}= 1, if the arc $(v_i; v_j)$ is included to the route of minimal length and x_{ij}= 0, otherwise. Then, mathematical formulation of the observed personal task about minimal way in the graph can be written in the following way:

$$174x_{12} + 237x_{13} + 299x_{14} + 639x_{25} + 143x_{26} + 181x_{36} + 246x_{37} + 85x_{43} + 310x_{47} + 192x_{58} + 248x_{67} + 243x_{68} + 129x_{78} \rightarrow \min_{x \in \Delta\beta}, \quad (1.3)$$

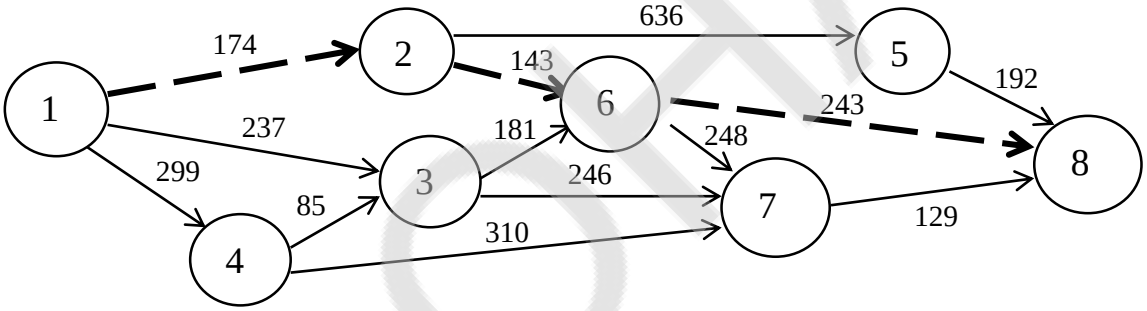
where the set of acceptable alternatives $\Delta\beta$ form the following system of limitations of the type of equality and inequality:

$$\begin{cases} x_{12} + x_{13} + x_{14} = 1 \\ x_{58} + x_{68} + x_{78} = 1 \\ x_{12} - x_{25} - x_{26} = 0 \\ x_{13} - x_{36} - x_{37} + x_{34} = 0 \\ x_{14} - x_{34} - x_{47} = 0 \\ x_{25} - x_{58} = 0 \\ x_{26} + x_{36} - x_{65} - x_{68} - x_{67} = 0 \\ x_{67} + x_{37} + x_{47} - x_{78} = 0 \end{cases} \quad (1.4)$$

Let's note that these variables x_{ij}, to which weighting function of arcs h is undetermined and equal 0, are not included to the mathematical formulation of the task (3) and (4). To solve this task with the help of MS Excel we'll arrange original data on the page (pict. B.1, appendix B) and will use superstructure «the search of solution» (pict. B.2, appendix B).

After performing calculations by MS Excel the qualitative solution will be received. The result of task solvation in the minimal way in the graph is optimal value of varieties which is found $x_{12} = 1,\ x_{26} = 1,\ x_{68} = 1$, another varieties equal 0. To the founded optimal solution correspond the value of the objective function $f_{opt} = 560$.

The analyse of the founded solution shows that minimal way in the original oriented graph connect the top 1 – Slovyansk with the top 8 – Tcherkassy include the following arcs (1.2), (2.6), (6.8). So, the founded optimal route of moving from starting point Slovyansk to the final – Tcherkassy includes consistent moving between neighbour settlements: from Slovyansk to Kharkiv, from Kharkiv to Poltava, from Poltava to Tcherkassy (pict. 1.7). moreover, the common length of the way will be minimal and equal 560 km.



Picture 1.7 – Oriented connected graph of logistics ways with optimal way

The storage in Slovyansk provides the needs of customers of East region of Ukraine with the production of corporation. The cities of this region are located not far from the storage so the corporation doesn't have large transport costs.

The central region of Ukraine provides maximum volume of distribution the production of the corporation and large turnover. In this region, Kiev particularly, large wholesale consumers of the corporation's production are situated, a great number of shopping hypermarkets and shops which sell ceramic production, different kinds of tile, mosaic and so on.

The territory of Western Ukraine is the farthest from the storage place, the delivery of production to the cities of western Ukraine needs the largest transport costs.

So, we suggest, as an alternative or as an addition to the usage of optimization tasks with the help of MS Excel in distribution activity of «Zeus Ceramica» to locate additional distributional storage in Kyiv. This solution can save transport costs and improve the indicators of logistical principles – the delivery of production to the consumer in certain place in time with minimal transport costs.

Also, to improve the organization of distribution activity we recommend to interrogate the clients permanently about periodicity and time of production delivery and on the ground of this data to plan fixed routes of delivery to the key-clients. It will

give an opportunity to load exactly the truck, will reduce transport costs and the client will know the exact time of delivery.

To optimize the danger and to use full opportunities of corporation it is necessary to inform the consumer with the help of advertisement and web-site about the corporation's events (every actions or new product appearance), to keep the existing level of prices and accent the attention of consumer on the service quality and production quality, to use actions and discounts more frequently, to widen the net of production distribution.

Conclusions. Today it is necessary to pay much attention to the process of organization of distribution activity for more effective work of corporation and receiving good indexes of activity in general. In terms of increased level of competition on markets and increased consumer's requirements to the production quality and service, decreased consumer's paying ability and demands it is needed to introduce effective working system for organization corporation's distribution activity, because today almost every corporation asks actual question and puts the tasks of optimization and improvement of distribution activity and decrease the level of costs. «Zeus Ceramica» is the corporation which develops, increases the number of consumers every year, comes to the new markets and improves the quality of production and service.

Getting acquainted and analysed its work we proposed the mechanism of distribution activity modernization. One of the main propositions is an implementation of optimization tasks with the help of MS Excel. Thanks to the tasks of minimal cost methods we can calculate optimal and economically profitable plan easily and fast, the quantity of production supplying to the consumer in conditions of having some storages. But unlike the minimal way task in the graph, we cannot calculate the shortest way without turning back twice to the same point. Minimal way tasks in the graph based upon finding optimal supplying ways with the aim to save costs and time.

The alternative proposition to minimize transport costs is the definition of optimal location of additional storage of distributional centre in Kyiv which can be possible to move production to the West and Central regions of Ukraine from.

The improvement of distribution activity organization will let to plan rationally supplying of ready production on the corporation's storages in the future, to deliver production to the consumers as fast as possible with minimal transport costs and to improve the distribution activity organization.

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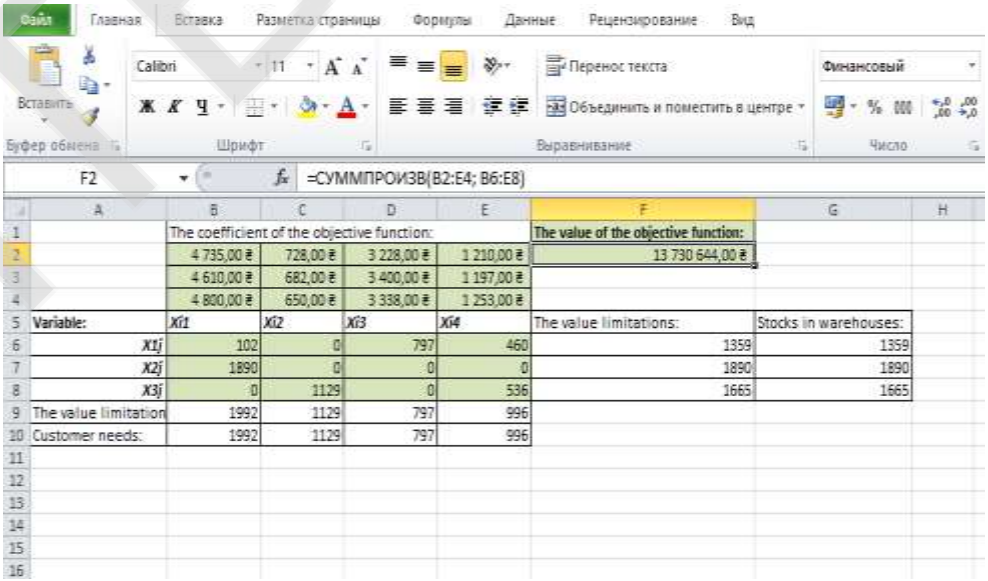
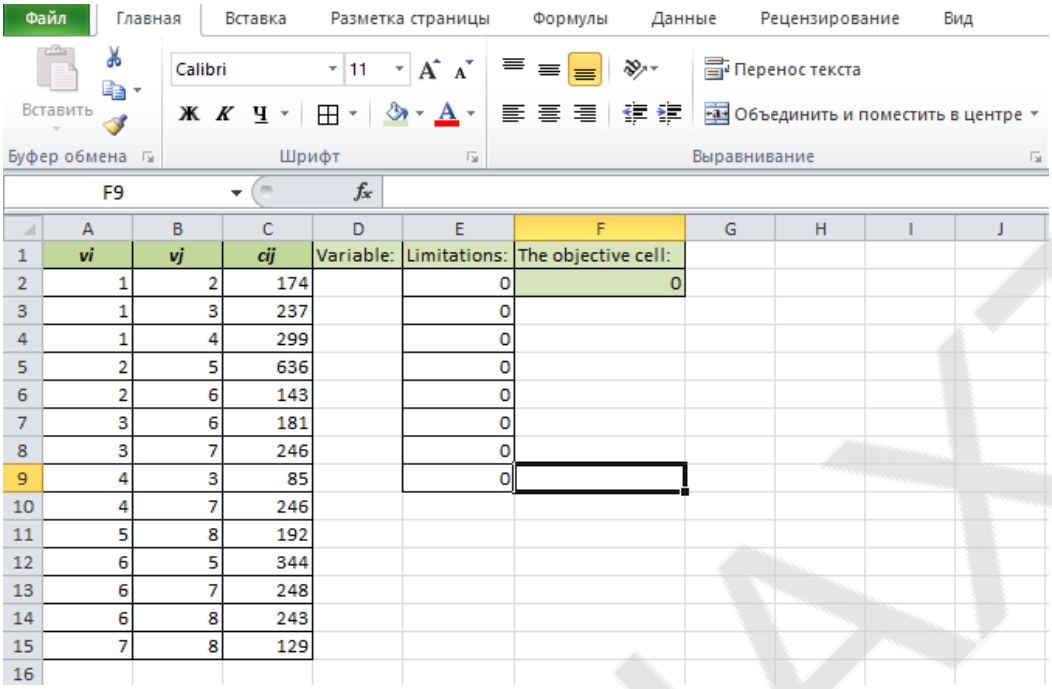
APPENDIX A



	A	B	C	D	E	F	G	H
1		The coefficient of the objective function:				The value of the objective function:		
2		4 735,00 ₴	728,00 ₴	3 228,00 ₴	1 210,00 ₴	13 730 644,00 ₴		
3		4 610,00 ₴	682,00 ₴	3 400,00 ₴	1 197,00 ₴			
4		4 800,00 ₴	650,00 ₴	3 338,00 ₴	1 253,00 ₴			
5	Variable:	Xi1	Xi2	Xi3	Xi4	The value limitations:	Stocks in warehouses:	
6	X1j	102	0	797	460	1359	1359	
7	X2j	1890	0	0	0	1890	1890	
8	X3j	0	1129	0	536	1665	1665	
9	The value limitation	1992	1129	797	996			
10	Customer needs:	1992	1129	797	996			
11								
12								
13								
14								
15								
16								

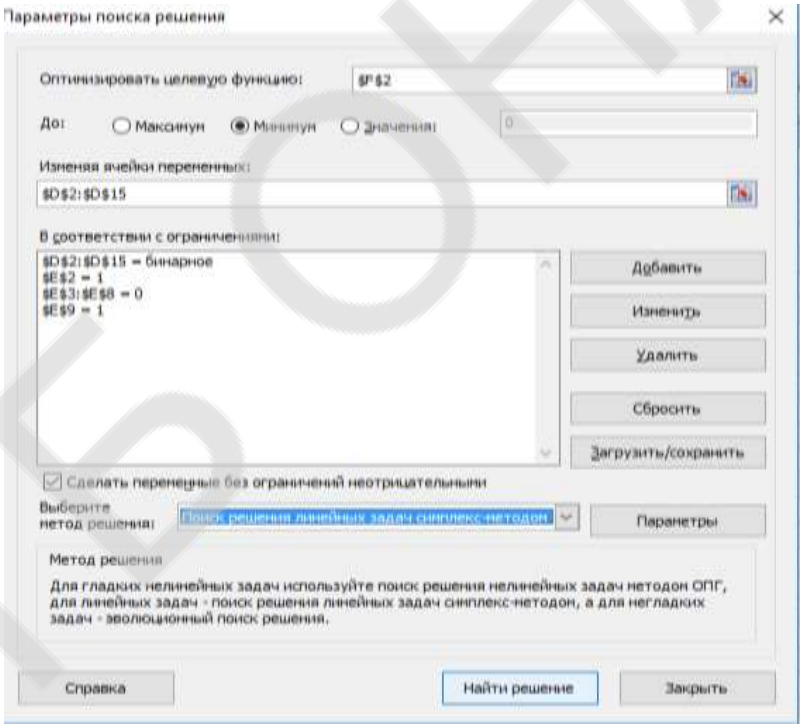
Picture A.1 – Quantitative solution after fulfilment of calculations by MS Excel

APPENDIX B



	A	B	C	D	E	F	G	H	I	J
1	*vi*	*vj*	*cij*	Variable:	Limitations:	The objective cell:				
2	1	2	174		0	0				
3	1	3	237		0					
4	1	4	299		0					
5	2	5	636		0					
6	2	6	143		0					
7	3	6	181		0					
8	3	7	246		0					
9	4	3	85		0					
10	4	7	246							
11	5	8	192							
12	6	5	344							
13	6	7	248							
14	6	8	243							
15	7	8	129							
16										

Picture B.1 – Original data for fulfilment the task of minimal way in the graph



Picture B.2 – An example of use superstructure «The search of solution» for the task of minimal way in the graph

DEVELOPMENT OF PROMOTION HYBRID TECHNOLOGY POLICY OF CARS AS AN SOCIAL-ETHICAL MARKETING ELEMENT

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Supervisor: Boienko Olena
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Abstract*. The relevance and significance of the promotion of hybrid technology in general and for Toyota in particular is explored in the work. In the course of the analysis, the main advantages and disadvantages of vehicles with alternative fuels sources (electric vehicles and hybrids) were been formed, and tendencies of increase of potential consumers for them in the automobile market were revealed. In addition, the need to promote hybrid technology has been proven to preserve the environment, minimize the use of non-renewable fuel, and save customers` budgets.*

We have proposed and proved the effectiveness of, in our opinion, the algorithm of distribution policy. We have proposed and proved the effectiveness of, in our opinion, the algorithm of distribution policy. The strategy consists of the following stages: a comparative analysis of demand for hybrid cars and electric cars, a SWOT analysis and the model of Porter's 5 forces; description of the general and target portrait of car owners of hybrids; identifying points of contact with customers at different stages of the life cycle; development of basic point ideas for promotion and effective digital-tools.

The object of the study is Toyota hybrid cars. The subject of the research is the management of the promotion of hybrid cars in the market of Ukraine.

General and special research methods were used in the work, namely: methods of analysis and synthesis; methods of statistical analysis of indicators of economic activity of enterprises, a method of transition from abstract to concrete (in the development and justification of the algorithm of promotion strategy), as well as methods of economic analysis (tabular, graphical, comparison).

The results of the study were successfully tested in the professional scientific publication «Modern Economics».

Keywords*: social-ethical marketing; hybrid cars; promotion policy; hybrid technology; trust "Toyota".*

I. Introduction.

The global problems of modern times related to pollution, climate change, constant rise in fuel prices - all this has led to new directions in the development of innovations, including in the automotive industry. Indeed, companies focused on both their image and innovation have quickly taken care of energy conservation and fuel economy issues. Against the background of the continuing strengthening of environmental regulations in industrialized countries and, as a consequence, improvements to the series production of vehicles, studies are ongoing on the replacement of energy sources of vehicles. Among the possible options to date, the most promising are the projects of an electric vehicle and a car with a combined power unit, that is, hybrid cars.

In the modern conditions, the question about the level of competitiveness of the enterprise and its products is rapidly developing. As is known, the level of competitiveness of the enterprise depends, including, on the quality of products, its consumer properties. The competitiveness assessment provides an opportunity to identify both strengths and weaknesses. In turn, it is allows the company to strengthen its market position, develop a strategy of behavior in the market in a timely manner, increase the number of consumers and the volume of sales.

II. Analytical review of references.

The issue of promoting hybrid technology as an element of social-ethical marketing has not been thoroughly addressed. Some theoretical aspects are considered in D. Bowman [1], E. Viardot [2], R. Hell [3] and others. It should be noted, that practical recommendations and promotion strategy for Toyota hybrids have not been considered at all by either domestic or foreign scientists.

III. Object, subject and methods of research.

The object of the study is Toyota hybrid cars. The subject of the research is the management of the promotion of hybrid cars in the market of Ukraine.

General and special research methods were used in the work, namely: methods of analysis and synthesis; methods of statistical analysis of indicators of economic activity of enterprises, a method of transition from abstract to concrete (in the development and justification of the algorithm of promotion strategy), as well as methods of economic analysis (tabular, graphical, comparison).

IV. Research results.

In the contemporary context, road transport is certainly an integral part of the life of the population. In addition to the undeniable amenities that a car creates in a person's life, obviously, it is the most common means of transportation and meets certain specific needs, such as the thirst for travel, knowledge of the world, and more. This has led to a rather significant increase in car sales in Ukraine over the last three years (Fig. 1).

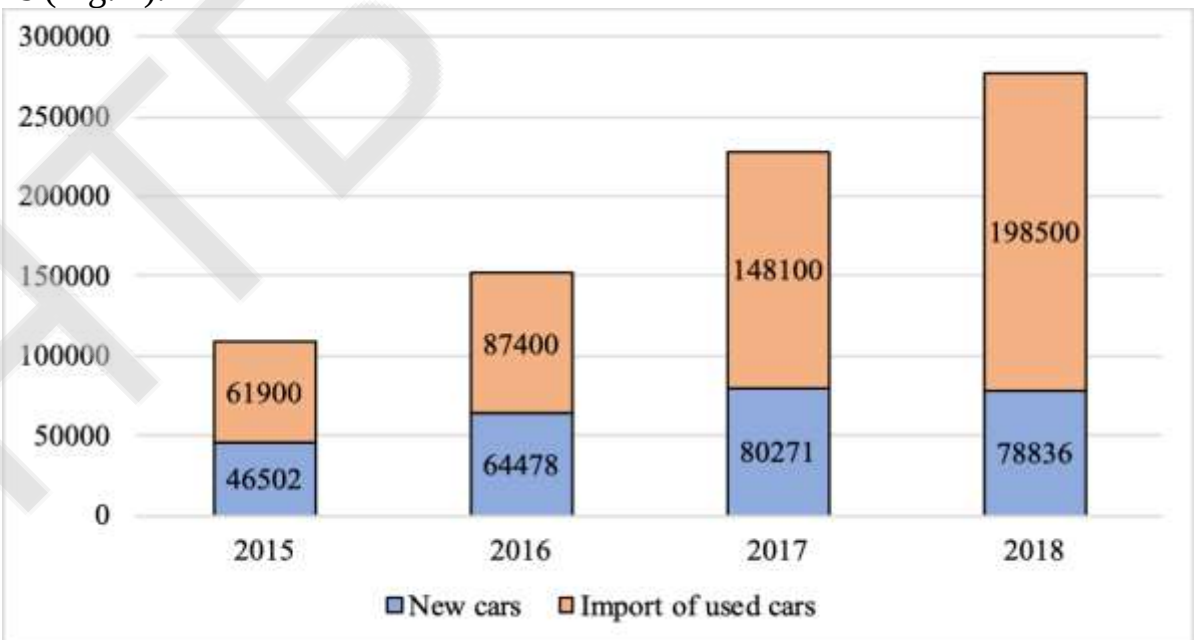

Fig.1 Sales dynamics of new passenger cars and imported used cars in Ukraine during 2015-2018 [4]

In 2018, annual sales of new cars in Ukraine decreased by 2% due to increased imports of used cars.

By the number of cars per thousand people in the list of countries, Ukraine was far from the first place. According to 2016, our country ranked 71st out of 185, in other words, 202 cars account for one thousand inhabitants (statistically every fifth Ukrainian could have a car) [5].

If you analyze the sales volume of new passenger cars in Ukraine in the last two years, then we can conclude, that Toyota is a leader in sales, indicating a high level of awareness and customer loyalty to this brand (Table 1).

Table 1

Sales of the most successful passenger car brands in Ukraine 2017-2018

Brand	Sales, 2018	Share of sales, 2018	Sales, 2017	Share of sales, 2017	Deviations 2018/2017
TOYOTA	9631	12,29%	9515	11,85%	1,22%
RENAULT	8691	11,09%	8652	10,78%	0,45%
VOLKSWAGEN	6185	7,89%	6082	7,58%	1,69%
SKODA	5393	6,88%	5639	7,02%	-4,36%
NISSAN	5190	6,62%	4250	5,29%	22,12%

**developed by the authors on the basis of [6]*

The positive aspects of personal road transport include:

- speed and convenience of movement;
- increased mobility;
- maneuverability;
- opportunity to travel;
- private business, etc.

There are also a number of disadvantages, namely:

- high maintenance costs;
- danger of movement;
- highway restarts and more.

But there is another important drawback – causing great harm to the environment. Environmental pollution occurs at all stages, from the production of the car and its operation to the recycling process, both the cars themselves, and the fuels, oils, and so.

During the same operation, large quantities of gases, nitrogen oxides and sulfur are released into the atmosphere, which in turn are damaging to the environment. In 2016, Ukraine ranks first in the world in terms of deaths from air pollution [7].

An important drawback is also the high cost of cars, that run on gasoline. The presence of all these shortcomings led to the need for creation and improving new cars, which in the first place, will be more environmentally friendly and less costly.

Recently, the idea of ending 100% use of natural resources has become more common, non-renewable resources and transition to alternative types of resources. We are talking about electric and hybrid cars.

An electric car is a car that runs on one or more engines powered by a standalone power source (batteries, fuel cells, capacitors, etc.). Without a permanent place with a

three-phase power outlet, it is very uncomfortable to use an electric car, and because of the lack of car chargers at gas stations movement in some regions of Ukraine is limited or impossible.

In turn, the hybrid machine has two engines: gasoline and electric, working at the same time. The motor is responsible for starting the car and driving at a low speed of 40-50 km/h, and when accelerating the car to higher speeds, the internal combustion engine starts to work. That's why most manufacturers are leaning towards developing hybrid models, which, on the one hand, solve an environmental problem, on the other – absolutely independent of the development of charging infrastructure [8].

The main advantages of hybrid cars that promote their distribution, according to the buyers themselves:

1. Low fuel consumption when operating in urban mode and environmental friendliness of the car. It is established that the average fuel consumption of hybrid models does not usually exceed 6.5 (4.8) l (suburban) traffic mode. For all-wheel drive cars – 10.6 (7.6) l / 100 km.
2. Striving for advanced technologies, innovative solutions. Most buyers buy hybrid machines, aware of their involvement to the modern technical achievements of the automotive industry. The design of the hybrid system is fundamentally different from a traditional power plant.
3. Drivability and high comfort: hybrid cars have a wide range of options as standard set – such as navigation system, air conditioning, front and rear airbags, automatic inclusion of windshield wipers, power steering, system of course stability, keyless entry in passenger compartment, options for winter operation, etc.
4. High reliability. Studies of operating conditions have allowed to determine the patterns of change in the technical condition of the hybrid car. The probability of any malfunction of the hybrid transmission when running 100,000 km is only 15%. For comparison, in a typical car power plant, this value approaches 100%. The life of expensive elements of a hybrid transmission is 8-10 years. Most hybrid cars manufactured before 2000 are operated without major problems. High-voltage battery breakdowns are mainly caused by misuse of the vehicle (such as driving without gasoline), the case of premature battery failure due to aging is very rare [9].

Problems preventing the spread of hybrid cars:

1. The cost of hybrids. High-voltage battery and other parts of the power plant increase the price of the machine by 30%.
2. The used vehicles are not well-serviced by leading car manufacturers. As a result, service station staff are unable to provide quality service and repair [9].

Hybrid machines have gained considerable popularity in Europe over the last 10 years, their sales make up about 50% of the total all cars sales. In Ukraine, this rate is low and is 4.5% of the total number of registered cars in 2018 (Fig. 2).

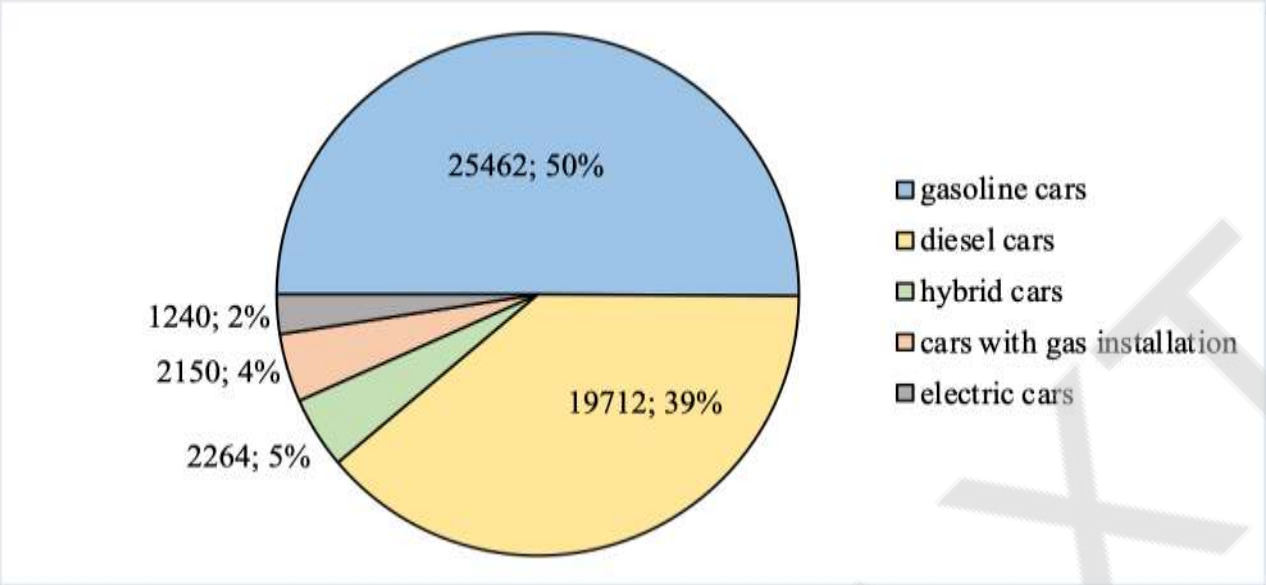

Fig. 2 Number of registered cars in Ukraine in 2018 [4]

In 2018, 3504 electric and hybrid machines are registered in Ukraine. Anyway, the total number of registered electric and hybrid cars in Ukraine reached 15 696 units. At the same time, in August 2018, Ukrainians registered nearly 1,000 cars of both types. Dynamics of electric vehicles are negative – they were 8% less than in July (564 cars). Hybrids over the same period "increased" by more than 14% (Appendix A). The average age of Ukrainian electric cars is higher than that of hybrid cars – 4,2 years versus 2,9 years. The largest number of electric vehicles and hybrids is registered in Kyiv – 4647 units [9].

Top 3 Most popular electric cars by number of registrations in August:

- Nissan Leaf - 371 units;
- BMWi3 – 27 units;
- Tesla Model S – 21 units.

Top 3 Most popular hybrids by number of registrations in August:

- Toyota Rav-4 Hybrid – 113 units;
- Chevrolet Volt – 65 units;
- Toyota C-HR Hybrid – 37 units.

According to the data presented in Appendix A, it is determined that Toyota is the leader among hybrid cars in the Ukrainian market. Additionally, Toyota is also a leader in this segment in Europe through its experience and practice. The first Toyota Prius hybrid was launched in 1997. While environmental and fuel economy issues were not at the forefront of the car's competitive advantage, and the profits from the sale of hybrid cars didn't cover the cost of their production, the company worked at a loss. And yet it was a bold move, calculated for the long-term perspective that justified itself. And in 2018, the company released 2 more models of hybrid cars - RAV4 and C-HR.

To maintain its leading position in the hybrid segment, companies need to improve their Toyota RAV4 hybrid technology promotion policy, because this model has the best sales indicators. It is a front-wheel drive / all-wheel drive cozy, spacious and comfortable for both city and long-distance travel. Positioning is a car for family people.

Given the growing competition in the hybrid segment and their popularity among Ukrainians, Toyota needs to step up its strategy of promoting hybrid technology on the example of Toyota RAV4 Hybrid. We have developed an effective, in our view, algorithm for the distribution policy of this car model, which consists of the following steps:

1. Comparative analysis of demand for hybrids and electric cars, as the latter are the main competitors of the hybrid segment.

2. Assessing the strengths, weaknesses, opportunities, and threats of Toyota hybrid technology (SWOT analysis) and given the strength of competition in the market.

3. Description of the overall and target portrait of hybrid car owners as a whole and the selected promotion model, in particular.

4. Identify points of contact with customers at different stages of the life cycle.

5. Developing basic point ideas for promotion and effective digital tools.

During the analysis of demand for hybrid machines in Ukraine on the Internet the following peculiarities were detected using the Google Trends app:

1. Consumer interest in hybrids is growing, but electric cars are ahead of them by the number of requests (Fig. 4). Both categories are characterized by seasonality – peak requests are in the winter months.

Fig. 4 Dynamics of queries and hybrids of Google users in Ukraine [11]

2. Demand of categories for hybrid and electric car is increasing every year. During 2017-2018, the search for hybrids has increased more than 2000 times (Fig. 5).

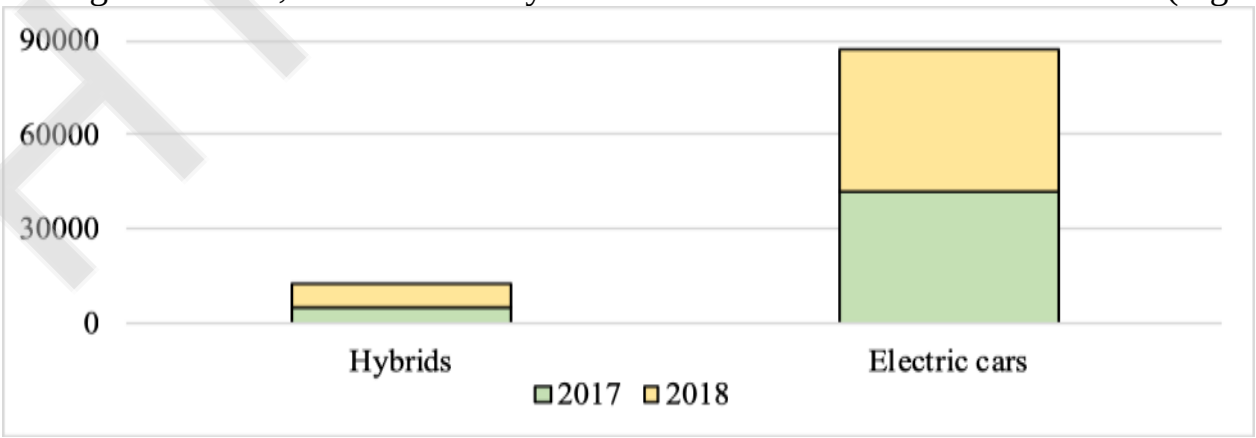

Fig. 5 The number of requests by category «hybrids» and «electric cars» in Ukraine [11]

This information interest arises from the annual increase in gasoline and diesel fuel prices (Fig. 6). Logically, as the number of cars on the road increases, the number and duration of congestion increases, and therefore fuel costs are rising. In this case, the advantage of hybrid cars is obvious, because they consume electricity in urban congestion and fuel at low cost in the highways.

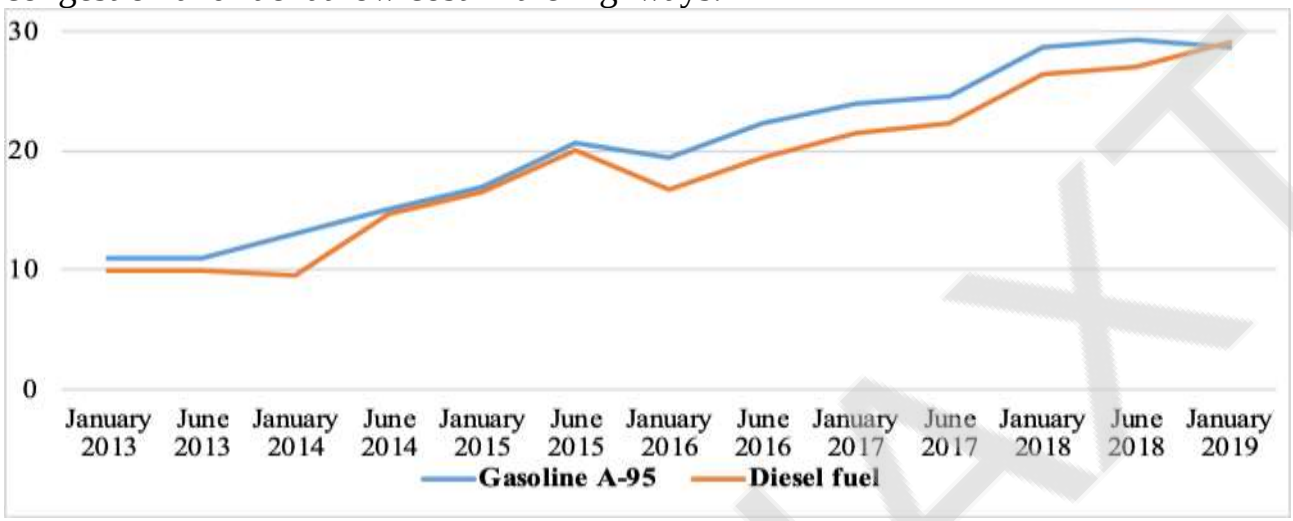

Fig.6 Dynamics of average fuel prices during 01.2013-01.2019 [12]

According to the data presented in Fig. 6 we can see that users' interest in electric cars is almost 6 times higher. This situation is due to a number of problems:

- consumers are poorly informed about hybrids and confused with electric vehicles;
- there are no beneficiaries such as in Europe (example, tax exemptions);
- the eco-fashion in the minds of Ukrainians not yet sufficiently formed;
- there are many myths (doesn't start in winter, can blow off in the middle of the city road, etc.).

So, to raise awareness of electric vehicle supporters, it is necessary to formulate the significant advantages and features of hybrid cars. To do this, we conducted a SWOT-analysis of Toyota hybrid technology (Table 2).

The Table 2 concludes that the strengths and opportunities are far greater than the weaknesses and threats.

The main strength is efficiency, which is reflected in the same cost of gasoline in the city (approx. 8 l / 100 km) and electric motors in urban congestion (0 liters of gasoline / 100 km compared to conventional gasoline engines consuming 15 l / 100 km).

Another strength is design. If you consider the design of Toyota RAV4 HYBRID, this car is suitable for people aged 35 years. Restrained lines, spacious passenger compartment and multifunctionality. It is possible to ride such a car on a family trip with comfort.

Because SWOT analysis looks at the market situation as a whole and does't concretize specific cases, it is advisable to use Porter five forces analysis. Model allows you to discover the level of economic competition and develop a strategy to minimize weaknesses. For Toyota hybrid technology, this analysis is important, as competition from major industry players such as Volkswagen, General Motor, BMW, Toyota, Mitsubishi is growing significantly may lead to the loss of leadership in the hybrid market.

Table 2

SWOT-analysis of Toyota hybrid technology

Strengths	**Weaknesses**
1. Cost effectiveness. Fuel economy in city driving / in traffic jams. 2. The design is much better than the main competitors in this segment. 3. Reducing the risk of uncontrolled charging. Compared to electric cars, the consumer may forget to charge the car and not start. With hybrids, this problem is solved by switching to a conventional gasoline engine and no need to charge the electric motor. 4. Saving. For Ukrainians who have less purchasing power, it is quite profitable to save on fuel, which is growing monthly. 5. Guarantee. Toyota has been producing hybrid cars for 20 years, then this indicates a high level of reliability and provides a great warranty on hybrid systems (5 years).	1. High cost of cars compared to gasoline 2. Less power 3. More maintenance works and repair costs. 4. Low consumer awareness about hybrid cars
Opportunities	**Threats**
1. Increase your target audience through the work of innovators and super innovators. 2. Environmental promotion. 3. Unstable financial situation promotes redistribution of Ukrainians' preferences for hybrid cars, which they see as an economic decision 4. Positive plotting experience of the association "hybrid technology = Toyota", can be used to promote these cars in other markets in Europe.	1. Increase in used imported hybrid cars from Europe and the USA. 2. Fierce competition with the electric car market

**developed by the authors on the basis of [13]*

Therefore, Toyota must consider the following 5 competing forces:

– Competitor analysis (High impact): the car market is competitive because of growing consumer demand, as well as the increasing pace of urbanization. Toyota's main competitors in the hybrid segment, such as Volkswagen, Mercedes, General Motors, Ford, they are trying to be the best service provider [1]. The hybrid car segment is considered to be the largest value-added market for consumers, taking into account fuel consumption.

– Threats of new competitors (moderate degree of influence): threats to new entrants to the automotive industry are significantly low due to high capital requirements and stringent industry requirements. On the other hand, new firms are not included in the hybrid segment as full-fledged manufacturers, but as manufacturers and suppliers of individual parts [2]. This reduces contact with existing business customers and creates opportunities for joint operations of new manufacturers.

– Substitute product threats (Strong impact): the market distinguishes hybrid cars from other manufacturers, such as the Volkswagen Golf Hatchback and Nissan

Leaf almost similar in characteristics but with less fuel consumption. These factors indicate the need for more intensive innovation in the work process of firms.

- Trading power of consumer (low impact): although the number of firms operating in the hybrid segment is increasing, but the market power of consumers remains minimal. This is related to the value of Toyota products and high switching cost of the electric motor [1].
- Trading power of suppliers (moderate degree of impact): the sales force of suppliers is considered to be moderate due to the specific needs of car companies. Requirements for quality standards and product compatibility are paramount for companies, allowing suppliers to support the pricing process [3]. However, organizations such as Toyota have reduced the bargaining power of suppliers, by implementing vertical integration into their supply chain [2]. In addition, a high level of equity also reduces the bargaining power of suppliers.

Therefore, an important recommendation for Toyota hybrid technology is to maximize the company's benefits for its value-added manufacturing process, that is, optimizing the supply chain management process, which needs to be constantly improved and adapted to the changing business environment. First of all, it is necessary to create innovative aspects in hybrid cars, keeping the price of products, because consumers appreciate hybrid cars since of their low fuel consumption and the ability to use gasoline for fast driving.

According to the analysis, we can describe a general portrait of current owners of Toyota RAV4 HYBRID cars, which looks like this:

- Innovators and super innovators who fight for the environment and like spacious cars.
- Typical hybrid consumers are often initiated in the topic of technology and mainly works in the field of information technology.
- These car owners like to keep abreast of technological progress, they read and are interested in innovative innovations.
- It is very meticulous and thoughtful in making important purchasing decisions. They like exploring all the available sources of information pertaining to the product.
- Cars are chosen mainly from rational characteristics, such as economy, reliability, guarantee, availability of maintenance, practicality.

If we summarize and detail the characteristics of the above hybrid car owners, the typical consumer Toyota RAV4 HYBRID can be characterized as follows:

- men, women, aged 30-45, most often domestic and with children;
- often buy a car for a woman as the second car in the family;
- what is important to the consumer is reliability, fuel economy, versatility;
- basic customer needs from the car – a reliable, practical car for both the city and out of city. Spacious – you can fold things up for kids but not as big as other Toyota SUVs.

As the target audience of hybrid technology carefully selects cars, then they go through different stages of the customer life cycle (Appendix B). During these stages,

consumers are actively analyzing, comparing analogues, watching video reviews and read comment of their future transport (Fig. 7).

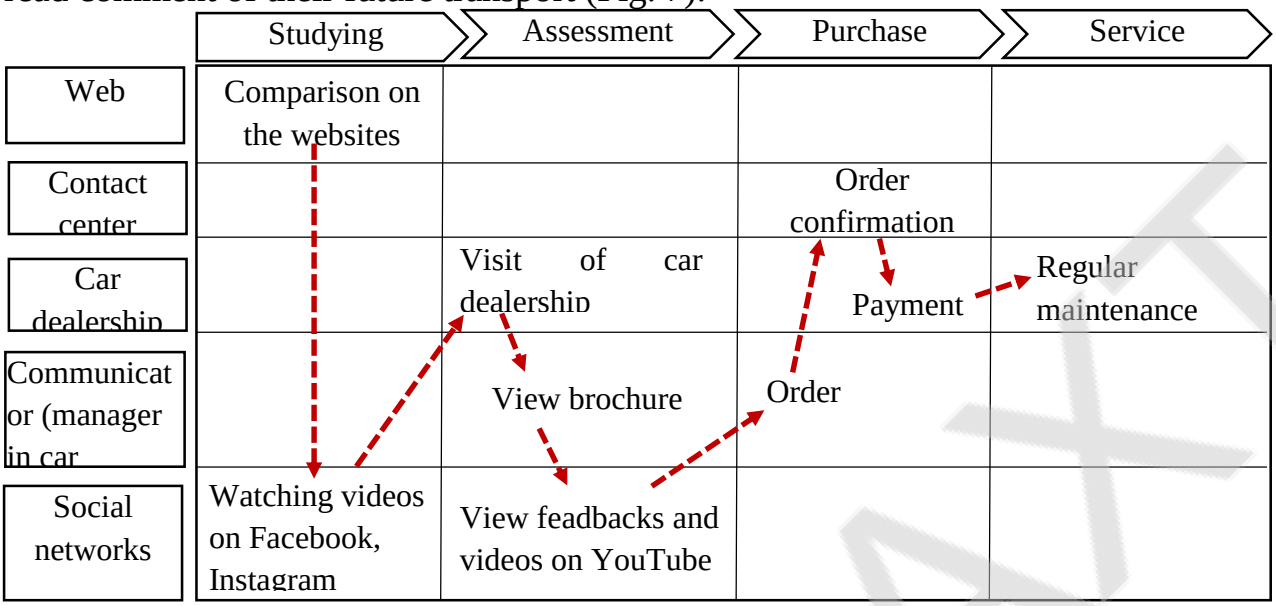

Fig. 7. Touchpoints in different stages of the life cycle of customers

**[is developed by the author on the grounds of 6]*

So, we can see that the first step is to collect and analyze market information, because just then the buyer becomes inclined to make the purchase decision, in our case, a Toyota RAV4 HYBRID hybrid car. Next, we, as marketers, need to persuade the customer to make the purchase. That is why it is advisable for the company to advertise on major consumer touch points, in particular:

- Google contextual ads on automotive sites that have the largest Ukrainian audience.
- These include auto.ria.com (150-200 million people a week), rst.ua (45-50 million people), ab.ua (2-2.5 million people), automoto.ua (3 -3, 5 million people), avtosale.ua (500 thousand people - 1 million people).
- Payment of for articles-reviews and recommendations for Toyota RAV4 HYBRID hybrid car on such popular portals as: Avtopodbor UA (1.71 thousand people), AutoUkraine (38 thousand people), CarPoint (5.2 thousand people), Pavel Starkov Blog (12.1 thousand people), Millenium (159.5 thousand people), Sumy Racing Team (180 thousand people);
- collaboration with well-known bloggers on social networks Instagram and Facebook.

In the second stage, it is necessary to convince the client of the correctness of his decision to buy a hybrid car. This can be achieved through direct marketing through contact centers and sales managers. The main criterion in the field of car sales is the proper and professional advice of managers. According to the results of our focus group (150 people), the decision to buy a car from a client is 52.4% formed by a car dealership consultant, another 9.4% is formed by salon information campaigns, the 8.7% speed of paperwork and only 4.7% on the purchase of an auto-client stimulate additional gifts. The key ideas for promoting Toyota RAV4 hybrids are:

1. Passing the test drive.
2. Discount for service and after-sales service.

3. Advertising to bloggers who are thought leaders in Ukraine. These should be both female and male videos.

4. Conducting raffles to promote hybrid technology. As an idea, create a banner with a summary of hybrid technology, and you will play on souvenirs of companies among those who share it.

5. Promotion of Toyota RAV 4 hybrid technology using the following data:

- "Driving a car in the city is not cheap pleasure".
- "We care about nature together".
- "The family will say "thanks" for a quiet holiday".
- "Be trendy with Toyota hybrid cars".
- "Economical in the city, energetic out of city".

In view of the above points, we have developed the main digital tools, namely:

1. CEO-optimization and site design. This is the first thing a potential customer faces when choosing a car, so the site should be easy to use and stylish in terms of color. The main thing that should be – the price and specifications in table format.

It is very easy to evaluate the content of a site: we need to be questioned focus groups on children 8-12 years and adults 60-70 years. If they understand everything, then the designers worked for glory. SEO-optimization is required for the Toyota site to be first highlighted in a banal search query ("тойота рав4 гібрид").

2. Advertising on television. Since hybrids are in high demand from locals, advertising must be appropriate. Advantages of traffic in urban traffic and the rhythm of the city – here's what future hybrid owners need. In addition, you do not need to specify vehicle specifications, just list the main features and benefits.

3. Approval of community marketing, namely the organization of closed parties for the fans and potential Toyota hybrid cars customers. Such events require the presentation of models, personally answer all the questions and provide advice of varying nature.

The target audience of hybrid car enthusiasts can be gathered from an existing customer base, involve online channels. You can also apply ad units such as:

1) Outdoor Advertising. Advertising on banners that are near constant traffic jam (6-10 points), in order to attract the attention of drivers, who begin to consider the surroundings out of boredom. Advertising in restaurants, cafes, which related to the eco-industry, that is, supporters of environmental marketing.

2) Cross sales and promotions: joint promotion with banks and insurance companies; with visitors to suburban eco-complexes - a gift for the purchase of a Toyota hybrid car.

3) Implementation of CRM database for the contact center in order to report incoming calls and adding them to the database for further direct marketing.

As a separate point, consider the content topics for filling the site and own social media pages:

- Travel stories. Traveling Ukraine or the world on hybrid car mechanics is a motive of confidence.

- Car presentations. The script and presentation should be prepared and the mandatory press.

– Test drive videos and car reviews. The client always wants to see photos and videos in real time, to understand whether or not to spend time going to a car dealership.

– Posts showing the service. Cup of coffee or tea and candy in branded packaging always raise the level of customer satisfaction.

So, we recommend a promotion policy for Toyota RAV4 HYBRID, which should be focused on individual approaches both online and with traditional advertising. The process of internet marketing, in the main, should be focus on building relationships with consumers. Social media marketing, SEO, viral marketing will be the most desired form of marketing, which should be considered to promote hybrid technology. The promotional process will also help build public relations with stakeholders, so that the real information can be processed by the target audience.

IV. Conclusions

The automotive industry is one of the most competitive segments of the world market. The importance of hybrid cars in today's environment, this is based on their environmental significance. In addition to rising fuel prices in Ukraine consumers also consider the consumer capabilities of vehicles. In the harsh and changing business environment of today the competitive advantages are in the gold weight and entails a number of important qualities for the company survival, such as efficiency, stability, quality and quantity of products, environmental friendliness and other. All these factors affect the competitiveness of the company, which is able to ensure the implementation of social and ethical marketing both externally and internally. In the course of the study, we found that it was expedient for Toyota to strengthen its presence in the hybrid car market, by promoting their products online and offline. Since brand positioning also affects the consumers behavior of a particular brand, therefore, promotion policies should also focus on building the unmatched, long-term customer relationships and increase loyalty to hybrid technologies in Ukraine.

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НТБ ОНАХТ

Appendix A

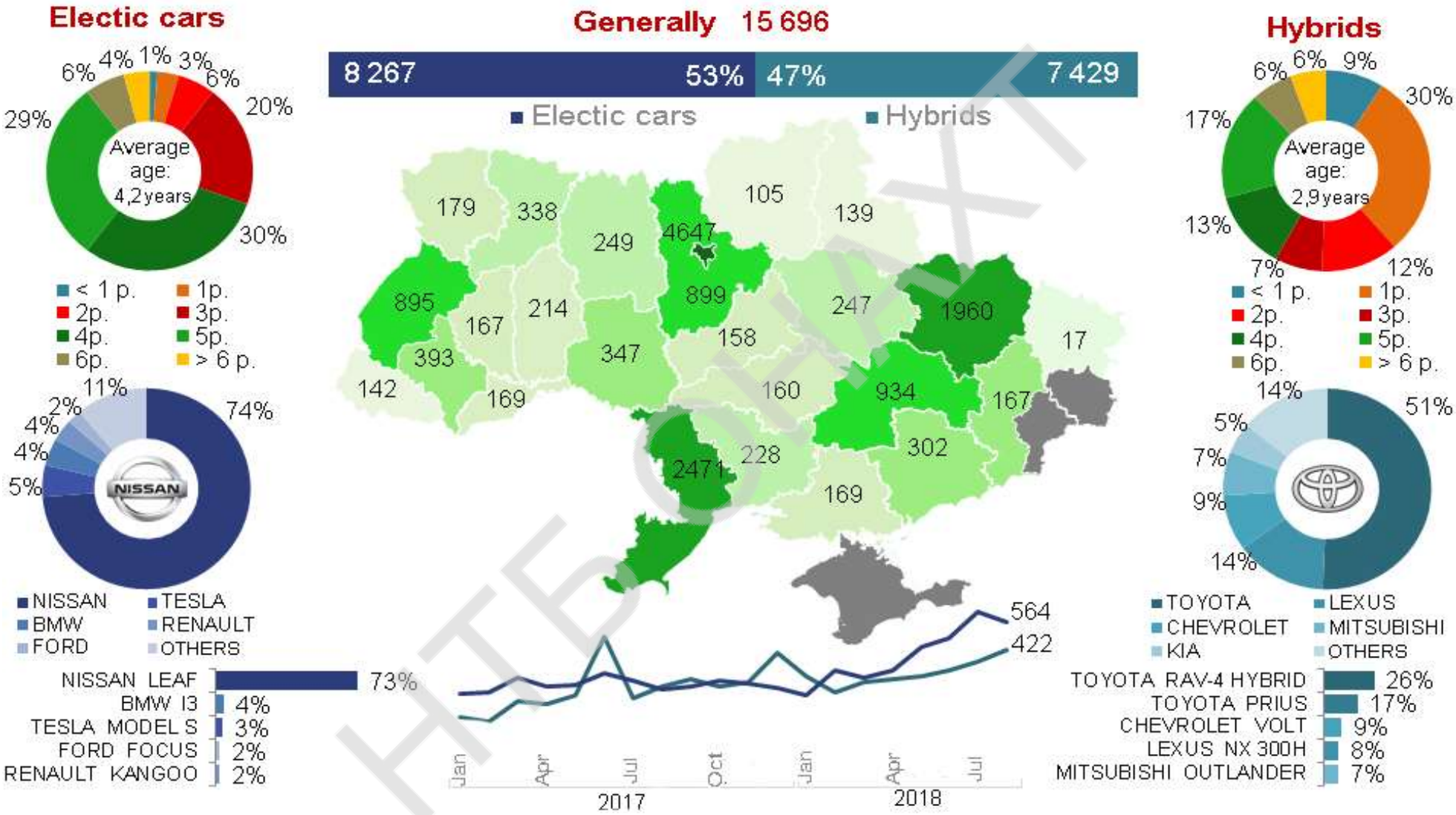
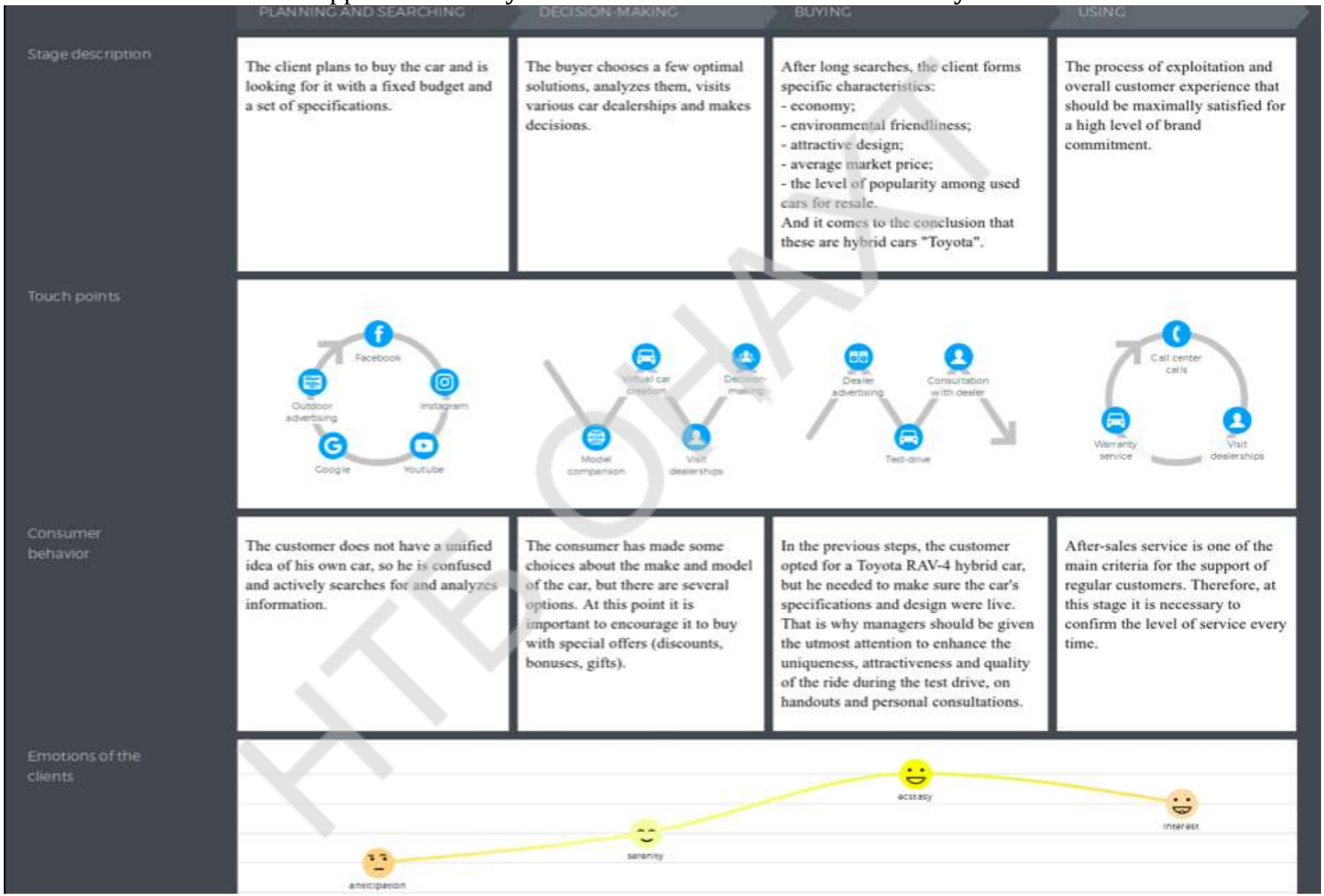


Fig 1.– Infographics of the number of registered cars and hybrids in Ukraine as of 01.09.2018 [7]

Appendix B – **Toyota RAV4 HYBRID Consumer Lifecycle***



* [is developed by the author on the grounds of 13]

EXPORT-ORIENTED ANALYSIS APC REFINERIES

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Belarusian-Russian University (Belarus)

Abstract: *As the result of this research theoretical and practical aspects of analyzing the prospects of export-oriented production of agricultural enterprises are studied. The main results of research: system and complex analysis of production reserves of export-oriented production is offered; the analysis of factors influencing the output of export-oriented production of agro-industrial complex enterprises is made and the directions of perspectives of their use are revealed; information-analytical environment for analytical substantiation of perspectives of export-oriented production development is developed, as well as for information support in substantiation of managerial and planned decisions; investment and reference points are developed.*

Keywords: *analysis, dynamics, factor, reserve, cost price, labor, material resources, investment project, efficiency.*

I. Introduction

The relevance of the topic is conditioned by the system of national priorities formulated in the National Strategy for Sustainable Social and Economic Development of the Republic of Belarus for the period up to 2030, among which are growth and diversification of exports of goods and services, ensuring a balanced foreign trade [7]. The process of export orientation has become the main link that characterizes the country's international relations and is aimed at gaining a place in world markets of products and manufactures [8]. Export deliveries of agro-industrial complex enterprises are of special importance in the system of foreign economic activity of the republic. The important component of development of export potential of the organization is revealing and use of production reserves of export-oriented production, development of effective export strategy, realization of which will allow to take a worthy place in the foreign market. Researches in this direction were carried out in JSC "Bunker - confectionery company "Domochai", specializing in the production of bakery products and focused on the sustainable development of exports.

II. Analytical review of literature.

The works of scientists E. S. Balashova, N. E. Bondarenko, S. N. Gnatiuk, A. G. Baranovsky, M. K. Zhudro, T. N. Kokina, P. V. Manin, G. V. Savitskaya, T. N. Fateeva, V. Vidasova and others were used in the work.analytical materials and normative documents (laws, decrees) of the executive and legislative power bodies [7, 8]; official data of the National Statistical Committee [9]; data published in mass media; sources of the Internet global network [10], as well as internal sources of information of the enterprise under investigation. The article by E.S. Balashova analyzes the dependence of the efficiency of the enterprise's activity on the availability and operation of the mechanism for identification, evaluation and use of reserves [1]. The article by N.E. Bondarenko shows that production of competitive products on the world markets is impossible without the implementation of a systematic approach,

which includes building in practice a system of interrelations and equal opportunities between subjects on the "supply line", as well as the formation of institutions that ensure the sustainability of agricultural producers in the domestic market and their entry into foreign markets [2]. T. A. Korkina, A. S. Kostarev have revealed the stages of evolution of the notion of "production reserves"; considered the definition of intraproductive reserves of development; presented the classification of intraproductive reserves of enterprise development, which creates the basis for their complex and purposeful evaluation and implementation in order to increase enterprise competitiveness [5]. D.K. Shevchenko, O.V. Kirsanov in their work investigate the problems of identification of production reserves, their evaluation and use to increase the efficiency of enterprise activity; they offer classification of intraproductive reserves [12]. In P.V. Manin's research the results of management of the export potential of the industrial enterprise are grounded, the factors influencing the efficiency of the use of export with the allocation of the internal reserves are singled out [6] G.V. Savitskaya considers in her work the factors and reserves of the development of the export potential of the industrial enterprise; she suggests the directions of the development of the export potential of the industrial enterprises due to the involvement of its unrealized elements in the export activity, researches the factors of the export potential development.

III. Object, subject and methods of research

The object of the research is the foreign economic activity of the enterprise, opportunities to increase its export deliveries.

Object of research - production reserves to increase the output of export-oriented products.

The purpose of scientific work is to develop information and analytical environment for management of export-oriented production development of the agro-industrial complex enterprise. The main objective of the research is the formation of theoretical foundations and practical directions for the use of production reserves and creation of conditions for increasing the output of export-oriented products.

Research methods: general scientific methods of analysis and synthesis, generalization, analogies, method of discounting, comparison, analytical methods, flexible budgeting method, statistical and economic-mathematical methods of analysis.

IV. Work results

The working format of the research was built in the economic and analytical environment of JSC "Boulochno - Confectionery Company "Domochay" (JSC "BPC "Domochay"). The analysis of dynamics of financial and economic indicators for the last 3 years revealed a decrease in the dynamics of all levels of profit, the growth of costs for the ruble of marketable products, the deficit of own circulating assets (Table 1 Presentations).

These indicators point to the relevance of search and realization of production reserves of export-oriented production in the context of sustainable development of the economy of the republic and enterprise.

Table 1- Analysis of dynamics of financial and economic indicators of OJSC BPC Domochai

Indicator	2016 y.	2017 y.	2018 y.	Rates of change, %		
				2017/2016	2018/2016	2018/2017
The volume of output in, thousand rubles.						
- at current prices	28 326,0	32 515,0	35 832,0	114,79	126,50	110,20
- in comparable prices (in 2016 prices)	28326,00	24337,57	25945,98	85,92	91,60	106,61
Revenue from sales of products, thousand rubles	38358,00	44264,00	47862,00	115,40	124,78	108,13
Cost of sales, thousand rubles	34756,24	40978,19	45006,59	117,90	129,49	109,83
Gross profit, thousand rubles	3601,76	3285,81	2855,41	91,23	79,28	86,90
Management expenses, thousand rubles	376,68	489,45	235,06	129,94	62,40	48,03
Cost of sales, thousand rubles	352,08	314,36	529,35	89,29	150,35	168,39
Profit from product sales, thousand rubles	2 873,0	2 482,0	2 091,0	86,39	72,78	84,25
Profit before tax, thousand rubles	175,0	643,0	36,0	367,43	20,57	5,60
Net profit, thousand rubles	59,0	205,0	12,0	347,46	20,34	5,85
The average number of employees, people	971	933	920	96,10	94,76	98,61
PPF labor productivity in comparable estimates, thousand rubles	29,176	26,085	28,202	89,41	96,66	108,12
Costs per ruble of marketable products, rub.	0,906	0,926	0,940	102,17	103,78	101,57
Capital productivity of fixed assets, RUB	1,226	1,406	1,607	114,70	131,10	114,30
Working capital turnover ratio, times	4,282	4,877	4,227	113,88	98,70	86,67
Profitability of sold products, %	8,096	5,940	4,568	73,37	56,43	76,90
Return on sales, %	7,490	5,607	4,369	74,86	58,33	77,91
Current liquidity Ratio at the end of the year	0,624	1,103	1,263	176,85	202,46	114,48
Ratio of own short-term funds at the end of the year	-0,603	0,094	0,208	-15,51	-34,53	222,57
Ratio of financial liabilities with assets at the end of the year	0,460	0,490	0,472	106,34	102,53	96,41

Analysis of the results of foreign economic activity of OJSC "BPC "Domochay" in the context of export-oriented production development (tables 2 - 5; figures 1 - 4 of the presentations). The main markets for products are the domestic market of the Republic of Belarus in terms of regions, as well as the market of near and far abroad (Table 2).

ЧЕРНОВИК

Table 2 - Analysis of sales dynamics of bakery products of JSC "BPC "Domochai" by regions of the Republic of Belarus and for export, tons

Indicator	2016 y.	2017 y.	2018 y.	Rates of change, %		
				2017 / 2016	2018 / 2016	2018 / 2017
Mogilev region., including:	48 731	48 761	46 310	100,06	95,03	94,97
Mogilev	20 309	20 311	20 320	100,01	100,05	100,04
Minsk region., including:	108	112	116	103,70	107,41	103,57
Minsk	89	85	87	95,51	97,75	102,35
Vitebsk region	68	61	65	89,71	95,59	106,56
Gomel region	8	6	7	75,00	87,50	116,67
Brest region	41	31	26	75,61	63,41	83,87
Grodno region.	3	2	5	66,67	166,67	250,00
Export supplies	1 016	914	953	89,97	93,81	104,27
Total	49 975	49 887	47 482	99,82	95,01	95,18

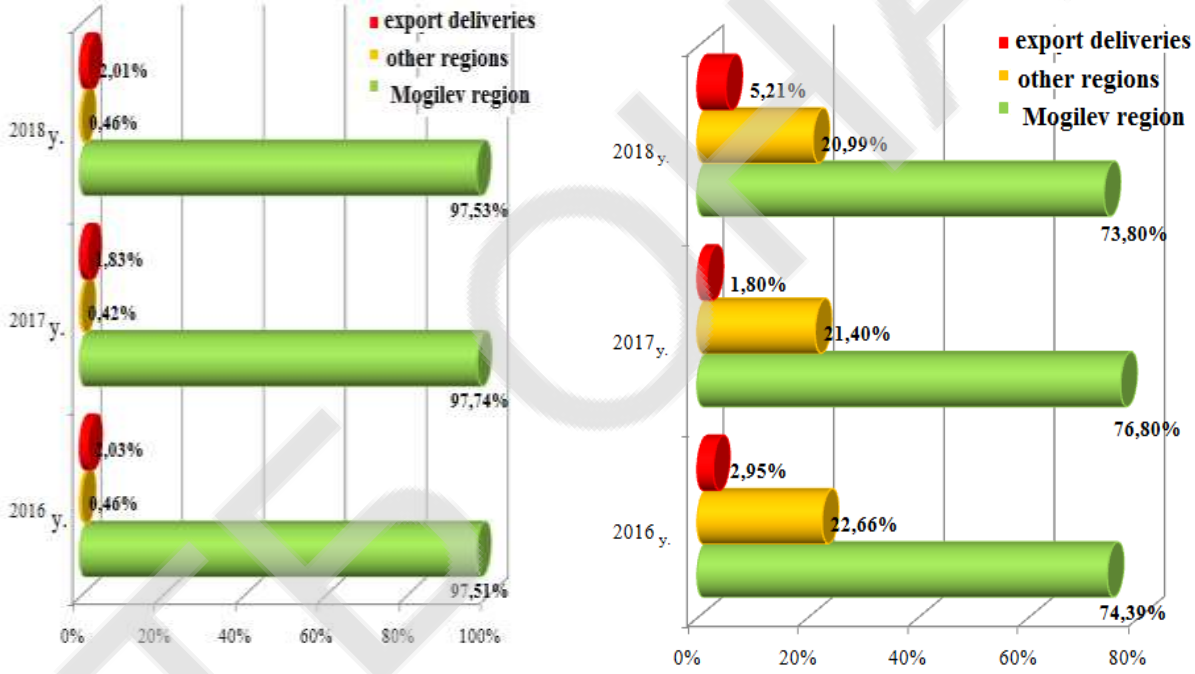
The largest share in the assortment structure of output of JSC "BPC "Domochay" is accounted for by bakery products (in 2018 it was 65.28%; the share decrease as compared to 2017 was 4.01 p.p.). The next in terms of capacity is the group of confectionery products: in 2018 the specific gravity made 22.69%; the increase of the share as compared to 2017 was observed. - 0,66 p. p.). Horizontal analysis of the dynamics of volume parameters has established a downward trend in the assortment position of bakery products: the volume of sales in 2018 amounted to 47482 tons and decreased against 2016 - 2017 by 4.99 and 4.82%, respectively. In 2018 bakery products supplies in the Mogilev region decreased: the reduction rates were 95.03 and 94.97%, respectively. There is a trend of increase in volumes of bakery products sold by the company for export: in 2018 the volume of bakery products shipped for export made 953 tons and grew by 4.27% as compared to 2017, and decreased by 6.19% as compared to 2016 (Table 2).

Analytical data indicate active sales of confectionery products in this time interval: in 2018, the volume of confectionery sales amounted to 5,454 tons and increased compared to 2016 - 2017 by 11.73 and 12.87%, respectively (Table 3).

The volume of confectionery products supply in the domestic market increased in dynamics for all regions of the Republic: the relative growth in 2018 in Mogilev region was 8.46%; in Minsk, Vitebsk, Gomel, Brest and Grodno regions, respectively, 11.94; 10.29; 23.66; 7.61; 25.0%. The company's export volume in 2018 is defined as 284 tons of confectionery products, which corresponds to the positive dynamics of export growth by 3.27 times against 2017 and growth by 96.88% against 2016. (Table 3). Vertical analysis of bakery products market structure has shown that practically all bakery products of OJSC BPC Domochai are sold in the Mogilev oblast: in 2016-2018 the share of this market made 97.51; 97.74; 97.53%. The share of export deliveries in 2018 was 2.01 % and increased by 0.17 p.p. as compared to 2017; as compared to 2016. - decreased by 0.03 p.p. as compared to 2016. (Figure 1).

Table 3 - Analysis of sales dynamics of confectionery products of JSC "BPC "Domochai" by regions of the Republic of Belarus and for export, tons

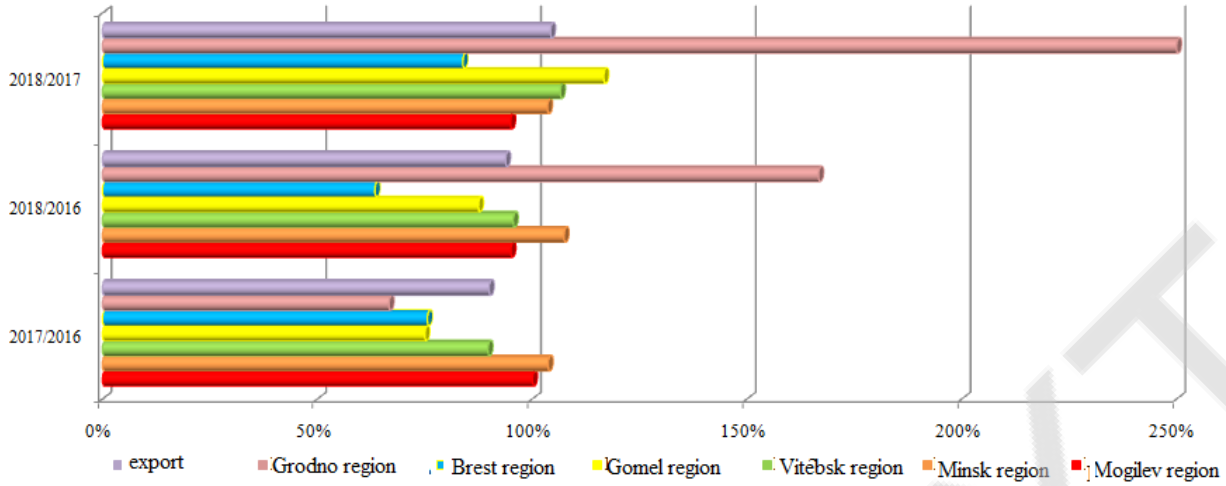
Indicator	2016 y.	2017 y.	2018 y.	Rates of change, %		
				2017 / 2016	2018 / 2016	2018 / 2017
Mogilev region., including:	3 631	3 711	4 025	102,20	110,85	108,46
Mogilev	1 631	1 673	1 700	102,58	104,23	101,61
Minsk region., including:	132	134	150	101,52	113,64	111,94
Minsk	68	71	80	104,41	117,65	112,68
Vitebsk region	69	68	75	98,55	108,70	110,29
Gomel region	92	93	115	101,09	125,00	123,66
Brest region	759	683	735	89,99	96,84	107,61
Grodno region	54	56	70	103,70	129,63	125,00
Export supplies	144	87	284	60,14	196,88	327,37
Total	4 881	4 832	5 454	98,99	111,73	112,87



a) **b)**

Figure 1 - Analysis of the structural dynamics of sales in the regions of the Republic of Belarus and for export,%: a) bakery products b) confectionery

Export shipments increased in 2018 vs. 2017, but were below the 2016 level. The dynamics indicators were as follows: 93.81 and 104.27% (Figure 2).



Indicator	Rates of change, %		
	2017 / 2016	2018 / 2016	2018 / 2017
Mogilev region	100,06%	95,03%	94,97%
Minsk region	103,70%	107,41%	103,57%
Vitebsk region	89,71%	95,59%	106,56%
Gomel region	75,00%	87,50%	116,67%
Brest region	75,61%	63,41%	83,87%
Grodno region	66,67%	166,67%	250,00%
Export supplies	89,97%	93,81%	104,27%

Figure 2 - The rate of change in sales in the domestic and foreign markets, %

In 2017 - 2018, bakery sales volumes by regions decreased: Vitebsk, Gomel, and Brest regions: the decline rates for 2018 were 95.59, 87.50 and 63.41%, respectively. This trend is determined by the influence of external factors of functioning: the market of Mogilev region is fully covered by demand and at the same time there is an active growth of competition; at the markets of other regions there is a competition with local producers.

The share of exports in the total volume of bakery and confectionery shipments in 2018 was 2.01 and 5.20%, respectively. Export geography of JSC "BPC "Domochay" covers regions of the Russian Federation, countries of near and far abroad. There were noted the basic rates of decline for 2017 - 2018: 89.97 and 93.81%, respectively; the level of decline in export shipments in 2017 is slightly lower than in 2018). In 2018, bakery products exports increased by 4.27% compared to 2017, respectively. This increase in exports is a result of increased shipments of bakery products to the Russian Federation. In 2017 - 2018, bakery export volumes to Russia decreased as compared to the base year of 2016 by 8.07% and 12.03%, respectively; at the same time, in 2018 as compared to 2017 there was an increase in shipment volumes by 7.38% (Table 4).

Table 4 - Analysis of export volumes of JSC "BPC Domochai" by main types of products in physical terms, tons

Export by type products and segments	2016 y.	2017 y.	2018 y.	Rate of change, %		
				2017/2016	2018/2016	2018/2017
Baked goods						
Export total, tons	1 016,00	914,10	953,10	89,97	93,81	104,27
including						
- Panama	34,53	60,70	54,31	175,79	157,28	89,47
- Turkmenistan	15,24	61,80	48,78	405,51	320,08	78,93
- Russian Federation	966,23	791,60	850,01	81,93	87,97	107,38
Confectionary products						
Export total, tons	144,00	86,60	283,50	60,14	196,88	327,37
including						
- Panama	-	-	5,45	-	-	-
- Turkmenistan	3,50	22,80	17,50	651,43	500,00	76,75
- Russian Federation	140,50	63,80	260,55	45,41	185,44	408,39

There was a significant increase in export volumes in 2018 for confectionery products in the assortment: as compared to 2016, there was a 1.97-fold increase as compared to 2017. - by 3.27 times compared to 2017. Supplies of confectionery products in the Russian segment increased: in 2018 as compared to 2016, the growth was 85.44%, compared to the previous year - an increase of 4.08 times. In Turkmenistan, the largest export volumes in terms of this assortment position were recorded in 2017: 6.51 times growth as compared to 2016. In 2018, exports of confectionery products increased by 5 times compared to 2016 and decreased by 23.25% compared to the previous year. Confectionery products are represented by gingerbread, oatmeal biscuits, sugar, sweets, flour and sugar, cakes, pastries, etc. Export geography of confectionery products has expanded: in 2018. 5.45 tons of confectionery products were shipped to Panama. When studying the dynamics of exports for 2016 - 2018, it was determined the average annual rate of decline in exports of bakery products at 96.86%; the average annual growth rate of confectionery export at 140.31%.

The results of the analysis of the structure and dynamics of the export of JSC "BPC "Domochay" (Table 5) by geographical segmentation in the context of individual assortment positions. Sukhari" products group was exported mainly to Turkmenistan (the share in the total volume of exports by these assortment items was 12.23%).

The Corn Sticks Group exported to the Russian Federation, particularly to Kaliningrad, where it supplied USD 1.71 thousand, which is 5.03 times more than in 2017. Significant deliveries of confectionery products of JSC "BPC Domochay" for export in 2018 were made to Kaliningrad (North-Western Federal District) and Krasnodar (Southern Federal District). The growth rate in Kaliningrad was 291.49 %; in Krasnodar products were shipped by USD 102.1 thousand. (there was no shipment in 2017). At present, there is a stable demand in all considered markets, the number of orders received by the company in 2020 is planned to increase on average by at least 5%. A significant share of confectionery products is produced on the grissini line.

Table 5 - Analysis of structure and dynamics of export of JSC "BPC "Domochay" products in the context of separate assortment items

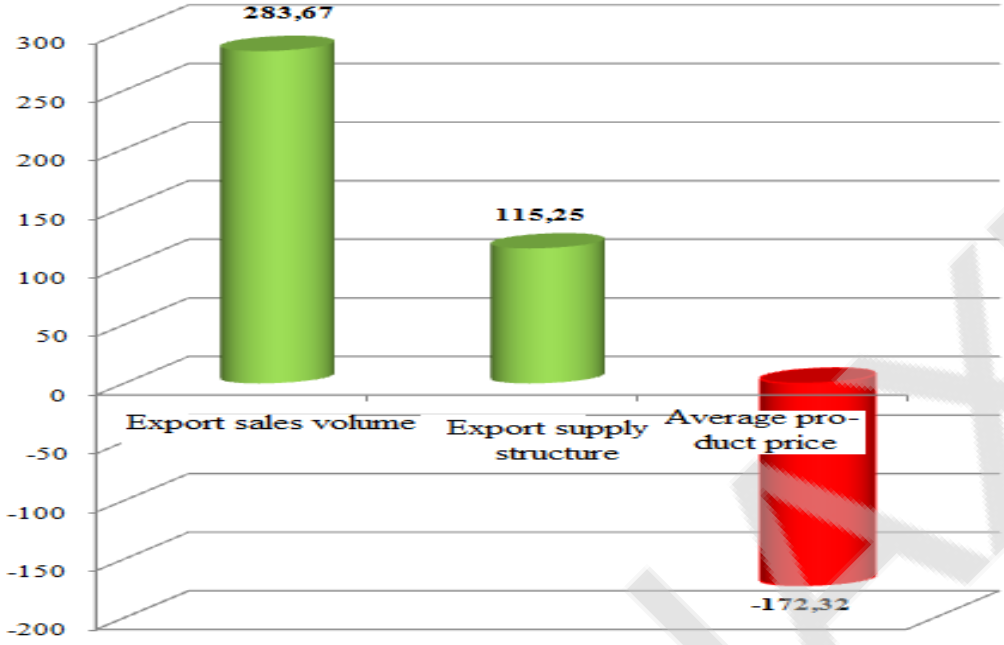
Export by type products and segments	Export, thousand dollars		Rate of change, %	Export structure, %		
	2017 y.	2018 y.		2017 r.	2018 r.	deviation
Confectionary products						
1. Export total	151,40	352,46	232,80	77,97	84,97	7,00
including						
1.1.Russian Federation	121,94	319,90	262,34	62,80	77,12	14,32
thereof						
- Kaliningrad	5,76	16,79	291,49	2,97	4,05	1,08
- Krasnodar	0,00	102,10	-	0,00	24,61	24,61
- other RFs	116,18	201,01	173,02	59,83	48,46	-11,37
1.2 Turkmenistan	29,46	19,83	67,31	15,17	4,78	-10,39
1.3 Panama	0,00	12,73	-	0,00	3,07	3,07
Breadcrumbs						
Export total	36,53	53,08	145,31	18,81	12,80	-6,02
including						
- Russian Federation	1,10	2,36	214,55	0,57	0,57	0,00
- Turkmenistan	35,43	50,72	143,16	18,25	12,23	-6,02
Cornsticks						
Export total	6,25	9,26	148,16	3,22	2,23	-0,99
including						
- Kaliningrad	0,34	1,71	502,94	0,18	0,41	0,24
- other RFs	5,91	7,55	127,75	3,04	1,82	-1,22
Total	194,18	414,80	213,62	100,00	100,00	0,00

Analysis of export shipment factors of JSC "BPC "Domochai" products.

The results of factor analysis of export volumes are shown in Figures 3 and 4 of the Presentations. Revenue from export sales increased by USD 226.60 thousand due to changes in the amount of export products, by USD 283.67 thousand; due to changes in the commodity structure of export products by USD 115.25 thousand; due to changes in the amount of export products by USD 283.67 thousand. (Figure 3). Export shipments decreased by USD 172.32 thousand due to changes in the average price in foreign currency for certain products. For all items considered for export, there was an increase in the natural volume of shipments, which resulted in an increase of exports by $283.67 thousand. Thus the greatest positive influence of the sales volume factor is on bakery products: the size of influence is defined in the sum of USD 238,96 thousand.

Analytical data show the redistribution of export-oriented products in favor of its expensive types (confectionery products, other types of products), as evidenced by the growth of exports as a result of the impact of structural shifts by $ 115.25 thousand. Positive structural shifts in favour of confectionery and other products resulted in export growth of USD 307,98 thousand and USD 8,45 thousand respectively. Decrease in the share of bakery products negatively affected the output of export-oriented products and corresponds to the decrease of export supplies by USD 196.39 thousand. Reduction of average selling prices for export-oriented products was established,

which negatively influenced the results of export operations and decreased the efficiency of export potential of the enterprise.

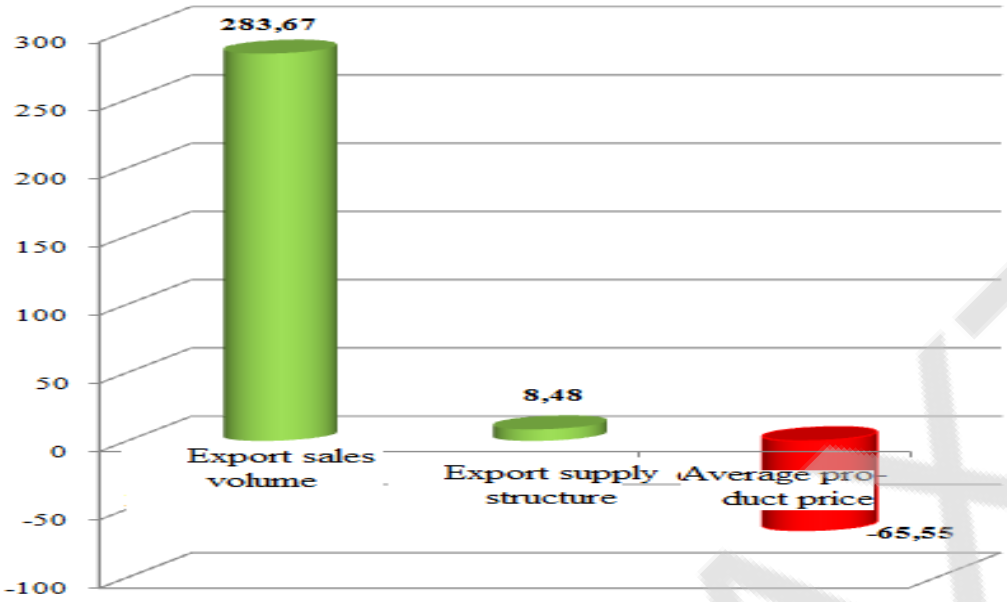


Export of products	Change in export volume in value terms, thousand USD			
	total change, thousand dollars	including through (export change factor)		
		export sales volume	structure export deliveries	average production price
Baked goods	-28,16	238,96	-196,39	-70,74
Confectionery products	201,06	36,26	307,98	-143,17
Other products	53,70	8,45	3,66	41,59
Total	226,60	283,67	115,25	-172,32

Figure 3 - Results of factor analysis of product export by assortment, thousand dollars

The greatest decrease in the average selling price falls on confectionery products (the relative decrease in price is established at the rate of 28,89 %): quantitative influence of the factor -143,17 thousand dollars.

Factorial analysis of export of BPC "Domochay" products by markets (Figure 4) showed that revenue from export sales increased by $226.60 thousand, including due to the growth of natural volume of export products by $283.67 thousand; due to the change in the structure of export sales by $8.48 thousand; due to the change in the structure of export sales by $8.48 thousand.



Sales market	Total change, thousand dollars	Including through (export change factor)		
		export sales volume	structure export deliveries	average production price
Russian Federation	253,30	239,70	60,83	-47,23
Panama	-0,08	18,80	-20,01	1,14
Turkmenistan	-26,62	25,18	-32,34	-19,46
Total	226,60	283,67	8,48	-65,55

Figure 4 - Results of factor analysis of export of products by sales markets, thousand dollars

The decrease in the average price in the markets had a negative impact on the performance indicator: the impact of the factor was -65.55 thousand USD. The increase in the volume factor for export sales led to an increase in exports in value terms of 239.70 (Russian Federation), 18.80 (Panama) and 25.18 (Turkmenistan), respectively. The greatest positive influence of the sales volume factor is noted on the Russian market. The structural factor also had a positive impact on shipments of BPC Domochai products to the Russian Federation: the amount of influence was USD 60.83 thousand. Decrease in the share of exports to the markets of Panama and Turkmenistan decreased country exports by USD 20.01 thousand and USD 32.34 thousand, respectively. The impact of the price factor on export volumes is negative for the leading markets of the Russian Federation and Turkmenistan: the decrease in average prices reduced export volumes by 47.23 and 19.46 thousand USD, respectively. Insignificant increase was received on the factor of growth of sale prices in panama (1,14 thousand dollars).

As reserves of growth of sales of export-oriented production the following is considered: optimization of assortment of production in a context of manufacture of new bakery (confectionery) products demanded in the external market and maintenance of high level of profitability of sales; search of the favorable markets of

sales of production for export on parameters of volume and price (expansion of geography of export deliveries of products).

2. The analysis of production cost in the system of export-oriented production development of JSC "BPC "Domochay" (tables 6-10; figures 5-12 Presentations).

Analysis of production and sales costs. On the whole, production costs of the enterprise increased by 3 029.22 thousand rubles or 9.91% (Table 6).

Table 6 - Analysis of Formation and Structure of Costs of Production and Sales of OJSC BPC Domochai Products

Cost structure by elements	Amount, thousand rubles			Cost structure, %		
	2017 y.	2018 y.	change	2017 y.	2018 y.	change
1 Material costs	23 024,34	25 482,60	2 458,26	75,30	75,83	0,53
1.1 raw materials and supplies	21 182,48	23 576,85	2 394,36	69,28	70,16	0,88
1.2 works and services of a production nature	396,38	457,25	60,87	1,30	1,36	0,06
1.3 fuel	774,34	779,06	4,72	2,53	2,32	-0,21
1.4 electrical energy	666,39	665,25	-1,15	2,18	1,98	-0,20
1.5 other material costs	4,03	4,33	0,30	0,01	0,01	0,00
2 Costs of wages	4 478,36	4 813,34	334,97	14,65	14,32	-0,32
3 Social contributions	1 522,64	1 636,53	113,89	4,98	4,87	-0,11
4 Depreciation of fixed assets	871,92	1 064,59	192,67	2,85	3,17	0,32
5 Other costs	677,91	607,34	-70,57	2,22	1,81	-0,41
Total production costs, including:	30 575,18	33 604,40	3 029,22	100,00	100,00	0,00
– variable costs	26 606,52	29 454,26	2 847,74	87,02	87,65	0,63
– regular expenses	3 968,66	4 150,14	181,49	12,98	12,35	-0,63

The largest share in the structure of costs in 2017 - 2018 are material costs: 75.30 and 75.83%, respectively. In 2018 this indicator increased by 10.68%, the share in the structure of costs in the dynamics increased by 0.53 p. p. As part of material costs in 2018 there was an increase in costs for raw materials by 2 349.36 thousand rubles, fuel - by 4.72 thousand rubles. The growth of material costs in 2018 was due to an increase in costs by lines: raw materials and supplies - by 11.30%; services of third parties - by 15.36%; fuel - by 0.61%. The relative reduction of energy for technological needs was defined as 1.15 thousand rubles or 0.17 %. Labor costs in the structure of production costs amounted to 2018. 14.32 %, which is 0.32 p.p. lower than the share of this cost category in 2017. There was an increase in depreciation of fixed assets by 192.67 thousand rubles and a decrease in other costs - by 70.57 thousand rubles. (Table 6).

Graphical interpretation of the structural cost dynamics shows that production of BPC Domochay products is material intensive: the specific weight of material costs in 2017-2018 was 75.30 and 75.83%, respectively (Figure 5).

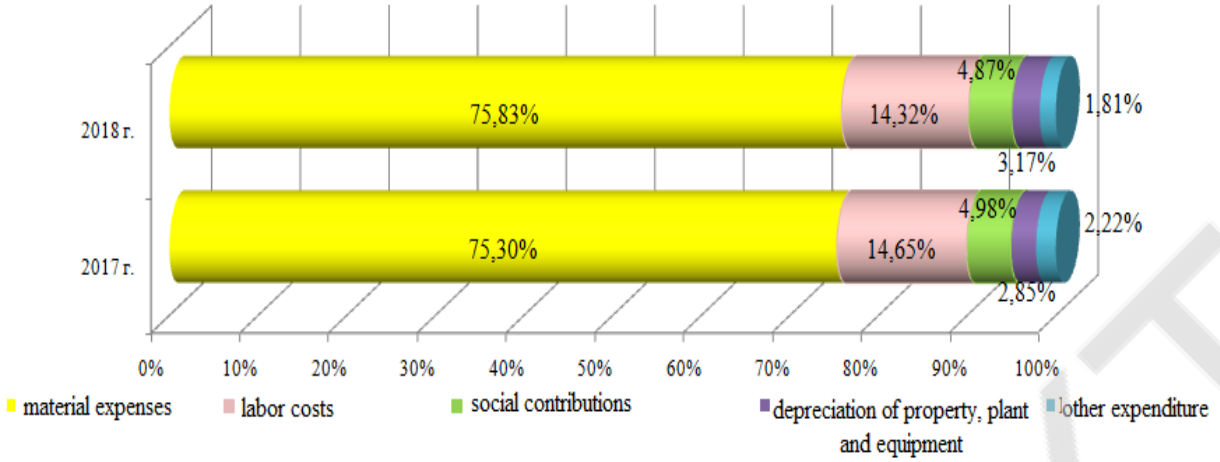


Figure 5 – Analysis of the structural dynamics of costs by economic elements, %

Positive structural dynamics can be seen in terms of material costs (0.53 p.p. increase), including an increase in the share of raw materials and supplies (0.88 p.p. increase); depreciation charges (0.32 p.p. increase). In the structure of costs, the specific weight of labour costs has decreased (0.32 p.p. reduction; social allocations (0.11 p.p. reduction); other costs (0.41 p.p. reduction). Absolute increase in variable costs in the dynamics made RUR 2,847.74 thousand with simultaneous growth of their specific weight in the structure of costs by 0.63 p. p.

Table 7 (input data for factor analysis) has been compiled to calculate cost indicators under different production conditions. The coefficient of change in natural volume of production (Kn) is calculated based on the statoutcheckability data (Kn = 1.0064).

Table 7 - Absolute values of indicators for factor analysis

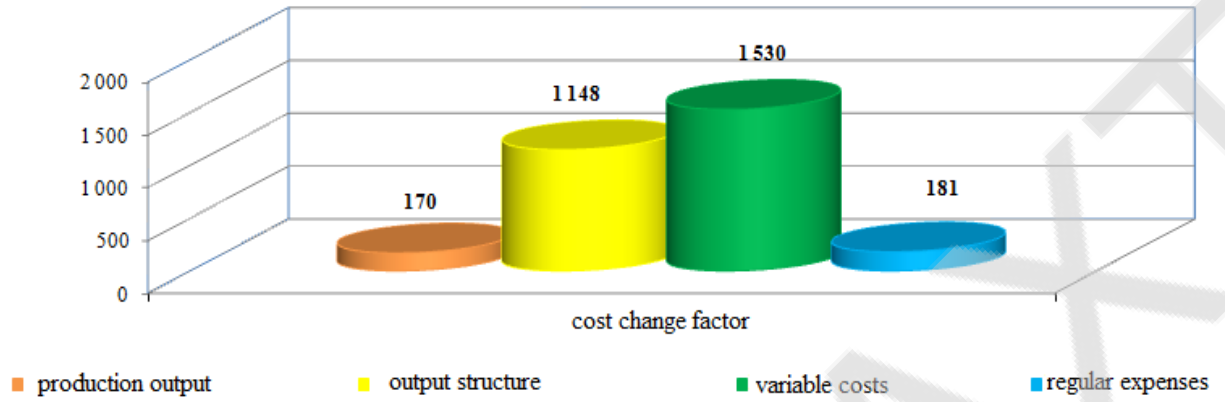
Indicator	2017 y.	2018 y.	Change rate, %
Specific Variable Costs per 1 Tonne of Production (bi), thous.	0,492	0,541	110,00
Volume of production (Q), tons	54 062,00	54 408,00	100,64
Amount of variable costs (Zvar), thousand rubles	26 606,52	29 454,26	110,70
Amount of fixed expenses (A), thousand rubles	3 968,66	4 150,14	104,57
The cost of marketable products (TP), thousand rubles	32 515,00	35 832,00	110,20
Costs of production	30 575,18	33 604,40	109,91
Ratio of change in natural production volume (Kn)	1,0064		
Index of Bakery and Confectionery Products Prices (Iz)	1,0459		

Calculation of the quantitative influence of factors on the change of the resultant indicator is made by the chain substitution method (Table 8).

Table 8 - Costs and Marketable Products at Different Factor Values

Costs	Method of calculation	Indicator level, thousand rubles
Basis costs Z_0 (2017 y.)	$A_0 + \sum Qi_0 \times UDi_0 \times bi_0$	30 575,18
Based on actual volume of production (Z_{usl1})	$A_0 + \sum Qi_1 \times UDi_0 \times bi_0$	30 745,46
Based on actual volume and structure of production (Z_{usl2})	$A_0 + \sum Qi_1 \times UDi_1 \times bi_0$	31 893,20
In fact, at the base value of fixed costs (Z_{usl3})	$A_0 + \sum Qi_1 \times UDi_1 \times bi_1$	33 422,92
Actual costs of the reporting period Z_1 (2018 y.)	$A_1 + \sum Qi_1 \times UDi_1 \times bi_1$	33 604,40

Results of the factor analysis have shown: the greatest negative influence from the point of view of growth of a level of expenses under the flexible budget was made by increase in variable expenses which is connected with increase on separate articles of direct material and labour expenses as a part of production cost price, and also structure of release of production in favour of its costly kinds (Figure 6).



Cost Change Factor	Calculation Algorithm	Amount of influence, thousand rubles
Volume of production	Z	170,28
Output structure	Z	1 147,74
Variable costs	Z_{usl3} Z_{usl2}	1 529,71
Fixed expenses	Z	181,49
Total	Z	3 029,22

Figure 6 - Factor analysis of production costs, thousand rubles

The increase in production costs was determined by the increase in variable and fixed costs: the influence of factors is 1,529.71 and 181.49 thousand rubles, respectively. Changes in the structure of products manufactured indicated an increase in total production and sales costs by RUB 1,147.74 thousand. The slight increase in physical output by 0.64% resulted in an increase in costs of RUB 170,28 thousand. The increase in variable costs determined the largest increase in the resultant indicator by RUB 1,529.71 thousand, which is due to an increase in production volume and overspending on material costs items (expenses for basic and auxiliary raw materials, packaging, fuel and electricity), expenses on remuneration of main workers.

Analysis of commodity product ruble costs. Commodity product ruble costs analysis is performed in the following order: comparative analysis of actual marketable product ruble costs in the reporting year 2018 with baseline values for 2015 - 2017; factor analysis of changes in marketable product ruble costs; identification of reasons and generalization of marketable product ruble costs reduction provisions. Commodity product ruble costs in 2018 decreased slightly by RUB 0.0025 compared to 2017 and increased by RUB 0.0317 compared to 2015. (Figure 7).

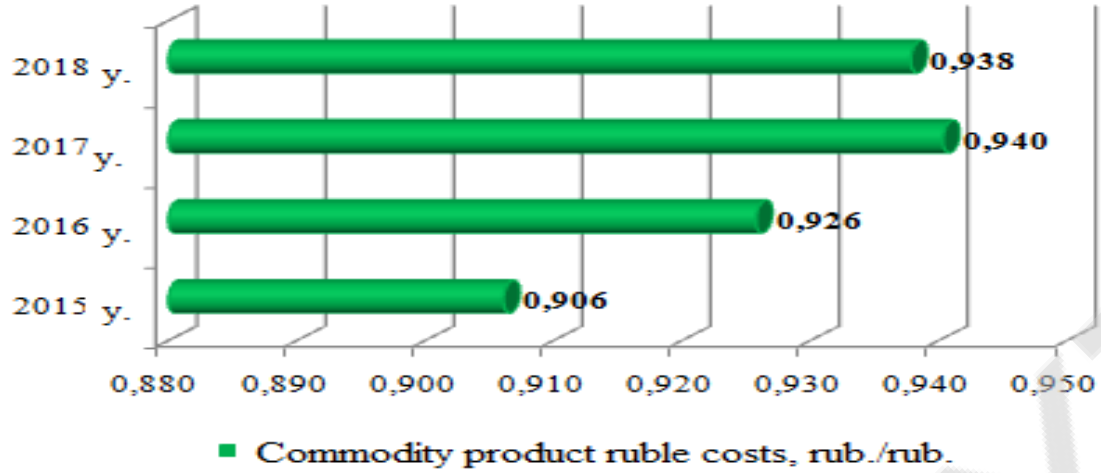


Figure 7 – Dynamics of commodity product ruble costs, rub.

The increase in this indicator is explained by higher growth rates of production costs as compared to the marketable products growth rates. On the whole, the level of this indicator is below one unit, which corresponds to profitable production

Assessment of the current parameter of costs on ruble of marketable products is supplemented by calculation of the size of influence of factors on change of the analyzed parameter (Figure 9). In 2018, there was a decrease in costs per ruble of marketable products by 0.0025 rubles, which is associated with the growth of production volumes (the size of the influence -0.0008 rubles); changes in the structure of products (the size of the influence 0.0050 rubles), an increase in selling prices (the size of the influence -0.0469 rubles). Other factors determined the growth of the effective indicator. Growth of costs per 1 ruble of commodity products occurred as a result of increase in variable costs (the size of influence 0.0448 rub.), growth of fixed costs (the size of influence 0.0053 rub.).

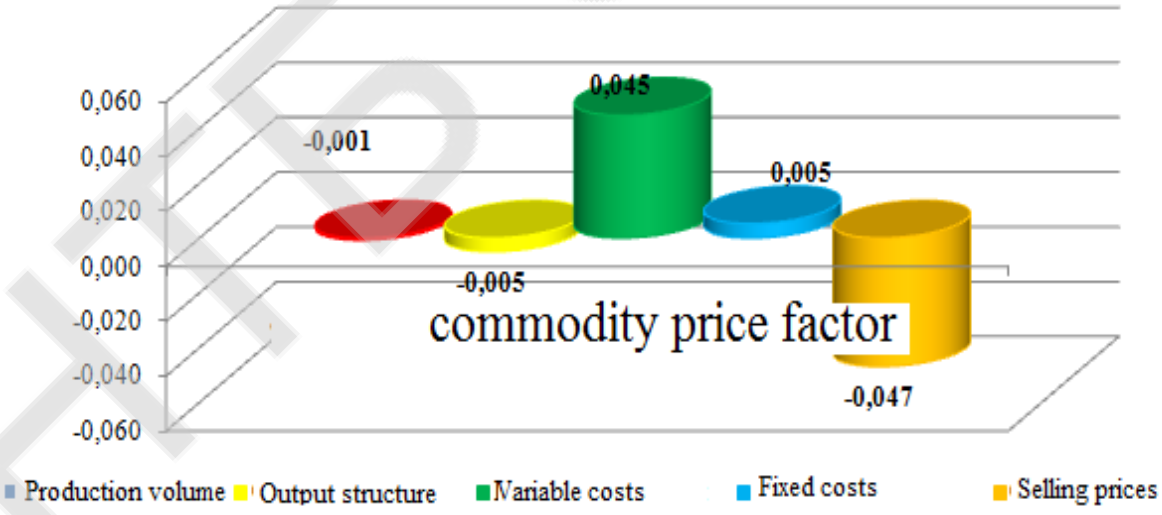


Figure 9 – Factor analysis of marketable product ruble costs, rub.

The increase in variable costs indicates resource intensity of production and an increase in the cost of consumed resources, taking into account the resource price factor (Figure 9).

In 2018 there was a decrease in the wage and other costs intensity with a

simultaneous increase in the material intensity (due to the negative deflator of prices for materials, a slight increase in the volume of produced goods), amortization intensity (Figure 8).

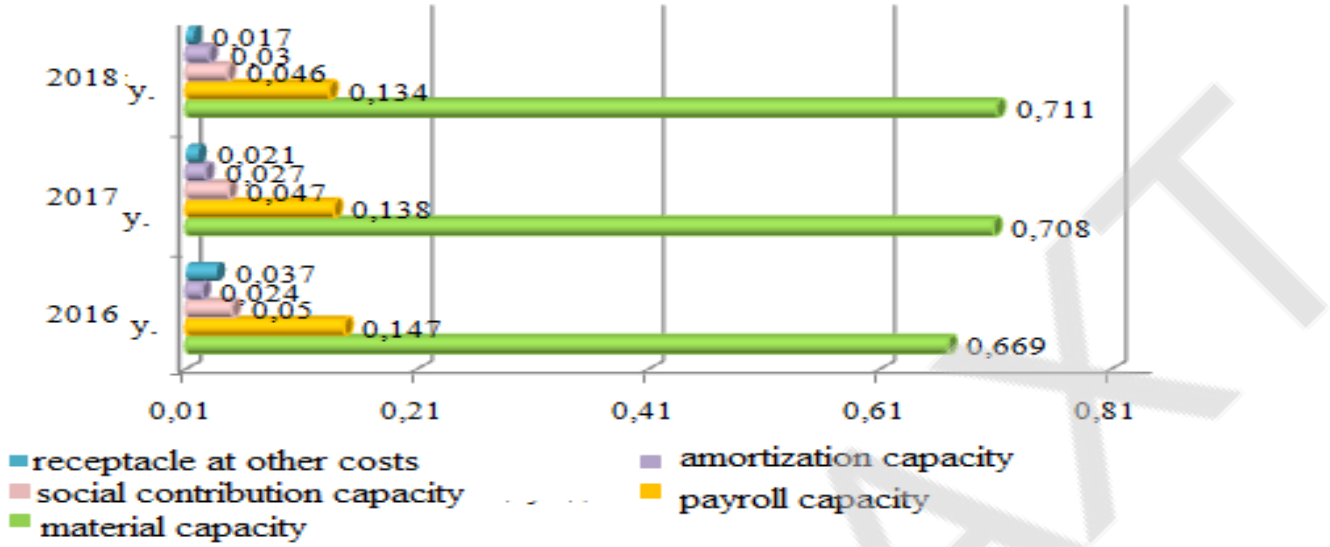


Figure 8 – Dynamics of commodity product ruble costs by elements, rub.

At the same time, the structure of costs per 1 rouble of products by elements does not change significantly. In the analysis of indicators for 2016 - 2018 more significant deviations are noted: growth in the final line of 0.012 rubles. A significant growth of material intensity in the amount of 0.043 rubles was established (mainly due to the increase of raw materials costs, fuel and electricity costs).

In 2018, the capacity of labour costs decreased by RUB 0.012 and 0.003, respectively, as compared to 2016-2017, the capacity of social contributions - by RUB 0.004 and 0.001, the capacity of other costs - by RUB 0.020 and 0.003, respectively. At the same time, the material intensity increased by 0.043 roubles as compared to 204156 and by 2017. - by RUB 0.003, 2017 The analysis of the given data testifies to growth of efficiency of activity of the enterprise and testifies to necessity of development of measures on improvement of functioning of JSC "BPC Domochay" in a number of directions. As for the result achieved in 2018 in terms of the level of costs on the ruble of products sold, it should be noted that this indicator has decreased in dynamics, but its level remains quite high.

Analysis of prime cost of some kinds of export production. The cost price is considered to be a pricing factor that largely determines the competitiveness of export products. For carrying out of the given block of the analysis in group of confectionery products the assortment positions which occupy the greatest specific weight in volumes of export-oriented manufacture, are in demand and the most popular at buyers are chosen: taralli with aroma of vanilla (Figure 10); grissini vanilla (Figure 11).

The structural diagram below shows that the largest specific weight falls on the main and auxiliary raw materials and auxiliary materials (from 16 to 18 %). The high level of automation of confectionery production process on the grissini line indicates the low level of salary in the structure of production cost. Structural shifts are practically not visible on the presented charts.

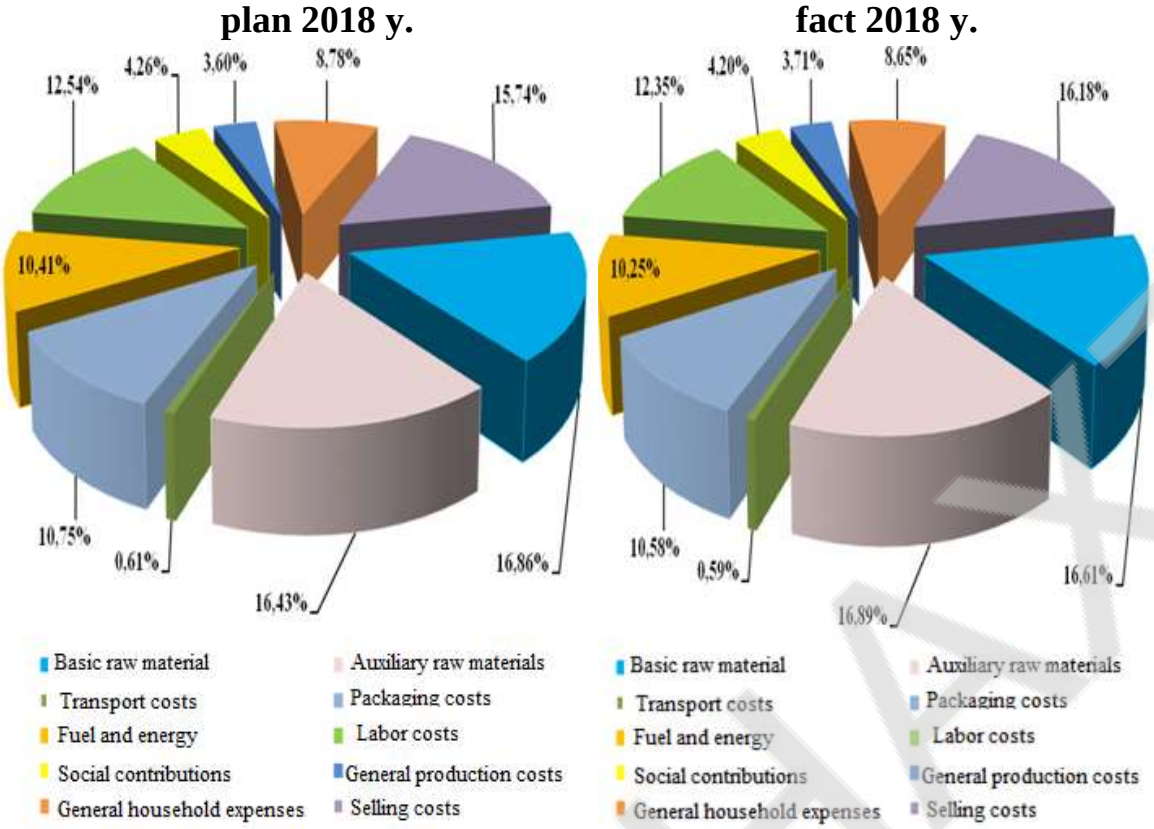


Figure 10 – Cost structure of «Taralli with vanilla scent» product

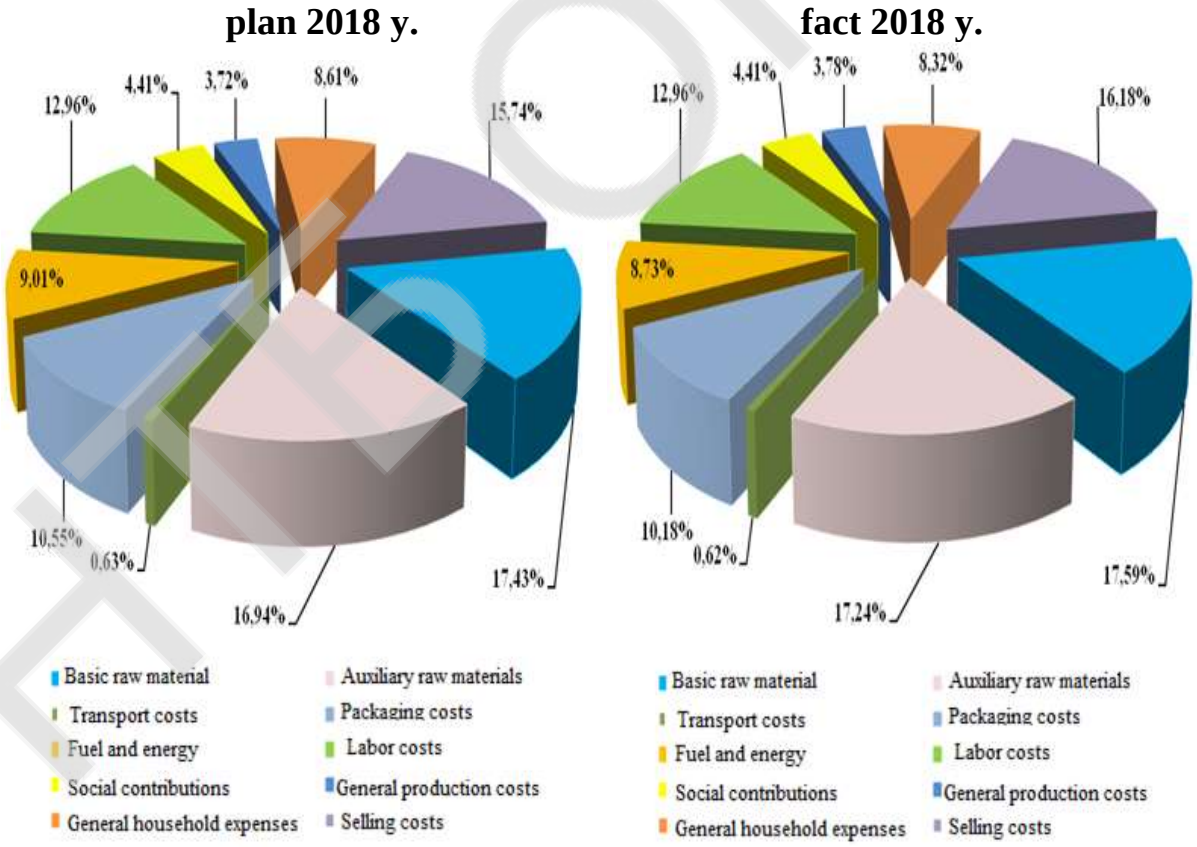


Figure 11 – Cost structure of «Grissini vanilla» product

The following analysis provides for the study of factors of change in unit cost of production; the factor analysis is performed by the chain substitution method (Tables 9,10). Table 9 provides background information for a factor analysis of the cost per tonne for the selected assortment items.

Table 9 - Input data for factor analysis of the cost of 1 tonne of product

Indicator	Plan	Fact 2018 y.	Absolute deviation
Vanilla-scented Taralli			
Volume of production (Q), tons	50,75	55,89	5,14
Amount of fixed costs (A), thousand rubles	25,45	30,13	4,68
Amount of variable costs per product (b), rub.	2 429,86	2 594,39	164,54
Cost of 1 tonne (C), rub	2 931,25	3 133,47	202,22
Grissini Vanilla			
Volume of production (Q), tons	60,59	63,84	3,25
Amount of fixed costs (A), thousand rubles	31,99	36,12	4,13
Amount of variable costs per product (b), rub.	2 568,65	2 772,07	203,42
Cost of 1 tonne (C), rub	3 096,60	3 337,89	241,29

Calculation of influence of factors on change of cost price of confectionery products is made by a chain substitution method and is presented in tables 10.

Table 10 - Analysis of the cost of 1 tonne of confectionery products

Cost of 1 tonne (C), rub		Factors		
		production rate	fixed costs	variable costs
Vanilla-scented Taralli				
C_0 (plan)	2 931,25	50,75	25,45	2 429,86
C_{usl1}	2885,14	55,89	25,45	2 429,86
C_{usl2}	2968,932	55,89	30,13	2 429,86
C_1 (fact 2018 y.)	3 133,47	55,89	30,13	2 594,39
Balance of factors	202,22	**-46,11**	**83,79**	**164,54**
Grissini Vanilla				
C_0 (plan)	3 096,60	60,59	31,99	2 568,65
C_{usl1}	3069,725	63,84	31,99	2 568,65
C_{usl2}	3134,469	63,84	36,12	2 568,65
C_1 (fact 2018 y.)	3 337,89	63,84	36,12	2 772,07
Balance of factors	**241,29**	**-26,88**	**64,74**	**203,42**

The total change in the cost of 1 ton of "Taralli with Vanilla Scent" product is 202.22 rubles. This overconsumption was obtained as a result of the growth of variable and fixed costs; the increase in production volumes for this name of confectionery products provided a decrease in cost price by 46.11 rubles. The increase in cost of production is the result of significant growth of variable costs (the size of the factor influence is 164.54 rubles); fixed costs (the size of the factor influence is 83.79 rubles). Similar calculations were made at the cost price of "Grissini Vanilla" product. The production cost per tonne of the product in 2018 increased by RUR 241.29 as compared to the planned figures. This growth is caused

by the increase in costs of main and auxiliary raw materials, packaging costs, fuel, electricity (the amount of influence of variable costs is 203.42 rubles).

The absolute growth on all articles of calculation of considered assortment positions is established. Increase in the industrial cost price is connected with growth of expenses on raw materials, auxiliary materials, fuel and energy for technological purposes, expenses for labour payment of industrial workers. Concerning the product "Taralli with vanilla aroma" the increase in profit and profitability accordingly on 143,58 roubles on 1 ton of production and 2,83 p. p. On the product "Grissini vanilla" - the increase in financial results accordingly on 102,20 roubles and 1,23 p. p. p.

Analysis of direct material and labor costs in the cost of goods. The analysis of direct material and labor costs and indirect costs is performed for confectionery products, the share of which in the structure of export-oriented products in 2018 was 29.76%: taralli; grissini. In the process of analysis, it has been established that the highest specific weight in the production cost of the JSC "BPC "Domochay" is occupied by the expenses for the main and auxiliary raw materials, packaging materials, fuel and electricity for technological needs (Figure 12). In 2018, there is a 16.37% growth in total costs as compared to 2017. The growth of this indicator was due to an increase in material costs, in particular, in the items "Raw materials and supplies", "Fuel", "Electrical energy", which is due to the increase in resource costs, provided that the production volumes of products slightly increased and direct material costs increased even more. In general, these structures of direct and indirect costs speak about material intensity of production.

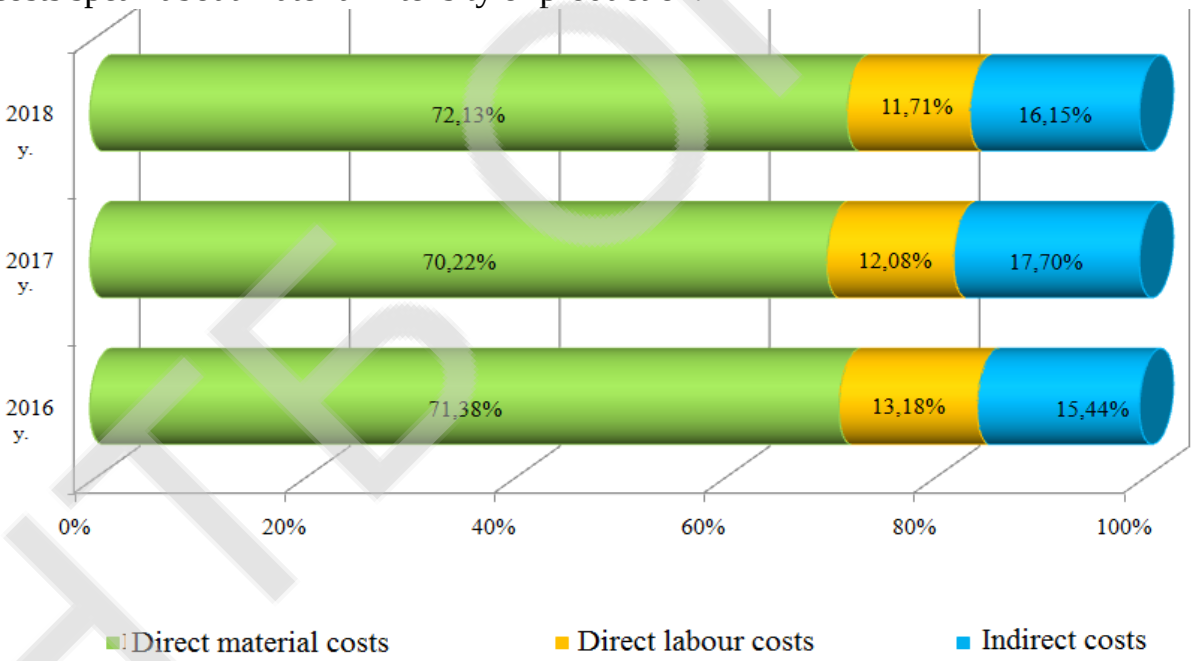


Figure 12 - Structural dynamics of costs by categories of direct and indirect costs of JSC «BCC «Domochai»

3. Analysis of production reserves for reduction of export production costs in the context of use of resources of JSC "BPC "Domochay" (Tables 11 - 13 Figures 13 - 15 Presentation). The production reserves of export-oriented production are revealed by the results of the analysis of the factors of changes in the dynamics of efficiency of the use of resources (human resources, fixed and circulating assets).

Analysis of labor resources efficiency factors and reserves for export-oriented output growth of JSC BPC Domochai. In 2018, the total number of employees of the enterprise decreased slightly, the structure was redistributed in favor of managers and specialists (0.58 p.p.), while the share of workers decreased by the same amount accordingly. Decrease in the number of employees of the enterprise is accompanied at the same time by improvement in the quality of the structure due to attraction of specialists (extensive factors of production activity development are used).

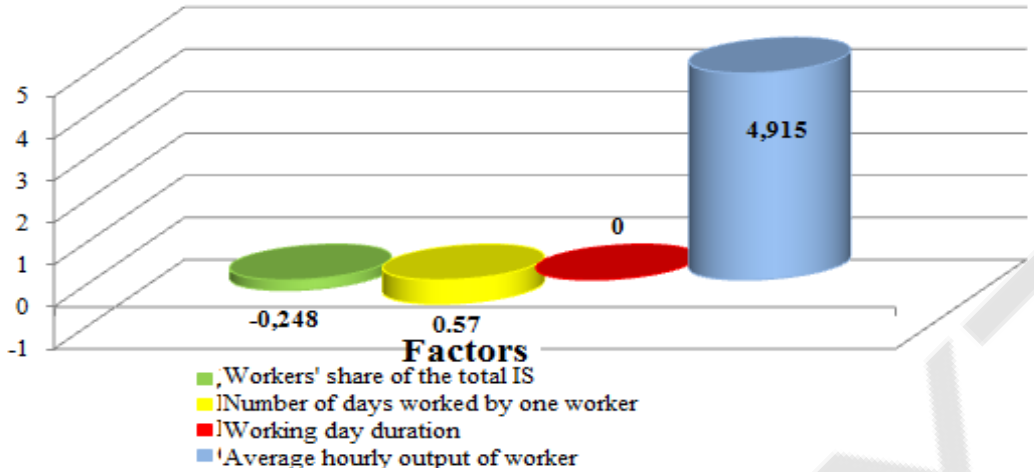
The average annual output of the enterprise's workers in 2018 is 4.098 thousand rubles or 11.76% higher than in 2017 (Table 11).

Table 11 - Analysis of Dynamics of Efficiency of Workforce Use of OJSC BPC Domochay

Indicator	2017 y.	2018 y.	Deviation	Rate of change, %
Volume of production, thousand rubles	32 515	35 832	3 317	110,20
The average number of industrial and production personnel, people	933	920	-13	98,61
The average number of workers, people	764	748	-16	97,91
The share of workers in the total number of workers (Ud), %	81,89	81,30	-0,58	99,29
Spent by one worker per year of days (D)	243	239	-4	98,35
Average duration of working day (P), h	8	8	-	100,00
Working hours fund, person-hour	1 813 752	1 759 040	-54 712	96,98
including a single worker, man-hour	1 485 216	1 430 176	-55 040	96,29
Average annual output of one worker W^{year} worker), thousand rubles	34,850	38,948	4,098	111,76
including one worker, thousand rubles	42,559	47,904	5,345	112,56
Average daily output of worker (W^{d}worker), thousand rubles	0,175	0,200	0,025	114,44
Average hourly output of worker (W^{h}worker), thousand rubles	0,022	0,025	0,003	114,44
Average annual salary, rub.	8241,60	9397,20	1155,60	114,02

Average hourly output per worker in 2018 increased in the current estimate by RUB 0.003 thousand or 11.76% (Table 11). Average hourly output per worker in 2018 increased in the current estimate by RUB 0.003 thousand, or 14.44%, as compared to the 2017 output of RUB 0.022 thousand, or 11.76% (Table 11). Day-to-day losses in working time were noted. The increase in the average annual output at the enterprise is determined by the intensive factor, and the decrease by extensive factors, which can be considered positively and used as production reserves of labor productivity growth, export-oriented output and profit (Figure 13).

Average annual output of workers decreased by 0.248 thousand rubles due to a decrease in the share of the enterprise's workers in the total number of employees, with daytime losses of 0.570 thousand rubles. The length of the working day did not change and did not affect the resultant indicator.



Factor (xi)	Size of influence (ΔW^{year}worker xi), , thousand rubles	Share of factor, %
Workers' share of the total IS	-0,248	-6,05
Number of days worked by one worker	-0,570	-13,91
Working day duration	0,000	0,00
Average hourly output of worker	4,915	119,97
Total	4,098	100,00

Figure 13 - Factor analysis of the average annual output of an employee of the core business of JSC «BCC «Domochai»

The increase in labor productivity at the enterprise was determined by the increase in the average hourly output of a worker by 14.44% (the amount of influence of 4.915 thousand rubles in terms of all workers).

The increase in the dynamics of the labor remuneration fund in 2018 due to the disproportion between the rates of productivity rotation and wages and salaries was determined in the amount of 71.57 thousand rubles (8645.42 x (1 - 1.081 / 1.090)) and considered as a production reserve for the growth of efficiency of production and output of export-oriented products.

Analysis of efficiency factors of material resources use and growth reserves of export-oriented production output of JSC "BPC Domochay". Outpacing growth rates of material costs in comparison with the growth rate of output were established, which determined the increase in material intensity of production and reduction of material output. As a negative fact it is necessary to note increase in material consumption by 0,003 roubles or by 0,43 %. At the same time, the material intensity of direct material costs increased to a greater extent - by 0.023 rubles or 3.81% (Table 12).

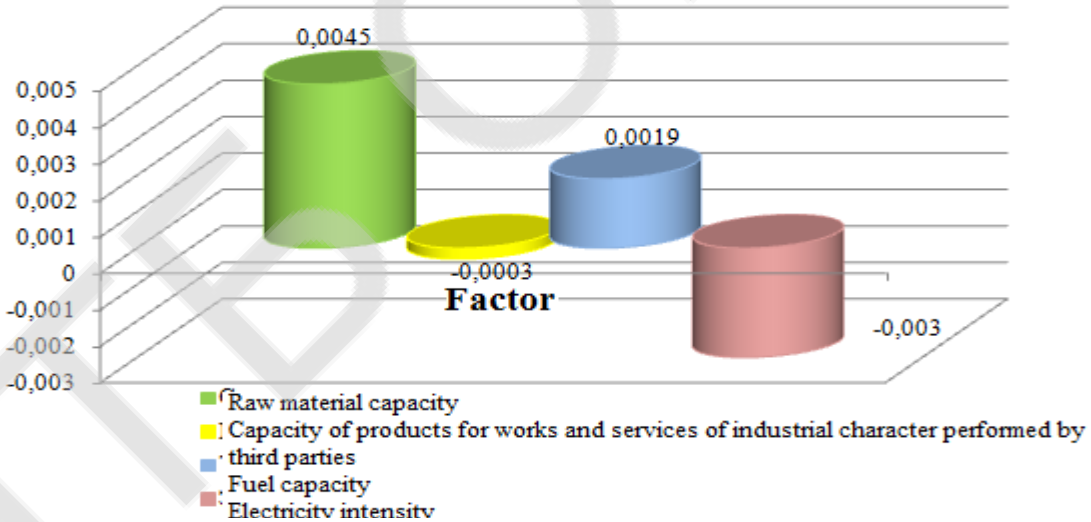
The increase in material intensity of BPC "Domochay" OJSC products in dynamics by 0.0031 roubles occurred due to the following factors (Figure 14): the increase in the raw material intensity of the capacity (the size of the factor influence is 0.0045 roubles); the increase in fuel intensity in dynamics: correspondingly, the material intensity increased by 0.0019 roubles or 0.43% (Table 12).

Decrease in energy intensity of the output products in 2018 as compared to 2017 determined the reduction of material intensity by 0.0030 rubles.

Table 12 - Analysis of private indicators of material intensity of products

Indicator	2017 y.	2018 y.	Deviation
1 Production output, thousand rubles	32 515,00	35 832,00	3 317,00
2 Material costs, thousand rubles	23 024,34	25 482,60	2 458,26
2.1 Raw materials and supplies, thousand rubles	18415,45	20454,55	2 039,10
2.2 Works of industrial nature performed by third parties, thousand rubles	256,35	271,56	15,21
2.3 Fuel, thousand rubles	3532,88	3961,42	428,54
2.4 Electric and thermal energy, thousand rubles	819,67	795,06	-24,61
3 Material capacity of products total, rub.	0,7081	0,7112	0,0031
3.1 Raw material capacity, rub.	0,5664	0,5708	0,0045
3.2 Product capacity for works performed by third parties, rubles	0,0079	0,0076	-0,0003
3.3 Fuel capacity, rub.	0,1087	0,1106	0,0019
3.4 Electric power intensity, rub.	0,0252	0,0222	-0,0030

Analysis of Fixed Assets Use Effectiveness Factors and Growth Reserves for Export-Oriented Products of OJSC BPC Domochai. The share of the active part of fixed assets in the dynamics decreased by 1.102 p.p., as well as the level of technical condition of fixed assets in terms of renewal, retirement, depreciation, average age of equipment. The results of the analysis of factors of intensive and efficient use of fixed assets of OJSC BPC "Domochay" (Table 13, Figure 15) show: due to changes in the structure of technological equipment (in favor of less expensive equipment), the level of the active part stock allocation increased by 0.228 rubles.



Factor	Size of influence on material capacity, rub.
Raw material capacity	0,0045
Capacity of products for works and services of industrial character performed by third parties	-0,0003
Fuel capacity	0,0019
Electricity intensity	-0,0030
Total material intensity of products (balance of factors)	0,0031

Figure 14 - Factor analysis of material capacity of JSC «BCC «Domochai» products

Table 13 - Factor analysis of the active part of fixed assets yield

Endowment of active part of fixed assets	Indicator level, rub.	Factor of change in yield				
		equipment structure	number of days worked	shift ratio	shift duration	average hourly output
Basically (2017 y.)	1,922	8,494	335	1,700	11,250	2,548
Conditional 1	2,150	7,594	335	1,700	11,250	2,548
Conditional 2	2,169	7,594	338	1,700	11,250	2,548
Conditional 3	2,041	7,594	338	1,600	11,250	2,548
Conditional 4	1,889	7,594	338	1,600	10,412	2,548
In fact (2018 y.)	2,230	7,594	338	1,600	10,412	3,007
Balance of factors	2,230 - 1,922= 0,308	2,150 - 1,922= 0,228	2,169 - 2,150= 0,019	2,041 - 2,169= -0,128	1,889 - 2,041= -0,152	2,230- 1,889= 0,341

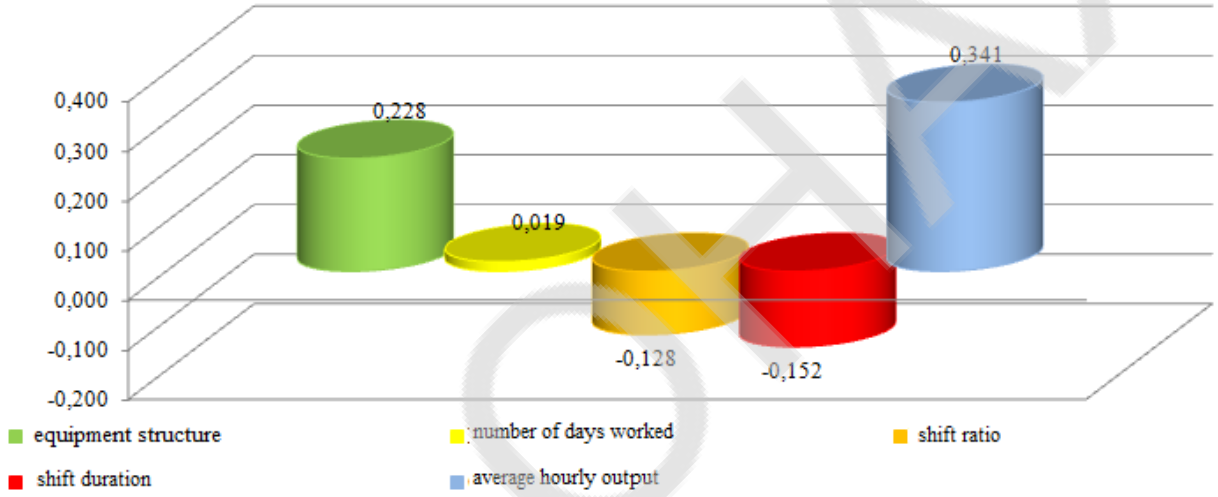


Figure 15 - Analysis of factors of change in asset allocation of the active part of fixed assets of JSC «BCC «Domochai»

Decrease in the operating time of a unit of equipment determined a decrease in the active part of fixed assets allocation by RUR 0.260. The number of days on average worked by one machine in the time interval under consideration increased by 3 days in accordance with the production calendar and determined a RUB 0.019 growth in the active part of the asset. Decrease in the equipment shift ratio determined a decrease in the active part of the funds yield by 0.128 rubles, intra-shift equipment downtime determined a decrease in its yield by 0.152 rubles. The positive effect of the average hourly output of equipment was established: the increase in the average hourly output of a unit of equipment resulted in an increase in the active part fundraising by RUB 0.341.

4. Investment oriented management of export production development of JSC "BPC Domochay" (Tables 14-19 of the Presentation). As an effective tool of perspective development of export-oriented production of JSC "BPC Domochay" the investment project is considered, which provides for realization of production reserves revealed in the analytical part in the following directions: providing competitive price; improving quality of export-oriented production; improving organization of sales activity in foreign markets (marketing approach to research of snow products market needs). The review of the snack

market according to the data of "Market Analytics" company has shown the expediency of production of the given group of products (key chains, rings, straws and other kinds of products) and export to the Russian Federation, Ukraine, Turkmenistan, Kazakhstan [10]. The purpose of the investment project is to create conditions for increasing the output of export-oriented products of JSC "BPC "Domochai". Technological and economic effect of introduction of the snack production line is summarized in Table 14 of the Presentation: creation of conditions for increasing the output of export-oriented products as a result of introducing a new product - snacks to the market; increasing the productivity of the equipment used in the JSC "BPC "Domochay" at the production site № 3; increasing the capacity utilization at this production site of the enterprise up to 85%; reducing the raw materials, energy and labor intensity and, accordingly, the direct and indirect cost of production.

Table 14 - Investment oriented development management of export-oriented production of JSC «BCC «Domochai»: effect of introduction of a snack production line

T	E
- minimizing losses of time, raw materials, energy resources for preparation, start-up and production; - no time losses on technological breaks (automatic switching of technological process on assortment positions of products); - possibility of non-stop changeover of the equipment and transition to another kind of assortment positions of snacks at the expense of raw materials supply according to the recipe by precision dispensers;- high speed and accordingly productivity; - reduction of material resources losses as a result of ensuring high accuracy of atomatic dosing of ingredients of products recipes; - dosing accuracy and nominal consumption of raw materials in accordance with the recipe for making snacks; - possibility to use domestic main and auxiliary raw materials; - automated production and synchronization of production and sales activities; - minimum number of scrap; - energy saving, as these devices are equipped with raw material level sensors.	- expanding the range of export-oriented products; - decrease in the prime cost of production in directions: decrease in material consumption (including raw materials consumption, fuel and energy consumption), labour consumption, level of overhead costs per unit of production; - elimination of losses of working hours of the equipment, workers; - increase in productivity of the equipment, workers (average hourly output of the equipment; average hourly output of workers; - increase in sales volumes of competitively capable products in foreign and domestic markets; - expanding the geography of export deliveries; - increase in volumes of export deliveries; - increased brand awareness of JSC «BCC «Domochai»; - increased competitiveness of products in terms of price and quality parameters; - capacity utilization in this unit of production of the enterprise up to 85%.

The investment project of introduction of the automated snow production line according to the commercial proposal of UE "Vladimir" and equipment cost of 584 thousand rubles was developed. The implementation of the investment project for the introduction of a snack production line at BPC Domochay provides for an increase in the volume and efficiency of export-oriented production: increase in export sales,

capacity utilization up to 95% as a result of technology development and implementation of snack production.

Financing of the investment project. According to the results of work for 9 months of 2019 the low level of net profit (48 thousand rubles) was established, which does not provide investment activity of the organization. As a source of financing of the investment project of introduction of the snack production line of JSC "BPC Domochay" was considered a leasing company and a lessor - the leasing company LLC "ASB Leasing" (Table 15).

Table 15 - Terms of leasing of LLC «ASB Leasing»

Leasing terms and conditions	Characteristics of the parameter
Leasing subject	Automated line for the production of snack groups of products (key chains, rings, straws or individual snack shapes)
Lease term	30 months
Cost of the leasing object	584,358 rubles RB
Lease interest	13% p.a. (annuity accrual scheme)
Initial facility fee	10 %
One-time fee	1 %
Depreciation (monthly)	3,33 %

The total cost of purchase, dismantling, installation and commissioning works under the investment project of implementation of a snack production line is 584358 rubles. Calculation of lease payment flows (contract with LLC ASB Leasing) is presented in Table 16. The cost of leasing payments amounted to 665,981.32 rubles, which corresponds to the price increase of the leasing object by 81,623.32 rubles or 13.97 %. The discounted value of leasing payments, taking into account tax benefits from leasing, was determined as RUB 442,787.82 thousand, which is 24.23% lower than the value of the investment object (Table 16), indicating beneficial use of leasing.

Table 16 - Perspective analysis of leasing payments under the investment project of implementation of the snack production line

Indicator	01.01.20 – 31.12.20	01.01.21 – 31.12.21	1.01.22 – 01.07.22	Total
Lease payment, rub	305 053,66	220 709,76	140 217,90	665 981,32
Tax concession on leasing, rubles	54 909,66	39 727,76	25 239,22	119 876,64
Post-tax value of leasing	250 144,00	180 982,00	114 978,68	546 104,68
Discount factor at a discount rate of 13%, unit shares	0,885	0,783	0,693	2,36
Present value of lease payments	221 366,38	141 735,46	79 685,99	442 787,82

Prospective analysis of financial indicators based on the investment project implementation results (Tables 17 - 19 Presentation).

Calculation of financial results from the implementation of the investment project outside the automated snow production line is presented in Table 17.

Table 17 - Calculation of income from the implementation of the investment project for the introduction of an automated snow production line

Indicator	2020 y.	2021 y.	2022 y.
Snack sales volume, t	617,317	864,244	987,708
including			
Bretzel product, t.	192,527	269,538	308,044
Rings product, t.	223,748	313,247	357,997
Straw product, t.	201,042	281,459	321,667
Cost of production 1 t, rub	3187,85	3347,243	3548,077
Sales price 1 t, rub.	3347,243	3581,549	3902,885
Revenue from sales, thousand rubles	2066,31	3095,33	3854,91
Production and sales costs, thousand rubles	1967,91	2892,83	3504,46
Expenses on marketable products rouble, thousand roubles	0,952	0,935	0,909
Profit from sales, thousand rubles	98,40	202,50	350,45

Export volume before the introduction of the snow production line is taken on the basis of the level for 2018 taking into account the average annual growth of export volume for 2016 - 2018 in the amount of 23.95%, adjusted for the risks of foreign economic activity of the enterprise. The price of 1 ton is assumed to be USD 1,098.18 for 2018. (USD exchange rate adopted at the level of 1.974). Export costs have been set in accordance with their relative export intensity indicator at the level of 2018 at $0.938 (USD exchange rate adopted at 1.974).

The calculation of profit from the sale of snow products was made taking into account the growth of production volumes, cost increases and is shown in Table 18.

Table 18 - Prospective analysis of profit growth from the investment project of implementation of the automated snack production line

Indicator	2019 y.	2020 y.	2021 y.	2022 y.
Export volume before implementation of the line, t	1477,785	1625,563	1869,397	2149,807
Price 1 ton, USD.	1098,18	1098,18	1098,18	1098,18
Revenue from sales to line implementation, thousand USD	1622,87	1785,16	2052,93	2360,88
Cost of rouble of products shipped for export before implementation of the line, USD	0,938	0,938	0,938	0,938
Production and sales costs before the implementation of the line under the flexible budget, thousand dollars	1521,98	1674,18	1925,31	2214,10
Profit from product export to line implementation, thousand USD	100,89	110,98	127,63	146,77
Export volume of snow products, t	-	432,122	604,971	691,395
Price 1 ton, USD.	-	1695,66	1814,36	1977,15
Revenue from the export of snow products, thousand dollars	-	732,73	1097,64	1366,99
Cost of rouble of products shipped for export after implementation of the line, USD	-	0,952	0,935	0,909
Cost of production and sales after implementation of the line under the flexible budget, thousand USD	-	697,84	1025,83	1242,72
Profit from snack products export, thousand dollars.	-	34,89	71,81	124,27
Total profit from the export of products, thousand dollars.	100,89	145,87	199,43	271,04
Relative profit growth, %	100,00	44,58	97,67	168,65

In accordance with the above conditions, the prospective line of profit on export of products before introduction of the production line of snow products of JSC BPC Domochay is defined as USD 100.89; 110.98; 127.63; 146.77 thousand (USD exchange rate adopted at the level of USD 1.974). The relative increase in profit after introduction of the investment project in 2020 - 2022 is defined in the amount of 44,58; 97,67; 68,65 % accordingly.

For the purpose of the current assessment of the projects' prospects, the calculation of net present value (NPV) has been made taking into account the annual economic effect from the implementation of the investment project for the introduction of an automated snow production line in the first 3 years of the project life cycle and a discount rate of 13%. Results of calculations are brought in the table 19.

Table 19 - Evaluation of investment project efficiency. Calculation of net discounted value, thousand rubles

Years	Amount of investment	Sales revenue on domestic and foreign markets	Discount factor (discount rate 13%)	Discounted capital investments	Discounted income	Net Present Value (NPV)
2020 year	305,05	153,53	0,88496	269,96	135,87	-134,09
2021 year	220,71	283,54	0,78315	172,85	222,06	49,21
2022 year	140,22	448,63	0,69305	97,18	310,92	213,74
Total	665,98	885,70	-	539,99	668,84	128,86
Parameters for evaluating the efficiency of an investment project: IRR = 60 + [(5,14 / (5,14 - (-4,62)) x (70 - 60)] = 65,27 %; MIRR = 1,10841 - 1 = 0,10841 (10,841 %) from the equation: 539,99 = 735,331 / $(1 + MIRR)^3$. PI = 1,239 (668,84 / 539,99).						

Results of the discounted analysis of efficiency of realization of the project specify expediency of its realization: net discounted cost is defined at a rate of 128,86 thousand roubles; payback period of the project taking into account the discounted streams - 29,06 months (2,42 years), profitability index - 1,239; profitability of investments - 23,86 %; internal rate of return - 65,27 %; modified internal rate of return MIRR - 10,84 %.

V. Conclusions.

In the work the theoretical and practical aspects of the formation of information and analytical environment to identify the prospects for export-oriented production of JSC "BPC "Domochay" are studied. The geography of exports is represented by cities, regions and districts of the Russian Federation, countries that are not members of the Commonwealth of Independent States. The largest share of exports is to CIS countries, including the Russian Federation. The most promising direction of export potential development is increasing sales of confectionery products. As production reserves of increase in output of export-oriented products of JSC "BPC "Domochay" are established: reduction of working time losses and further increase of labour productivity, in particular, average hour output of workers as a result of automation of

production and reduction of labour intensity of technological operations of bakery and confectionery production; maintenance of positive proportions of labour productivity and wages growth in a context of expanded reproduction; elimination of losses of time; elimination of losses of labour productivity and wages.

As an effective tool of export-oriented production management BPC "Domochay" JSC considered an investment project that provides for implementation of production reserves identified in the analytical part. The purpose of the investment project of introducing an automated snack production line is to create conditions for increasing the output of export-oriented products. The source of investment financing in this project is ASB Leasing LLC. The economic effect is calculated in the following directions: increase of sales volumes in the domestic and foreign markets; expansion of sales geography, including the markets of Russia, Ukraine, near and far abroad; increase of loading of production capacities of the enterprise; decrease of raw materials intensity, energy intensity, labour intensity and accordingly direct material and labour costs as a part of production cost price as a result of use of progressive technological process and high-tech equipment. The estimation of economic efficiency of the project, made according to the international standards, has defined profitability of the project offered to realization.

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НТБ ОНАХТ

FORMATION COMPETITIVENESS ENTERPRISES SPECIALIZING IN THE PRODUCTION OF BREAD AND BAKERY PRODUCTS

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Abstract. *The questions of formation competitiveness enterprises specializing in the production of bread and bakery products are studied, as well as the current state, tendencies and problems of development of the baking industry in Ukraine are analyzed.*

It is established that there is a tendency to decrease the production volume of bakery products in Ukraine, loss of production capacity due to the occupation of part of the territory of the country. The leaders among the regions of Ukraine, identified by Dnipropetrovsk, Kyiv and Kharkiv regions, were identified. It has been found that these products are not deficient at the moment, but studies indicate a strong shadow market segment that does not report to the departments of statistics.

The factors of influence on the level of competitiveness of the baking industry are investigated, where the significant factors are the increase of prices for other foodstuffs, accessibility of purchase, marketing, advertising, positive image of the producer.

In the example of Kharkiv region the main competitors of the baking industry are investigated and the integral indicator of competitiveness for such enterprises is calculated.

Keywords: *competitiveness, level of competitiveness, enterprises specializing in the production of bread and bakery products, culture of nutrition, formation of competitiveness.*

I. Introduction.

Traditionally, bread and bakery products are of particular importance in the culture of Ukrainian nutrition. These products consist about 40% of the total calorie content of the Ukrainian people's diet. The production of bread and bakery products belongs to the strategic branches of our country's economy since not only food but also national security of the country depend on the efficiency of the performance of the enterprises that specialize in bread and bakery products. The social significance of bread, the need for stable and timely supply of qualitative and fresh produce to the population lead to the need to analyze the market for bread and bakery products, as well as to study the competitiveness of the enterprises that specialize in bread and bakery products. Actually, this study is dedicated to these issues.

II. Analytical review of the literature.

A number of scientific works of academic economists have been dedicated to the problems and prospects of the development of bread and bakery industry, in particular these issues have recently been considered by: Vasilchenko O.M., Govorukha Zh.A., Gryshchenko A.M., Davydyuk Yu., Dzyuba O.M., Drobot V.I., Rotated D.V., Kokovskaya S.I., Kostetska N.I., Litvinyuk O.P., Navolskaya N.V., Netyazhuk M.V., Obidina I.I., Oprah O.A., Prokip M.I., Repich T.A., Samilenko N.Y.,

Senishisha L.O., Strunin V.V., Teleshevskaya S.M., Urba S.I. , Fedorova T.V., Filonenko T.M. and others [1-9]. However, the bread and bakery industry is dynamic so that means it is constantly changing, developing and it needs some further researches, and it is also strategically important to study the competitiveness of enterprises that specialize in bread and bakery products.

III. Object, subject and methods of research.

The object of the study is the process of forming the competitiveness of enterprises specialized in the production of bread and bakery products.

The subject of the research is theoretical, methodical and practical questions on formation of competitiveness of the enterprises specializing in the production of bread and bakery products.

Research methods: abstract and logical - in the study of the essence of competitiveness of enterprises specializing in the production of bread and bakery products; systematic - in research and generalization of factors and aspects of competitiveness of enterprises; method of analysis and synthesis - in the study of the formation of competitiveness of enterprises specializing in the production of bread and bakery products; graphical method – for visual display of research results; method of economic and statistical analysis - to analyze the production of bread and bakery products in Ukraine; expert assessments, the method of SPACE analysis.

IV. The results.

The study of condition, problems and prospects for development in bread and bakery market of Ukraine was, is and will remain relevant in the future under any circumstances of country's economic development.

For a better understanding of "bread" situation in Ukraine, it is necessary to examine the statistical information of bakery production from 2010 to 2017. [10, p. 281].

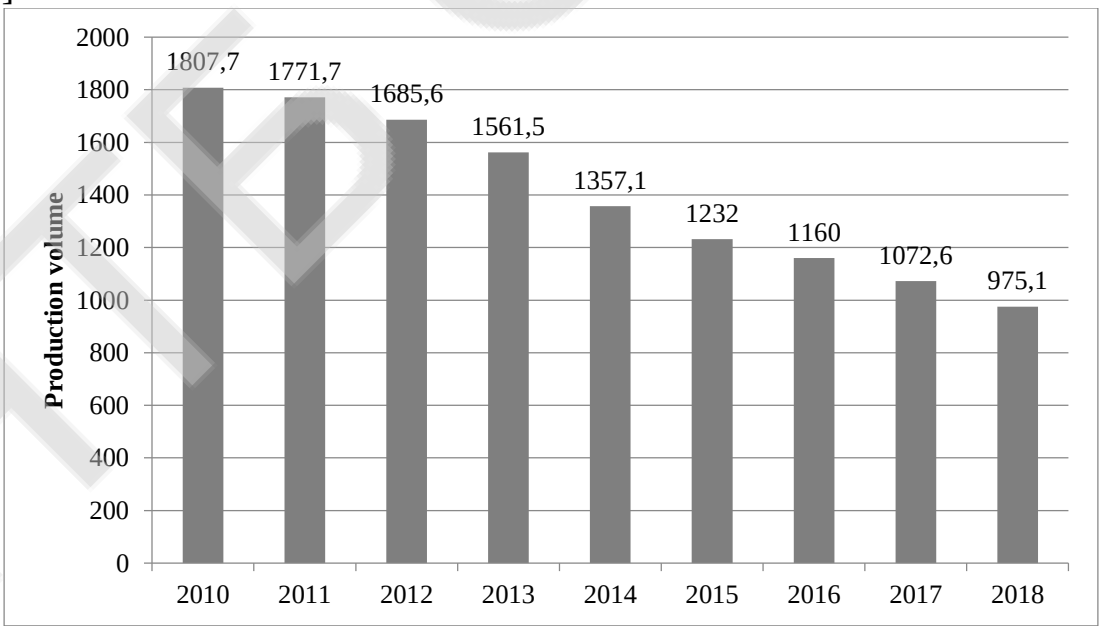

Fig. 1. Dynamics of bread and bakery production in Ukraine in 2010–2018

Thus, there is a tendency of decreasing of bakery products production in Ukraine: from 1807700 tons in 2010 to 975100 tons in 2018, that means that the

production has fallen by 54% in comparison with 2010. From 2010 to 2013 there was a gradual decrease in bakery products production, in 2013 flour production was 1561500 tons, and after 2013 there was a sharp decline: 1357100 tons in 2014, 1232000 tons in 2015, 1160000 tons in 2016, 1072600 tons in 2017, 975100 tons in 2018 [10, p. 281] These changes stem from objective reasons: a production fall due to leaving of Crimean peninsula territories, Donetsk and Luhansk regions, which significantly supported that field (its part in total bakery production in Ukraine in 2010 was 3,4%, 8.9% and 4.1% respectively) from the market. The loss of production capacities due to the occupation of a part of country's territories caused the geographical adjustment in bakery production.

Thus, according to the results of the first half of 2015, bakery production in Donetsk region fell by 69.5% or 47500 tons. As a result, its part in the production fell by almost 6%, and its position on ranking list got worse as it moved from the second to the eleventh place. In Luhansk region, the bakery production decreased almost by eight times. For the sake of clarity, the information about bread and bakery production of different regions are presented below (Fig. 2).

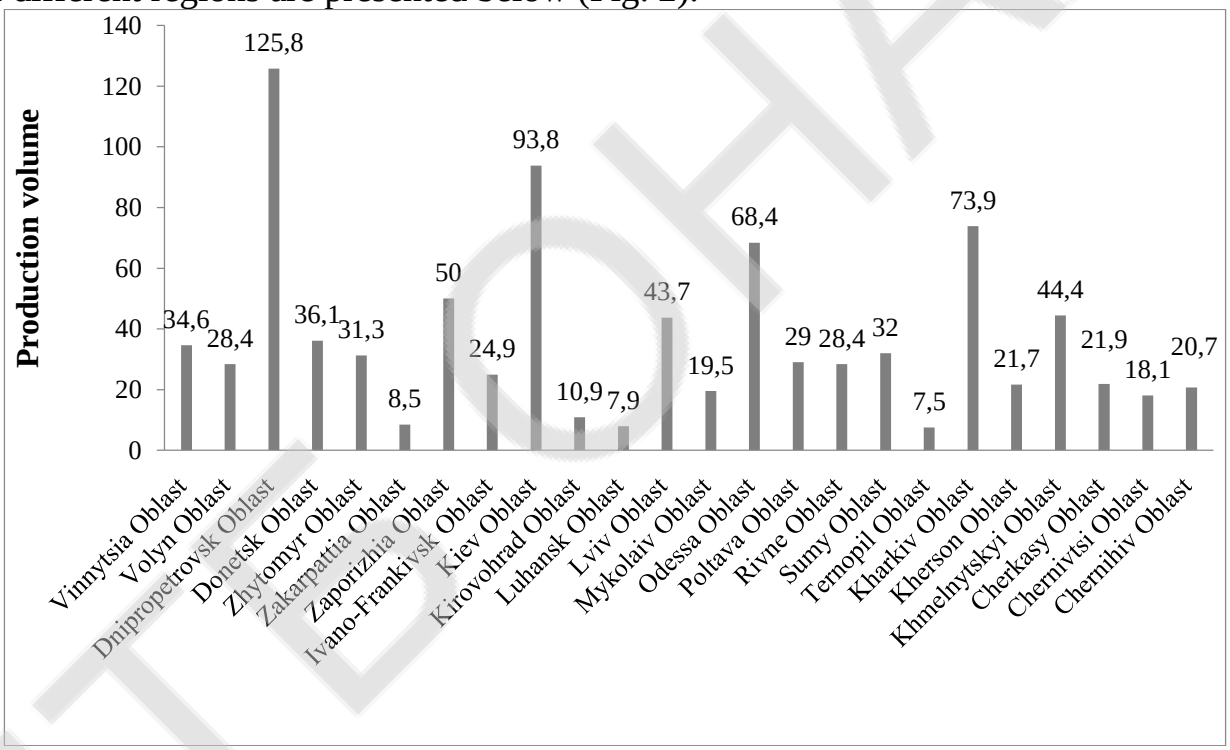

Fig. 2. Bread and bakery production by regions of Ukraine in 2018

In 2018 the leaders among Ukrainian regions were: Dnipropetrovsk region – 125800 tons, Kyiv region – 93800 tons and Kharkiv region – 73900 tons, and Odessa region – 68400 tons and Zaporizhzhia region – 50000 tons The leaders in 2010 were: Dnipropetrovsk region – 186700 tons, Donetsk – 161600 tons and Kharkiv regions – 131300 tons, and Odessa – 93900 tons and Zaporizhzhia regions – 74800 tons [10, p. 281].

Ukraine produces over one million tons of bread and bakery products annually, which does not fully supply Ukrainian population with these products, as bakery production, according to statistics of the State Statistics Service of Ukraine, was 23 kg

per person in 2018, and the actual consumption of bakery production was 100 kg per person [10, p. 99], as it is shown in the chart 1.

Chart 1

Indicators of production and actual consumption of bread and bakery products in Ukraine from 2010 to 2017

Year	Bread production (thousand tons)	Population, thousand people	Production for 1 person, kg	Actual consumption of products per person, kg	Deviation +/-(the production from the consumption)
2010	1807,7	45963	39	111	-72
2011	1771,7	45779	39	100	-61
2012	1685,6	45633	37	109	-72
2013	1561,5	45553	34	108	-74
2014	1357,1	45426	30	109	-79
2015	1232,0	42929	29	103	-74
2016	1160,0	42603	27	101	-74
2017	1072,6	42485	25	101	-76
2018	975,1	42153	23	100	-77

That is, the deviation of consumption over production is (-77 kg). And from 2010 to 2018 there was a decrease in bread production from 1807.7 thousand tons in 2010 to 975.1 thousand tons in 2018, together with the population decreased from 45963 thousand people to 42153 thousand persons, and therefore the value of the production indicator per person also decreased - from 39 kg/person to 23 kg/person. The actual consumption of bread also decreased: from 111 kg per person in 2010 to 100 kg per person in 2018. Production consumption deviations remain at approximately the same level: -72 kg in 2010, -74 kg in 2015 and -77 kg in 2018.

Comparing the actual data of the State Statistics Service of Ukraine with the real state of the bakery products market, we can conclude that there is in fact no shortage of these products. This situation is due to the emergence of a strong shadow market segment: bread is sold in kiosks registered as FOP or without registration at all. Due to this, they are able to reduce the cost of products, which are often made in unsanitary conditions and can not meet any quality standards. But as it is profitable, the shadow market segment accounts for about 60% of all bakery production. Such businesses do not report to statistical departments, which distorts the actual data. In addition, in recent years, one of the causes that led to the decline was the loss of production capacity due to the occupation of part of the country. Also, many supermarkets in Ukraine specialize in the production of their own bakery products, but this production is not fixed. And also it is necessary to consider baking of bakery products at home.

There are many factors that affect the competitiveness of businesses specializing in the production of bread and bakery products. Among which are the external and internal factors [4 p.2-5; 6 p.97, 98]. To external include:

- social (population, sex and age, food culture, income level);
- political and legal (legislative acts, political situation);
- economic (price, income level).

The internal include:

• raw material resources of the enterprise (availability of limited quality raw material resources of the enterprise; type of resource, cost and availability of the resource; market share of the enterprise as a production unit);

• personnel potential of the enterprise (structure and qualification of personnel; number of staff);

• marketing activities (availability of marketing service; availability of information and regulatory and methodological basis of management; image of the enterprise; sales opportunities to expand the geographical boundaries of the market; the presence of an extensive sales system; product quality);

• enterprise strategy (mission statement, long-term goals, paths and decision-making rules for the most effective use of strategic resources, strengths and opportunities, elimination of weaknesses);

• innovation and investment activities (number of research and production staff at the enterprise; costs of research, development and technological innovations; availability of cooperation with scientific units; possibility of profitable attraction of external financial resources; size of internal sources of financing);

• geographical location of the enterprise (access to raw materials; access to transport networks);

• production activity (features of applied technology and technology; level of mechanization and automation of labor; research activity; range, structure and quality of production);

• financial and economic activities (financial reporting standards used; solvency; profitability and profitability).

It should be noted that in recent years the culture of nutrition, which has been heavily influenced by the media, has changed, presenting bread as a high-calorie product whose usefulness is in doubt. Recently, the world trend is a healthy lifestyle, which includes healthy, or as it is called "proper" nutrition, the basis of which is to reduce the consumption of carbohydrates, the content of which exceeds the norm in bread. However, bread and bakery manufacturers have found an approach to such consumers by expanding their range to include non-yeast, gluten-free dietary bakery products. Expansion of the range helps to increase the demand and increase the competitiveness of enterprises specializing in the production of bread and bakery products. Today we see a wide range of bread on the market, not including other bakery products: from "social" to "elite", different flavors - from different flour (wheat, rye, corn, buckwheat), with different additives (bran, raisins, raisins, raisins, raisins, raisins dried apricots, nuts, sesame, poppy, cumin, fenugreek, hot pepper, sunflower seeds, pumpkin seeds, etc.), various shapes and sizes ("brick", loaf, baguette, mini-baguette, round meadow, loaf, pita), whole and half, cut and uncut. Even the most demanding consumer will find something to their taste.

An important factor for both producers and consumers is the price of bread and bakery products. Thus, according to statistics for January 2019, the most expensive bread was in Kiev, and the cheapest in the Odessa region. These data were obtained by the Ukrainian Association of Retailers by calculating the value of the bread basket. The bread basket included 1 kg of wheat bread from the highest grade flour, 1 kg of wheat bread from the first grade flour, 1 kg of rye bread and 0.5 kg of loaf. The most

expensive regions were: Kyiv – 95 UAH and Kyiv region – 81 UAH; Zhytomyr region – 75 UAH; Transcarpathia – 73UAH; Volyn – 71 UAH. The "cheapest" regions are: Odessa region – 63 UAH; Nikolaev – 64 UAH; Dnepropetrovsk – 65 UAH; Lugansk – 65 UAH; Ternopil region – 65 UAH. The intermediate position was occupied by: Donetsk and Cherkasy regions – UAH 71 each, Ivano-Frankivsk, Lviv and Khmelnitsky regions – UAH 70 each, Kirovohrad, Poltava and Kherson regions – UAH 69 each, Zaporizhia, Sumy and Chernihiv regions – UAH 68 each, Vinnytsia, Rivne and Kharkiv – UAH 67 and Chernivtsi – UAH 66 [11].

Thus, by analyzing the state of bread production and the market of this industry, we can summarize the aspects of influence on the level of competitiveness of the bakery industry (Fig. 3) [17, p. 57-61].

Aspects of influence on the level of competitiveness of the baking industry	
cause an increase in consumption	*cause a decrease in consumption*
- raising prices for other foods	- decrease in population;
- high-level trade organization;	- psychological impact of the media;
- high quality products;	- distribution of household appliances for baking bread at home;
- effective advertising;	- changing the tastes of consumers with the emergence of trends in healthy lifestyles and healthy eating.
- positive image of the manufacturer;	
- expansion of the range;	
- availability of purchase.	

Fig. 3. Aspects of influence on the level of competitiveness of the baking industry

From Fig. 3, we see that one of the main aspects of the impact on competitiveness that causes an increase in product consumption is the increase in prices for other foods. It is also well-known that due to a well-thought-out pricing policy, an important aspect is the affordability of purchases compared to previous years. Important aspects are marketing, advertising, positive image of the manufacturer.

We also emphasize the importance of organizing trade. Let's take this into the example of Kulinichi LLC, which took a good position in the market, taking advantage of such important advantages as comfortable customer service, focusing on a particular consumer, where corporate trade plays a significant role. Kulinichi LLC has created a competitive environment in the bread and bakery industry, thereby displacing small businesses.

Today, the bread and bakery market is filled with products from different manufacturers. In 2017, the main representatives of the domestic bread market were such companies as Lauffer Group (Odessa Loaf, Donbasshlib, Khlibinvest) – 6,45 %, PJSC "Kyivhlib" – 6,42 %, TM "Kulinichi" (Kyiv, Kharkiv) – 4,73 %, PJSC“Concern Khlibprom” (Lviv, Vinnytsia region) – 3,33 %, TM“Khlibodar”(Zaporizhzhia region) – 3,11 % (chart 2) . [12].

Chart 2

The main participants in the bread and bakery market of Ukraine

Supply chain	Number of participants	The main participants
Production	More than 100 bakeries and over 400 mini-bakeries	PJSC “Kyivkhlib”, LLC “Khlibni Investitsii”, JSC Concern “Khliboprom”, LLC “Kulinichi” Bakery, GK «Formula of taste», GK «Khlibodar», Holding Gold Harvest Lauffer Group
Wholesale	More than 100 participants	August-Key LLC, Athena Group LLC, Tema-B LLC, TD Hekta LLC, Alta Vista LLC
Retail	Retail chains, supermarkets, shops, MAFs, food markets	
End consumers	Population in Ukraine	

It is worth noting that the largest baking capacity in Ukraine is owned by the Lauffer Group. The average daily output of bakery products is 800 tons [16]. PJSC "Kyivhlib", a recognized leader of the Ukrainian bakery market, which includes 9 production sites in the capital and the Kyiv region, has a significant competitive position. At its own production capacity, the company produces 750 tons of bakery and 20 tons of pastry a day. Today the company's product range includes 700 items. The Kulinichy trademark, having taken the leading position among national bakeries, has established itself as a worthy producer of quality bread products. Today the company includes 10 specialized baking complexes in Kharkiv, Kyiv and Poltava regions. The productivity of enterprises is 650 tons of bakery products per day [14]. In addition to large companies, the domestic bread and bakery market covers another 400 mini-bakeries with a capacity of 1 ton per year.

In the Kharkiv region, which is among the top three among other regions of Ukraine in the production of bread and bakery products, the volume of bakery products in recent years has decreased from 112426 tons to 73870 tons in 2018 [15].

At the present stage, the competitiveness of enterprises specializing in the production of bread and bakery products is taking place to a greater extent, as explained above, due to such aspects as trade organization and assortment policy. For example, in the Kharkiv region, the leaders of bread production have traditionally been and remain LLC Kulinichi and TD Saltivsky, but in recent years the LLC Novo-Bavarian Khlibzavod and LLC Roma have entered the market (Pervomaisk, Kharkiv region). Also in the bakery market we can see such producers as: PJSC “Lyubotinsky Bakery”, Osnovyansky Bread. In addition to these enterprises in Kharkiv, you can buy products from neighboring regions, in particular, competitors in this field are the enterprises of LLC Poltava-Khlib, LLC Sumy Polyanytsia, and TM Riga Khlib, Chernihiv.

A powerful and main competitor of LLC Kulinichi at this time is LLC "Roma", although a few years ago, such competitor was TD Saltivsky, which was transferred to the management company "Korovaevo" for its debts. Saltivskyi as well as LLC Kulinichi had its own trading network - booths with branded trade all over Kharkov, which gradually began to disappear from the market in 2017 due to their

financial situation. In 2018, among other players, the "bakery arena" was released by LLC "Roma", which is located in the city of Pervomaysk in the Kharkiv region and even has establishments of corporate trade in this town, which, in addition to the main products, which are on the shelves of trade establishments of Kharkov, you can also buy additional bakery products (cakes, cookies, burgers, hot dogs, etc.).

Let us determine the current level of competitiveness of LLC Roma in the bakery market for further recommendations for its improvement. To do this, we propose to calculate an integral indicator of competitiveness, which takes into account such factors as: the price of products, the range of products, the duration of existence of the company, the design of packaging, the presence of a network of branded trade, advertising. To estimate the weighted values of these factors, we use a survey method, which was attended by 22 experts (business executives, experts in the baking industry, teachers in economic disciplines, etc.). Yes, we can conclude by analyzing the experts' answers and rounding up the values in chart 3.

Chart 3

Weighting factors of the competitiveness of the baking industry enterprises obtained by the survey method

№	Competitiveness factors	Weight value
1	Product price	0,4
2	Product range	0,3
3	Duration of existence of the enterprise	0,1
4	Packaging design	0,05
5	The presence of branded network	0,1
6	Advertising	0,05

The competitiveness level of Roma LLC is estimated in comparison with LLC Kulinichi, TD Saltivskyi, Novo-Bavarian Khlibzavod and Poltava-Khlib LLC. For this purpose, experts were asked to evaluate the competitiveness factors of these enterprises on a 5-point scale (chart 4).

Such factor as the duration of existence of the enterprise was estimated depending on the year of establishment of the company: LLC "Roma" – 1992, LLC "Kulinichi" – 1995, TD "Saltivsky" – 2001, LLC "Novo-Bavarian Bread Factory" – 1995 and LLC "Poltava-bread" – 2011. The factor "Availability of corporate trade network" was estimated as follows: LLC "Roma" – 4, LLC "Kulinichi" – 5, TD "Saltivsky" – 4, LLC "Novo-Bavarian" – 1, LLC «Poltava bread» – 1.

We summarize the integrated value of the integrated indicator of competitiveness of the studied enterprises in chart 5.

Table 4

Experts's results of the survey on the competitiveness factors of in the studied enterprises*

Experts	Competitiveness factors																			
	the price of products					product range					packaging design					advertising				
	R	K	S	N-B	PB	R	K	S	N-B	PB	R	K	S	N-B	PB	R	K	S	N-B	PB
1	5	5	5	4	5	5	5	4	5	4	4	5	3	5	3	3	5	3	5	2
2	5	5	5	3	4	5	5	5	4	4	5	5	4	3	4	3	5	4	4	3
3	4	5	4	4	4	5	5	5	5	5	4	5	3	4	3	3	5	3	5	3
4	5	5	5	5	4	5	5	5	4	3	5	5	5	5	4	4	5	3	4	2
5	5	5	5	3	3	5	5	5	4	4	5	5	3	3	3	3	5	3	4	2
6	4	5	4	4	5	5	5	5	5	3	5	5	3	4	4	4	5	4	5	3
7	5	4	5	5	4	5	4	4	3	3	5	4	4	5	3	3	5	3	3	4
8	5	5	5	3	5	4	5	5	4	4	5	5	3	4	3	3	4	3	4	2
9	5	5	5	4	4	5	5	5	5	3	5	5	3	3	5	4	5	3	5	3
10	4	5	5	3	4	4	5	5	3	3	5	5	4	4	4	4	5	3	3	2
11	5	4	5	5	3	5	5	5	4	3	5	5	3	5	3	3	4	4	4	3
12	5	5	5	3	5	4	5	5	3	5	5	5	3	4	4	3	5	3	5	2
13	4	4	5	4	4	5	5	4	5	3	5	5	4	3	5	3	5	3	4	3
14	5	5	4	3	4	5	5	5	4	3	5	5	3	5	3	3	5	3	3	2
15	5	4	5	3	4	5	4	4	3	3	5	5	3	4	3	3	5	3	4	3
16	5	5	5	5	4	4	5	5	5	3	5	5	3	3	4	4	5	3	5	3
17	5	5	5	3	4	5	5	5	4	4	5	5	4	5	3	3	5	3	4	2
18	5	5	5	5	5	5	5	5	3	3	5	5	3	4	4	4	5	4	3	3
19	5	5	5	4	4	5	5	4	5	3	5	5	3	4	4	4	5	3	5	2
20	5	5	5	4	3	5	5	5	4	5	5	4	3	5	3	3	5	3	4	3
21	5	5	5	5	4	5	5	5	3	3	4	5	3	4	4	4	5	3	3	2
22	5	5	5	4	4	5	5	5	4	3	5	4	3	5	3	3	5	3	5	2
Consolidated importance	**4,8**	**4,8**	**4,9**	**3,9**	**4,1**	**4,8**	**4,9**	**4,8**	**4,0**	**3,5**	**4,9**	**4,9**	**3,3**	**4,1**	**3,6**	**3,4**	**4,9**	**3,2**	**4,1**	**2,5**

*Legend: R – Roma, K – Kulinichi, S – Saltivskyi, N-B – New-Bavarian, PB – PoltavaKhlib.

НЕ ОРИГІНАЛ

Chart 5

The summary of integrated values of the integrated indicator of competitiveness of the studied enterprises

Enterprises	Competitiveness factors						An integral indicator of competitiveness
	the price of products	product range	duration of existence of the enterprise	packaging design	availability of branded network	availability of branded network	
	Weight value						
	0,4	0,3	0,1	0,05	0,1	0,05	
LLC Roma	4,8	4,8	5	4,9	4	3,4	0,047
LLC Kulinichi	4,8	4,8	4	4,9	5	4,9	0,048
TD Saltivskyi	4,9	4,8	3	3,3	3	3,2	0,043
LLC "Novo-Bavarian"	3,9	4,0	4	4,1	1	4,1	0,037
LLC Poltava Bread	4,1	3,5	2	3,6	1	2,5	0,033

As can be seen from chart 5, the highest value of the integral indicator of competitiveness is LLC Kulinichi 0,048, however, LLC Roma is not much lower than the value of this indicator 0,047. Saltivskyi, Novo-Bavarian and Poltava-Khlib have lower competitiveness indicators - 0,043, 0,037 та 0,033. It means that LLC "Roma" can boldly expand the market and reach the level of the whole Kharkiv area with its branded trading network alongside LLC "Kulinichi".

V. Conclusions.

As follows, the production of bread and bakery products in Ukraine is steadily declining. This trend continues in Kharkiv area. However, these data does not take into account the volume of baking at home, in small bakeries, supermarkets and households.

Based on the results of the analysis of the competitiveness of enterprises specializing in the production of bread and bakery products, it can be concluded that the decrease in volumes in Ukraine is due to such factors as: food culture, which is strongly influenced by the media, presenting bread as a high-calorie product the usefulness of which is in doubt. Recently, the world trend is a healthy lifestyle, which includes healthy, or as it is called "proper" nutrition, the basis of which is to reduce the consumption of carbohydrates, the content of which exceeds the norm in bread. However, bread and bakery manufacturers should find an approach to such consumers by expanding the range to include non-dairy, gluten-free dietary bakery products, which will increase the competitiveness of such businesses.

So the competitiveness of enterprises specializing in the production of bread and bakery products is taking place to a greater extent, as has been clarified, due to aspects such as trade organization and assortment policy.

Using the example of the Kharkiv area as the main competitors of the baking industry and calculating the integral competitiveness index, it was found that LLC Kulinichi has the highest value of the integral competitiveness indicator 4,9, but

LLC Roma is not much lower than this figure of 4.815. Saltivskyi, Novo-Bavarian and Poltava-Khlib have lower competitiveness indicators. It means that LLC Roma can boldly expand the market and reach the level of the whole Kharkiv area with its corporate trade network along with LLC Kulinichi.

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НТБ ОНАХТ

ANALYSIS AND DECISION OF REGIONAL ECONOMIC VITALITY AND ITS INFLUENCING FACTORS

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Astract*. Regional economic vitality is an important component of regional comprehensive competitiveness. Therefore, how to grasp the key factors and effectively improve the regional economic vitality is a research direction with practical value.*

Through researching a large number of related literatures, this article proposes two issues for research: 1. Taking a region as an example, establishing a relationship model of regional economic vitality influencing factors, proposing action plans, and analyzing regional economic vitality from the perspective of population and corporate vitality trends Impact of change. 2. Select a suitable index system to establish a mathematical model for measuring regional economic vitality, and rank regional economic vitality in Beijing, Shanghai, Guangzhou, Shenzhen, and some second-tier cities.

For the first question, this article starts from five aspects of economic aggregate, corporate benefits, government regulation, residents' situation and environment, selects 22 indicators, uses correlation analysis method to select 8 optimal indicators, and then uses subjective weighting method and The model combined with objective weighting method obtains the weight of each indicator, scores the regional economic vitality, and obtains the relationship model of the factors that influence the regional economic vitality, and proposes an action plan. Finally, it uses regression analysis to find that the population growth rate negatively affects the regional economy. Vitality, the growth rate of the number of enterprises is positively affecting regional economic vitality.

For the second question, this paper tests the relational model given in the first question. It is found that there is an error from the actual test, so it needs to be corrected. This article uses hypothesis testing model ideas and adds two correction coefficients based on a mathematical model of normal distribution, and then performs linear programming on the correction factors, and then tests the relative error to determine whether it makes the probability histogram follow a normal distribution image The relative error is less than 0.05, and then the hypothesis is justified based on the conclusion. After correction, it was found that it was indeed within the acceptable range, and the top three cities that got the economic vitality were Shanghai, Beijing, and Shenzhen.

Based on the previous conclusions, this article puts forward a series of suggestions for promoting the development of talents, informatization, technological innovation, and industrial upgrading in Beijing. It provides a reference for the sustainable development of regional economic vitality and the improvement of regional competitiveness. Value.

Keywords: *Regional economic vitality; Correlation analysis method; Normal distribution model*

1 Introduction

Against the background of the current deepening reforms, the booming new technological revolution around the world has pushed the world economy to move forward at a faster pace. Under the pressure of huge international competition, how to strengthen the economic system of a region Vitality has become an urgent issue at this time. In this paper, by scoring major cities in China, establishing related mathematical models, analyzing and researching regional economic vitality, asking and solving problems, and seeking solutions to the problem.

2 Literature analysis

Although economic vitality has long been proposed to be of great significance to the economic development of a country or region, there is little relevant literature on the study of regional economic vitality. The index system used by different scholars in the same region is different. The index system used is also different, which has caused the economic vitality research index system to be ununiform.

Regarding regional vitality, Zhou Tianbao first, Yang Anqin (1985) proposed that urban vitality is manifested as the ability to self-development and improvement of urban production relations. In addition, urban vitality is also manifested as meso-economic control, regulation, and organization of coordinated macroeconomic development. The ability of the overall economic system to operate [1]. Lu Mingyang (2011) and others believe that the city's competitiveness is the best reflection of urban vitality, and the two have a positive correlation. When selecting the index system, mainly refer to the city competitiveness index system, and use the principal component analysis method for the Inner Mongolia Autonomous Region. Twelve prefecture-level cities were evaluated for vitality to obtain a city ranking [2].

Regarding economic vitality, Cui Jian (2008) believes that high-efficiency investment is the main way to improve the economic vitality of the country [3]; Cao Yongfu (2017) proposed the impact of the decline in the economic vitality of the United States in "U.S. economic vitality decline: facts, causes and consequences" The strength of the medium and long-term economic growth in the United States is mainly reflected in the slowdown of new company establishment, the decline of listed companies, the shrinking growth potential of SMEs, the company's aging, and the decline in power market liquidity. It also explains the causes and consequences of this phenomenon. However, no data model has been used to prove which indicators are affected, and to what extent [4].

Regarding regional economic evaluation, Wang Shenglan (2013) used a combination of fuzzy comprehensive evaluation and information entropy to evaluate the vitality of major cities in Hubei Province, and analyzed economic vitality as the primary factor. He believed that economic vitality affected urban vitality. The key is to enhance the vitality of the city's economy and play an important role in urban development [5]. Yi Wei (2016) measured the economic vitality of various urban areas in Sichuan Province in the "Study on the Economic Vitality of Sichuan", and concluded that there is a positive correlation between the social production and human resource factors that affect economic vitality and economic synergy [6].

Scholars at home and abroad have adopted a variety of analytical methods, and in-depth research from all aspects on the necessity of improving the economic vitality of the city for the development of the city's economy. At the same time, it is also of

great significance to the modernization, vitality and vitality of China's urban development. The vitality evaluation laid the theoretical foundation.

3 Object, subject and methods of study

The research object of this article is the vitality of regional economy, and the research subject is the field of economics and administration. By establishing a suitable mathematical model to analyze and study the regional economic vitality, this paper proposes the following questions to solve:

1. Take a region as an example, establish a relationship model of the factors affecting regional economic vitality, propose an action plan, and analyze the impact on regional economic vitality changes from the perspective of population and corporate vitality trends.

2. Select a suitable index system to establish a mathematical model for measuring regional economic vitality. Select Beijing, Shanghai, Guangzhou, Shenzhen, and some second-tier cities to rank their urban economic vitality.

In addition, this article proposes the following model assumptions:

Assumption 1: Assume that the selected city index screening results can be completely analogized to other cities.

Assumption 2: It is assumed that the errors between the factors studied in this article are irrelevant.

Assumption 3: Assume that only systematic errors occur during data mining and processing research in this paper, and no random errors.

Assumption 4: Assume that the data scoring system is normally distributed.

Assumption 5: Assume that the distribution of the histogram intervals in Problem 3 is reasonable.

3.1 Establishment and Solution of Problem One Model

This article starts from the five aspects of economic aggregate, corporate benefits, government regulation, residents' situation and environment, selects 22 indicators, uses correlation analysis method to select 8 optimal indicators, and then uses subjective and objective weighting methods. The weight of each indicator is obtained, the regional economic vitality is scored, and the relationship model of the regional economic vitality influencing factors is obtained, and then an action plan is proposed. Finally, the regression analysis method and the gray prediction model are used to analyze the changes in population and corporate vitality trends. Impact. The specific analysis process is shown in the figure:

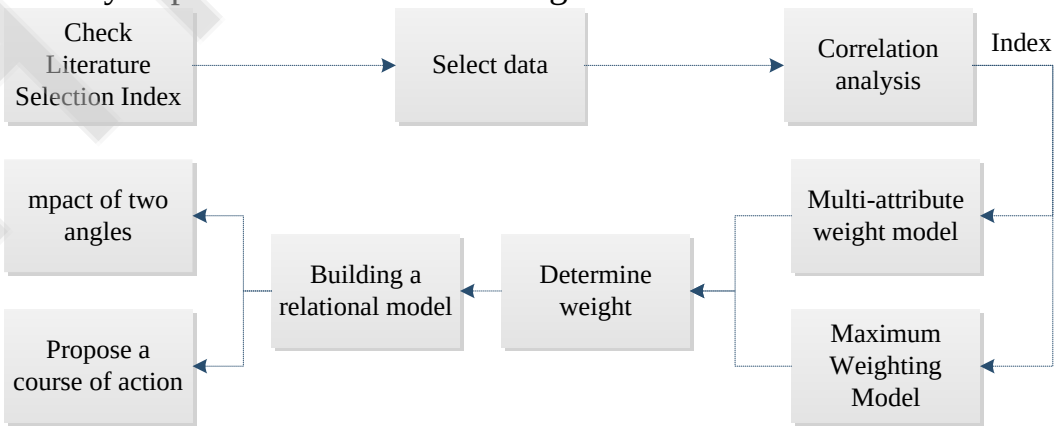

Figure 1 Problem-Idea flowchart

3.1.1 Selection of Evaluation Indicators for Regional Economic Vitality

(1) Index selection

Economic vitality is the extent to which a region supports its economy and society, and it is the ability to sustain economic growth. Drawing on the research of experts and scholars, this article takes Beijing as an example, starting from five aspects of economic aggregate, corporate benefits, residents, government regulation and environment, and selects 22 indicators based on the principles of scientificity, comprehensiveness and evaluability as follows:

Table 1 Selection of original indicators

First-level indicators	Secondary indicators
Economic aggregate	GDP per capita (yuan / person)
	Regional GDP (100 million yuan)
	Per capita GDP growth rate (%)
Business efficiency	Number of corporate entities (a)
	Growth rate of corporate legal entities (%)
	Funds for the development of new products by industrial enterprises above designated size (10,000 yuan)
	Total import and export of business units
	Total export of the location of the business unit (trillion US dollars)
Government regulation	Local fiscal revenue (100 million yuan)
	Local fiscal revenue growth rate (%)
	Local fiscal expenditure (100 million yuan)
	Proportion of local fiscal expenditure to GDP (%)
	Number of people participating in urban basic medical insurance at the end of the year (10,000 persons)
	Revenue of Urban Employee Medical Insurance Fund (10,000 yuan)
Residents	Household consumption level (yuan)
	Per capita disposable income of residents (yuan)
	Per capita disposable income growth rate of residents (%)
	Permanent population at the end of the year (10,000 people)
	Permanent population growth rate at the end of the year (%)
Surroundings	Urban green space (10,000 hectares)
	Per capita green space (10,000 hectares / person)
	Harmless treatment rate of domestic garbage (%)

(2) Data preprocessing

The data in this article comes from the National Bureau of Statistics, which selected 22 indicators of Beijing from 2009 to 2018. Because the data units are not uniform and the values are too large, direct processing will cause large errors. This paper uses normalization to standardize the data. The formula is as follows:

$$X^* = \frac{X - \min}{\max - \min}$$

The standardized results are detailed in the appendix.

The 22 indicators are analyzed by the correlation matrix method, and the determination rule is that the absolute value of an element above (or below) the main diagonal is very large (above 0.8), then the variables are considered to have more severe multicollinearity.

Based on this, this article removes the variables above 0.8, and selects 8 optimal indicators, which are the per capita GDP growth rate, the growth rate of the number of corporate entities, the total import and export of the business unit location, the total export of the business unit location, and the local fiscal revenue growth rate, Per capita disposable income growth rate, year-end resident population growth rate, harmless treatment rate of domestic waste. There is no serious collinear relationship among the above 8 variables, and their correlation can be found in the appendix. The specific indicator system of regional economic vitality evaluation is shown in the following figure: [7]

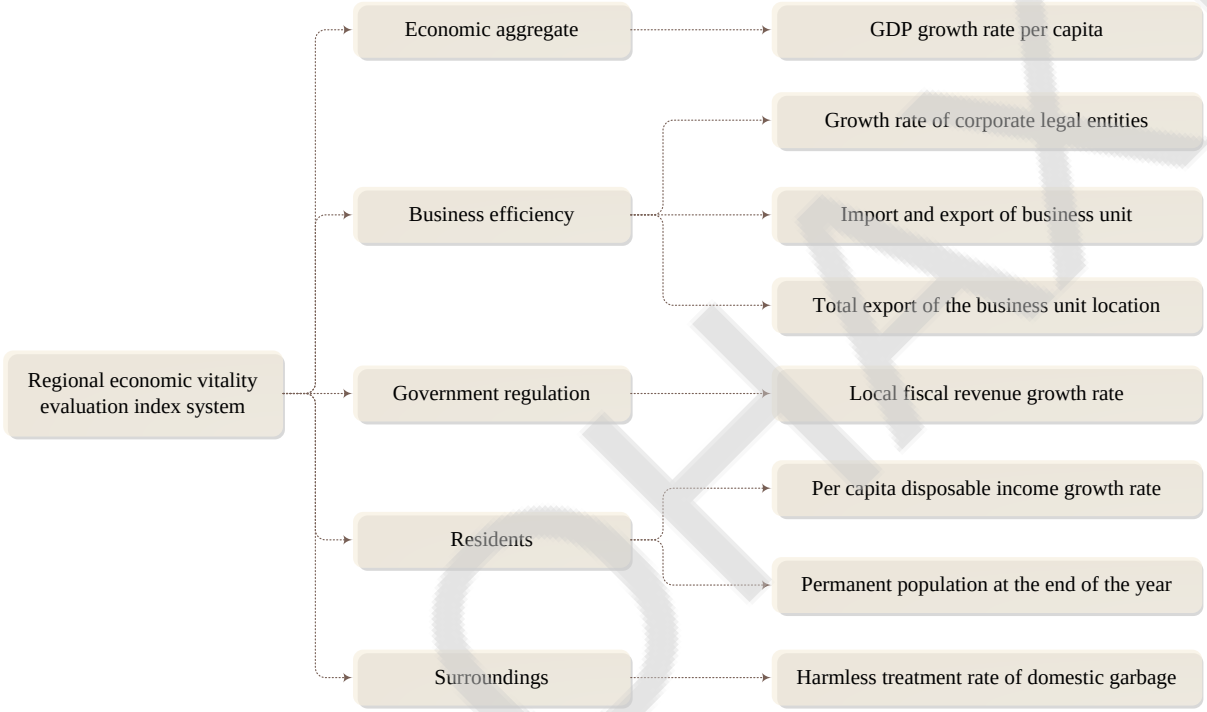

Figure 2 Evaluation indicators of regional economic vitality

3.1.2 Determining Weights with Subjective and Objective Weighting Methods

From the above, in the case of excluding multiple indicators, there are still multiple indicator quantities, and the complexity of decision-making is still high. Facing this kind of multi-attribute decision problem, weight analysis is obviously a good solution. Therefore, the determination of the weight of each indicator is obviously a very important link. The distribution of attribute weights will directly affect the final evaluation results. Therefore, in the process of comprehensive evaluation of multiple indicators, this article uses the subjective weighting method and the objective weighting method. The combined method combines qualitative analysis and quantitative analysis to make the weight values more reasonable and practical.

(1) Multi-attribute fuzzy comprehensive decision weight model[8]

Assume $C=\{c_1,c_2,\cdots,c_m\}$ for a solution to a problem, $U=\{u_1,u_2,\cdots,u_m\}$ is the attribute set, to evaluate and compare each scheme through the attribute set U, choose the best scheme. That is, each plan is comprehensively judged by a model, and then the results of different plans are compared to make a decision.

The flowchart of the multi-attribute comprehensive decision-making process is shown in the following figure:

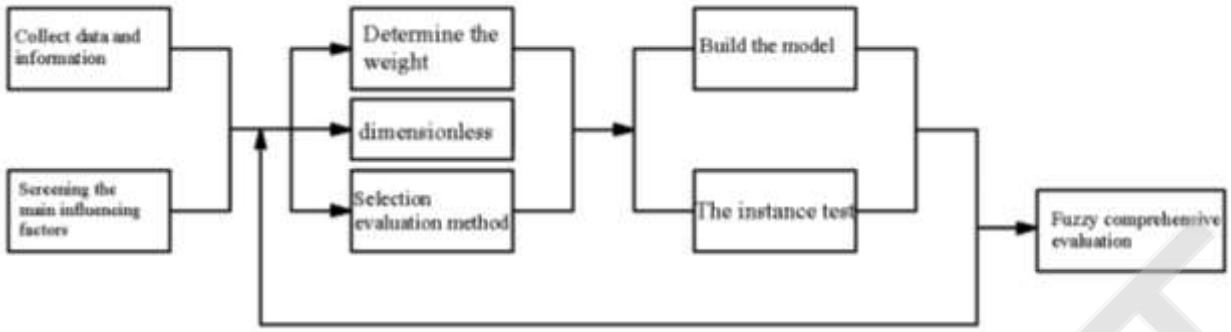

Figure 3 Multi-attribute comprehensive decision-making flowchart

The multi-attribute fuzzy comprehensive decision-making model, as a subjective weighting method, has the advantage that its weights are given by professionals considering actual conditions. However, its shortcomings are strong randomness. It does not link the actual numerical characteristics of the indicator with the method of determining the weight, and it does not show the dynamic change of the indicator weight with time.

Therefore, this paper combines it with the weighting model of dispersion maximization method, and uses a large amount of data to quantitatively analyze the ordering of weight values in accordance with the actual reasonable ordering weights, so as to make the weights change dynamically with time.

(2) Weighting model with dispersion maximization method

The dispersion maximization method is based on quantitative and qualitative analysis, and makes a quantitative evaluation of each index in a manner that maximizes dispersion, so that the results have mathematical and statistical characteristics.

Steps to maximize dispersion:

First, let the factor set be $U=\{u_1,u_2,\cdots,u_m\}$, The k given factors are $u_i(i=1,2,\cdots,k)$ of weight assignment value, secondly set V_j as the maximum deviation of the j-th indicator:

$$V_j=\max(X_j)-\min(X_j)$$

$$\max(X_j)=\max(X_{ij})$$

$$\min(X_j)=\min(X_{ij})$$

Then take the average of each factor's weight as its weight:

$$a_i=\frac{1}{k}\sum_{j=1}^{k}a_{ij}(i=1,2,\cdots,n)$$

The following restrictions exist in the calculation of weights:

$$\sum_{i=1}^{n}a_{ij}(j=1,2,\cdots,k)=1$$

$$\sum_{j=1}^{k}a_{ij}(i=1,2,\cdots,n)=1$$

Calculate each weight value under the above conditions.

(3) Determine the weight

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Table 2 Determine the weight

Index	Weights
GDP growth rate per capita	0.0778
Growth rate of corporate legal entities	0.2585
Total import and export of the business unit location	0.1194
Total export of the business unit location	0.1130
Local fiscal revenue growth rate	0.1559
Per capita disposable income growth rate	0.0811
Year-end resident population growth rate	0.1099
Harmless treatment rate of domestic garbage	0.0875

3.1.3 Establish the Relationship Model and Determine the Action Plan

(1) Establish the relationship model of the factors affecting economic vitality

Because the weight is the result of standardizing the data based on Beijing, if you want to apply it to different data in other cities, you need to modify the formula. And because the values of the weights are all positive, the positive and negative relationship between the index and the function value y cannot be reflected, so this article considers using the correlation analysis to calculate the positive and negative coefficients. The main method is to divide each coefficient by its data before normalization, and then modify the formula based on positive or negative correlation.

The relationship model of the factors affecting economic vitality is as follows:

$$y = -0.8969x_1 + 0.4216x_2 + 0.5573x_3 + 4.3814x_4 - 0.7363x_5 + 0.2275x_6 - 1.8920x_7 + 0.4150x_8$$

It can be seen that the growth rate of per capita GDP, the growth rate of local fiscal revenue, and the growth rate of resident population at the end of the year negatively affect the regional economic vitality. The growth rate of dominating income and the rate of harmless treatment of domestic garbage are positively affecting the regional economic vitality.

The 2009-2018 regional economic vitality score was calculated, and the score was modified. For comparison, this article enlarges the score by 100 times, as follows:

Table 3 Regional economic vitality scores

Years	Original rating	100x score
2018 year	0.8829221	88.29221
2017 year	0.7453814	74.53814
2016 year	0.5795811	57.95811
2015 year	0.6786326	67.86326
2014 year	0.7882847	78.82847
2013 year	1.0000670	100.0067
2012 year	0.7524676	75.24676
2011 year	0.5634553	56.34553
2010 year	0.6099048	60.99048
2009 year	0.5284320	52.8432

(2) Action plan

In terms of economy, use policies to lower the threshold for the development of enterprises, and support and subsidize them, thereby promoting the growth of the number of enterprises; in foreign trade, reduce tariffs, vigorously support import and export trade, and implement mutually beneficial and win-win agreements with other countries Foreign policy; in terms of government regulation, relax local taxation

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requirements to maximize local fiscal revenue; in terms of residents, reducing taxes and housing prices has significantly improved people's living standards and enriched people's lives; in the environment In terms of increasing investment in the environment and sorting waste, the city's environmental quality has been significantly improved.

3.1.4 Two-angle effect

Regression analysis is a method used to study the relationship between a phenomenon and its influencing factors. According to the number of independent variables, it can be divided into univariate regression and multiple regression. Based on the multiple regression model obtained above, it is concluded that the population growth rate negatively affects the regional economic vitality, and the growth rate of the number of corporate legal entities positively affects the regional economic vitality. This article uses a univariate regression model to analyze the impact of changes in population and corporate vitality on regional economic vitality.

（1） Trend of population change

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	-326.2972	239.1558	-1.364371	0.2096
C	77.65575	6.527493	11.89672	0.0000

R-squared	0.918765	Mean dependent var	71.29128
Adjusted R-squared	0.907361	S.D. dependent var	15.11416
S.E. of regression	14.43889	Akaike info criterion	8.354583
Sum squared resid	1667.851	Schwarz criterion	8.415100
Log likelihood	-39.77292	Hannan-Quinn criter.	8.288196
F-statistic	1.861508	Durbin-Watson stat	1.396607
Prob(F-statistic)	0.209592		

Figure 4 Impact of population growth rate on regional economic vitality

The relationship between regional economic vitality Y and population growth rate X with a high degree of fitting is obtained:

$Y = -326.2972X + 77.6558$

$t = -1.36$, $p = 0.2096 > 0.05$.This shows that at a significance level of 0.05, the linear effect of population growth rate on regional economic vitality is not significant. On the whole, the population growth rate negatively affects the regional economic vitality.

(2) Changes in corporate vitality

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	52.71410	21.02562	2.507137	0.0365
C	66.85770	4.185541	15.97349	0.0000

R-squared	0.940001	Mean dependent var	71.29128
Adjusted R-squared	0.930001	S.D. dependent var	15.11416
S.E. of regression	11.99648	Akaike info criterion	7.983961
Sum squared resid	1151.325	Schwarz criterion	8.044478
Log likelihood	-37.91980	Hannan-Quinn criter.	7.917574
F-statistic	6.285736	Durbin-Watson stat	1.090627
Prob(F-statistic)	0.036534		

Figure 5 The impact of the growth rate of the number of enterprises on regional economic vitality

The relationship between the regional economic vitality Y and the corporate vitality change X with a high degree of fitting is obtained:

$Y = 52.7141X + 66.8577$

$t = 2.51$, $p = 0.0365 < 0.05$.This shows that at a significance level of 0.05, the growth rate of the number of enterprises has a significant linear effect on the regional economic vitality. When other conditions remain the same, the regional economic vitality score increases by an average of 52.7141 points for each unit increase in the number of enterprises. On the whole, the growth rate of the number of enterprises is positively affecting the regional economic vitality.

(3) Inspection

From the comparison of the incremental changes in the number of enterprises in each region and the number of surviving companies in each province in 2019, it can be obtained that the number of surviving companies in the city will increase with the changes in the vitality of enterprises. It can be seen that the change trend of enterprises is positively correlated with the change of regional economic vitality. In the analysis of the weights requested in this article, it is seen that the growth rate of the number of corporate legal entities is higher, and the weight of the growth rate of the resident population at the end of the year is lower. This is also in line with the conclusions obtained by using the linear fitting mentioned above in this article, so it shows that the method and conclusion used in this article are correct.

3.2 Model Establishment and Solution of Problem 2

The second question asked to rank the economic vitality of cities. These cities occupy a certain position in China's regional economy and have strong representation. Although the relational model given in Question 1 is universal, measuring regional economic vitality is a complex issue. Therefore, to use the relational model of Question 1, you need to test the model. If the test finds that it is reasonable, then Question 3 remains. You can use the model from question one. However, when using the relational model given in Question 1 to conduct a scoring test, a great deviation from the actual situation was found. After re-examining this question, it was found that the score determined in this way did not take into account factors such as the geographical location of the east and west, and lacked enforceability. Therefore, in order to make it reflect the real performance as much as possible, the calculation formula of the above relational model will be processed, and correction coefficients will be added to ensure that it has the ability to reflect the real performance. The specific flowchart is as follows:

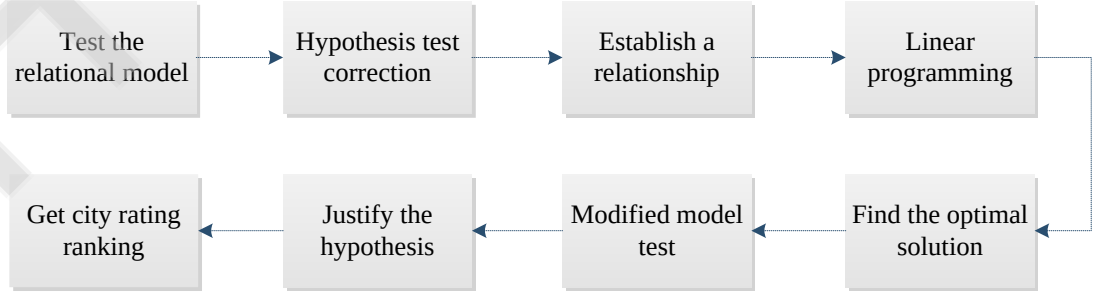

Figure 6 Flow chart of question 2

3.2.1 Test of Relational Model

Substitute the data into the relational model, and then draw the probability histogram of the score at intervals of 0.05. According to mathematical knowledge, most of the laws of nature are normally distributed. After comparing the two images with errors, we find that: two images There is a large gap between them, which cannot be used directly, as shown in the following figure:

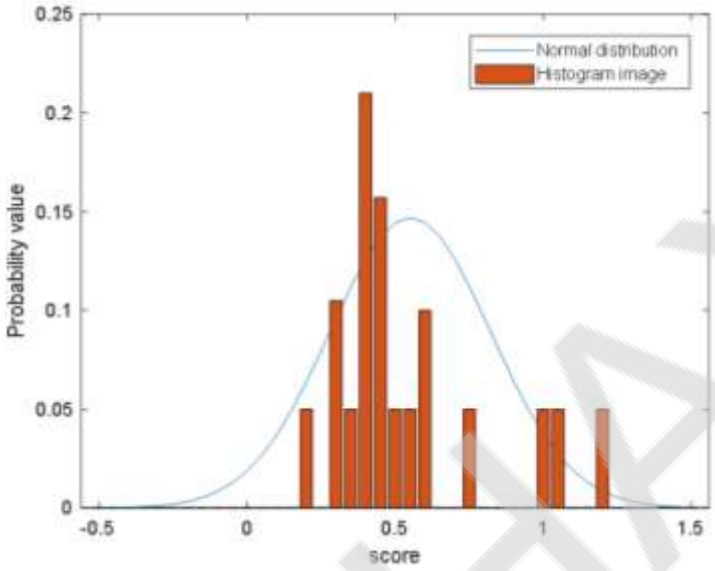

Figure 7 Error comparison of probability histogram before correction

From the above, the state of the original relation model fitting with reality is not as expected. To enhance its ability to reflect the real performance, it is necessary to use the knowledge in physics and increase the corresponding correction coefficients to modify the model. However, in the absence of experimental data, the most sophisticated experiments cannot be performed on the model. Therefore, the number of correction factors and their classification standards have become the biggest problems.

This article introduces a hypothesis testing model in probability theory on this issue. The main idea is to use hypotheses to draw conclusions, and then to prove the hypotheses based on the rationality of the conclusions.

3.2.2 Establishment and Solution of Hypothesis Testing Model

(1) Model establishment

Hypothesis testing is a method for inferring the population from a sample based on certain assumptions in mathematical statistics. The basic steps are as follows:

a. Establish hypothesis H0 and consider it correct.

b. Then accept or reject the hypothesis H0 based on the sample .

c. If the sample observations cause a "small probability event", hypothesis H0 should be rejected, otherwise hypothesis H0 should be accepted. Among them, the small probability event represents that the relative error with the normal distribution image is too large.

(2) Solving the preliminary relationship model

To solve this problem, first consider the correction factors. The basic steps are as follows:

a. Look for factors that need correction.

From the five attachments given in the title, it is not difficult to find that the title has a special reflection on the geographical location of the eastern and western regions and the registered capital of the corporate entity. This article may consider these two factors.

b. Modification.

According to previous research results, most of the laws in nature are normally distributed. It may be useful to set the scoring system constructed in this article to also be normally distributed. When the error between the corrected result and the normal distribution is within the allowable range Think the amendment is reasonable .

c. Fit the scores obtained from the relationship model.

According to mathematical knowledge, there are only two variables in the normal distribution function, which are only related to the mean and standard deviation. Therefore, the data obtained in the National Bureau of Statistics is substituted into the relational model and the result $U=\{u_1,u_2,\cdots,u_m\}$。

The formulas that fit the mean σ and standard S deviation are as follows:

$$\sigma=\frac{u_1+u_2+\cdots+u_n}{n}$$

$$S=\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(u_i-\sigma)}$$

d. Inspection.

Compare the scored histogram with the normal distribution function graph, and use the following formula to determine whether there are major discrepancies. If there are major discrepancies, consider modifying the correction factors. The correction factors are in line with reality, thereby improving the scope and accuracy of the formula.

$$\Delta t=\frac{t-t'}{t'}$$

Where t represents the value of the score, t' the value of the function of the normal distribution, and the relative error Δt. According to daily experience, it can be known that when $\Delta t\le 0.05$, the two images can be considered to be within the allowable error.

（3）Solving further relational models

Therefore, based on the above analysis, we can define further relational models regarding scoring:

$$t=k_1k_2y$$

Among them, k_1,k_2 represents the correction factor of the geographical location and the registered capital, respectively, and y represents the relationship indicated in Question 1.

In considering k_1, this article classifies the four economic regions divided in the question.

When considering k_2, we should first define a new classification standard for it, according to the appendix 4 of the title: in terms of enterprise size distribution, the differences between second-tier cities and Beijing, Shanghai, Guangzhou and Shenzhen are not as imagined. Large, so this article does not intend to use the size of

the registered capital as a classification criterion. Therefore, this article directly considers the number of enterprises with capital distribution> 10,000,000 when classifying.

When calculating the size of the registered capital, we can clearly find that there is an obvious classification trend in the data (see the attachment at the end of the article). The size of most of the registered capital is 50,000, only Shanghai, Shenzhen, Beijing, and Guangzhou. The city has reached more than 100,000. Therefore, the classification criterion is 100,000.

In order to compensate for the different influences of the above geographical locations, use k_1 to modify. The k_1 values in different cases are as follows:

In the eastern region： $k_1 = t_1$

In the central region： $k_1 = t_2$

In the western region： $k_1 = t_3$

In the northeast region： $k_1 = t_4$

In order to compensate for the above-mentioned different effects of the number of capital distribution companies, use k_2 to make corrections. The value of k_2 in different cases for the number of enterprises with a capital distribution greater than 10,000,000 is as follows:

Number of companies is greater than 10： $k_2 = t_5$

Number of companies is less than 10： $k_2 = t_6$

According to the characteristics of the normal distribution, the changes in mean σ and standard deviation S are as follows:

$$\sigma' = \frac{k_1 k_2 u_1 + k_1 k_2 u_2 + \cdots + k_1 k_2 u_n}{n}$$

$$S' = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(k_1 k_2 u_i - \sigma')}$$

3.2.3 Analysis of Images before and after Correction

By observing the image before correction, it can be found that the place with the highest frequency is different from the image with the normal distribution, and by studying the position with the highest frequency, most other cities in the middle can be found. The most intuitive response of the correction coefficient on the image: histogram Graph of movement. Therefore, it may be useful to move it to σ', which is both realistic and an interpretation of the image.

At the same time, it can be seen in the image that the values of the four cities of North, Shanghai, Guangzhou, Shenzhen are leading the country, which is expected. This is expected, and their distribution is more in line with the trend of normal distribution. Therefore, in order to reduce The error makes the model more convenient. It will be used as a standard to distinguish it from other coefficients, and its related coefficients will not be modified.

From the above, the following relations can be obtained:

$t_1 = 1, \quad t_5 = 1$

$$t_2 \times t_6 = \frac{\sigma'}{\mu}$$

Where μ is the score of the highest frequency of the image before correction.

From the above, it can be found that there are already three relations. In the face of four unknowns to find the optimal solution, according to mathematical knowledge, it can be known that linear programming can be used for processing. get:

$t_1 = 1$, $t_2 = 1.235$, $t_3 = 1.054$, $t_4 = 1.138$, $t_5 = 1$, $t_6 = 0.958$

Substituting the calculated correction coefficient into the original expression gives the following figure:

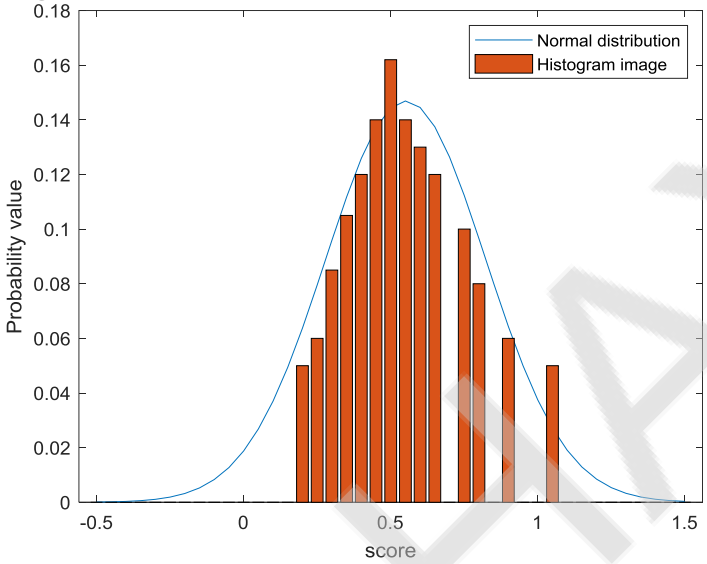

Fig. 8 Error comparison of probability histogram after correction

After testing, it can be found that the modified scoring function has a more normal distribution and a smaller $\Delta t = 3.283\%$ than the function before the correction. Therefore, the assumptions given in the previous analysis can be considered to be all true. The scoring function can be widely applied to this problem.

4 Results

4.1 Ranking results of regional economic vitality question 2

From the above analysis, the scores and rankings of the urban regional economic vitality (100 times magnification) are as follows:

Table 4 Scoring and ranking of regional economic vitality

City	Shanghai	Beijing	Shenzhen	Guangzhou	Tianjin	Hangzhou	Chongqing	Nanjing	Ningbo	Wuhan
score	111.65	103.65	100.55	87.99	79.25	78.44	64.61	59.61	57.96	57.15
ranking	1	2	3	4	5	6	7	8	9	10
City	Zhengzhou	Suzhou	Dongguan	Chengdu	Shenyang	Qingdao	Changsha	Xi'an	Kunming	Zhengzhou
score	56.92	50.58	50.58	50.33	50.21	46.61	41.42	40.02	29.38	
ranking	11	12	13	14	15	16	17	18	19	

It can be seen that the top three cities in terms of economic vitality are Shanghai, Beijing and Shenzhen, followed by the second tier cities.

5 Conclusions

After the establishment, application and derivation of the problem model, this article establishes a perfect relationship model of the factors affecting the economic vitality. Through the study of the model, it is found that the growth rate of per capita GDP, the growth rate of local fiscal revenue, and the growth rate of resident population at the end of the year negatively affect the regional economic vitality, the growth rate of the number of corporate units, the total import and export of business units, the total

export of business units, and residents. The growth rate of per capita disposable income and the rate of harmless treatment of domestic waste are positively affecting regional economic vitality. Based on this, this article makes the following suggestions for the development of Beijing: [9]

(1) Pay attention to human capital and improve the flow of talents.

Human resources are the first resource for regional economic development. In a knowledge economy society, the progress of a city depends on human capital, and knowledge spillovers require human capital. Therefore, Beijing should give full play to human capital, play a role in promoting corporate growth and regional economic growth, establish a sound mechanism for the free movement of talents, and realize the huge role of talent resources in promoting the regional economy. It is necessary to seize opportunities, make good use of talents, and maximize To the maximum extent stimulate their potential and vitality, improve their use efficiency, and promote the local scientific culture and economic prosperity and development.

(2) Accelerate the process of informatization and promote sustained economic growth.

Information, as the most critical factor in today's social productivity, plays an important role in socio-economic growth. Informatization is also an important driving force for investment, capital and talent flow, and it plays an important role in promoting the generation, exchange, release and transmission of information between regions. Therefore, in order to increase the positive impact of Beijing's investment in enterprises, the level of informatization must be improved.

(3) Utilize geographical proximity to form the diffusion of technological innovation.

Technological innovation can improve the nuclear and competitiveness of enterprises, increase the operating efficiency of enterprises, and promote the transformation of the economic growth mode of enterprises. It is necessary to create a macro environment for technology diffusion, make good use of the convenience of geographical proximity, and increase the imitation and diffusion of new technologies. In order to strengthen the regional positive impact of enterprises, promote the economic development of Beijing, and improve the economic competitiveness of Beijing.

(4) Strengthen enterprise support and promote industrial upgrading.

Small businesses are at a disadvantage in local competition. Therefore, the Beijing Municipal Government should increase its support for small enterprises, use capital support, technological innovation support, broaden financing channels, help market development, and other methods to improve the living environment of small enterprises and strengthen their competitiveness. In addition, while focusing on supporting the development of advantageous industries, we must actively develop high-tech industries and use high-tech to transform traditional industries, promote the upgrading of the industrial structure, and increase the number of enterprises in Beijing.

(5) Increase investment in poor areas and increase per capita disposable income of residents in poor areas.

At the same time as Beijing's rapid economic growth, the gap between regions is also growing, which is not only detrimental to social stability, but also restricts Beijing's economic development to a certain extent. To reduce regional disparities, it

is necessary to increase investment in areas with poor economic development. Therefore, it is necessary to increase investment in less developed regions, create an excellent investment environment, enhance the attractiveness of regional economies, lift these regions out of poverty, and then rely on their own driving forces to promote economic development. In addition, at the same time, the per capita disposable income of residents in poverty-stricken areas must be increased to achieve the chain effect of first being rich and then being rich, so that the economic vitality of Beijing can be developed sustainably. [10]

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7 Appendix

(1) Correlation analysis

Table 5 Correlation analysis

	x1	x2	x3	x4	x5	x6	x7	x8
x1	1.0000	-0.1971	-0.7151	-0.5094	-0.0133	0.8334	0.6166	-0.2421
x2	-0.1971	1.0000	0.3885	0.1956	-0.0354	-0.3848	0.0525	0.1559
x3	-0.7151	0.3885	1.0000	0.8216	0.1232	-0.6753	-0.3444	0.3628
x4	-0.5094	0.1956	0.8216	1.0000	-0.1569	-0.5223	-0.5135	0.4013
x5	-0.0133	-0.0354	0.1232	-0.1569	1.0000	0.0009	0.2745	0.1380
x6	0.7334	-0.3848	-0.6753	-0.5223	0.0009	1.0000	0.7988	0.0912
x7	0.6166	0.0525	-0.3444	-0.5135	0.2745	0.7988	1.0000	0.2074
x8	-0.2421	0.1559	0.3628	0.4013	0.1380	0.0912	0.2074	1.0000

(2) Standardized treatment

Table 6 Standardized data

Particular year	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
2018 year	0.0941	0.0183	0.2787	0.2724	0.0968	0.0000	0.0727	1.0000
2017 year	0.0924	0.0116	0.1487	0.1268	0.0905	0.0000	0.0698	1.0000
2016 year	0.2500	0.1393	0.0000	0.0749	0.2214	0.1294	0.2121	1.0000
2015 year	0.2414	0.2461	0.0000	0.0881	0.2611	0.1956	0.3294	1.0000
2014 year	0.0858	0.0503	0.0000	0.0189	0.1181	0.0477	0.1283	1.0000
2013 year	0.0697	0.6233	0.0382	0.0453	0.0000	0.0086	0.0927	1.0000
2012 year	0.0623	0.0267	0.0380	0.0000	0.1115	0.0144	0.0946	1.0000
2011 year	0.0904	0.0000	0.2855	0.0468	0.1214	0.0098	0.2708	1.0000
2010 year	0.0864	0.0000	0.0375	0.0398	0.1415	0.0360	0.1468	1.0000
2009 year	0.1443	0.0152	0.0000	0.0030	0.3759	0.0466	0.1010	1.0000

(3) Number of enterprises

Table 7 Number of enterprises with registered capital greater than 10000000

City	Shanghai	Shenzhen	Beijing	Guangzhou	Chongqing City	Chengdu City	Nanjing	Hangzhou	Suzhou	Tianjin
Number of enterprises	14.17	13.93	15.38	8.06	6.28	5.45	5.02	4.38	4.82	3.93
City	Qingdao	Dongguan	Zhengzhou	Wuhan	Xi'an	Ningbo	Changsha	Shenyang	Kunming	
Number of enterprises	3.69	3.91	3.88	3.58	3.38	2.80	2.57	1.96	2.12	

YOUTH ENTREPRENEURSHIP AS A MAJOR COMPONENT OF STATE DEVELOPMENT

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Abstract. *Youth entrepreneurship can play an important part in facilitating economic development and job creation. It is now widely accepted that there are many good reasons to promote youth entrepreneurship, as it is an important tool in stimulating the region's economy. While young people often turn to self-employment because they cannot find jobs elsewhere, entrepreneurship can provide them with valuable skills such as critical thinking, decision-making, leadership, teamwork and innovation - all of which remain relevant for the rest of their lives. This refers to the skills, talents and experiences young women and men draw on to meet the challenges they face at home, in their communities, at school, and in the labor market. The purpose of the study is to improve the system of government programs or policies that helps to promote youth entrepreneurship and overcome existing problems. It also aims to define functions of youth entrepreneurship and the importance of government measures for supporting and development entrepreneurship among young people. The relevance of this topic is not only in promotion of entrepreneurship, but also in fostering employment opportunities, boosting economic competitiveness and promoting local and regional development.*

Keywords: *youth entrepreneurship, employment, business activity, youth, economic development, employment, innovative potential.*

I. Introduction.

Youth entrepreneurship plays a major role in resolving such socio-economic problems as job creation, reduction of unemployment and skill training. Enlargement of opportuities and enhancing the impact of youth entrepreneurship results the importance of use of its potential. Youth entrepreneurship is an essential segment of small business, which influence on the economic growth and development of the whole country. Due to the significant impact of youth entrepreneurship on raising of living standards of the population, it is possible to see the relevance of this topic in the modern world.

II. Analytical review of the literature.

The problems of starting a business among young people and the conditions of their business development are explored by many domestic and foreign scientists and economists, among them are: J. Sei, J. Schumpeter, P. Drucker, B. Drayton, J. Mayr, I. Marty, O. Vyshnyak, T. Gladka, M. Golovaty, V. Golovenko, A. Gorshkova, A. Kaminsky.

III. Object, subject and methods of research.

The object of study is the phenomenon of youth entrepreneurship as a major component of state development at the current stage.

The subject of research is formed by theoretical and practical aspects of government support and popularization of business creation among young people.

All research activities took place in the field or remotely through an online research platform. This approach gave us deep insight in the entrepreneurship environment. Results of the survey showed that achieving the development of youth enterprise and increasing entrepreneurial activities among young people is a responsibility that must be shared by all relevant tiers of government.

IV. Results of work.

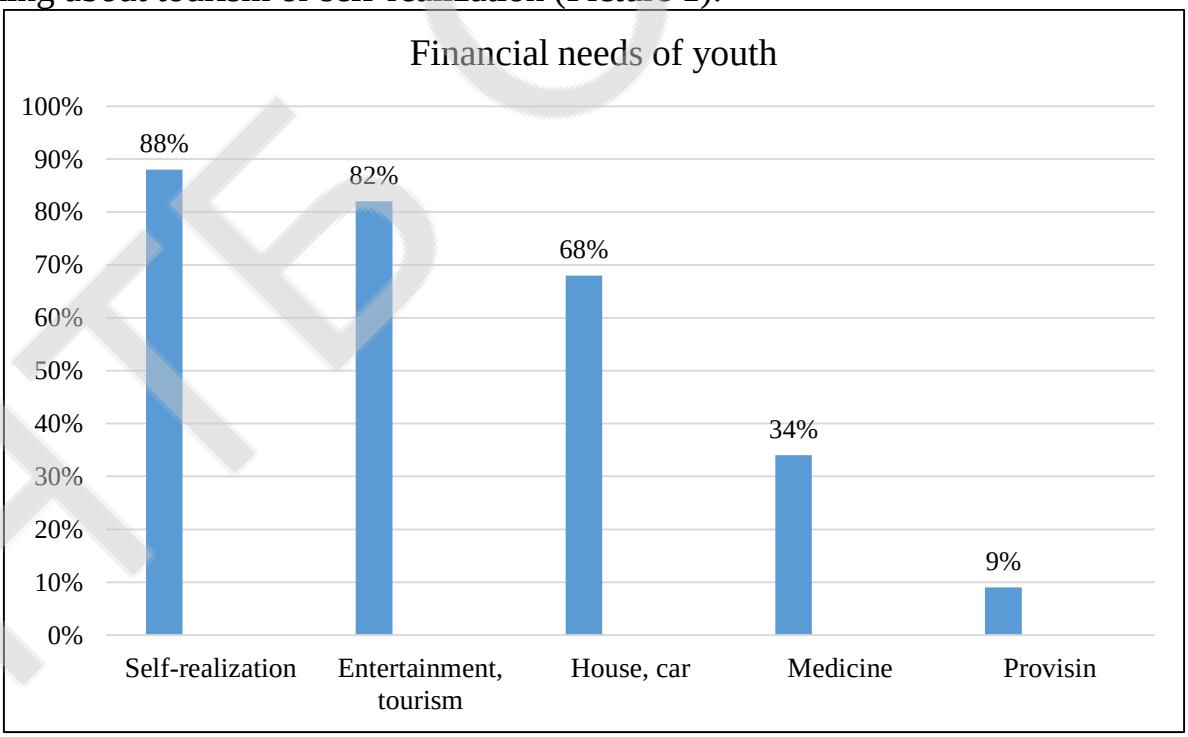
Youth is an important component of modern Ukrainian society, the carrier of its intellectual potential, the determining factor of economic progress. Young people are most sensitive to innovations, less conservative, and therefore an active participant of entrepreneurship.

Youth entrepreneurship is an element of youth employment that provide our economy with new businesses and additional jobs. The development of youth entrepreneurship is one of the most important areas of economic policy of the country.

By creating opportunities and actions that encourage young workers to perform different activities can be used in various programs regionally and across the country as well. Approximately 300 million people aged 18 to 30 in the world do not have stable workplace or are unemployed at all. 20% of them have skills and passion to create their own business, but for various reasons, only 5% use these skills at this level [10].

The benefits of youth entrepreneurship as a main factor in youth employment should be emphasized. Today, young businessmen must become a social force, whose economic interests are completely in line with interests of region and state.

The main cause of becoming a young entrepreneur is to satisfy basic needs. Most young people can hardly afford to buy essential things for living (laptop, car), not talking about tourism or self-realization (Picture 1).



Picture 1. Financial needs of youth

Young entrepreneurs are interested in creating a healthy, civilized economic environment based on strong competition and the opportunity to maximize their creative potential [4, p. 135].

Allocation of youth as a priority segment of entrepreneurial activity is greatly important because of its specific economic characteristics, benefits and weaknesses (Table 1) [1].

Table 1

Benefits and weaknesses of young entrepreneurs

Benefits	Weaknesses
✓ High innovation activity ✓ Creative thinking ✓ High mobility, the speed of decision making ✓ High level of ability enrich and upgrade their entrepreneurial knowledge and skills according to modern requirements ✓ Taking risks ✓ Persistence and pation in work, especially at its initial stage	✓ Lack of social experience ✓ Lack of goodwill ✓ Weak practical skills in applying economic laws ✓ The problem with starting capital ✓ Insecurity from the influence of government structures ✓ Insecurity from influence of criminal structures

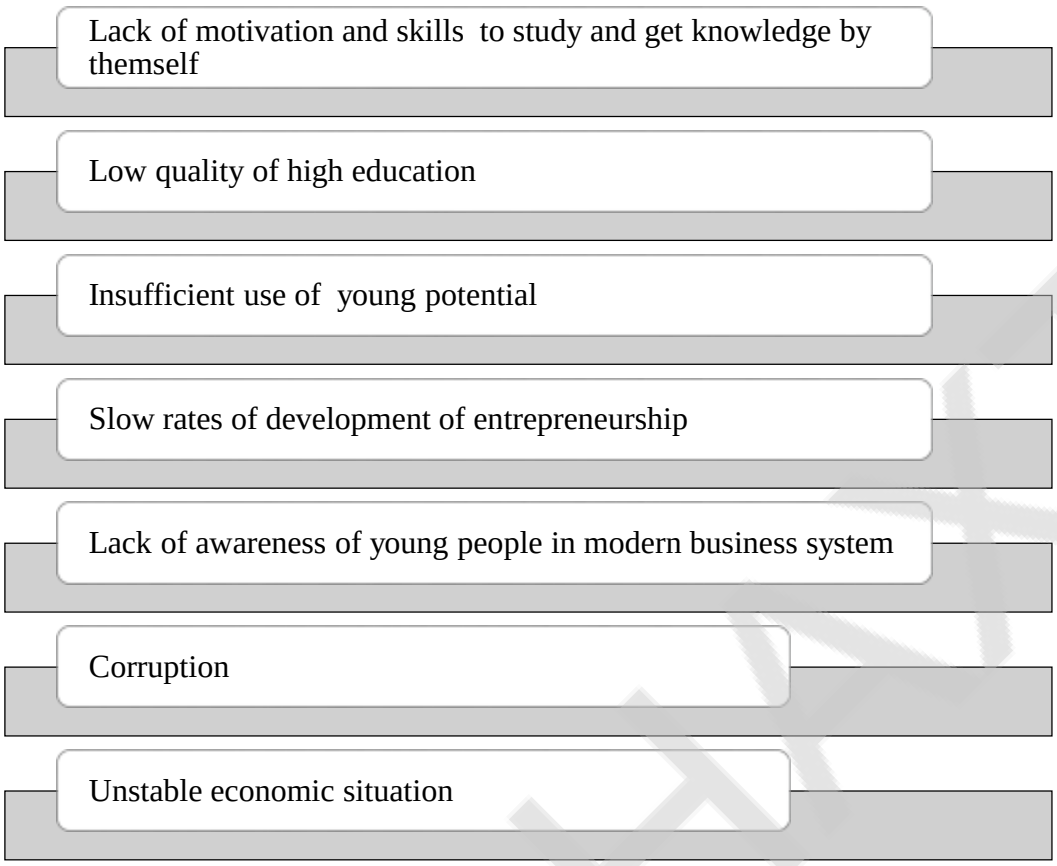
Therefore, it is important to identify the main tasks for supporting youth entrepreneurship, development of their strong skills and reduction of weaknesses.

However, in our country this process is very slow today. The sector of small businesses in Ukraine include over 2 million companies. Almost 10 percent of young people between the ages of 18 and 28 are engaged in entrepreneurship. Only 10 percent of people, who are 29-39 years old are well-educated, active and professionally trained. However, despite the advance in investment climate, the overall unemployment rate continues increasing [9].

Support and development of youth entrepreneurship, both by public authorities and non-governmental organizations, is a key in increasing youth employment and creating new jobs. Moreover, 42.5% of young people in Ukraine believe that doing business is the way to succeed in life [7].

According to the State Statistics Service, 34% of officially registered unemployed people are under the age of 35. Unfortunately, the employment situation of young people will only get worse in the coming years. There is no effective mechanism in Ukraine to guarantee young professionals a job. That is why it is necessary to adopt the experience of developed countries and create the conditions for self-employment of young generation. It is impossible to disagree that successful market relations will not exist without an effective functioning of entrepreneurial activities, which require appropriate conditions for organization and promoting entrepreneurship for all categories of population, especially for young people [1, p. 188].

After graduation, students face with problems that restrain them from getting a job, they have been dreaming about. The main barriers on the way from business idea to its implementation in young generation are described in the following picture.

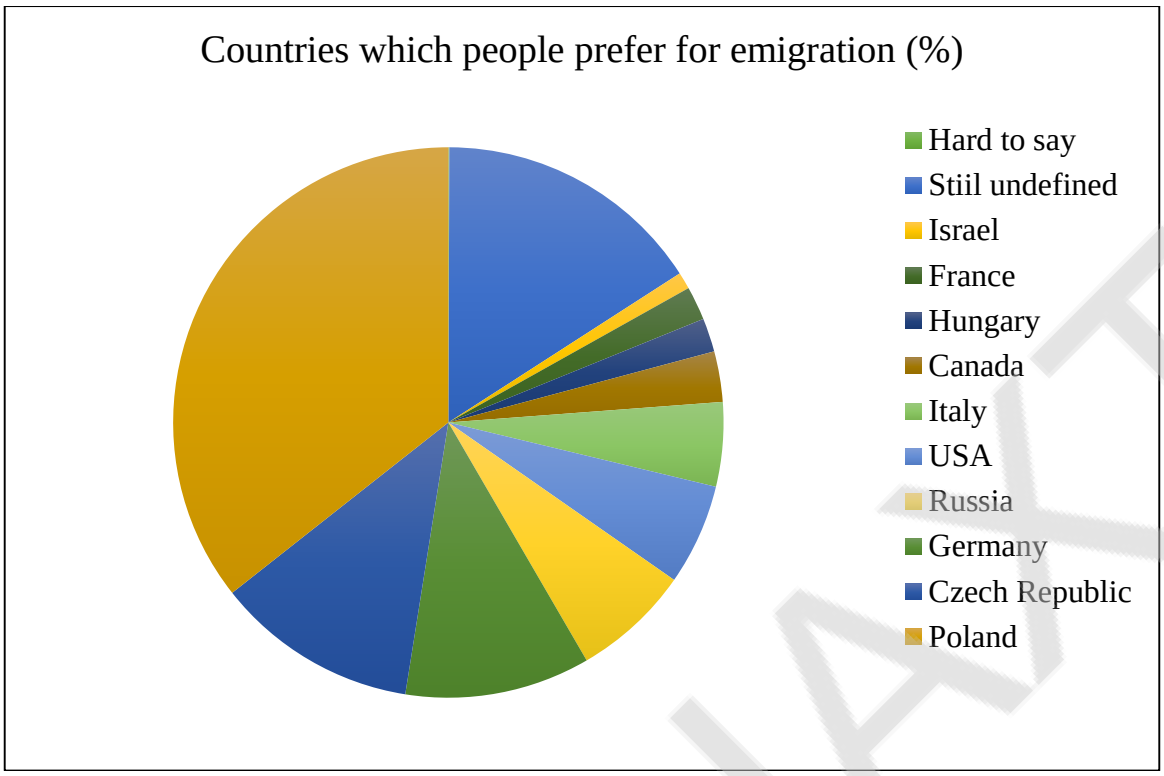


Picture 2. Main barriers to creating business

It's important to mention that in our country there is no understanding of fundamental role of youth entrepreneurship in economic transformation. As a rule, entrepreneurship takes secondary place in economy of the country, that is reflected in decisions made by various authorities [5]. Thus, there are many disorganizing processes in the system "society with youth". The most significant are: level of education and material well-being of the youth; desire to study and need to work; striving for independence and financial dependence on parents, work with a pleasure and recuires of labor market; desire to solve their own problems independently and real participation in management decisions [4].

Well-developed countries shows us that investing in youth is a good background for a competitive economy. However, only well-educated, financially well-off and satisfied young citizens are able to bring maximum benefit to the country. So the country itself is greatly responsible for creating a decent start-up environment for young people and its further development.

In April 2018, Kiev International Institute of Sociology conducted a survey for assessing the plans of Ukrainians for long-term living, work, study or emigration abroad (Pic. 3).



Picture 3. Most attractive countries for emigration

For majority the most attractive country to live in is Poland (36%). Less number of respondents chose the Czech Republic and Germany: 12% and 11%. Russia is chosen by only 7% of respondents and the United States by 6%. 5% and 3% of respondents plan to go to Italy and Canada. Other countries are indicated by no more than 1% of respondents [10].

The most progressive experience in providing conditions for development of youth entrepreneurship is made by European Union and the United States. The share of small and medium-sized businesses in these countries is almost 95%. In most European countries government aim to recognize the prospect of small business to and take steps to build entrepreneurial climate and favorable market conditions for their development. The US economy consist of more than 28 million small businesses, that represent 99.7% of all employers in the country. They make up about 45% of the total salary fund. Annually small businesses create between 60 and 80% of new workplaces. There are an incredible number of different business support programs in the USA. In particular, professional businessmen support young entrepreneurs through training and development programs (The Center for Entrepreneurship); business spaces at universities (business campuses, discussion clubs, consulting organizations, etc.); Funds (corporate funds, venture funds, charitable funds, fundraising funds, crowdfunding funds); business accelerators and incubators [3].

If summarize the global experience of promoting youth entrepreneurship abroad, it's possible to identify the main encouraging mechanisms that our government should provide:

1. Charity funds. The primary function of such funds is to finance start-up projects partly or completely when they worth it.

2. Student business clubs at university, which are engaged in organization of discussion clubs, conducting training courses, trainings, consulting in various areas of management and business.

3. National and international business clubs that provide access to information not only for students of one particular university, but for any young and prospect entrepreneur.

4. Business campuses. Academic courses with an extended practical part, created in order to develop and implement business projects.

5. Business incubators for students or young entrepreneurs, created to facilitate implementation of business projects by those who have less experience than others. For example, they are provided with an office (commercial and industrial as well) space at reduced prices and with other privileges.

6. Youth discussion clubs, which are created to improve business culture and to educate young people how to cope with business problems. Traditionally, such clubs organize student conferences, business schools or seminars with experienced businessmen.

7. Consulting student organizations that are created specifically to support students who only begin to implement their business projects. They assist young entrepreneurs with drawing up business plans, give them an advice about financial, or marketing or management issues [3, c.286].

In fact, Ukrainian schools of youth entrepreneurship provide a significant theoretical knowledge for those who want to learn business. But they don't always provide practical experience that helps not only to make business, but also to keep it afloat, invent, realize, find solutions and create an individual organizational culture.

Among the programs that help young people to start their own business in Ukraine are:

1. «Skills Lab: Own Business». Provides the development and improvement of youth skills that are necessary for successful business.

2. «Hand of Help» - a pilot project of the Ministry of Social Policy of Ukraine. It is implemented with the support of World Bank in the context of extended strategy of modernization the system of social support.

3. «Build yours». This portal is a part of special program for entrepreneurs and those who dream of becoming them. It includes sucn advantages: quick account opening, credit card and convenient online bank; useful tools for doing business from program partners; finances help.

4. «Start and improve your business» - a training idea for those who have promising ideas for organizing their own business [2].

Today we have many resources to teach start-upers and executives an effective tool for doing business. Several large business schools, that give young people important knowledge in key areas - economics, marketing or accounting, have emerged in educational market in recent years. However, having received a theoretical background, it is important to secure it by taking part in workshops or with a help of by entrepreneur mentoring. Practice abroad will enrich young and ambitious entrepreneurs with acquired skills and knowledge. On other hand, General managers will have an opportunity to learn about new prospects and creative business ideas of

future businessmen or even find a worthy partner. In general, the development of youth entrepreneurship can help to reduce irregularity in a labor market, support youth employment and improve the economic situation of region. However, currently, the issue of tax legislation, which is constantly changing, lack of clear business rules, a huge number of administrative barriers to the creation and formation of business structures, remain crucial to the government.

The research of different forms of youth entrepreneurship promotion shows that its support should be provided in different directions: financial, consulting, information, infrastructure, educational. Among the most common forms are various clubs that bring together the audience with similar interests.

V. Conclusions.

In order to solve the problem of youth entrepreneurship, government should involve social institutions, public and non commercial organizations and professional entrepreneurs in this process. Such phenomenon will ensure: intensification of youth entrepreneurship projects; creation of personnel reserve to increase the competitiveness of national innovation system; accumulation of intellectual potential; increasing the number of socially responsible business representatives; spreading the culture of entrepreneurship among young people; increasing the number of jobs due to the development of small business. This strategy will increase the government support of young and ambitious people and offer an innovative alternative for economic growth for young people. At the same time, it is important to understand that young people should be directly involved in solving regional problems and should not play the role of object in learning and socialization. Successful youth policy will help to address challenges of doing business in order to be able to run prosperous ventures. These measures, in our view, will promote the development of youth entrepreneurship, creating a comfortable business environment.

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НТБ ОНАТ

TRADE NETWORK LOYALTY PROGRAMS: THEORETICAL BASIS AND METHODICAL ASPECTS OF EFFICIENCY ASSESSMENT

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Abstract*. The paper studies the approaches to the definition of the term "loyalty program", suggests its own understanding of the term. The dependence of the loyalty program goal on the stage of the company life cycle is examined. Material and non-material client privileges are investigated. The advantages and disadvantages of loyalty programs are determined. The work highlights the main features of loyalty programs of the most popular supermarkets in Odessa. Recommendations on creation of additional privileges of loyalty programs in the B2C segment are given. Methodical approach to assessing the effectiveness of the promotional offer*

Key words*: loyalty program, customer lists, customer loyalty program.*

1. INTRODUCTION

The constant growth of competition in the market requires that modern entrepreneurs not only monitor the quality of goods (services), take care of the service etc., but also work directly with the needs of each client. Companies are faced with the task of developing mutually beneficial relationships with consumers that would allow them to receive stable profits, both in the present and in the future. The problem of customer loyalty is exacerbated every day, as the volume of supply of the same type of goods from different companies (brands) is growing, and at the same time the economic crisis is escalating, which entails a decrease in the effective demand of the bulk of the population. In such a situation, entrepreneurs are forced to constantly fight for the number and quality of customers. Finding the optimal ratio of preferences for consumers and maximum income for companies is a priority. In order to solve this problem it is necessary to develop your own competitive loyalty program.

II. ANALYTICAL REVIEW OF LITERATURE

The term "loyalty program" relatively recently appeared in everyday life of ordinary Ukrainians, the reason for this was the increased competition between sellers of goods of similar consumer properties.

In the phrase "loyalty program" the key word is loyalty - the quality of remaining faithful [1, c.13]. In the dictionary of Vladymyr Dal, the word "loyal" is devote, merciful, generous, affectionate, humane, friendly. According to the definition in the economic encyclopaedia "loyalty" is giving preference to certain goods and services by the target group of consumers.

In modern scientific literature there are different interpretations of the term "loyalty program". Thus, Mr. Khomich argues that loyalty programs include a number of activities aimed at increasing the emotional (good attitude) and behavioural (repeated purchases) loyalty of the buyer to the market offer of the supplier of goods or services [2]. Customer loyalty "strategically plays the role of competitive advantage of the enterprise, becomes an indicator of the ability to carry out innovative transformations not only in the production sector, but also in the service sector" [3, p.62].

"A loyal customer comes to the store in spite of the other, financially more profitable offers in the market, his positive attitude to the seller is mostly in the emotional sphere...", says O. Sahanda [4, p. 109]. Y. V. Vasin notes that loyalty is an indicator of how positive the attitude of a client is to everything that is connected with the company's activities, products and services, its brand and image [5, p. 60]. Thus, we can say that the main common feature of all loyalty programs is the development of measures that will foster long and effective relationship between the client and the company.

III. OBJECT, SUBJECT AND METHODS OF THE STUDY

The purpose of this work is the analysis and generalization of the main approaches to the development of loyalty programs, determination of the place of loyalty programs in the formation of consumer attitudes to the company.

The object of the study are the loyalty programs of companies that operate in the B2C segment.

The subject of the research is the approaches to the creation of loyalty programs.

In the topic research, the following methods were used: logical – to clarify the term "loyalty program"; comparative – to define customer privileges, advantages and disadvantages of loyalty programs and identify the main features of loyalty programs of supermarkets in Odessa; analytical – to make recommendations for the creation of successful loyalty programs of supermarkets.

IV. RESULTS OF WORK.

From my own experience I know that, in some cases, customers are even able to sacrifice something to get the effect of the loyalty program. For example, the client chooses a fitness club to which it is necessary to go half an hour, instead of a fitness club located near his own home. In this case, he sacrifices his own time (non-material loss) and funds for the road (material loss). Achievement of this effect is possible due to minor subtleties, namely a longer activation period of the club card, a longer period of "freezing" services, additional opportunities associated with discounts for long-term use of services, etc. But if such a situation occurs, it means that the effect of the loyalty program from the client's point of view exceeds its material and intangible costs. Summarizing the above interpretations and our own experience, we can say that the loyalty program is certain actions of the company which lead to the fact that customers will again come to the company to make purchases of its goods or services with a high degree of probability, even if they will need to sacrifice something for this.

Modern economic literature identifies several target groups of customers loyalty programs: designed for end users (B2C); designed for entrepreneurs (B2B); designed for distributors (B2D); integrated programme.

The most popular programs in Ukraine are focused on end users. The study is devoted to these programs.

In the above example we have shown that the consumer receives from the trip to the fitness club its benefits, for which he agrees to bear material and intangible losses. These losses are compensated by certain benefits, in other words, privileges, that loyalty programs give. In general, we can differentiate material and non-material privileges. Each of them is not used in its pure form, so it is necessary to choose a balance between these types of incentives. Material privileges are usually associated

with cost savings, of which there are few varieties, while non-material privileges can be various. Table 1 systematizes material and non-material privileges, identifies their subspecies and characterizes each of them.

Table 1 shows that the material benefits of loyalty programs are the most diverse in their content characteristics, and these programs are the most common in modern supermarkets. This information is confirmed by the international research Agency IFAK. It states that the level of penetration of discount, bonus and other cards among the population of Ukrainian cities is 74%. On average, the Ukrainian consumer has four cards, of which he actively uses only two. Most often these are cards in the sphere of food retail [7].

Table 1 Types and characteristics of customer privileges of loyalty programs

Types of customer privileges	***Subspecies of customer privileges***	***Characteristics***
Material privileges	Discount programs (discount cards and their simplified version-coupons for a one-time discount)	Ther main idea is to provide the buyer with 2 to 7 percent discount on the purchase amount
	Cumulative discount programs.	The benefit of the buyer depends on its purchasing activity. Under such programs the client can accumulate up to 30% discount on the purchase amount;
	Bonus incentive programs.	The main idea of such programs is that, while making purchases, the client receives prize points, bonuses, having accumulated a certain number of which, he can use them as money or get a prize.
	Prize draws among buyers.	The point is in the material benefit of the buyer in the form of a prize, which is supported by the emotional component of the "happy occasion".
	Cash - back customer loyalty programs	Allow the customer to return a certain percentage from each purchase to the specified Bank card
Non-material privileges	Possibility to purchase an exclusive product	Gives a customer the opportunity to buy a rare and valuable product
	Extended information about the company's products or services	Allows customers to navigate the products or services of the company in a timely manner to make a well-informed choice
	VIP − service	Provides the client with the status of significance, and emphasizes their success
	The provision of information about the periods of discounts on goods or services of the company	Allows the customer to save money

Based on [2; 6]

In table 2, let us consider the advantages and disadvantages of loyalty programs that provide material benefits.

As you can see from the table, each program has its advantages and disadvantages. The least effective, in our opinion, are the programs related to the prize draws, because it totally depends on the" lucky chance", and there is a certain degree of distrust (non-transparent establishment of the winners).

Discount programs, cumulative discount programs and cash–back loyalty programs are very similar, but they are deprived of the main competitive advantage. Competitors can easily duplicate them or even offer customers higher discounts.

Table 2 Advantages and disadvantages of loyalty programs

	Characteristics	Discount programs	Cumulative discount programs	Bonus Incentive programs	Prize draws	Cash – back programs
Advantages	Ability to create a client base	+	+	+	+	+
	Contribution to the increase in the frequency of purchases	–	+	+	–	–
	Impossibility of repetition by competitors	–	–	+	–	–
	No direct reduction of revenue	–	–	+	–	+
Disadvantages	Decrease in exclusivity, possibility of duplication by competitors	+	+	–	+	+
	Direct reduction of revenue	+	+	–	+	–
	High cost of implementation	–	–	+	–	–

Based on [8; 9]

Loyalty bonus programs are becoming widespread. In each company they differ and have their own individuality, but have one common drawback – the high cost of implementation. Most often, the so-called "artificial intelligence" programs are used which independently search for the corresponding consumer in the client databases and give them targeted offers.

Long-term studies of loyalty programs have shown that loyalty programs lead to a reduction in the transfer of buyers to another brand by 30% and to an increase in the turnover of goods by 10%; retention of only 5% of the total number of buyers leads to an increase in profits by 50-85%; the cost of attracting new buyers is 5-10 times higher than the cost of holding existing ones; 20% of buyers provide 80% of profits. It is for the retention of these buyers that loyalty programs should be directed [10, p.41]. From these facts we conclude that the purpose of the loyalty program may vary depending on the development of the company and the market situation.

All companies in the market share one common goal – to increase profits. Achievement of this goal is possible by increasing the number of sales, which in turn is achieved by increasing the number of customers. Thus, the main goal of the loyalty program is to increase the number of customers. But it should be noted that the purpose of the company depends on what stage of the life cycle it is. Figure 1 shows the transformation of the loyalty program's goal depending on the stage of the company life cycle. For the startup stage it is typical that most customers are interested in the company's products, because it is something new in the market. It is at this stage that is advisable to get acquainted with the target audience of buyers and offer them to issue cards. At the stage of growth, it is necessary to pursue a policy of multidimensional impact on the organization of client benefits and to take into account all possible cases of loss of profits of the company. It is this stage of the life cycle that is the key to how high the company will rise on the life cycle graph. Mature companies are mainly engaged in the retention of acquired customers. The longer the company manages to

do this, the longer the brand lasts in the market. All stages of the company's life cycle are associated with competition with other similar market participants. The positive result of this struggle is achieved through constant monitoring of competitors' prices, their promotional offers, service conditions, etc.

Successfully devised loyalty program is not one hundred percent success in the market, especially when it comes to grocery supermarkets. IFAK experts note the transformation of factors that form customer loyalty, and emphasize the reduction of the role of such factor as "price-quality" and the growth of "customer focus" [7].

The most popular among the population are the so-called" shops at home" which allow you to shop after work, and some of them around the clock. In addition to additional customer privileges, consumers are guided by the level of prices, the breadth and depth of the range of products presented, the cleanliness and general atmosphere of the store, the level of service and much more.

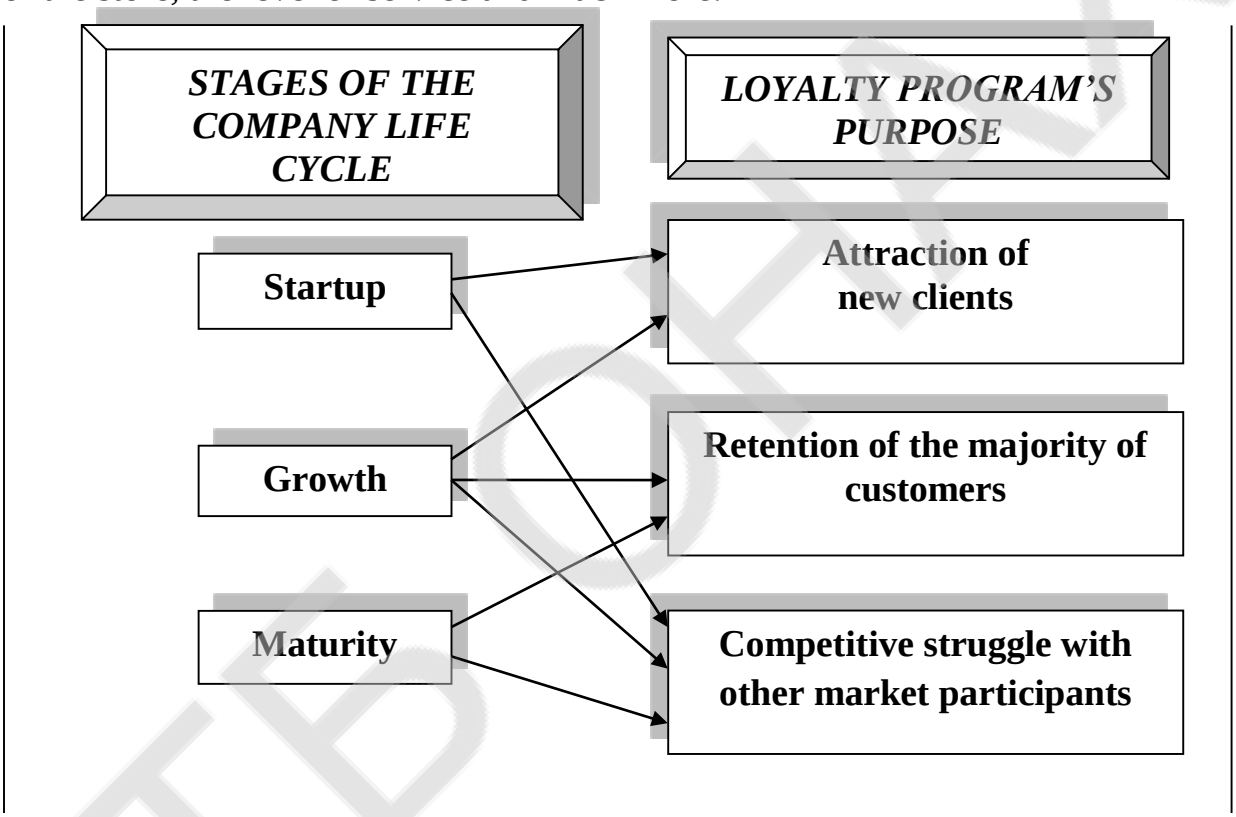

Fig. 1 Dependence of the loyalty program's goal on the stage of the company life cycle

Currently, supermarkets of such brands as "Silpo", "Tavriya V", "Kopiyka", "ATB", "Furshet", "Obzhora" and others are widely spread in the Odessa region. Approaches to the organization of interaction with the client in these trade organizations are different. For example, the ATB network does not use loyalty programs, the main concept of supermarkets is the sale of goods at the lowest prices. The network of supermarkets "Silpo", which belongs to one of the largest trade industrial groups FozzyGroup, occupies the first place by the number of customers who use client privileges according to the company IFAK (31% of the total number of consumers involved in loyalty programs in Ukraine); network of supermarkets "Furshet" features 9%; the supermarkets "Tavria V" and "Obzhora" -3%.

Taking into account the fact that by the number of retail facilities in Odessa leading positions are occupied by retail chains "Tavria" (36 shopping facilities), "Silpo" (20 shopping facilities) and "Kopiyka" (38 shopping facilities), let us consider the components of loyalty programs of these supermarkets in table 3.

Table 3 Comparative characteristics of loyalty programs of supermarkets in Odessa.

Criterion	«Tavria V»	«Silpo»	«Kopiyka»
Program name	«Clover bonus»	«Personal account»	Discount «Kopiyka»
Program type	Bonus program	Bonus program	Discount program
Conditions of joining the program	The card of the regular buyer is issued on condition of one-time purchase of goods in the amount of not less than 50 UAH.	The card of the regular buyer is issued on condition of one-time purchase of goods in the amount of not less than 39,99 UAH.	The card of the regular buyer is issued on condition of one-time purchase of goods in the amount of not less than 1000 UAH.
Basic benefits	Point accumulation, the ability to pay points for goods directly through the card	Point accumulation, , the ability to pay points for goods if their size is more than 1000 points (1 hryvnia=1bal). Points are received by the client once every three months in the form of a coupon with the amount of accumulated points, which is sent in letters or in electronic form	The opportunity to receive a discount on goods from 3-5%
Conditions for additional benefits	Participation in the "Clover bonus" campaigns provides an opportunity to increase points	Bonus coupons provide the opportunity to receive additional points for the products that the customer buys the most often, as well as limit discounts on the amount of one purchase	Discount for the next month: 4% in case of purchase of goods in the amount of not less than 1200 UAH.; 5% in case of purchase of goods in the amount of not less than 2000 UAH.
Additional benefits to simplify the use of the loyalty program	Mobile application availability	Mobile application availability	None
Limitation of use of the program	Bonuses are not awarded for products participating in other promotions		
The presence of partners of a loyalty program	T-sprint cafe,"Tauris",a network of shops "Kosmos", "GLITTER and BUCKET»	Bank “Vostok”	None

Compiled by the author on the basis of information from the official websites of supermarkets "Tavria", "Silpo", "Kopiyka”

Let's analyze the information from the table 3 for each position:

1) in terms of the conditions of joining the loyalty program, the most attractive programs are those of the supermarkets "Tavria V" and "Silpo". Their entrance barriers are quite low, in contrast to the "Kopiyka", where you need to make a purchase of 1000 UAH;

2) in terms of convenience for the client, the basic conditions of the loyalty programs of "Tavria V" and " Kopiyka " are optimal, since the card is a tool that allows you to get a discount, unlike "Silpo", where you need to have cards and coupons;

3) conditions for obtaining additional benefits are attractive in "Tavria", because you can buy products of any category in any amount;

4) additional benefits to simplify the use of the loyalty program are available only in "Tavria", namely mobile application-bonus card;

5) only the supermarkets "Tavria B" and "Silpo" have the partners of the loyalty program. "Tavria V" has a more extensive network of partners.

Examination of loyalty programs of popular supermarkets in Odessa has shown the focus of the main promotional activities on material privileges, while non-material are given little attention. We suggest to aim attention at such privileges as the organization of parking spaces for regular customers, special events for VIP-consumers, donations for charity, differentiation of customer service etc.

In our view, the expansion of partnerships in the loyalty programs would be also relevant. For example, if a customer visits a certain network of fitness clubs, he may have additional discounts on the products of the department of healthy nutrition, and vice versa, if you visit a certain supermarket and buy there the products of the department of healthy nutrition, you can get a discount to the fitness club. Similar partnership programs can be created, for example, with child nutrition departments and relevant child development clubs, stationery departments with educational institutions and so on.

A very convenient element of the loyalty program is a mobile application that allows a customer to learn about the promotions of supermarkets, as well as use the bonus (discount) card.

Methodical approach to assessing the effectiveness of the promotional offer

The main objective of the loyalty program is to maintain the existing customer base, since it is usually difficult to attract new customers (especially when the retail facility has been operating for more than two years). The main instrument of loyalty programs are promotions. In this paper we propose a methodical approach that allows to take into account the main aspects of the development of the address proposal and to evaluate the effect of the conducted targeted promotional activities, that is, personal proposals to each client. Consider the situation when a supplier makes a promotional offer. Such an offer can be carried out for many reasons, the main of which is the excess of this product in the supplier’s warehouses.

In the case of a supplier’s proposal, it is necessary to study the circle of customers who usually buy this particular product and develop targeted advertising for them. It is advisable to place such advertising in applications on smartphones, for example Viber.

When developing an address proposal, we propose to adhere to the following algorithm:

Segmentation of customers (study of customers who buy this particular product for a long time (for example, one year), study customers who buy this product in other packaging options; study customers who buy products of this brand, but promotional products buy other delirium). In selected segments, it is necessary to determine the indicator of the frequency of purchases and from here distinguish regular and random purchases. Depending on the type of product, you need to offer different threshold values to determine regular and casual customers)

To study the prices of similar goods from competitors (the price should be lower than the average market price, otherwise the supplier's promotional offer should be rejected);

Develop high-quality and understandable advertising (it can be targeted advertising in a mobile application, but there can also be other types of advertising, for example, banners).

We suggest to evaluate the effect of the conducted address action for the selected product by the following formula 1:

$$E = \begin{cases} \sum_{i=1}^{n} K_i^b * T_i^b < \sum_{i=1}^{n} K_i^s * T_i^s \\ \left(K^s - \frac{\sum_{i=1}^{n} K_i^s - K^s}{\sum_{i=1}^{n} K_i^b - K^b} * K^b\right) * T^b - V \end{cases} \quad (1)$$

where,

i – the product serial number of the selected category;

n - quantity of product in the category;

K_i^b – number of sales of the i-th product in this category during the base period;

T_i^b– trade markup of the i-th product of this category for the base period, UAH;

K_i^s- the number of sales of the i-th product in this category during the promotion period;

T_i^s - trade mark-up of the i-th product of this category during the promotion, UAH;

K^s – the number of promotional goods sold in the base period;

K^b – the number of promotional goods sold in the base period;

T_b– trade mark-up of the network for promotional goods during the promotion, UAH;

V - expenses for sending advertising messages in Viber, UAH These costs include the number of messages sent (Ks) and the cost of sending each message (Ps). It should be noted that Ks ≥ Kr. Thus, the cost of sending advertising messages in Viber can be represented as V = Ks*Ps.

The promotion takes a certain amount of time, so the base period should be chosen in the calculations, which is equal to the promotional period by the number of days.

Under the trade mark-up (allowance) is understood the amount of costs of trading networks associated with the turnover of goods made in the course of its sale in retail trade and profit.

The trade margin before the promotion, and during the promotion should be different. This allowance during the promotional period should be less, but should not be zero.

We will test this model for calculating the effectiveness of a stock using an example. Let one of the suppliers of the distribution network working under TM "Real Oil" offers to hold a promotional offer providing for a reduction in the price of a 1 liter bottle. During the promotion, it is proposed to reduce the trading margin from 55 to 25 UAH.

The next step is to segment customers to determine the number of targeted offers for customers. Over the past year, we make the following conclusions.

Table 4 Sales volumes of TM "Real Oil" sunflower oil in various segment

Indicator	Bought sunflower oil TM "Real oil" 1 lite	Bought sunflower oil TM "Real oil" 0,5	Bought other goods of TM "Real oil", but sunflower oil 1 and 0.5 l of another band
The number of customers with loyalty cards, people, incl	46355	31755	35770
random (number of purchases less than or equal to 12)	35470	21675	29654
constant (number of purchases over 12)	10885	10080	6116
TOTAL (constant (number of purchases over 12)	**27081**		

Thus, the cost of mailing is 27081*0,48 = 12999 UAH, where 0,48 – the cost of one Viber message. Usually mailing is NOT carried out for a single product, as retailers develop promotions. Therefore, to obtain a more expedient result, it is necessary to divide the costs of send by the number of goods presented in it.

Table 5 Input data for evaluating the effectiveness of the model 1

Indicator	base period	promotional period
Weighted average sales by sunflower oil categor	114905	135623
Sales volume of promotional good	5145	12162
trade margin	28	18

E = 101 747 UAH

From the obtained calculations it is clear that all the conditions for the effectiveness of model 1 are fulfilled, so the promotional offer presented is effective

V.Conclusions

Loyalty programs are now part of daily life of Ukrainians. Well-chosen customer privileges even lead to certain sacrifices on the part of the buyer.

The study has given the characteristic of tangible and intangible client benefits and proved that the most common in Ukraine are tangible client benefits.

The advantages and disadvantages of loyalty programs where the overwhelming number of privileges is material are identified. The common advantage of such

programs is the ability to create a client base that allows a company to directly study the customer needs.

The dependence of the purpose of the loyalty program on the stage of the life cycle of the company is determined. The main features that should be inherent in loyalty program at each stage of the company development are highlighted.

The analysis of loyalty programs of the most common supermarkets in Odessa, namely "Tavria V", "Silpo"and "Kopiyka" is carried out. Their advantages and disadvantages from the client's point of view are established.

Among the recommendations for the improvement of modern loyalty programs the study puts special emphasis on the following: improvement of non-material privileges, the development of partner programs and simplification of use of the loyalty programs with a smartphone.

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MARKETING ACTIVITIES OF THE UNIVERSITIES OF POLAND AND UKRAINE: CONDITIONS, METHODS, PROSPECTS

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Abstract. *In the scientific work the research of the essence of marketing activity of the institution of higher education is conducted, was determined the feature of educational services as a product. Analyzed dynamics of the main indicators of the higher education system of Poland and Ukraine. Considered the main trends regarding the structure of higher education institutions by form of ownership, the number of Polish, Ukrainian and foreign students. Based on the analysis of the situation of the educational services markets of Poland and Ukraine, proposals have been developed to improve the methods of promotion of educational services, taking into account the experience of the Polish and Ukrainian universities.*

Kew words *higher education institution, student, higher education market, marketing, promotion, higher education services.*

I. Introduction.

The modern world is becoming more globalized every day. This applies to all areas of activity. But the most dynamic changes are happening in the field of higher education. Unfortunately, most of the changes are related to the external environment: changing the attitude of employers to higher education diplomas, reducing restrictions on getting education abroad, increasing geometrically the number of open courses of the best universities in the world, etc.

On the other hand, higher education is one of the systems with a high level of inertia and bureaucratization. That is why higher education institutions should pay more attention to global trends and quickly implement modern innovations in their activities, including in the field of developing a strategy for promoting their services, in order to maintain their positions and stay ahead of competitors.

The international market for higher education is about $ 100 billion. According to UNESCO, higher education institutions in more than 140 countries are present on the world market of educational services. According to statistics, a foreign student spends about a fifth of their own expenses in the host country on study, and four-fifths on accommodation, food, entertainment, and the like. In the United States, higher education is the fifth export item of the American economy in monetary terms, which sometimes exceeds the amount of revenue from arms exports. In Australia, the education industry is the third-largest source of budget revenue to the country's economy. In 2014, the Canadian government recognized international education as a key factor in creating new jobs and improving welfare and plans to double the number of international students to 450,000 by 2022. This will increase the cost of foreign students in the country to 16.1 billion dollars and will create at least 86.5 thousand new jobs in Canada [1].

II. Analytical review of literature.

General issues of research on the higher education market in Ukraine devoted to the research of Dmitrieva V.Y., Kratt O.A., Danilishina B., Kutsenko V., Avsheniuk N. and others [1-3]. Special attention is paid to the issues of marketing and management of higher education, researchers like: Matviyev M., Ilyashenko S., Obolenskaya T., Reshetilova T., research problems and develop methodological approaches for their solution [4-5].

The situation of the Polish higher education market has been investigated in the works of Pavlovsky M., Jakubowska A., Penar D., Drapinska A. [6-9].

III. Object, subject and methods of research.

The object of the research is the higher education market of two countries: Ukraine and Poland in terms of marketing and management. The subject of the study is the aspects of forming a system of marketing events promoting educational services on the example of Polish and Ukrainian universities

Scientific work was carried out with application of general scientific and special research *methods*, namely: the method of formal logic; systemic, statistical analysis; method of expert assessments; induction and deduction.

IV. Results of work.

Education is one of the most important subsystems of the social sphere of the state, providing the process of obtaining systematic knowledge, skills and abilities for the purpose of their effective use in professional activities. Effective marketing activities play a huge role in maintaining and strengthening the position of any company on the market.

A modern higher education institution (HEI) is not only an educational institution, it is also an organization engaged in market activities. Among the main activities (Fig. 1) are those that are specific only to educational institutions: educational, research activities, but most - essentially market ones: marketing end economic.

Today, there is a situation where the market of higher education institutions is regulated by the requirements of applicants whose preferences differ from the requirements of employers. Having actually two categories of consumers-future specialists and employers, HEI would have to act as an intermediary between these categories, but in trying to satisfy consumers, future students, HEI have lost this role, and the product they produce, qualified workers in specialties, often does not suit the employer, and not rarely the specialist himself and, as a result, the state as a whole. Focusing on the desire of school graduates to get higher education, HEI annually increased the number of licensed places, which became the main factor in the deterioration of the balance between what the market of educational services provides and what the labor market requires.

Higher education is becoming increasingly globalizing through the rapid development of technology, the popularity of distance learning, international internships, and the growing number of international academic programs. Studying abroad provides students with important cultural and personal experience, and increases their chances of finding employment in globalized sectors of the labor market.

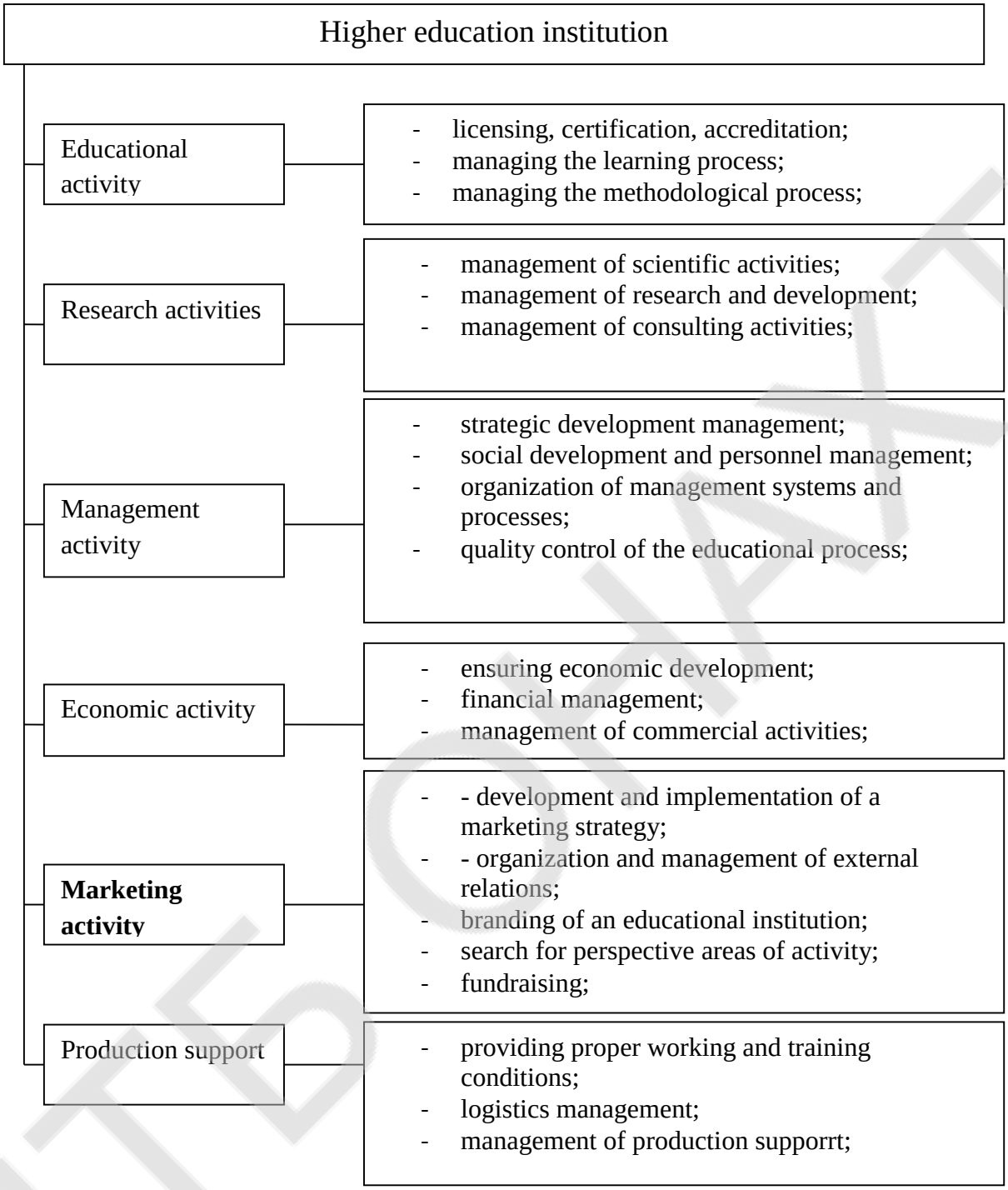

Fig. 1. The structure of the main activity of the modern institution of higher education (created by the author)

Modern higher education is characterized by certain trends:

- deepening international cooperation in the field of education;
- orientation of most countries towards the transition from elite education to high-quality education for all;
- significant dissemination of innovations while preserving national traditions and national identity of countries and regions.

For understanding of tendencies at the market of higher education, consider the education system in general and compare the Polish and Ukrainian systems – Addition A, table. A.1.

In General, the systems have more similarities than differences.

One of the main differences is the age of admission to higher education institutions. If in Ukraine it is 17-18 years, in Poland-19-20 years. In Poland, studying in a public institution of higher education financed from the budget, which enables all citizens to receive education in these institutions at public expense in private institutions of learning occurs through individuals, but not eliminated the social and academic scholarships. In Ukraine, state institutions of higher education have the opportunity to study both at public expense and at the expense of individuals.

One of the main concepts of this work is educational service. There are a great number of opinions regarding the definition of "educational service", so it is advisable to thoroughly understand its true meaning. Appendix B provides an analysis of the polysemy of this concept - Table B.1.

According to the Ukraine Law on Education: «educational service – a complex of actions of the educational agent, which are established by the legislation, educational programme and/or an agreement, have an established price and are aimed at achievement of expected learning outcomes by the education seeker» [10].

In our opinion, this definition is appropriate:

Educational services – these are specific benefits provided to the individual to meet his or her various needs (primarily educational) and which subsequently constitute a mutual interest for the community and each individual, in particular, for use in professional activity.

Thus, educational services are specific to other intangible services because the consequences of consuming these services are beneficial not only to the individual but also to the economy and society as a whole.

Can be distinguished the following features of educational services:

- like all services, they intangible and cannot be accumulated, but their results are accumulated as actions aimed at the formation of human capital;
- the educational service has a significant length of time;
- consumer of educational services must have a certain set of qualities (the level of education, the amount of knowledge, skills, and norms of social behavior, sometimes necessary additional requirements for health and gender);
- educational services are produced and consumed at the same time, they are fully provided to the consumer by the producer without intermediaries;
- active intellectual participation of the consumer is mandatory in the use of educational services;
- the quality of educational services affects the development of society, hence the state's interest in their quality and the need for education to meet the requirements of state control-even in a market economy.

When analyzing the features of an educational service, the relationship between the educational services market and the labor market must be taken into account. While operating in both these markets simultaneously, the educational institution, however, has one product with which it enters both markets. In the market of educational

services, an educational institution provides services whose consumers are students who indirectly represent the results of their activities in the labor market, where consumers are enterprises and organizations of various sectors of the economy.

Relations between labor markets and educational services are formed when an educational institution enters the labor market with the results of its educational activities mediated in the knowledge, skills and abilities of graduates.

The educational services provider is interested in ensuring that its programs are as fully consistent with the labor market as possible, and that graduates learn this program as best as possible for several reasons. The first reason is that the labor market defines the basic standards of quality of education in the form of changing demand for certain specialists, refinement of knowledge and skills that applicants for certain vacancies should possess. Secondly, the prospect of employment is an important motive that determines the choice of educational products by the consumer [5].

Product-education service is active in the market, has a dependent demand and is competitive, and therefore also requires effective marketing.

Higher education is one of the sectors in Poland that has developed most dynamically and undergone the most radical transformations since the early 90's of the XX century. The higher education system in Poland is represented by public and non-public higher education institutions. Non-public organizations have existed since 1989. All higher education institutions have the same standards for the organization of teaching and educational process. In Fig. 2. shows the number of higher education institutions in Poland by type of ownership. The data shows that the number of state institutions is stable - their number from 102 units in 1990 reached its maximum in 2010 (139 units), today equals 130 units [11,12,13].

While private higher education institutions have started to grow rapidly - the first institutions were established in 1989, the maximum came in 2010, as of 2018, the number will be 267 institutions.

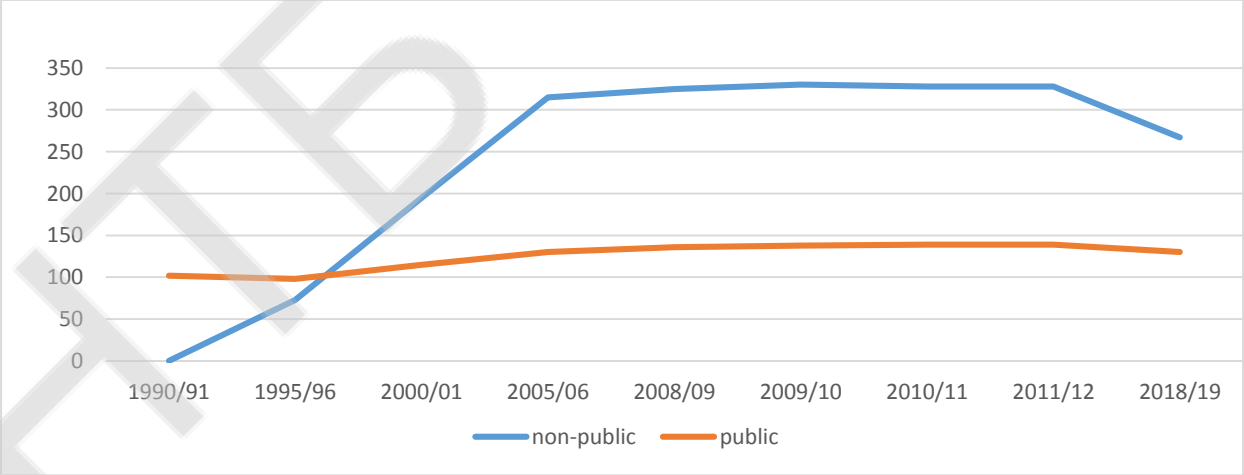

Fig. 2. Dynamics of the number of higher education institutions in Poland

Since the dissolution of the Soviet Union, the network of universities in Ukraine has grown largely due to the emergence of private services. According to statistics, the number of institutions of higher education has increased from 149 in 1990 to 353 in 2009, after which the number gradually drops to 282 2018 [14]. Consider the dynamics of the number of higher education institutions in Ukraine - Fig. 3.

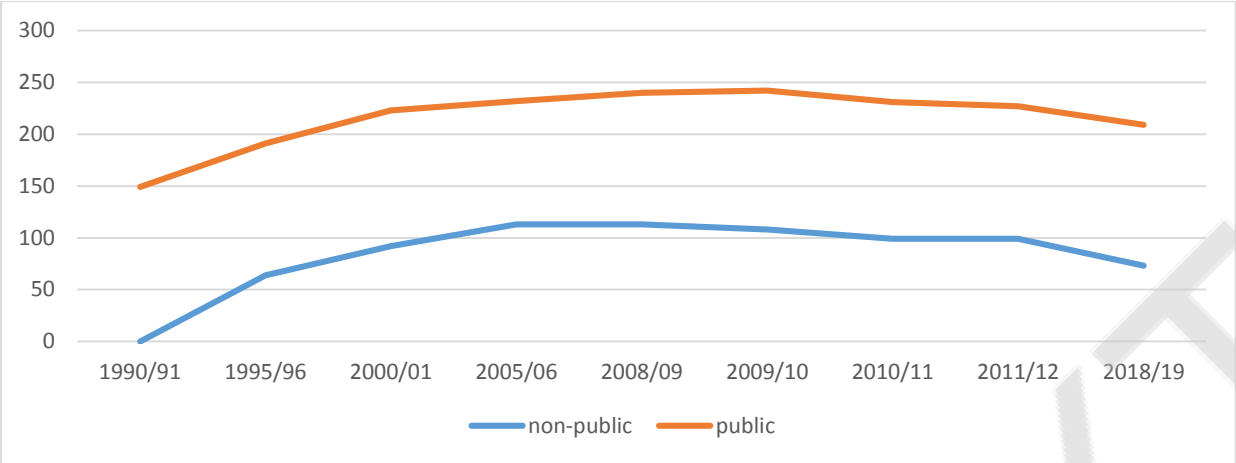

Fig. 3. Dynamics of the number of higher education institutions in Ukraine

The number of higher education institutions, both public and non-public, has been increasing in Ukraine. Thus, public institutions increased from 102 in 1990 to 242 in 2009, and decreased to 267 in 2018. The number of private higher education institutions has also grown rapidly since 1991, peaking in 2005-2008 - 113, down to 73 in 2018 [14].

With similar general trends, the dynamics of the number of higher education institutions in the two countries, there are certain differences-the growth of public institutions in Poland was 27%, and in Ukraine-40%. The number of non-public institutions in Poland as of 2018 exceeds their number in Ukraine by 3.6 times.

The fig. 4 shows the dynamics of the number of students in these countries.

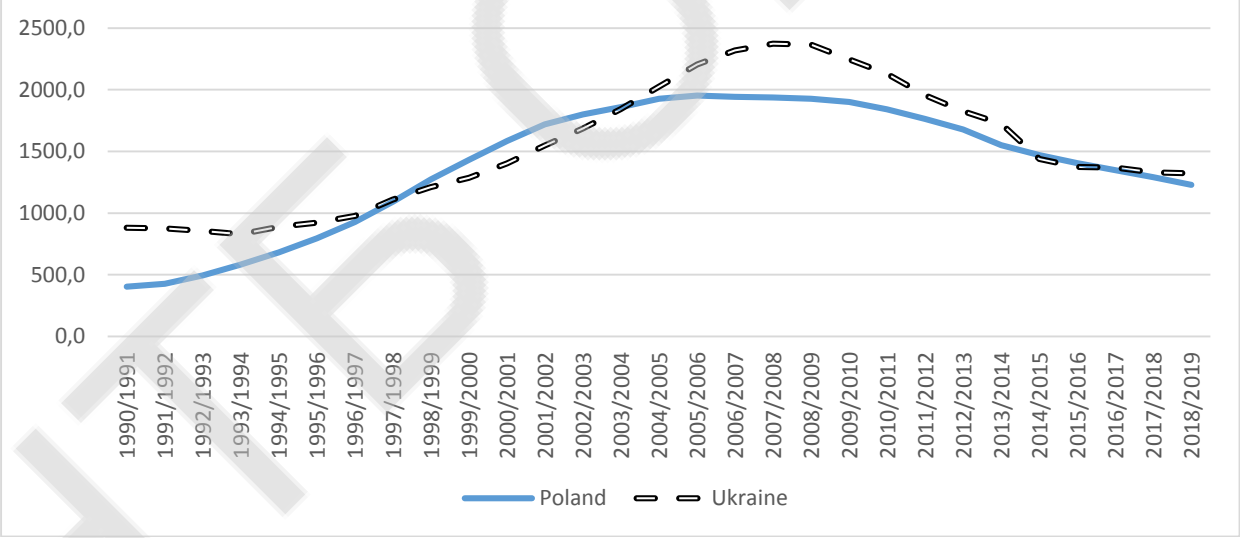

Fig. 4. Dynamics of the number of students in Poland and Ukraine

If in 1990 the number of students in Polish universities was twice lower than in the Ukrainian (403.8 and 881.3 thousand, accordingly), then by 2018 their number is almost equal. The common trend is going to decrease. For evaluation general indicator of situation in higher education, created table 1, in which indicators are calculated for Ukraine, Poland and Germany.

These calculations show the difference in the number of population and students in these countries, the share of students is about 3%, so in Poland there are 321 students

per 10,000 people, in Ukraine – 314, in Germany – 345. The ratio of the form of study is different: in Germany only 3.2% of students choose part-time study, in Ukraine - 15.4%, and in Poland - more than a third - 34.2%.

Table 1 Main quantitative indicators of higher education (2018/19)

Indicator	Poland	Ukraine	Germany
Population, million persons	38,3	42,1	83,02
Number of students, in thous.	1230,25	1322,3	2868,2
Number of students per 10 thousand population, persons	321	314	345
Number of full-time students, in thous.	809,2	1119,1	2776,4
%	65,8	84,6	96,8
Number of part-time students, in thous.	421	203,2	91,8
%	34,2	15,4	3,2
Number of foreign students, in thous.	78,3	48,8	394,7
%	6,4	3,7	13,8
Number of higher education institutions, units	397	282	426
including non-public, units	267	73	120
%	67,3	25,9	28,2
The average number of students in one institution, persons	3099	4689	6733
Number of students studying abroad, in thous.	44	83	140,4
%	3,8	6,5	5,7

The table is based on the data of the [11,12,13,14,15]

This is explained by the fact that in Germany, it is more affordable to study for public funds, full-time education in Ukraine allows young men to a postponement from service in the Armed forces of Ukraine. In Poland, almost every third university is non-profit, where tuition must be paid by student, but a lots of Polish students choose a part-time form of study that costs less and makes it possible to combine study with work.

Polish higher education is more integrated into the European Higher Education Area than Ukrainian. EU membership gives an opportunity for Polish universities to participate in academic exchange programs such as Erasmus+. There is also integration on the European continent outside EU structures: CEEPUS, Fundusz Stypendialny and Szkoleniowy. In addition, Polish law has more loyal conditions for the recognition of foreign diplomas of higher education or academic degree. The result is twofold number of foreign students studying in Poland. Although this is far less than in Germany. Among these countries, unfortunately only in Ukraine, the number of Ukrainians receiving higher education abroad is almost twice as high as foreign students.

Ukraine is the largest student donor country for Poland - fig. 5.

Since 2014, the number of Ukrainians in Polish universities has started to grow rapidly, which is facilitated by the following factors: language and territorial proximity; simplified admission procedure, without External independent evaluation (EIT); the cost of studying in private universities does not exceed the cost in Kiev institutions of higher education; the easiest way to legalize their stay in Poland on the one hand, political and economic instability in Ukraine on the other hand.

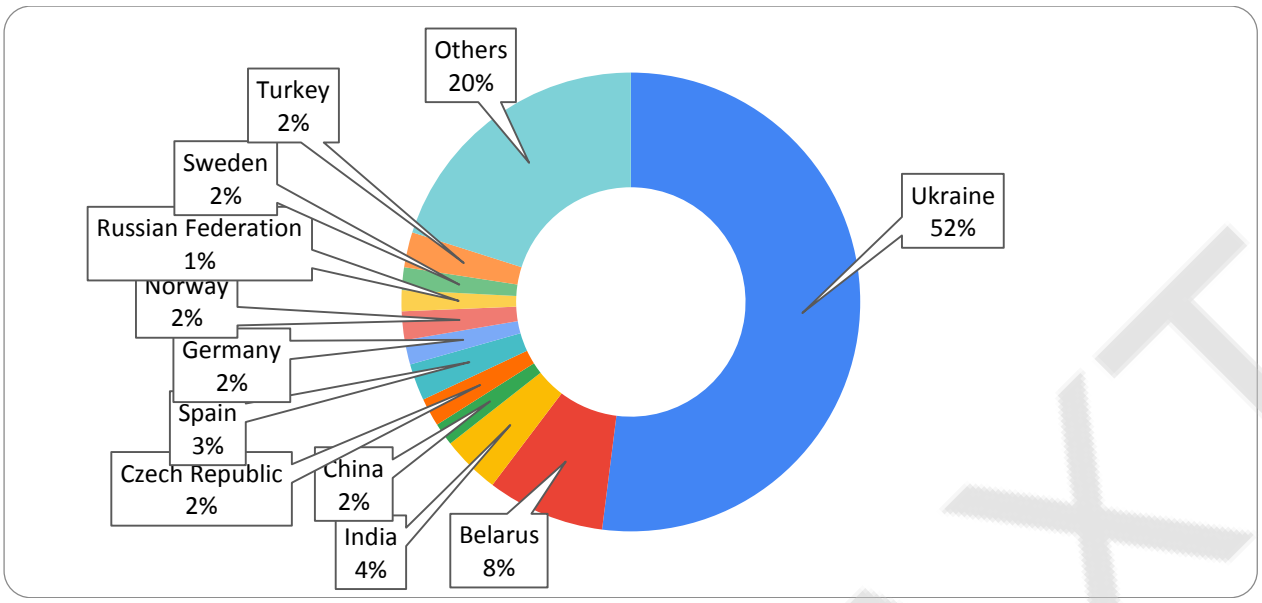

Fig. 5. Countries of origin of foreign students from Polish universities (2018)

Among foreign students in Ukraine, the largest number is occupied by citizens from India, Azerbaijan, Morocco and Turkmenistan- fig. 6.

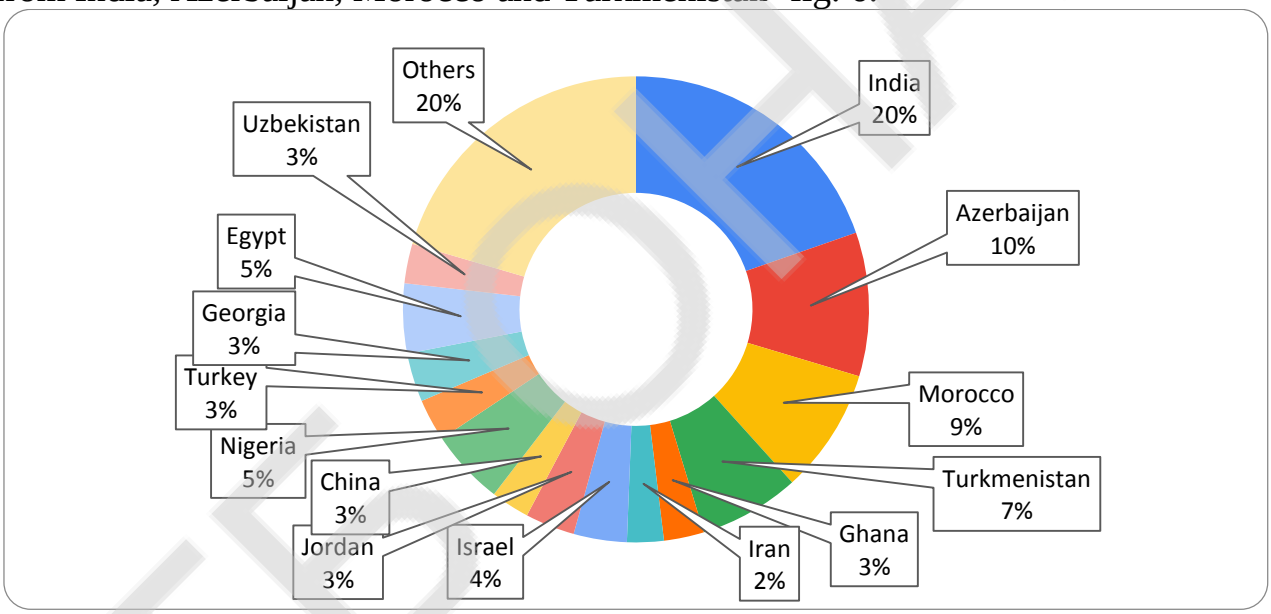

Fig. 6. Country of origin of foreign students of Ukrainian Universities (2018)

The main problem of attracting foreign students to study at the universities of Ukraine is that the education sector of Ukraine is not oriented towards European students. Higher education institutions practically do not offer programs aimed at the formation of international student groups (such as Eastern studies at the University of Warsaw), the number of universities which offers English-language education does not exceed ten.

The analysis showed the following results:

- the number of students is decreasing both in Poland and in Ukraine;
- political and economic instability in Ukraine contributes to increased student migration, mainly to Poland;
- decline in the number of students in Poland has slightly stopped, because of Ukrainian students, but this is a temporary situation.

All this leads to increased competition between higher education institutions for each student. Moreover, both in Poland and in Ukraine. To ensure success in this

struggle, it is necessary to develop the marketing strategy of the institution in common: to study the target segments of consumers and form an appropriate range of their services, to make decisions regarding pricing policy. Special attention should be paid to the communication strategy: with whom, how and when to communicate. In the context of globalization, it is an effective communication strategy that will ensure the necessary demand for higher education services.

Marketing strategy – this is the formation of specific goals and objectives by employees of the organization to improve sales of goods/services in certain target markets for a certain period (short-term, medium-term and long-term). In order for the marketing strategy to be applied correctly, it is necessary to determine the purpose of the research, the target audience, the forms of financing, the size of the budget and so on. Based on the marketing strategy, specific promotional activities of the organization are developed and we will set specific goals in front of the higher education institution (table 2).

From the point of view of promoting a product or service from the manufacturer to the consumer, there are two strategic directions according to which the pull strategy is applied, aimed at consumers, and a push strategy, aimed at representatives of the trading network; it is possible to use a combination of them.

Table 2 Communication goals of the higher education institution

Goals	Expected result
Economic	Increasing the number of applicants, attracting new customers, etc.
Image	Creating, restoring, maintaining or improving the image of the HEI to improve customer loyalty, which helps to increase the number of applicants and as a result - students and improving competitive position
Informational	Informing about new specialties, stimulating submission of documents and entering the university, informing about changes, novelties
Social	Informing applicants about a variety of social events aimed at supporting the applicant, his family (young families), the availability of rooms in dormitories, and so on.

Created by the author

For effective involvement, it is necessary to inform, orient and motivate students. The table 3 shows the activities that are appropriate to do.

Table 3 Types of marketing activities targeted on applicants

Type of event	Purpose of event	Event results	Event examples
Informational	Increase the awareness of applicants about universities, specialties, and admission conditions.	Accumulation of a database of potential applicants	Open days, information days, seminars, advertising of HEI in the media and the Internet, targeted work with schools.
Profiling	To give a more complete picture of the curriculum, the learning process, the specialty received and the career after graduation.	Segmentation of entrants from the point of view of interest of universities in each of them.	Meeting with departments, excursions to production facilities, intellectual competitions for applicants from different universities, etc.
Motivating	Increase the loyalty of the target audience to a particular HEI, increase the desire to join.	Understanding of each target applicant of his plans, removal of objections of his and his parents, assistance in solving various issues.	Meeting with famous graduates, management and "stars" of universities, excursion to a sports camp or recreation center of universities, invitation to sports and cultural events, etc.

Created by the author

To improve the communication strategy in a higher education institution, it is better to apply the pull strategy, which involves focusing on the final demand, i.e., aimed at consumers. This type of communication strategy is used to: attract new consumers, retain existing consumers, increase motivation for using the product, and create consumer loyalty to the product or brand – table 4.

Table 4 Areas of marketing communications usededucational institutions in the promotion of educational services

Areas of communication	Main types and carriers
Mass media	radio, television, print, advertising in specialized publications.
Direct mail	information about the Open Day, organizing conferences or seminars, the results of events, etc.
Internet network	websites of HEI, online communication.
Public relation	editorial articles, press releases, presentations, anniversaries, vocational meetings in schools, technical schools, lobbying with state executive authorities.
Ivent-marketing	organization of business classes

Created by the author

Higher education institutions use different methods and tools in their marketing activities. Let's take a closer look at which methods are used in the example of two higher education institutions – Odessa National Academy of Food Technologies (Odessa, Ukraine) and University of Business and Administration in Gdynia (Gdynia, Poland) [16,17].

Odessa National Academy of Food Technologies is a public educational institution that provides higher education services to Ukrainian citizens and foreigners. Has the right to train specialists at the level of bachelor, master, doctor of philosophy and doctor of science. Full-time and part-time forms of education are used. Training takes place both at the expense of the state budget and at the expense of individuals and legal entities. At the beginning of 2019, 6,194 people were enrolled in the Academy [16], and another 3,123 people in the colleges that are part of the ONAFT. The Odessa National Academy of Food Technologies implements an active marketing strategy and applies modern methods The Academy has a marketing and advertising department, which performs organizational functions for career guidance, to which all teachers of the institution are actively involved.

University of Business and Administration in Gdynia is a non-public educational institution that provides educational services to Polish citizens and foreigners. Trains specialists at the level of bachelor, master, doctor of philosophy and doctor of science. Full-time and part-time forms of education are used. Studing is provided at the expense of individuals and legal entities. The university has a marketing department that plans and organizes marketing activities, as well as a recruiting department. Employees of the recruitment Department are directly engaged in career guidance activities without involving teachers.

Appendix C provides the main marketing activities used in these institutions (the table C.1).

As for the product policy, ONAFT only prepares for teaching certain subjects in English, as in most universities in Ukraine. At UBA in Gdynia there are specialties in which the teaching is entirely in English. The educational process is designed in such

way that students have opportunity to combine study with work: classroom classes are held 3 days a week.

There are certain differences in the pricing policy – this institution offers discounts to applicants and students: for a high certificate score, for active career guidance (on personal initiative), and other achievements. In addition, the best students in ONAFT have the opportunity to receive a scholarship from the company. At UBA also provides financial incentives to students by providing a scholarship that covers tuition costs.

Both institutions of higher education use a direct sales channel, which is a characteristic feature of marketing services. Admission to the bachelor's degree in Ukraine is built in such a way that at certain times applicants submit applications exclusively in electronic form, and in the case of enrollment – provide the original documents in person. In Poland, the application can also be submitted using Internet technologies - directly on the university's website throughout the academic year. From 2019, the whole procedure of admission to the university can take place online, students don't have to come to the university to submit the original documents.

The largest component of the marketing activity of a higher education institution is communication policy. Many tools are applied here. The first is advertising. Both universities actively use print advertising (leaflets, booklets, etc.) and outdoor advertising (billboards). But at UBA, much attention is paid to souvenir advertising products that can be purchased by everyone (wall calendars, notebooks, pens, folders, bags, sweatshirts, flash drives, cups, thermoses, toys, chocolates, stickers, clocks, badges, etc.).

UBA in contrast to ONAFT, doesn't use radio ads in supermarkets and advertising in transport because is restricted by law.

Both universities have branded cars.

The pride of the ONAFT is its own newspaper, which has been published since 1973 and is distributed on a subscription basis throughout Ukraine. The newspaper publishes news, interviews, staff and student articles, important announcements, vacancies and more.

It is important that the UBA has a personage-symbol in a lion suit, and the face of the university (ambassador) - a student (employee of the recruiting department), her photos on all advertising materials, on the university's website. She also runs a page on Instagram as university's ambassador.

Event marketing is also an active element of communication activities in higher educational institutions. The difference is that teachers are actively involved in ONAFT events: they conduct master classes, meet with students and their parents. Whereas in the UBA, all this is done by employees of the recruitment department.

UBA is somewhat ahead in its activity in the field of Internet technologies: website has a feedback function, an online assistant, and a virtual 3D tour.

To analyze activities in social networks, we will make a table 5.

The table 5 shows that the UBA is more active in social networks than the ONAFT.

Thus, the analysis showed that higher education institutions in both Poland and Ukraine operate in a highly competitive environment. This leads to the need to use maximum marketing tools to attract students to study.

Table 5 – Number of subscribers in social networks

Social network	ONAFT	UBA
Facebook	2432	8785
YouTube	598	1780
Instagram	2683	1177
LinkedIn	-	2899

The table is based on the data of the [18,19,20,21,22,23,24]

To assess the effectiveness of marketing activities, let's compare the dynamics of the number of students in the relevant institutions with the overall dynamics of the number of students in the country –fig. 7 and 8.

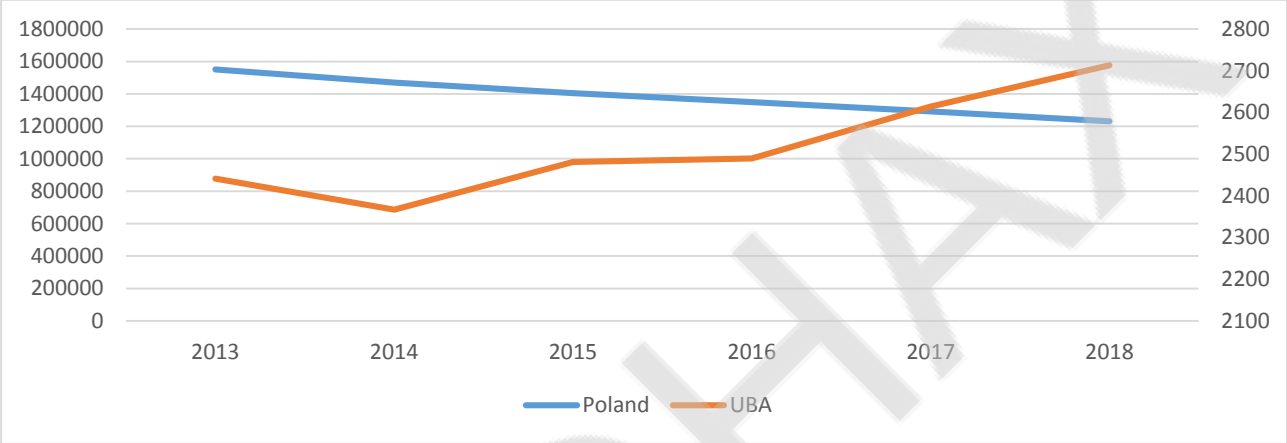

Fig. 7. Dynamics of the number of students in Poland and UBA

The positive dynamics of the number of students at the UBA is clearly visible, which shows a high level of efficiency of marketing activities.

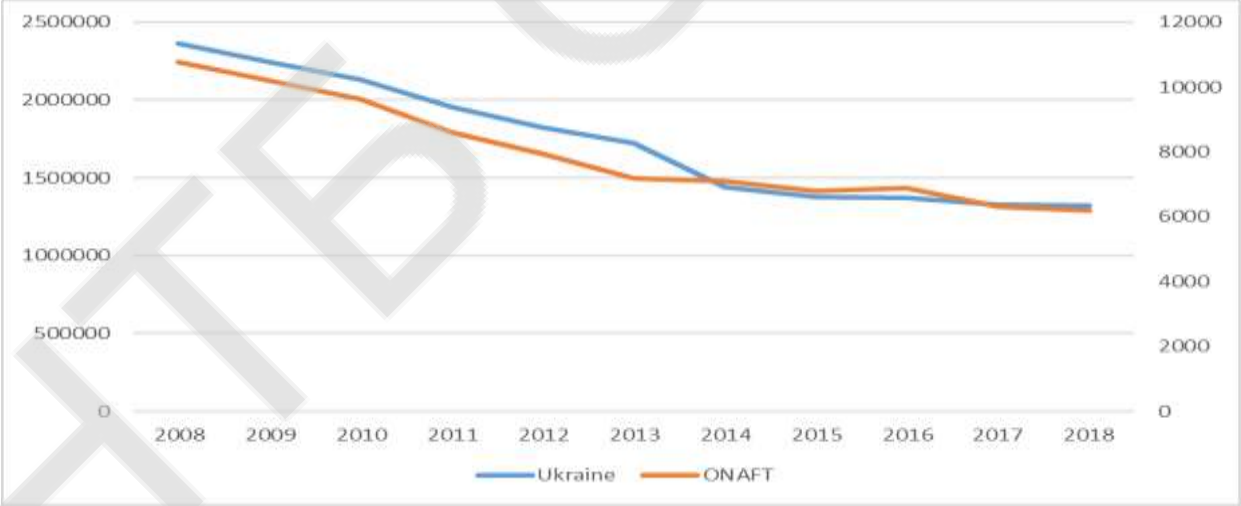

Fig. 8. Dynamics of the number of students in Ukraine and ONAFT

At the ONAFT, the dynamics of the number of students coincides with the total number in Ukraine, which is a good result too.

UBA carries out effective marketing activities, which allows increasing the number of students against the background of a general reduction. ONAFT also uses quite aggressive marketing, but its effectiveness is somewhat lower. It would be appropriate to step up activities on the Internet (improve the site, activate work in social

networks, and so on). Some resource cannot be used due to legal restrictions: tuition discounts.

In the future research, it is advisable to create a system for monitoring the effectiveness of components of marketing activities, build a purchase funnel on the basis of the received data and configure it, adding the necessary elements.

V. Conclusion.

The article defines the essence of marketing activities of higher education institutions, defines the feature of educational services as a product.

Based on the analysis of the dynamics of the main indicators of the higher education system in Poland and Ukraine, it was determined that most of the trends are similar: a decrease in the number of institutions, students, and increased competition.

The marketing methods used are quite similar, but in a Polish higher education institution their list is broader and more effective.

The perspective direction is to create a system for monitoring the effectiveness of the components of marketing activities, based on the data obtained to build a purchase funnel and configure it, adding the necessary elements.

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24. https://www.linkedin.com/school/wy%C5%BCsza-szko%C5%82a-administracji-i-biznesu-im.-e.-kwiatkowskiego-w-gdyni/

Addition A

Table A.1 Comparative characteristics of education systems in Poland and Ukraine

Specification	Duration of study	Age	Required conditions for the next level
	Ukraine		
Pre-primary education	1-4	2-6 By law, it is mandatory from 5 years old, in fact, it doesn't work	-
Primary education	1-4 grade	6-10	State final certification, which takes place in the school Specialized schools have the right to take entrance examinations to secondary school
Lower secondary schools	5-9 grade	11-15	State final certification, which takes place in the school
Upper secondary schools	10-11 grade from 2026 year – 10-12 grade	15-17	External independent evaluation conducted by a special authority exclusively outside of school
Post-secondary schools/ Professionally-technical education	3-4 years	15-19	
Bachelors' studies	4 years 2-3 years after associate's degree	17-18	
Master's studies	1,5 -2 1-3 years in the field of medicine, veterinary	21-22	
Doctoral degree programs	from 4 years	from 21-22	

Continuation of table A.1.

Specification	Duration of study	Age	Required conditions for the next level
	Poland		
Pre-primary education	1-3 grade	3-6	mandatory "0" reception class
Primary education	1-8 grade	7	compulsory exam
Lower secondary schools	-		
Upper secondary schools	3-year special job-training schools 4-year specialised secondary schools 5-year technical secondary schools 2-3 year sectoral vocational schools	required to study until 18. year of life	Matura examination / Secondary school-leaving examination
Post-secondary schools/ Professionally-technical education	1–2,5	19-20	
Bachelors' studies	3 years - first-cycle programmes with bachelor's degree 3,5- 4 years first-cycle programmes with engineer title	19-20	
Master's studies	1,5 -2 years	22-23	
Doctoral degree programs	from 2 years	25	

Created by the author

Addition B

Table B.1 Polysemy the concept of " educational service»

№	Author	Definition
1	Obolenskaya T.E. [1]	Educational service is a specific product that satisfies a person's need to acquire certain knowledge, skills and abilities for their further use in professional activity.
2	Nikolayenko S. [2]	Educational services - are intangible, but social goods, a system of knowledge, information, skills and practical skills to meet its various educational needs and the realization of their consumer's personal abilities.
3	Alexandrov V. [1]	An educational service is an organized learning process for obtaining the necessary knowledge, skills and abilities. This is a special intellectual product that is provided by the party that organizes and implements the training process, and is held by the other party, which can be both a student, a quality controller of the service, and a payer for it.
4	Trubich S., Maikovich T. [4]	An educational service - is an intangible service of a special kind as a sphere of human activity that creates a useful productive effect, is not embodied in a material form, its qualification and professional qualities.
5	Kadachnikov S.M. [3]	An educational service - is an economic good that has utility from the point of view of its consumers and requires costs for its production.
6	Kaleniuk I. [5]	Educational services or products of educational activities are the result of various (pedagogical, educational, scientific, organizational and managerial) activities by employees of the education sector to meet the educational needs of individuals and the entire society.
7	Ogarenko V. [2]	An educational service - is an educational product that represents a certain activity that is carried out by the manufacturer, and in the course of which the consumer's need for education.

Created by the author

Addition C

Table C.1 Components of marketing activities ONAFT and UBA

Components		State institution of higher education in Ukraine	Non-public institution of higher education in Poland
Pricing policy			
Discount system (for high score of certificate, for career guidance, etc.)		-	+
Product policy			
education in the national language		+	+
education in english		-	+
Place (sales) policy			
Direct sales, applying directly at the university		-	+
Direct sales, applying through the electronic entry system		+	+
Promoution (communication) policy			
Advertising	print advertising	+	+
	external	+	+
	souvenir products	-	+
	television	+	+
	radio	+	+
	radio in supermarkets	+	*
	on transport	+	*
	billboards	+	+
	at public transport stops	-	+
Public relations	interviews on television	+	+
	shooting special TV shows	+	-
	donor activity	+	+
	business days, job fairs	+	+
	symbol of the university	-	+
Exhibition activities	within the country	+	+
	abroad	+	+
Event Marketing	open days in a higher education institution in the form of quests outside the institution	+	+
	Master classes in the university	+	+
	Master classes in schools	+	+
Internet technology	university website	+	+
	virtual 3D tour	-	+
	callback order	-	+
	pop-up dialog box (online assistant)	-	+
	active channel on YouTube	-	+
	Facebook	+	+
	Instagram	+	+
	Linkedin	-	+
	Telegram	-	-
Personnel			
Staff employees	marketing department	+	+
	recruitment department	-	+

Note * - is illegal in Poland

Created by the author

FORMATION OF PERSONNEL POLICY OF THE CIVIL SERVICE SYSTEM

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Abstract*. The main problems of personnel policy formation of the Ukrainian civil service system are analyzed in the work, on the example of the Southern office of the State Audit Office. The scientific approaches to understanding the essence of the state personnel policy are covered. The goals, principles and purpose of the state personnel policy are substantiated. The paper points out that the formation of an effective personnel policy is a rather complicated and contradictory process, since there are many problems that need effective solutions.*

The need to apply innovations in the practice of personnel management is substantiated. The essence of the concept of "personnel innovation" is revealed, factors of innovation potential are determined.

It has been proved that public service in a democratic society should be an institution open to public scrutiny, since openness of the public service will promote its authority and prestige, without which it is impossible to attract the most worthy young people to the service. Prospects for further scientific research have been identified.

Keywords: *personnel management, personnel policy, innovative methods, human resources, public service.*

Introduction

The realization of the building task Ukraine as a sovereign and independent, democratic, social, rule of law, the completion of administrative and judicial reforms is impossible without the formation of a civil servants body that would meet the modern requirements stipulated as a new role of the state in relation to society, and the purpose of effectively performing civil servants' functions. It is emphasized that: "The success of radical socio-economic and political transformations in Ukraine depends first and foremost on the effective work of executive bodies of all levels. Equipping them with highly qualified personnel capable of ensuring the economic and social development of the state has become of paramount importance "[7].

The relevance of the research topic is also determined by the acute shortage of highly qualified moral staff training, which is related to the crisis of human resources of the civil service in Ukraine and the lack of the its formation mechanism development. The problem of the civil servants orientation to the needs of society and the human being remains urgent, where the beginning of the new outlook formation of the civil service personnel should become their awareness of their main role, which is to provide services to the population.

Analytical review of the literature

The issue of personnel support of the executive authorities is a subject of constant attention of national and foreign managers and scientists. The necessity of system personnel policy formation, significant changes in the selection and placement

of personnel is analyzed in the works of famous Ukrainian scientists: V. Averyanov, O. Voronko, S. Dubenko, Y. Zhovnyrchyk, V. Knyazev, G. Lelikov, V. Lugovoi, V.Ya. Malinowski, N. Nizhnik, V. Oluyko, P. Pavlenchyk, S. Seryogin, Graham Martin and Susan Hetrick, who in their work "Strategic Approach to Human Resource Management" characterized the principles of human resources formation.

However, despite the wide range of research on personnel issues, the issues of personnel policy formation in the context of ongoing systemic reforms in Ukraine are not sufficiently covered and therefore need further study.

The purpose of the study is to highlight the peculiarities of the current state of the state personnel policy and to find new approaches in the field of improving the mechanisms of recruitment of the civil service of Ukraine.

Object, subject and methods of research

The object of the research is the processes and mechanisms of forming the personnel policy of the civil service system.

The subject of the research is theoretical and practical aspects, principles and methods of forming the personnel policy of the civil service system.

In order to solve these problems, the following research methods were used:

– systematic - for the study of external and internal processes of formation of personnel policy of the civil service;

– systematization - to analyze the essence of the concept of "personnel policy";

– observation - to identify the real state of personnel policy in public services;

– comparison - to identify shortcomings of personnel policy in state bodies and to develop directions for its improvement.

Results of work

Exploring the current problems in the formation of personnel policy of the civil service system of Ukraine, it should be noted that among scholars there is no single approach to the interpretation and definition of the concept of state personnel policy. In particular, in the Encyclopedia of Public Administration, state personnel policy is defined as a purposeful, long-term strategic activity of the state aimed at the formation, preservation, strengthening, development and rational use of human, labor, human resources of the country, determination for achieving this goal long-term goals, - economic and political tasks, specific measures for ideological, programmatic and resource support of the main prerequisites for economic realization [1.]. According to V. Malinovsky, state personnel policy is a state policy in the sphere of public service, the main purpose of which is the improvement of human resources, the creation of a capable state apparatus capable of efficiently fulfilling the tasks and functions of the Ukrainian state through the honest fulfillment of the civil servants assigned to them by public servants powers [2, p. 165].

According to Oluyk V., state personnel policy is a system of organizational, legal and other measures authorized by the state entities to form personnel support for state bodies, state-owned enterprises, institutions and organizations that ensure the performance of state functions [3, p. 20]. We share the scientific position of Zhovyrchik Y. that the personnel policy as a social phenomenon, having a multilevel structure, is much wider in content than the state personnel policy, in which the state, which cannot solely decide, acts of all personnel problems [4, p. 103]. An important document

defining the purpose, goals and priority tasks to be pursued by the modern state personnel policy is the “Strategy of the state personnel policy for 2012-2020” [5].

Strategic goals for the implementation of the state personnel policy are [5]: development of mechanisms for attracting highly qualified specialists, successful entrepreneurs, employees of financial and economic sphere, capable graduates of higher educational institutions to work in the public administration; the renewal of recruitment technologies for management positions with a number of employees with experience in lower-level positions in the relevant field of activity; formation of effective personnel reserve for management positions in the spheres of public administration; strengthening the requirements for the moral qualities of persons involved in management activities in order to avoid possible manifestations of corruption, to prevent conflicts of interest, to improve the procedure of disciplinary proceedings; introduction of modern technologies of personnel management for successful solution of production and management problems in the public sector of economy; training and professional development of senior civil service executives capable of ensuring the effectiveness of public policy in public administration and leadership in administrative and economic reform.

Establishing an effective staffing policy in Ukraine requires solving a significant set of problems that are listed in Table 1.

Table 1

Problematic complex of personnel policy [6]

Name of the problem	Characteristic	Ways to solve
Conceptual	Obsolescence of the personnel concept in terms of understanding of the personnel system, personnel processes, the role of the state, compliance with the post-industrial information society with a market economy	Establishment of monitoring and systematic research of personnel processes, creation of sectoral and leading research institutes, formation of national expert co-operative societies
Legal	Lack of a comprehensive legal framework for the human resources of society and the state	Formation of a holistic system of legal regulation of the personnel system, personnel work and personnel policy
Institutional	Lack or underdevelopment of institutions and organizations of personnel work, personnel system and personnel policy	Formation of relevant institutions and organizations, enhancing their institutional capacity, ensuring their dynamic development
Financial	Insufficient material and financial support for human resources, management, policy	Priority funding for HR, management and policy
Technological	Absence or outdated personnel technologies	Formation of a portfolio of personnel technologies
Personnel	Absence or obsolescence of personnel engaged in personnel work, personnel management, personnel policy	Establishment of training and retraining of the personnel engaged in personnel on each

When raising the issues of requirements for the staff of public administration, the above-mentioned conceptual line "state" - "public service" - "specialist" should be taken into account, as well as the influence of the essence and substantive

characteristics of each of these concepts on the final result - elaboration scientifically substantiated requirements for the staff of public administration bodies, which by their purpose should facilitate the filling of the organizational structures of the public administration system by the profession and qualification of personnel, with involving formation of their motivation to effective labor organization of their effective use, professional and social development, achieving sustainable degree of staff mobility as well as their social security, taking into account the democratic foundations of building our country and the provision of priority rights, freedoms and lawful interests of individuals.

We conducted research on the personnel policy formation problem of the civil service system in Ukraine, on the example of the Southern office of the State Audit Office. The bodies of the State Audit Service of Ukraine exercise independent public financial control on behalf of the Government. The bodies of the State Audit Service of Ukraine include the State Audit Office and its interregional territorial bodies: North, Northeast, South, Western, Eastern offices of the State Audit Service.

The State Audit Office is the central body of executive power, whose activity is directed and coordinated by the Cabinet of Ministers of Ukraine and which ensures the formation and implementation of state policy in the sphere of state financial control. The State Audit Office and its interregional territorial bodies are legal entities of public law, have seals with the image of the State Emblem of Ukraine and their name, their own forms, accounts in the institutions of the State Treasury Service of Ukraine.

The legal acts that regulate the activity of the State Audit Office are the Budget Code of Ukraine, the Law of Ukraine "On the Fundamental Principles of State Financial Control in Ukraine", the Cabinet of Ministers of Ukraine "On Approval of the Regulation on the State Audit Service of Ukraine" and others.

According to the tasks assigned to it, the Southern Office of the State Audit Office:

1) generalizes the practice of applying the legislation on issues within its competence, develops proposals for improvement of legislative acts, acts of the President of Ukraine and the Cabinet of Ministers of Ukraine, regulatory legal acts of ministries and submits them to the Cabinet of Ministers of Ukraine in due course;

2) exercise control in: ministries, other executive bodies, state funds, compulsory state social insurance funds, budgetary institutions, public sector entities, as well as enterprises, institutions and organizations that receive funds from budgets all levels, state funds and compulsory state social security funds, or use state or communal property;

3) realizes the state financial control through the implementation of: the state financial audit; public procurement audits; inspection; procurement monitoring; control over the state of internal audit;

4) exercise control over: the purposeful, efficient use and conservation of public financial resources, fixed assets and other assets; achieving budget savings and efficiency in the activities of budget spending units; purposeful use and timely repayment of state guarantees credits; the reliability of determining the need for budgetary funds when drawing up the planned budget indicators and the appropriateness of budgetary commitments made by budget spending units to the

corresponding budgetary appropriations, the passports of the budget program; compliance with the long-term commitments of the energy service, approved in accordance with the established procedure, to the conditions of the purchase of the energy service; adherence to legislation at all stages of the budget process regarding state and local budgets;

5) conducts the assessment of management of budget funds, achievement of their economy, state of financial and economic activity, efficiency and effectiveness in the activity of controlled institutions;

6) assesses the reliability of the financial statements of the supervised entities.

For the purpose of an in-depth study of the motivational aspects in the activities of the staff, the importance of the factors motivating labor behavior was evaluated. Ranking of the proposed motivating factors by importance for the different categories of respondents is presented in Table. 2.

Table 2

The importance of motivating factors

Top-level executives	Middle-level executives	Lower level executives
1. The amount of earnings	1. Wage saving guarantee	1. The amount of earnings
2. Decision-making autonomy	2. The amount of earnings	2. Guarantee of salaries
3. The success and prosperity of the organization	3. The success and prosperity of the organization	3. Good relationships with colleagues and management
4. Respect, authority, prestige, recognition of merit	4. Good relationships with colleagues and management	4. The success and prosperity of the organization
5. Guarantee of salaries	5. Independence in decision making	5. Respect, authority, prestige, recognition of merit
6. Good relationships with colleagues and management	6. Respect, authority, prestige, recognition of merit	6. Independence in decision making
7. Justice of remuneration	7. Consideration of thought in decision making	7. Opportunity to show creativity
8. Increasing competence	8. Justice of remuneration	8. Justice of remuneration
9. Workplace comfort	9. Consideration of thought in decision making	9. Increasing competence
10. Opportunity to show creativity	10. Awareness of the state of affairs	10. Possibility of promotion
11. Consideration of thought in decision making	11. Opportunity to show creativity	11. Increasing competence
12. Awareness of the state of affairs	12. Workplace comfort	12. Workplace comfort
13. Possibility of promotion	13. Possibility of promotion	13. Awareness of the state of affairs

Own research

As can be seen from the table. 2, the first place among the motivating factors is the size of wages and the guarantee of its preservation.

Measures that, in the opinion of employees, can positively influence the work performed, are presented in Fig. 1.

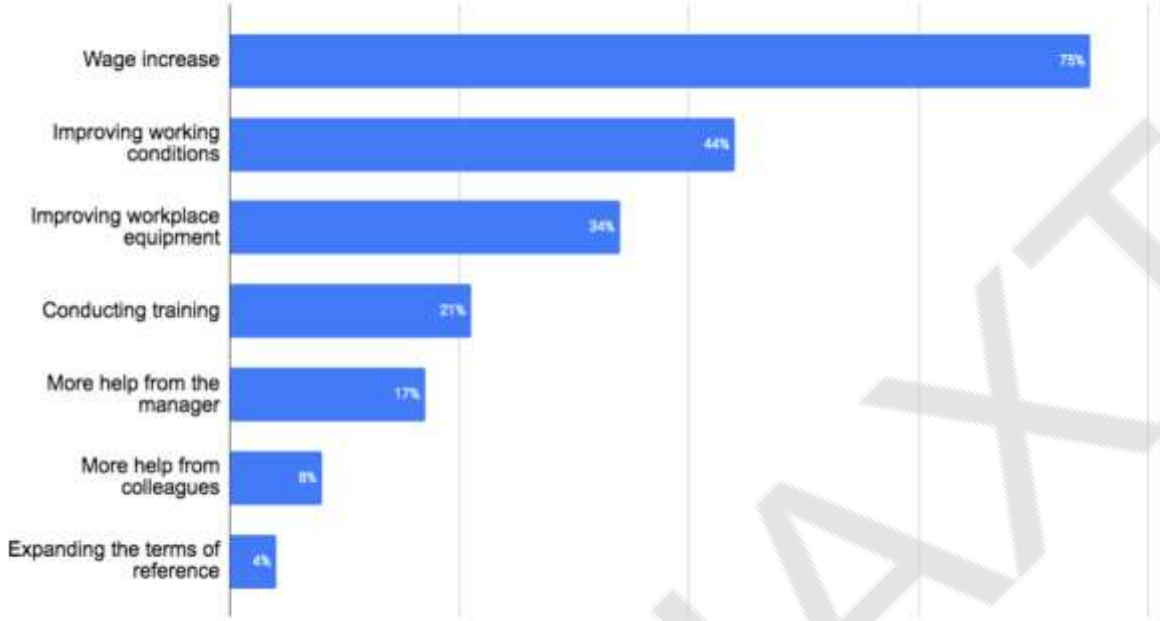

Fig. 1. Measures that can have a positive impact on the work being done
Own research

In the opinion of the majority of respondents, the quality of work performed can be positively influenced, first of all, by raising wages, improving working conditions and equipping workplaces, as well as training.

According to the respondents, the most significant factor that could induce an employee to change their place of work is higher wages, as well as factors such as more interesting work, more comfortable working conditions and broader career opportunities.

Satisfaction with the organization of the workplace was evaluated by such parameters as the space around the workplace, the location of the workplace, light, noise, air. Assessment of employee satisfaction with the content of work and development opportunities was carried out on such important parameters as: position at the enterprise; system of distribution of powers; system of distribution of responsibilities; career opportunities; the possibility of advanced training; degree of participation in social processes in the enterprise.

Most respondents consider their position in the company relatively stable at this time. However, they have no confidence in tomorrow. This is mainly due to frequent structural changes and number optimization processes. This creates uncertainty in tomorrow, increases the level of anxiety in the team, which, in turn, can negatively affect productivity.

The system of distribution of powers at the enterprises, the assessment of which is presented in Fig. 2, employees do not consider it correct, noting that the current system slows down operational activities, difficulties in decision making, and the management of enterprises should be given more authority to subordinate employees, especially in situations where much depends on the speed of decision making. But at the same time, responsibility for the work being done should also be increased.

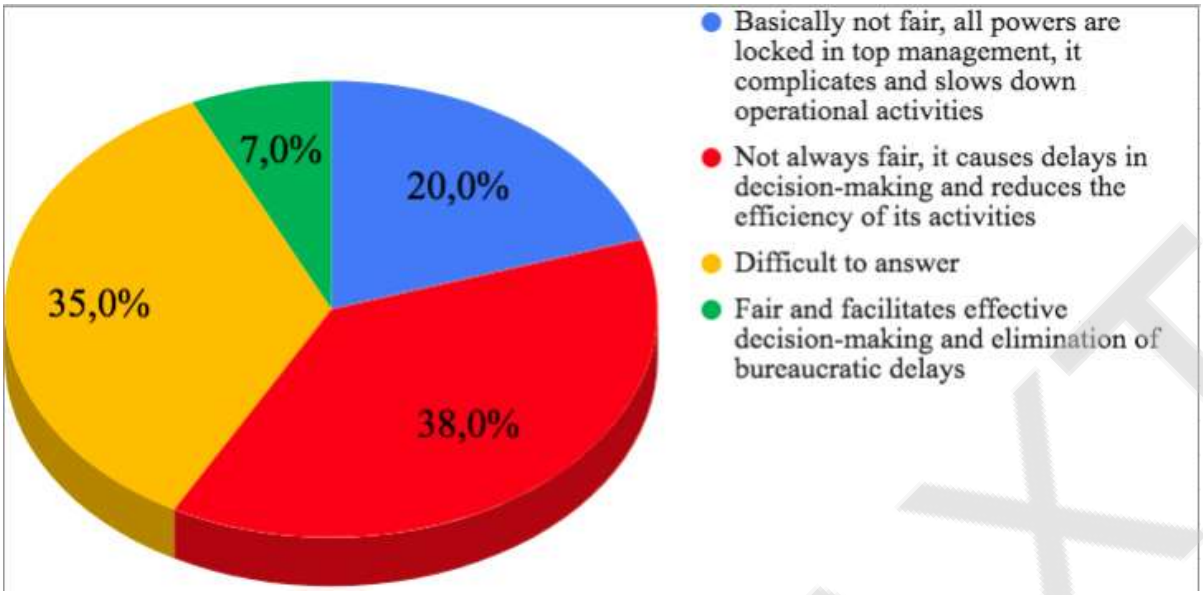

Fig. 2. Evaluation of the system of distribution of powers at the enterprise
Own research

And although the limits of liability, according to the data presented in Fig. 2, at the enterprises defined by clear regulatory documents, most employees consider these boundaries not quite fair and transparent.

As a recommendation, it may be suggested that unit managers pay attention to the clarity and unambiguity of the positions of job descriptions of employees who distribute both the rights and responsibilities of employees. Items such as 'Perform other job-related supervisor assignments' can not only be widely interpreted by both supervisors and subordinates, but may also blur the boundaries of everyone's responsibility. The system of career advancement, which is presented in fig. 3.

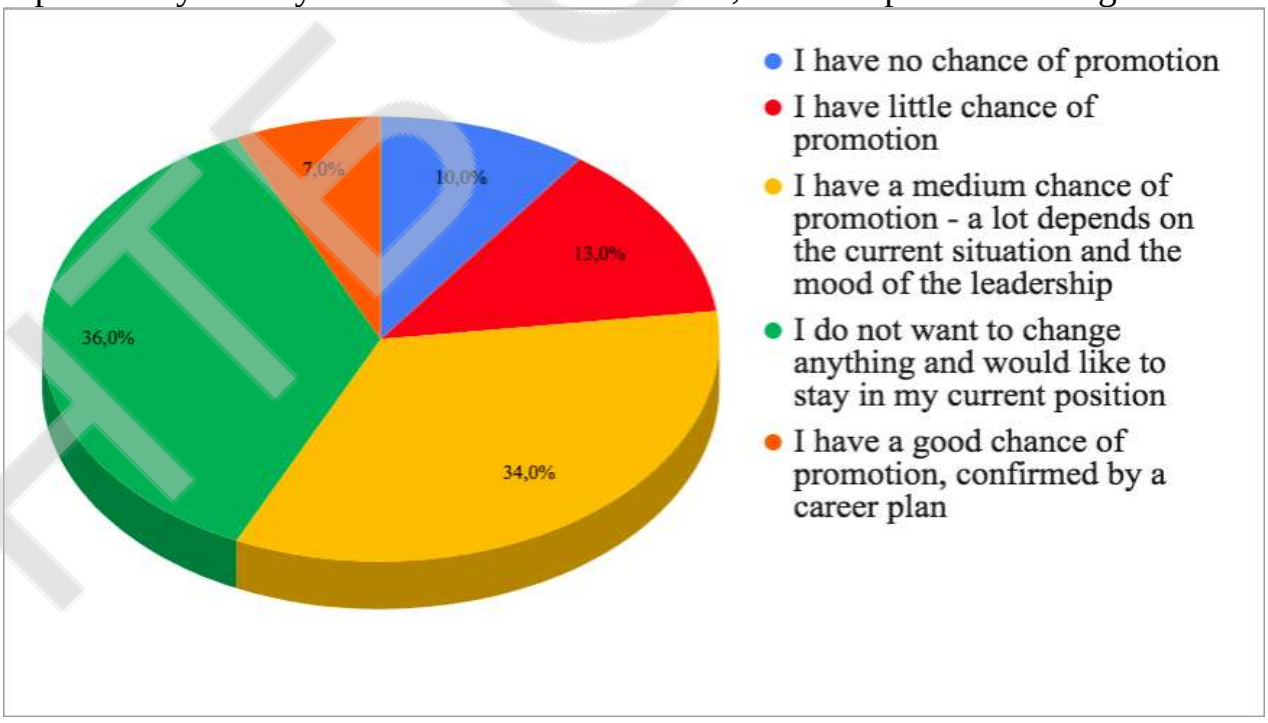

Fig. 3. Assessing career opportunities for employees
Own research

Sometimes, in the opinion of the respondents, decisions on job promotion are made unreasonably. As a result, half of the workers rated their chances of promotion as medium or low.

An ambiguous picture has been obtained regarding the assessment of training opportunities. On the one hand, more than 20% of respondents study and improve their skills at the expense of the enterprise, and 21% do it on their own. On the other hand, almost a third of the respondents either failed to answer this question or did not want to study and improve their skills.

This study showed the insufficient level of involvement of state employees and, in particular, young people in social processes, which in most cases play a significant role in the development and self-realization of personnel, allow for a time to abandon production and expand the circle of communication in the enterprise.

The problems identified during the study, such as relationships in work teams, the ability to communicate with their manager in a problem situation, the possibility of self-fulfillment in work deserve close attention, because regardless of the unit, the value of communication in production remains an important factor. When assessing the level of motivation of the staff, the results were distributed as follows: very high - 11.0%; high - 17%; the average - 56.3%; low - 8.9%; very low - 7.6%, 17% of respondents consider their motivation to be insufficient.

The study found that the organization did not have a well-defined "concept" or strategy for motivation. We find that many managers have a misunderstanding of how to build a motivation strategy within the organization. This strategy must be developed for the enterprise and applied at all levels of its organization. It is necessary to train managers. The basic motivation strategy existing at the enterprise is based on the practice of monetary rewards and penalties. Some executives feel that this is too narrow an area of motivation, inadequate to the motivational environment and production needs of the organization in the future.

Table 3

Factors of decrease of desire of work of employees

What do you think are the factors that reduce your employees' desire to work (other than wages)?	**The number of people who responded (%)**
Insufficient skills, lack of training programs, poor training	35
Absence of necessary working conditions, Adverse working conditions	26
High intensity of work, superfluous workload of workers	14
Weak disciplinary measures, lack of control	27

Own research

As can be seen from the table. 3, the main factor in reducing the desire to work is the lack of professional qualification, and this is also reflected in employees' opinions regarding the adequacy of earnings to the level of qualification and professionalism. The level of motivation of managers is generally rated as high (45.1% of respondents), and the ratings, in the aggregate, do not fall below the average. In turn, the level of employee motivation is generally rated above average (52.4% of respondents), but in some cases such assessments as “low level of motivation” (11% of respondents) and “very low level of motivation” are given. (2.4%). A significant number of managers

(36.6% of respondents) believe it is logical that in terms of influence on the personnel the most effective is the complex of internal and external types of motivation. At the same time: External positive motivation (material incentives, approval of colleagues and staff, prestige) is placed in the first place (31.7% of respondents); on the second (19.5%) - internal motivation; to the third place (11%) - external negative motivation.

However, from our point of view, at this stage of the life of the organization and in the context of its characterizing strategy (development strategy), emphasis should be placed on the intrinsic type of motivation. That is, when forming a motivational set of influences on an employee, the first place should be put on the methods of influence that encourage the employee to become aware of intrinsic motivation.

According to the analysis, we have identified two subspecies of active personnel strategy: rational and adventurous [8, p.74]. With a rational staffing strategy, management has both a qualitative diagnosis and a well-grounded prognosis of the situation and has the tools to influence it. The personnel service of the enterprise not only has the means of diagnostics of the personnel, but also the forecasting of the personnel situation for the medium and long-term periods. The organization's development programs contain short-term, medium-term, and long-term staffing forecasts (qualitative and quantitative).

With an adventurous personnel strategy, the management of the organization does not have a qualitative diagnosis, a reasonable forecast of the situation, but seeks to influence it. As a rule, the HR department of the enterprise does not have the means of forecasting the personnel situation and diagnostics of the personnel, but the enterprise development programs include the plans of personnel work, which are often focused on the achievement of goals important for the development of the enterprise, but not analyzed in terms of changing the situation. In this case, the plan of work with the personnel is based on a rather emotional, not well-reasoned, but maybe also a true idea of the purposes of work with the staff.

The Southern Office of the State Audit Office is characterized by the most active staffing strategy with its sub-type - the adventurous staffing strategy. Problems with the implementation of such a personnel policy may arise if the influence of factors not previously included in the review increases, which will lead to a dramatic change. The second reason for the differentiation of personnel policies may be a principled orientation to one's own or external personnel, the degree of openness to the external environment in the formation of personnel.

The need for personnel policy modernization stems from the content of the tasks facing the state today. New ideas, principles and technologies for resolving personnel issues should be developed that would reflect the current level of managerial science, practices and requirements of a democratic society in order to create a professional, politically neutral, responsible and authoritative civil service and service in local self-government bodies of European standard; selection of qualified personnel, which will meet the needs of the society, will effectively provide quality public services to the population; creation of legal, social and organizational prerequisites for successful realization of the professional potential of civil servants and local self-government officials.

The context of the innovation of recruitment methods, it is necessary to talk about the use of traditional recruitment systems (by competition, by contract, by election) and leasing of personnel (a form of temporary staff involvement from outside); open system of competitive selection on the basis of document comparison, questionnaire, testing; staff reintegration.

In the context of improving the organizational support of personnel policy, attention should be paid to the transition to a multifunctional multidimensional format of HR services activities, which will be relevant to the planned work; monitoring, evaluation, control, coordination of quality staffing; diagnostics of the level of competitiveness of officials, career support of graduates of public administration and civil service; control of the observance of anti-corruption and civil service legislation in the local self-government bodies.

Conclusions

Effective personnel policy of the state as a whole, and in particular in the state administration, is the key to successful development of any state, one of the factors for achieving the positive consequences of reforms. Only well-trained personnel who have the modern knowledge, skills and management skills are able to implement the innovations, achieve their goals, work on the formation of an effective system of public administration, solve urgent problems facing society. Predicting staff qualification is of great importance in the process of implementing organizational measures related to staffing. Predetermined forecast allows you to solve emerging problems and give the expected effect.

In order to improve the civil service personnel system, the following procedures and mechanisms should be implemented and improved: a system of criteria for the selection, promotion and promotion of civil servants based on the results of their assessment on the basis of qualifications and business qualities, rather than years of service, should be detailed and accessible; the organization of commissions that carry out evaluations with mixed membership, that is, the inclusion of not only the staff of the relevant body, but also scientists, specialists in the field of public administration, law, administration, and management.

General requirements for the development of profiles of professional competence of civil service positions in public bodies are:

- the application of uniform criteria for the formation and assessment of requirements for the level of professional competence of persons applying for vacant positions of public service;
- compliance with the tasks and functions assigned to a specific structural subdivision of a public authority in accordance with the provisions of this structural subdivision and the official duties assigned to a civil servant in accordance with the official instruction;
- orientation on perspective and innovative tasks of the civil service;
- unbiased attitude to the professional and social and labor interests of civil servants.

An important component of personnel policy should be the direction of human capital development by [14, p.18]:

- promotion of highly skilled labor, innovative activities, knowledge-intensive products, technologies of resource conservation.

- the transition in management systems from the dominance of classical management theories inherent in the era of industrial development to the concept of human capital.

- creation of a nationwide personnel information system that would allow for effective personnel policy implementation.

- support for creativity in all types of industrial, scientific, cultural and educational activities.

- implementation of information technology production practices, total computerization of society.

- material and moral support for talented youth.

Suggestions for improvement of the personnel management system in public authorities

State personnel policy should have the following essential features:

- a systematic approach that takes into account various aspects of personnel issues - economic, social, moral, social and psychological, etc .;

- scientific validity and realism of taking into account the needs of the society in the human resources, consistency and stage of solving strategic personnel tasks, involvement of trained specialists in the professional activity;

- unity and multilevel in terms of coverage of all human resources, personnel processes;

- perspective that determines the leading character, takes into account social progress, changes in the nature of work and managerial processes;

- democracy in terms of goals, social base and mechanisms for solving personnel problems;

- morality - education in every employee of such traits as honesty, confidence, civil responsibility;

- legislative security.

It is these traits, which become the principles, give the state personnel policy of integrity and substantive certainty, which make it possible to influence all personnel processes in the state. The development and implementation of a sound state personnel policy is an urgent need of Ukrainian society, the most important prerequisite for the successful implementation of an innovative state development strategy aimed at ensuring high rates of economic growth and achieving high standards of living for citizens.

With the development and complication of production, the acceleration of scientific and technological progress changes the requirements for personnel. Requirements for general education, economic, technical, technological training of workers and employees are being increased, to the level of their qualification. Questions arise about the rational use of manpower, the optimal assessment of human resources. And since these areas of management are related to the field of personnel work, at the same time the functions of personnel services of enterprises are expanded.

One of the tasks of the personnel work of the Organization is the organization of training and retraining of personnel, ensuring the development of skills of workers

directly in production in educational institutions. To this end, the organization should develop a training and material base, establish training facilities, courses and centers, schools for the study of advanced methods of work. It is possible to increase the effectiveness of the appraisal of management employees, as well as to ensure the objectivity of its assessments and conclusions, through the use of expert assessments of specialists and especially managers, carried out in the light of the opinions of experts of the same level with the appraised and subordinates.

An important problem is the skillful use of the reserve. It is necessary to determine in due time the time when the reservist should be promoted to the position in which he will bring the greatest benefit. It is advisable to envisage two areas in the reserve pool for advancement: operational and long-term reserves (for senior management positions with long-term training).

Training in the operational reserve, as practice shows, should not last more than three years, because "sitting" in the reserve demobilizing affects the activity of the employee enrolled in the reserve, because it violates his life goals and plans. This leads to a decrease in the effectiveness of the organization.

Consideration should also be given to questions relating to the examination of the suitability of a candidate for a replacement position. The suitability of a candidate for a position is determined, first of all, by his / her attitude to this position, by the presence of appropriate knowledge, skills, skills, and in other cases by his / her corresponding psychophysiological qualities. When selecting a candidate for the post of Head of Personnel Department, in case of such need, it is necessary to present qualification requirements to him not only in terms of educational qualifications, seniority of work in management positions, but also the availability of such qualities as the ability to work with people.

It is also important to raise personal responsibility and the interest of the staff in improving their skills. To put in direct dependence on its results attestation, business growth of specialists and establishment of their level of salary. Significant improvements are required in the regulatory framework for advanced training, in particular to ensure that it is compulsory and regular.

A prerequisite for improving the efficiency of management training and management training is a departure from the existing stereotypes of the organization and teaching methods. The system of training and advanced training of managerial personnel includes the following links: state inter-branch centers of training of managers; sectoral institutes for advanced training of managers and specialists; special faculties and courses at higher education institutions; courses.

The basis for the formation of an effective state personnel policy is a legal framework that meets the modern world requirements and is based on the latest approaches. After all, the relevant regulations define the priorities, goals of development and use of human resources of the state, determine the principles, forms and mechanisms of work with personnel.

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НТБ ОНАХТ

DEVELOPMENT OF PROFESSIONAL COMPETENCE IN RESTAURANT SERVICE BASED ON THE USE OF WORLDSKILLS INTERNATIONAL STANDARDS

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Abstract*. On the basis of the literature data in the work approaches to training of service personnel in modern conditions was considered. The work considers the relevance of the use of international standards, in particular Worldskills standards on the competence of "Restaurant Service".*

As a result, the project of Worldskills resource training center for restaurant services was developed on the basis of Mogilev State University of Food Tecnologies (MSUFT). The planning solution has been developed, educational, methodical and logistical support has been selected.

Field of application: training of specialists in the field of catering. The project is socially significant because it is aimed at high-quality training of various categories of catering personnel for the restaurant industry, which will contribute to the improvement of the service culture and the level of service in general.

Key words*: restaurant service, staff training, international standards, worldskills, resource training center.*

I. Introduction

High-quality service, development of a high quality service culture oriented to customers' needs are of paramount importance in the restaurant industry. If the service is not high enough, most guests will have a negative evaluation of the catering facility. The success and popularity of many restaurants is directly dependant on the culture and quality of service, the attentive and courteous attitude of staff to guests. This is the relevance of a wide range of requirements for restaurant staff.

In the Republic of Belarus and the CIS countries there is no serious market experience in the restaurant sector and long-term traditions. In addition, there is no established methodological base to help conduct restaurant business. Another difficulty is that, for many entrepreneurs, restaurant business is seen only as a source of profit that does not require much attention. The strategic advantages for the development of the network of restaurant business enterprises are due both to the increasing flow of tourists, and to the change in the culture of food, the use of foreign experience in the organization of undeveloped food. But many catering facilities have not fully appreciated the prospects of these strategic development directions, are unable to provide high quality products and services, individual approach to guests. In many ways, this situation is due to a shortage of qualified personnel.

To date, there are no adapted training programs in Belarus and there is no scientific and methodological support for the training of service personnel according to international standards. Since one of the current trends is the failure of local systems of professional standards in favor of national and international standards, it is advisable to train specialists in the service industry according to the Worldskills standard.

II: Analytical review of literature

Training in modern conditions is a factor of success of both the catering facility in general and individual employees, it can be individual and collective, planned and unplanned. To build professional training, a number of actions must be carried out: to determine the needs for training, to formulate its goals, to determine the applicable forms and methods of training, to calculate costs, to compare them with the capabilities of the firm, to create a training plan, to organize training, to control its course and to check the effectiveness of training. Of course, waiters and bartenders are trained at various courses and colleges, but it is not enough to work qualitatively in a given institution. Every restaurant has its own face, conceptual features which influence the specifics of guest service.

In order to train the staff of the enterprise with a large budget, special training companies can be involved, however, in order to ensure the necessary specific level and style of guest service, internal training is necessary. In this industry, both directions of education can be developed: external and internal. External training - training of personnel in courses, seminars, trainings, internships, competitions, etc. Internal training is represented by mentoring, rotation, internal seminars, shadowing ("to be the shadow of the learner"), self-learning. Cascade systems connect external and internal learning.

In the world practice, there was an idea of the optimal ratio of external and internal training: 80% of training falls on their own training center, and 20% is involved in the training.

One of the types of external training are competitions of professional skills. The competition is a competition with the aim of identifying the best of the participants. Competitions can be considered as a stage of professional development. Competitions of professional skills are held in order to increase the prestige and status of the profession in society, to identify and study new directions in a specific field.

Positive parties to participation in competitions of professional skill are:

- development of competence of service personnel, development of active life position, communicative abilities, aspiration to self-improvement, self-knowledge, self-actualization;
- creation of a favorable motivational environment for professional development;
- increase the rating not only of the specialist, but also of the institution where he works;
- development of creative abilities, establishment of new connections, introduction of new international standards in service sphere [1].

Worldskills is a good example of a professional skill competition. The goal of WorldSkills is to increase the prestige of working professions and develop professional education by harmonizing best practices and professional standards around the world through organizing and conducting competitions of professional skills, both in each individual country and around the world. Restaurant service is one of the competencies of the Worldskills service module [2].

According to the rules of the Worldskills Championship, young people from 17 to 22 years of age, representing the national team of one of the participating countries

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of Worldskills, can take part in the competition in the competence "Restaurant Service". In the framework of the Worldskills International Competition by the resolution of The Technical Committee and in accordance with the Constitution, Regulations and Rules of Competition, the minimum requirements for this competence were adopted [3].

During the competition, the competition platform is conditionally divided into zones corresponding to the blocks of the competition. The results of the participants' performance of the competitive tasks are evaluated by the group of experts. The number of experts corresponds to the number of contestants in the competence [4].

An important part of staff training is the consolidation and structuring of the knowledge gained. Therefore, it is advisable to introduce standards in the work of the service personnel.

According to the Worldskills standards, the specialist in the competence "Restaurant Service" demands not only skills, but also theoretical knowledge in seven areas: organization of work and management (knowledge and understanding of the types of catering facilities and the styles used by them for providing food services; the importance of the atmosphere of the restaurant for the full acceptance of food; financial and business requirements for managing the catering facility; relevant legislative and regulatory requirements; the importance of effective work to minimize waste and the negative impact of business on the environment and maximize environmental sustainability); communication and guest services (understanding the importance of effective communication and interpersonal communication in working with guests and colleagues; role of waiter in increasing sales); preparation for service (knowledge and understanding of the types of standard equipment and equipment of the restaurant); serving food (knowledge and understanding of food and beverage service styles and methods; components, cooking, serving and servicing methods for all dishes in the menu); serving drinks (in the beverage industry, the participant should know and understand the range of drinks that can be prepared and served in a restaurant or other facility; how to use special equipment properly and safely; types of dishes in which drinks can be served; appropriate accompaniment for drinks; trends in the sale and supply of beverages); alcoholic and non-alcoholic drinks; wine-making (the participant should be able to give full advice and guide on wine selection to the guests; define the range of wines according to smell, taste and appearance). Moreover, the requirements of the standard provide knowledge of the peculiarities of servicing guests of all religions and peoples, which is very relevant during the development of inbound tourism in Belarus [5,6].

The contest assignments for participants are divided into six modules: Fine Dining (the highest service), Casual Dining (the format that appeared on the verge of fast casual and fine dining), Banquet service (based on the techniques of Silver and Gueridone), Champagne and canapé service, Barista, Bar [7].

The competition task in the competence "Restaurant Service" reveals the professional skills of the contestant in all spheres of service, assesses not only the technique of performance, but also communicative skills in service. Moreover, the competition activity covers the assessment of the preparatory and final stage of the competitor's work, which allows to fully evaluate the service techniques of the participants.

Therefore, regular training and knowledge-building must be conducted and the processes standardized to ensure efficient organization of the service personnel. This can be done through the implementation of international standards. The developed international standard Worldskills is relevant, as it covers the full operation of the restaurant's staff. Moreover, due to the fact that the Worldskills competition takes into account new trends appearing in the restaurant service each time, the standard is modernized all the time.

III. Objects, object and methods of research

The object of the research is service activity. Restaurant service is a special activity aimed at meeting the needs of guests by providing catering services. Catering services are social and cultural services. Through the culture of service, the image of the organization is formed, the volume of services is increased, and, consequently, the demand of consumers for services is most fully satisfied. To date, the training of service personnel gives students only basic professional skills. In addition, there is currently no training and methodological base for training service personnel in accordance with international standards. Therefore, the subject of research in this work is scientific and methodological support for the organization of training of highly qualified specialists in the field of service for the restaurant industry.

The following methods of research were used in the work. Synthesis is a combination of the parts obtained in the analysis into something whole. As a result of the application of synthesis, knowledge obtained as a result of the use of the analysis in a single system is combined. Induction is the conclusion, the reasoning from "private" to "general", the reasoning from the facts to some common hypothesis. Deduction - obtaining an output in the reasoning from "common" to "private". That is, new knowledge about the subject is obtained by studying the properties of the objects of this class. The study of literature and other sources involves the collection of data in textbooks, encyclopedias, periodicals, normative documents, Internet resources. Theoretical analysis is the selection and consideration of individual parties, features, features, properties of phenomena.

IV. Results of work

As a result of the work, a project of Worldskills resource training center for restaurant service was developed on the basis of MSUFT, in particular, its educational programs. The list of educational courses of the resource training center will include training and retraining courses for bartenders and waiters with the assignment of qualification, crash courses for training waiters, bartenders, barista, sommelier. Crash courses are aimed at development of professional practical skills, independant study of theoretical material. After the end of the class, the students pass an exam consisting of a theoretical and practical part.

Training involves the division of the resource training center into several zones: Bar, Barista, Restaurant. The planned training center on restaurant service will be located in the audience of MSUFT. Due to the small room of the audience, it is not possible to place all zones for service. Therefore, it is advisable to use catering equipment to transform the service area into the required module. The restaurant service resource training center will be equipped with modern equipment and inventory necessary for training. The planning solution of the resource training center is

developed for each module. The list of equipment required to equip the resource center is presented in table 1.

Table 1 – List of equipment of Resource Training Center

Name	Quantity
Round Table Delta 1500	1
The magnetic-marker board Slim Akalim	1
Folding table Riviera	2
Folding table Delta	2
Catering chair 02-7006	6
Station Callax	1
Mobile Bar compact	2
Cocktail table Riviera	2
High chair Franklin	6
Refrigerator with built-in ice foamer Samsung RT25HAR4DWW	1
A cabinet-table	5
Kitchen cabinet	3
Thermopot KELLI KL-1498	1
EXPOBAR MONROC PULSER 2GR GREASE COFFEE MACHINE	1
Grinder EXPOBAR Tranquillo	1
Coffee scales CLASSIX PRO	1
Coffee bean box Moto	1
Microwave oven Horizon 20MW800-1378	1
Ice mill Leopold Vienna	1
Stationary Blender Tefal BL 522 D3E	1
Kitchen washing Ukinox STD800.600-5C 0LS	1
Laptop computer	1
Threejack	2
The portable gas cooker	1

Educational and methodological support is represented by literature, computer and information support of the educational process. The literature, which is the base for the express courses: GOST №30524-2013 "Public catering services. Services of public catering requirements. Requirements to the personnel) "; Decree of the Ministry of Health of February 10, 2017 No. 12 "On the approval Of Sanitary norms and rules" Sanitary and Epidemiological requirements for public catering facilities "; «Russian for restaurant workers», Rene Talalla; Technical description on the competence of «Restaurant Service» Worldskills; Textbook «Restaurant service», Re Novium; «Food and service, ninth edition» John Cuisins, Dennis Lillicrap, Suzanne Weekes; Encyclopedia "the Bible of the Barman. Everything about drinks. Bar crop. Cocktail Revolution", Fedor Evsevsky; Training manual "Coffee. Barista Bible: New taste technologies. Recipes, cocktails, advice, master classes ", Denisov D. I.

Computer and information support is provided by the following resources: Video materials for the textbook "Restaurant Service", Re Novium; International Bartenders Association Https://Iba-World.com; B.A.R. News https://barnews.press.

Thus, training and retraining of service personnel with assignment of qualification (waiter, barman), express training courses will be held in the resource training center. The training-methodical and material-technical support is chosen for training personnel

taking into account the requirements of the Worldskills standard under the competence of "Restaurant Service".

V. Conclusions

The service is an important aspect of the work of the catering facility. A waiter is the most important person in everything about giving guests attention and giving them the opportunity to enjoy meals. Therefore, a wide range of requirements is presented to the restaurant's service personnel. Regardless of working conditions, the universal qualities of an outstanding specialist are excellent communication and working with guests, which can be achieved with the constant improvement of knowledge in the labor sphere. Whatever the structure of the work, a well-trained and experienced specialist demonstrates a high level of personal responsibility and autonomy.

The high level of service for guests in the restaurant area is strategically important. The international standards Of Worldskills in the competence "Restaurant Service" summarize the requirements for catering personnel for representatives of all countries of the world.

The structure of the Worldskills standard according to the competence "Restaurant Service" meets the requirements of the methodological recommendations on the development of professional standards existing in the Republic of Belarus. Since one of the current trends is the failure of local systems of professional standards in favor of national and international standards, it is advisable to train specialists in the service industry according to the Worldskills standard.

VI. List of literature

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THE IMPORTANCE OF THE INTELLECTUAL PROPERTY IN PROMOTING THE INNOVATIVE ENTREPRENEURSHIP

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Abstract. *In the modern world the intellectual property (IP) plays an important role in generating new creative ideas for companies. The intellectual property, invention, creativity and innovation are considered the main elements which foster the entrepreneurship. The IP process is a key factor for the economic development. At the same time, it has a long history, conditioned by the main changes in the goods and services market. The word such as „know – how'', „patents'', „copyright'', „trademarks'', „industrial design right'' are the most important to define the intellectual property.*

Through this research the authors have proposed to present the notion of "intellectual property'' and its key-elements, as well as its role in fostering innovation and entrepreneurship. The role of intellectual property and its development trends were analyzed, by highlighting countries'practices in enhancing the role of IP in developing innovative entrepreneurship. A special focus of the paper is the analysis of IP development in the Republic of Moldova and comparative analysis with its neighboring country – Ukraine.

Key words: *intellectual property, know – how, patents, copyright, trademarks, industrial design rights, trade secrets, entrepreneurship, innovation.*

''Intellectual property is playing an increasingly important role for our group. It's just a fact of life in our business now that you have to cultivate and protect IP''
(Rudy Provoost)

Introduction

The role of intellectual property in all areas of activity has increasingly considerably. New business ideas appear, new companies are founded. To be unique on the market, the entities register it brand under it own name. And also, choose it own color, format, symbol and activity. Many business ideas fail in a short term, others focus on the needs of consumers and achieve the desired success. The intellectual property

Every state adopt policies, strategies, and take concrete steps in the protection of the intellectual property, because the intellectual property is an important aspect in the economic development.

The subject is very actual in the context in which the intellectual property generates the scientific progress, creates a lot of opportunities, protects firms, and offers the competitive advantage.

This research paper has the following objectives:

- analysis of the concepts of , consulting the specialty literature and the Law;

- analysis/ research of the trends in the IP development, focusing on several specific different countries;
- analysis of the IP in the Republic of Moldova in comparison with neighboring country – Ukraine;

Understanding the relationship between intellectual property and innovative entrepreneurship it's necessary to investigate how different countries apply policies and strategies for promotion and development of innovations and entrepreneurship.

Literature overview

The role of IP in innovative entrepreneurship

In the knowledge dominated economy, IP occupies an important place. The significance of traditional tangible assets such as land, labor, capital etc. is reducing and intangible assets (IA) such as information, creativity and inventiveness are receiving more attention. IP has made its way in accounting books of an organization. Intellectual property (IP) refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used mainly in commerce.

According to The Law of the Republic of Moldova no. 114 from 03.07.2014 regarding the State Agency for Intellectual Property (Chapter I, art.3) the intellectual property are the objects that result from the intellectual activity in the industrial, economic, commercial, scientific, informational, literary and / or artistic fields, as well as in other fields.

These authors (Falvey, Foster, 2006) consider that the main purpose of the intellectual property law is to encourage the creation of the wide variety of intellectual goods.

The know – how can be defined in various ways. According to World Intelllectual Property Organization (WIPO), trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises. Trademarks are protected by intellectual property rights. The know – how means specific knowledge, held by a person or an entreprise, over a product or manufacturing process, very often obtained through important and expensive research and development works. Also, the term of know – how includes a lot of technical information, which are secret, substantial and identified.

Gallini (2002) notes recent increase of patenting in new fields like biotechnology, software and business methods, and increased number of patents in these areas. In comparison with the 1980s, new patent applications in the USA to domestic inventors more than doubled by the late 1990s. Biotechnology and software patent grants doubled between 1990 and 2000. When talking about patent is understood a form of right granted by the government to an inventor or their successor-in-title, giving the owner the right to exclude others from making, using, selling, offering to sell, and importing an invention for a limited period of time, in exchange for the public disclosure of the invention. An invention is a solution to a specific technological problem, which may be a product or a process and generally has to fulfill three main requirements: it has to be new, not obvious and there needs to be an industrial applicability. To enrich the body of knowledge and stimulate innovation, it's compulsory for patent owners to disclose valuable information about their inventions to the public. "The history of patents does not begin with inventions, but rather with

royal grants by Queen Elizabeth I (1558–1603) for monopoly privileges... Approximately 200 years after the end of Elizabeth's reign, however, a patent represents a legal right obtained by an inventor providing for exclusive control over the production and sale of his mechanical or scientific invention... [demonstrating] the evolution of patents from royal prerogative to common-law doctrine" (Mossoff, 2001).

A copyright gives the creator of an original work exclusive rights to it, usually for a limited time. This idea is supported by Stokes (2011), who considers that copyright may apply to a wide range of inventive, intellectual, or artistic forms. Copyright does not cover ideas and information themselves, only the form or manner in which they are expressed. The specialty literature suggests some rules according to copyright:

– Copyright law protects creators of original material from unauthorized duplication or use;

– For an original work to be protected by copyright laws, it has to be in tangible form;

– In the U.S., the work of authors is protected by copyright laws until 70 years after their death.

So, what exactly is a trademark? Broadly speaking, the term ’’trademark’’ refers to recognizable sign, design or expression which differentiates products or services of a particular trader from similar products or services of other traders.

An important element of the intellectual property is the industrial design, simply, it is what makes a product look attractive, and increases the commercial value of goods. In other words, the industrial design represents a successful combination of colors, shapes, dimensions, configuration, containing aesthetic value.

A trade secret is a formula, process, design, instrument, pattern, or compilation of information which is not generally known, by which a business can obtain an economic advantage over competitors and customers. There is no formal government protection granted; each business must take measures to protect its own trade secrets (example: Formula of its soft drinks is a trade secret for Coca-Cola.)

According to the Law of the Republic of Moldova no. 845 from 03.01.1992 regarding entrepreneurship and business (Chapter I, art. 1), the entrepreneurship is the activity of manufacturing the production, execution of the works and the provision of services, carried out by citizens and their associations independently, on their own initiative, on their own behalf, at their own risk and under their patrimonial responsibility in order to ensure a permanent source of income. In this context, an entrepreneur is the person who practices a certain type of activities and pursues economic benefits, sometimes having losses from economic activity.

Innovation is spread across all areas, being considered an important generator of new ideas and inventions that have changed the world. In the literature exist a series of definitions and explanations of innovation. This idea is supported by Maranville (1992), who is agree that innovation represents the application of better solutions that meet new requirements, unarticulated needs, or existing market needs. According to Frankelius (2009) innovation is something original and more effective and, as a consequence, new, that "breaks into" the market or society. According to the Kanter

(1997) the innovation includes original invention and creative use. Widely, in the modern world are used process innovation and product innovation.

Object, subject and methods of study

A special focus of the paper is to analyze the performance of different states in the field of intellectual property, what are the gaps and what aspects can be improved. Finally, it will be possible to forecast optimistic data for Republic of Moldova.

As the object of study represents the intellectual property and its role in fostering the innovation and entrepreneurship.

In order to estimate how the intellectual property can contribute in promoting the innovative entrepreneurship, concrete countries are taken as an subject of study and the evolution of the intellectual property in these countries (China, Japan, Norway, Belgium, US, Romania).

As methods of study are used mainly the conceptual analysis/approach analysis related to such concept as: intellectual property, know – how, patents, copyright, trademarks, industrial design rights, trade secrets, entrepreneurship, innovation.

Also is used the empirical and statistical analysis to identify the main trends in the global level related by the intellectual property.

The comparative analysis allows to identify the main differences between Moldova and Ukraine in terms of the IP.

In order to bring value to this research, a questionnaire was elaborated and disseminated to Moldovan citizens to identify and achieve citizens' perceptions about word IP. The questionnaire was filled by 59 respondents.

The evolution of the IP at the international level

Innovation is increasingly concentrated in urban ''hotspots''. At the same time, these hotspots are connecting and collaborating across the world. New players, particularly Asian countries, are responsible for more and more scientific research and inventions, which were once the almost exclusive domain of a handful of rich economies. At the same time, this greater international spread has been accompanied – at country level – by increased concentration of innovative activity within a few densely populated areas. These urban areas are vibrant innovation ecosystems, such as Silicon Valley outside San Francisco in the U.S or China's Shenzhen–Hong Kong, a more recent hotspot. This paradox is more apparent than real, however; the world's most innovative urban agglomerations are also the most open to the outside world. Sometimes, they are better connected internationally than they are to their national hinterlands. Together, they form what economists have come to refer to as global innovation networks. Skilled individuals and innovative companies are at the center of these networks. Highly skilled workers gravitate toward innovative urban areas because they want to interact with one another and enjoy the amenities of metropolitan life. Large cities offer companies a large local market, specialized suppliers and academic institutions that allow them to reap economies of scale and scope. Knowledge, in turn, flows more fluidly among company and university researchers when they work in close proximity, fueling the innovation engine. This WIPO report analyses these dual trends, exploiting a rich data set of millions of patent applications and scientific publications. Its findings argue for increasing openness and support for

collaboration if innovation is to continue to flourish (WIPO report, 2019 – Executive Summary).

In Luxembourg carries out its activity a patent office - Freylinger Patent and Trade Mark Attorneys. They offer a comprehensive range of intellectual property services covering patents, trademarks, designs and copyrights. This includes receiving worldwide protection, portfolio management, strategic advice, commercial advice, licensing, enforcement, due diligence and also litigation. In the table 1 are illustrated states and type of services provided by this agency.

In conclusion, in the Europe exists a lot of IP offices. The offices which obtained a great number of elements of intellectual property are located in Austria, Belgium, France, Germany, Ireland, Luxembourg, and also United Kingdom.

Intellectual property rights (IPRs) have been acknowledged and protected in China since the 1980s. China has acceded to the major international conventions on protection of rights to intellectual property. In the same year, China joined the World Intellectual Property Organization (WIPO). China acceded to the Paris Convention for the Protection of Industrial Property on December 19, 1984 and became an official member on March 19, 1985 and also acceded to the Madrid Agreement for the International Registration of Trademarks in June 1989.

Table 1. – Trademark and Design protection in Luxembourg and Belgium obtained via the Benelux trademark and Benelux design granted by the Benelux Office for Intellectual Property (BOIP)

IP OFFICES	PATENTS	TRADEMARKS	DESIGNS	FORMALITIES – PATENT VALIDATIONS	FORMALITIES – RECORDALS BEFORE REGISTERS
EUROPEAN PATENT OFFICE	✓				✓
EUIPO		✓	✓		✓
BENELUX OFFICE		✓	✓		✓
AUSTRIA	✓	✓	✓	✓	✓
BELGIUM (*)	✓	✓	✓	✓	✓
FRANCE	✓	✓	✓	✓	✓
GERMANY	✓	✓	✓	✓	✓
IREALND	✓	✓	✓	✓	✓
LUXEMBOURG (*)	✓	✓	✓	✓	✓
SWITZERLAND	✓			✓	✓
UNITED KINGDOM	✓	✓	✓	✓	✓

Source: Office Freylinger Patent and Trademark Attorneys. Available online at: http://freylinger.com/world-intellectual-property-protection/ [accesed on 21.01.2020]

(*) Trademark and Design protection in Luxembourg and Belgium are obtained via the Benelux trademark and Benelux design granted by the Benelux Office for Intellectual Property (BOIP)

The enforcement of protection of intellectual property rights is particularly difficult in the People's Republic of China (PRC). Without adequate education with regard to intellectual property rights (IPRs), there is little awareness that infringement is a crime. Sometimes local protectionism may dilute the strength of central legislation

or the power of law enforcement. For instead, local governments might not want to genuinely support the work of copyright protection supervisors. It may create obstacles during IPRs investigation and assist local counterfeiters by letting them hide their production lines in safer places. When counterfeiters have good connections with local governmental or law enforcement officials, they may find an umbrella for their counterfeiting activity (Priest, 2006).

In the figure 1 there are some data from Nicholas Lardy at the Peterson Institute for Economics (April 20, 2018). This figure illustrates the rise total payments from China to all countries for the use of foreign intellectual property (the most relevant data – 1997 – 2017).

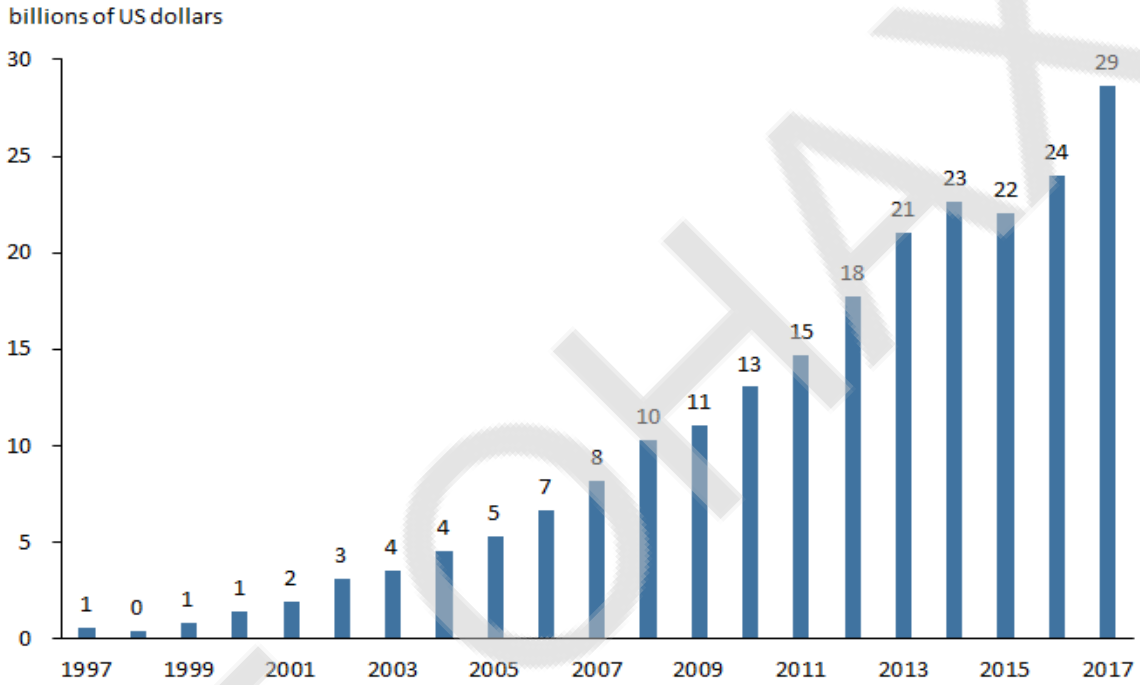

Fig. 1. Chinese payments for the use of foreign intellectual property, 1997 – 2017

Source: State Administration of Foreign Exchange of China. Available online at: http://conversableeconomist.blogspot.com/2019/07/payments-from-china-for-foreign.html [accesed on 23.01.2020]

According to the figure, there is a considerable increase in the expenditure for IP (almost 29 billions dollars in 2017) in comparison of 2015 when the expenditure represented 24 billions dollars. This fact demonstrates the importance of IP in consolidating of entrepreneurship and innovations. The knowledge also requires development costs.

In terms of patents, in 2018, the number of patent applications for inventions in China was 1.542 million. A total of 55,000 PCT international patent applications were received, marking a 9.0% increase year-on-year. 52,000 PCT applications were filed by domestic applicants, a 9.3% increase year-on-year. Foreign applicants filed 14.8 millions of applications for invention, marking an increase of 9.1% year on year. Figure 2 shows the increase of invention applications in China.

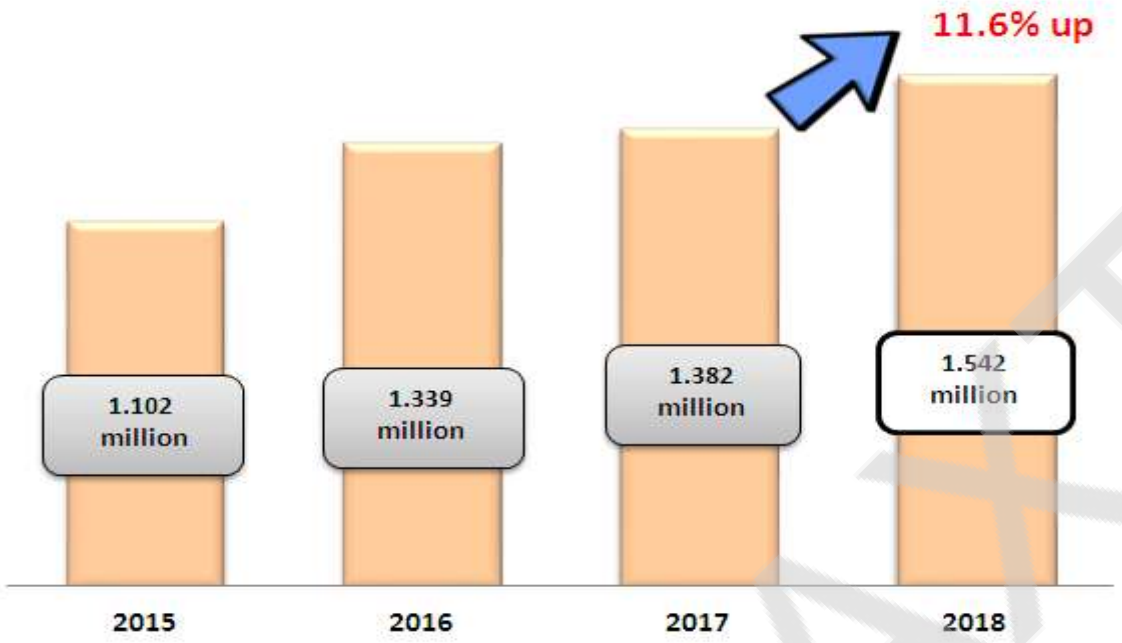

Fig. 2. Statistics of invention applications in China 2015-2018

Source: CNIPA released China's Intellectual Property statistics for 2018. Available online at: https://www.lexology.com/library/detail.aspx?g=f0e85203-cefa-4938-a124-c736cf4c8cc0 [accesed on 23.01.2020]

As the reference year serves 2018, when invention applications reached 1.542 millions, almost 12 %. For the next years, an increase of another 12 % is expected. That's because China is a fast economy, with the most important innovations and creative start - ups.

In term of invention patents, China has ten domestic companies, the most inventive. In table 2 are represented these companies near the volume of inventions patents.

Table 2. – Top 10 China domestic companies in invention patents granted in 2018

	Company Name	Volume
1	Huawei Technologies Co. Ltd.	3.369
2	China Petroleum & Chemical Corporation	2.849
3	Guang Dong OPPO Mobile Telecommunications Corp., Ltd	2.345
4	State Grid Corporation of China	2.188
5	BOE Technology Group Co., Ltd	1.891
6	Gree Electric Appliances, Inc. of Zhuhai	1.834
7	Lenovo (Beijing) Co., Ltd.	1.807
8	Tencent Technology (Shenzhen)	1.681
9	ZTE Corporation	1.552
10	Corporation PetroChina Company Limited	1.129

Source: CNIPA released China's Intellectual Property statistics for 2018. Available online at: https://www.lexology.com/library/detail.aspx?g=f0e85203-cefa-4938-a124-c736cf4c8cc0 [accesed on 23.01.2020]

The most famous company according to the volume of patents is Huawei Technologies Co. Ltd., a leading global provider of information and communications technology infrastructure and smart devices. Huawei's end-to-end portfolio of products, the best solutions and services are both competitive, practical and secure. The same China Petroleum & Chemical Corporation produces and trades petroleum and petrochemical products. The Company offers gasoline, diesel, jet fuel, kerosene, ethylene, synthetic fibers, synthetic rubber, synthetic resins, and chemical fertilizers. These companies apply a lot of innovations to develop their products and services to the highest quality standards.

In recent years, intellectual property in Japan is generating soaring revenue[1]. Intellectual property, which applies to intangible assets including brands, copyright, patents and industrial designs, covers everything from cultural icons like Super Mario and Hello Kitty to robotics advances by Fanuc Corp. The statistics show that food and beverages, motor vehicles, computers and electronics products, and machinery and equipment are among categories ranking highest in income globally from intangible capital, according to the World Intellectual Property Organization.

In Japan are implemented measures and basic policies to protect the IP. The proper protection of intellectual property (IP) rights promotes technological progress and sound competition, and also contributes to achieving affluent lifestyles and the development of society.

For example, the Mitsubishi Electric Group recognises that intellectual property (IP) rights represent an indispensable management resource essential to its future and must be protected. Through integrating business, R&D, and IP activities, the Group is actively strengthening its global IP assets, which are closely linked to the Group's business growth strategies and play a key role to both business and society, and also working on protecting IP rights. Therefore, it's possible to analyze structure of intellectual property division through elements illustrated in figure 3.

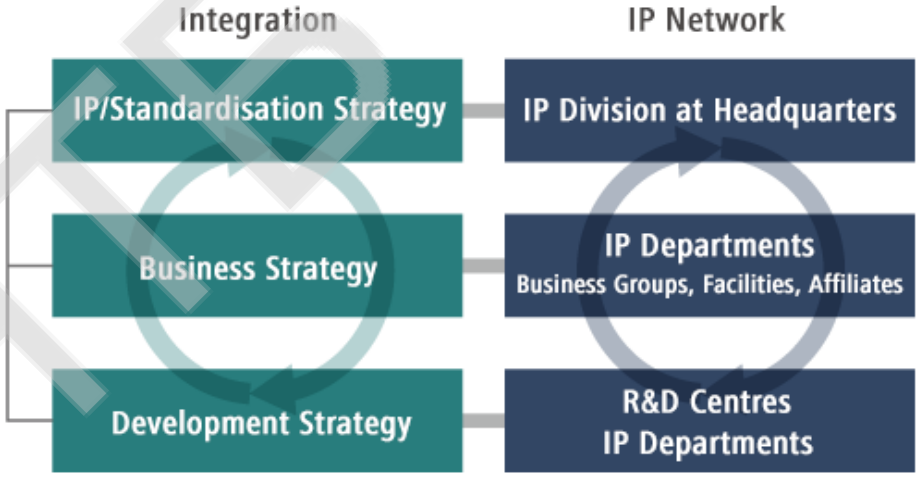

Fig. 3. Integrating Business, R&D and IP Activities

Source: R&D/technology Protection of Intellectual Property Rights. Available online at: https://nl.mitsubishielectric.com/en/about/global/rd/ip/index.html [accesed on 24.01.2020]

[1] rising incomes

All elements are connected to each other, it's not possible developing a policy without another one, because in business it's necessarry a complex analytical thinking and also creativity to obtain success.

In 2018 (the most relevant data), in Japan has increased the number of registered patents. Table 3 presents the number of patents and the applicant companies/ trademarks.

Table 3. – Number of patent registrations, 2018

Rank	Applicant	Number of patents
1	Mitsubishi Electric	4,348
2	Canon	4,288
3	Toyota Motor	3,301
4	DENSO	3,285
5	Panasonic	2,630

Source: R&D/technology Protection of Intellectual Property Rights. Available online at: https://nl.mitsubishielectric.com/en/about/global/rd/ip/index.html [accesed on 24.01.2020]

A greater number of patents was registered by Mitsubishi Electric (4,248) and Canon with a difference of 60 points.

As a state of analysis is Norway. In Norway activates Norwegian Industrial Property Office with a variety of services, such as:

- Trademarks;
- Designs;
- Patents / inventions;
- Other services: digital services, copy services.

Norway is the first at signing of the international agreements related by the intellectual property. Usually these treaties are signed for a long term:

- Patent Cooperation Treaty (PCT) – 20 years, an international patent law treaty, concluded in 1970. It provides a unified procedure for filing patent applications to protect inventions in each of its contracting states.
- Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks – 10 years; the system makes it possible to protect a mark in a large number of countries by obtaining an international registration that has effect in each of the designated Contracting Parties.
- Berne convention For the Protection of Literary and Artistic Works – 70 years, deals with the protection of works and the rights of their authors.

In Belgium also exists the Office for Intellectual Property, which regulates concrete policies for the development of the Intellectual Property. The OPRI's general mission is to protect intellectual property in Belgium. To the end, it is responsible for issuing and handling Belgian industrial property certificates, providing users with information on intellectual property, preparing legal texts, advising governments and representing Belgium internationally.

Figure 4 presents how increase the number of patents applications in the last years.

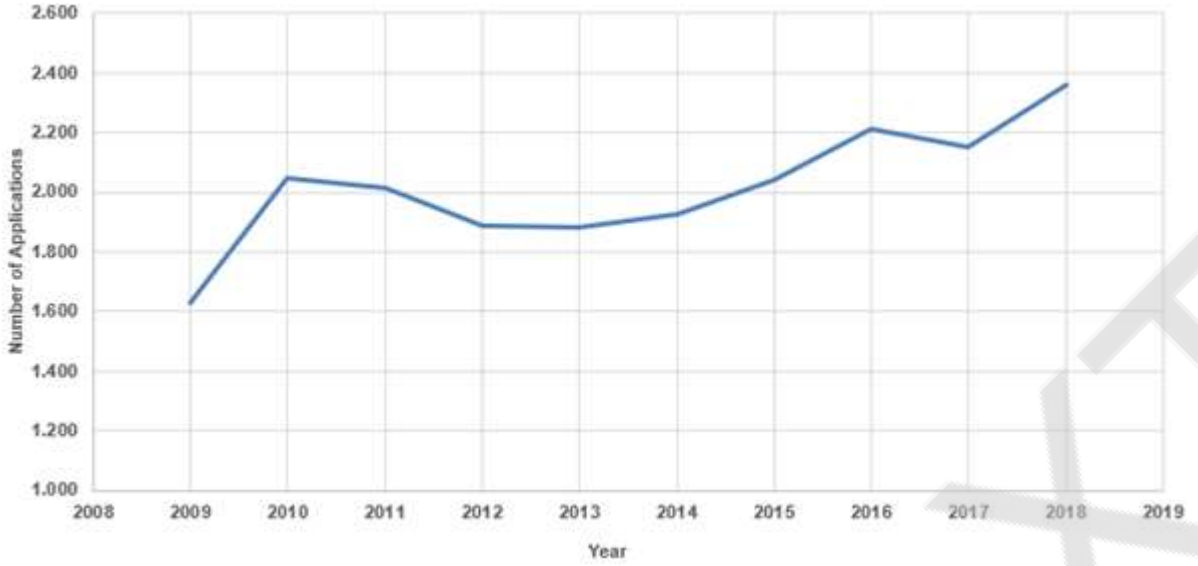

Fig. 4. Development of the applications from Belgium

Source: sirris driving industry by technology. Available online at: https://www.sirris.be/belgian-company-patents [accesed on 24.01.2020]

In 2018, the European Patent Office (EPO) registered 2,360 patent applications filed by Belgian companies and inventors, which represents an increase of 9.7% compared with 2017. Therefore, it's possible to appreciate an impressive growth of patent in the Belgium.

In the context of the ascending development of Belgian applications, it's essential to present the main 10 Belgian applicants, represented in figure 5.

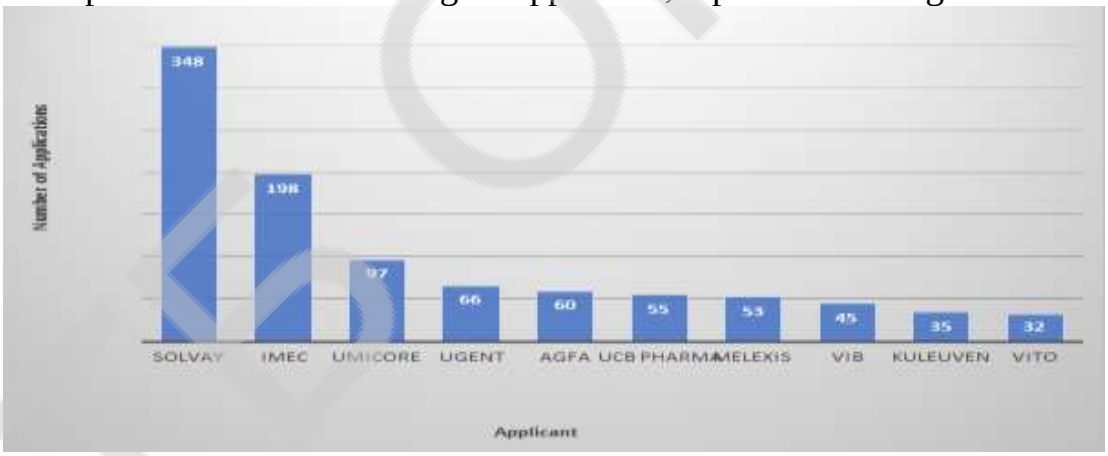

Fig. 5. Top 10 Belgian patents applicants

Source: sirris driving industry by technology. Available online at: https://www.sirris.be/belgian-company-patents [accesed on 24.01.2020]

Solvay is the top Belgian applicant to the EPO (348 applications). Followed by Imec (198 applicantions), Umicore (97 applicantions), Ghent University (66 applicantions) and Agfa (60 applicantions). Below in the top are situated VIB (45 applicantions), Kuleuven (35 applicantions) and VITO (only 32 applicantions).

US is a country with a vast creative potential. To protect the IP are implemented different toolkit.

According to the patents there are two agreements already signed, the Patent Cooperation Treaty (covering patents) and Hague Agreement (covering designs).

In the US practice, a trademark is a word, phrase, symbol, or design, or both, that identifies and distinguishes the source of the goods or services of one part from those of others. A U.S. trade mark generally lasts as long as the trade mark continues to be used and is defended against infringement. To keep a registration alive, the registration owner must file required maintenance documents at regular intervals.

Trade secrets are protected in the U.S. as long as the information is a secret, has commercial value, and reasonable steps are taken to protect that information. What is a "reasonable effort" to protect a trade secret may vary depending on the nature of the information you wish to protect. For businesses, implementing an effective trade secret policy is advisable.

Figure 6 designs the US companies granted the most patents in 2018.

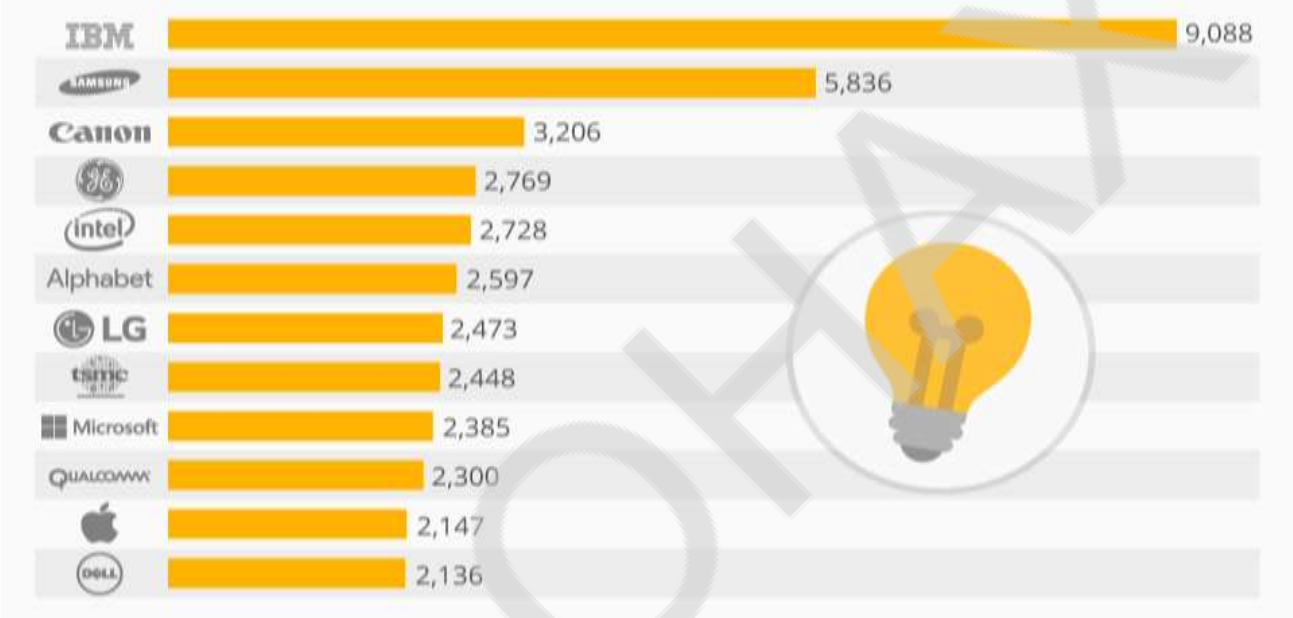

Fig. 6. The US companies granted the most patents in 2018

Source: statista. Available online at: https://www.statista.com/chart/7642/top-10-patent-recipients-in-the-united-states/ [accesed on 24.01.2020]

The most popular companies granted the most patents in 2018 consist of IBM (9,088 patents), Samsung (5,836 patents) and Canon (3,2016 patents). Apple is situated below in the top (position 11) with only 2,147 patents in 2018.

The intellectual property law in Romania has developed significantly in the period since the Romanian Revolution of 1989 because of the need to enforce various regional and international treaties and agreements, such as the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the European Directives on Biotechnological Inventions, on Trademarks and Geographical Indications, and on Supplementary protection certificates, the Trademark Law Treaty, the Patent Law Treaty, and the European Union regulation on the Community Trademark, and the need to harmonize domestic patent law with the European Patent Convention (EPC) and with the European Union.

The changes since 1989 cover virtually every aspect of IP law in Romania, including copyright and industrial property, including such relatively new considerations as integrated circuit topographies. The State Office for Inventions and Trademarks protects industrial property, and the Romanian Copyright Office protects

copyright and related rights (The National Strategy in the field of intellectual property, 2003 – 2007).

As it is know, Romania has signed important treaties, conventions and agreements in the field of IP:

- Paris Convention for the Protection of Industrial Property—1920;
- Madrid Agreement Concerning the International Registration of Marks—1927;
- European Patent Convention (EPC)—1973
- Patent Cooperation Treaty—1978
- Hague Agreement Concerning the International Deposit of Industrial Designs—1992
- Protocol Relating to the Madrid Agreement—1998;
- Strasbourg, Nice, Vienna and Locarno Agreements on Classifications—1998
- Trademark Law Treaty—1998 and other.

For Romania it's possible to analyze the evolution of the intellectual propert rights, presented in the figure 7.

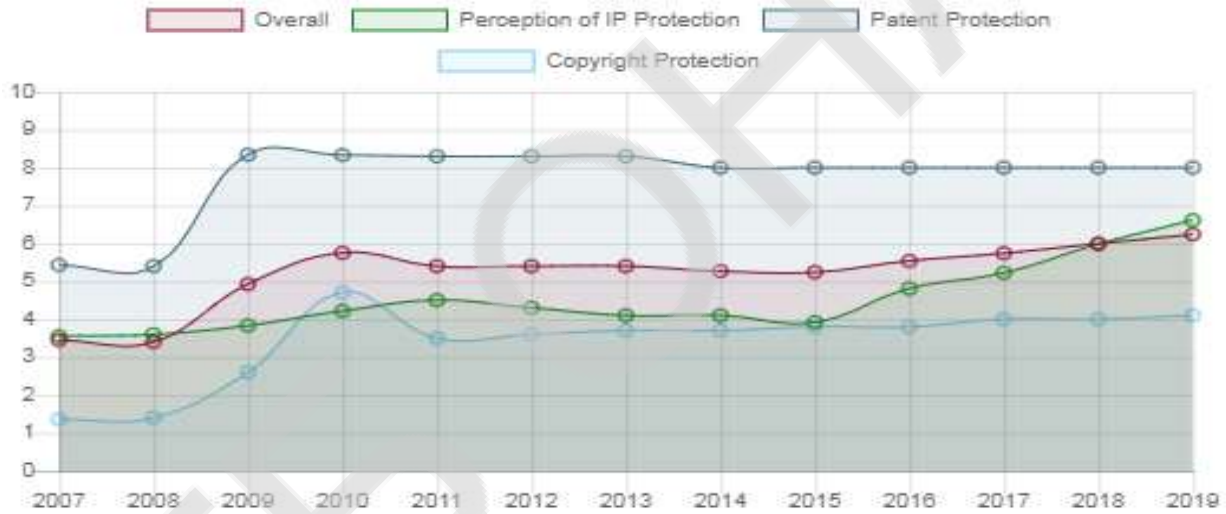

Fig. 7. Romania – the intellectual property rights, 2007 – 2019

Source: 2019 International Property Rights Index Romania. Available online at: https://internationalpropertyrightsindex.org/country/romania [accesed on 24.01.2020]

As a reference years serve 2018 and 2019, when patents reached the 8 level, without essential changes. About copyright, ity reached the 4 level (in 2018) and 4.1 level (in 2019), with the difference with only 0.1 points. The statistics indicate optimistic results for the 2020 year.

The evolution of the IP in the Republic of Moldova

Republic of Moldova has a lot of companies, which apply innovations and bright ideas in all sectors of the economy.

The protection of intellectual property is important for promoting innovation, for creating new jobs and for competitive importance in economies. A requirement of the Deep and Comprehensive Free Trade Agreement (DCFTA) for the Republic of Moldova is to modernize intellectual property rights (IPR).

In the Republic of Moldova activates State Agency for the Intellectual Property, which has a few basic directions, illustrated in figure 8.

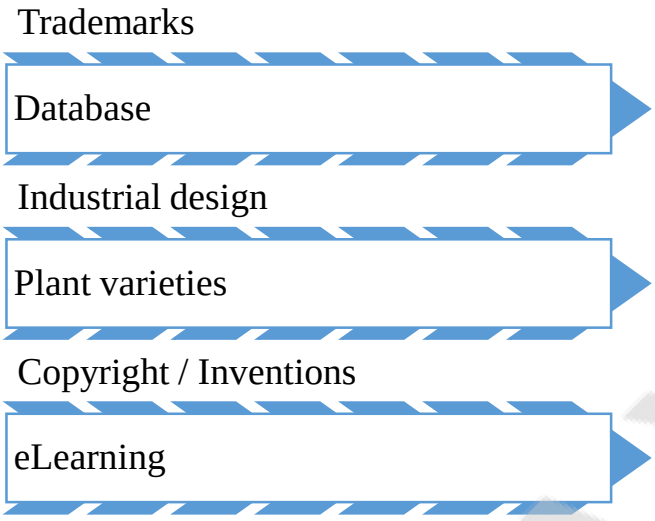

Fig. 8. Basic directions of the State Agency for the Intellectual Property

Source: Elaborated by the authors based on State Agency for the Intellectual Property data. Available online at: http://www.agepi.md/ro/about [accesed on 24.01.2020]

To conclude: the State Agency for Intellectual Property is a central administrative authority subordinated to the Government, responsible for promoting and carrying out activities in the field of legal protection of intellectual property regarding industrial property rights, copyright and related rights.

Every year, in the Chișinău takes place the international specialized exhibition ''INFOINVENT'', which offers the necessary framework for promoting the results of the work of researchers and inventors, as well as establishing partnerships for the implementation of innovations, new products and technologies.

The most relevant data about the IP of Moldova are from 2017. In the figure 9 is analyzed how are protected international property rights and on what places are situated comparative with other states, inclusive in relation with the neighboring country – Ukraine.

The International Property Rights Index consists of 10 factors, grouped under three components - legal and political environments, physical property rights and intellectual property rights. Each of the three components is rated on a scale from 0 to 10, where it is not possible for the result to be higher. According to The International Property Rights Index, the data in this ranking reveals that the Republic of Moldova is situated at the last place in Europe in terms of the protection of intellectual property rights. The Republic of Moldova obtained a score of 3,1781 points, the country registering the worst performances in the category of intellectual property rights. Ukraine is higher than Moldova, at the place 123.

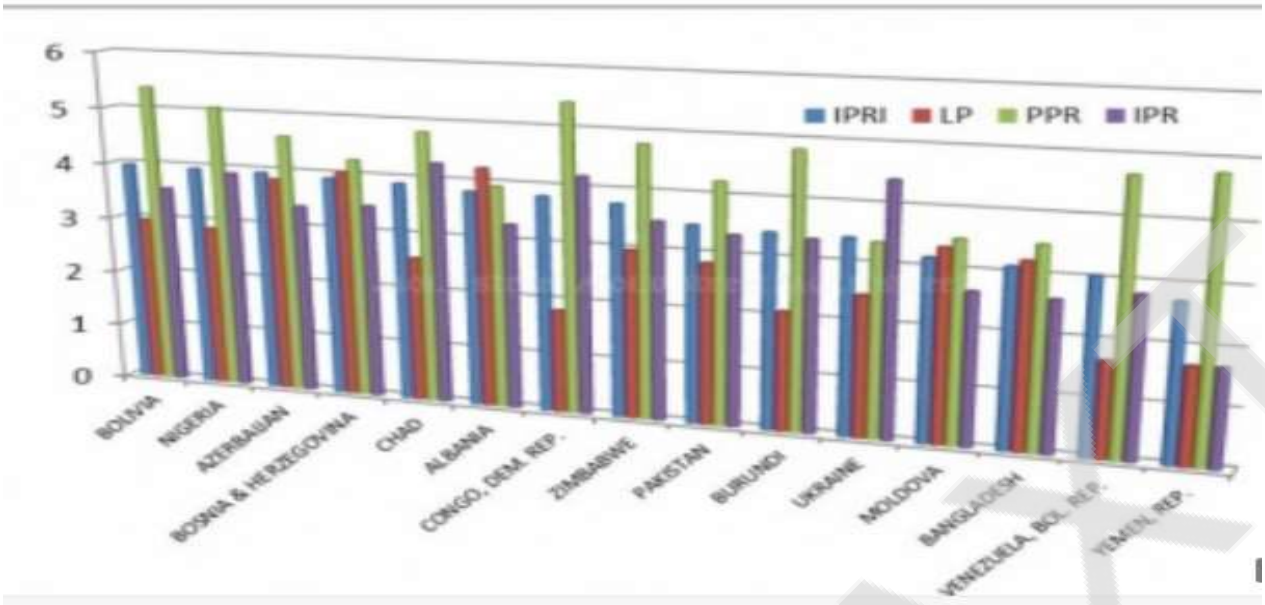

Fig. 9. International Property Rights Index (IPRI). Top 15 countries, 2017

Source: Jurnal. md. Available online at: https://www.jurnal.md/ro/social/2017/7/14/moldova-codasa-europei-si-la-protectia-drepturilor-de-proprietate-intelectuala-mai-rau-e-doar-in-yemen-venezuela-si-bangladesh/ [accesed on 24.01.2020]

IP development in the Ukraine

In general, in Ukraine activates the State Department of Intellectual Property, founded in 1993. In 1995, Ukraine adhered to the Berne Convention. Ukraine is also a member of the International Convention for authors' copyright, and of the Madrid Agreement (registration of trademarks) and the Patent Co-operation Treaty. In an effort to improve enforcement of the protection of intellectual property rights, Ukraine agreed to an IPR Action Plan in 2010. Thus far, there has not been much progress. An advantage for Ukraine is that it is the member of WIPO (World Intellectual Property Organization).

In the figure 10 are illustrated the performance indicators in terms of the intellectual property registered by Ukraine in December 2019, published by the Ukrainean Intellectual Property Institute (Ukrapatent).

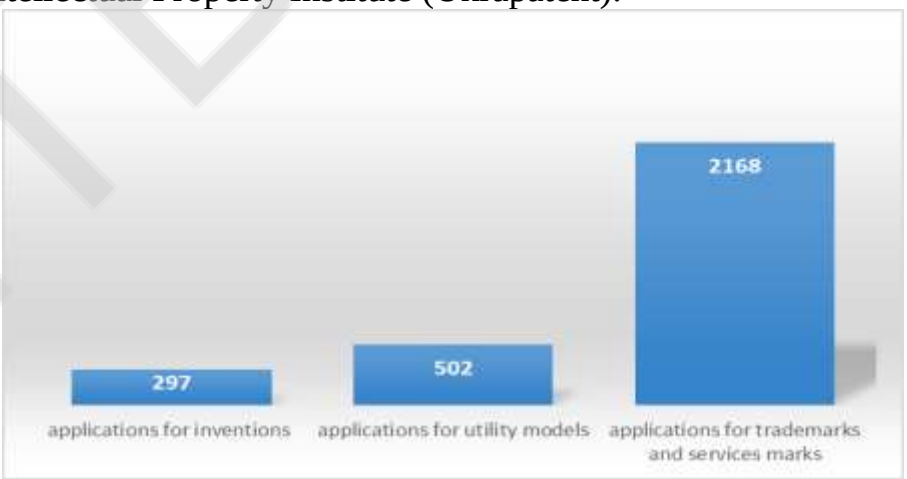

Fig. 10. Performances indicators of the Ukraine in terms of the IP, 2019

Source: Elaborated by the authors based on Ukrainean Intellectual Property Institute data. Available online at: https://ukrpatent.org/en/news/main/december-2019-performance-13012020 [accesed on 29.01.2020]

According to the Ukrainean Intellectual Property Institute (Ukrapatent) in december 2019 was registered more applications for trademarks and services marks, almost 2168 and the least was for invention applications (297), generated mainly by new trends and changes that often occur in science and technology

Results

Results present general perceptions of the Moldovan citizens about IP. All results are represented in the figures (11, 12, 13).

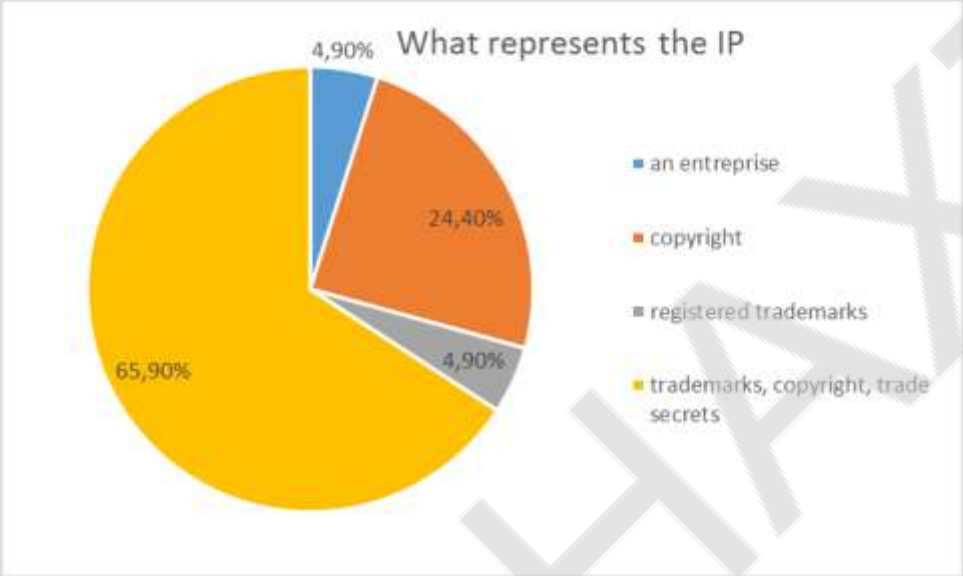

Fig. 11. Online questionnaire –what means the IP

Source: Online questionnaire – Intelllectual property (Moldova)

Most of respondents from Republic of Moldova (almost 66 %) consider that intellectual property represents trademarks, copyrights, trade secrets, etc. taken together. And only 10 % consider that IP is an entreprise or registered trademarks.

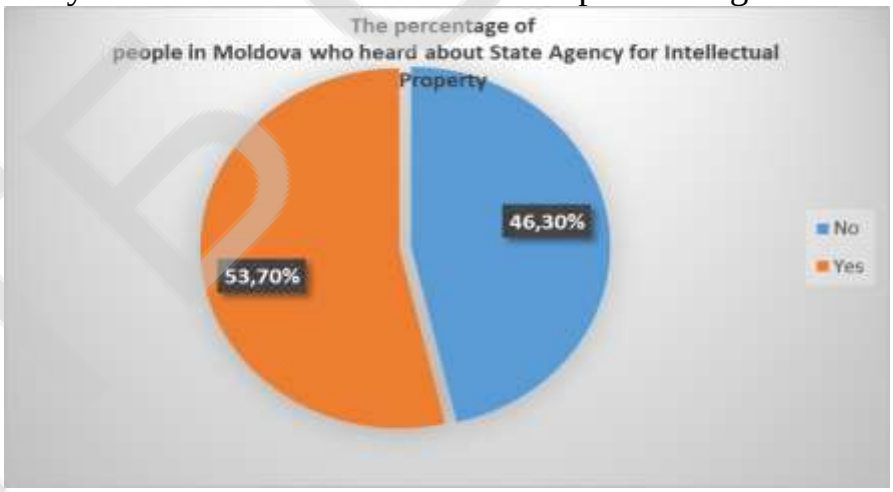

Fig. 12. Online questionnaire – the percentage of people who heard about State Agency.

Source: Online questionnaire – Intelllectual property (Moldova)

As seen, the vast majority (53,70 %) heard about State Agency of Intellectual Property and which is the main activity of it. 46,30 % replied that they did know or heard about this institution, which means that it's necessarry to promote intensely IP among the Moldovan citizens.

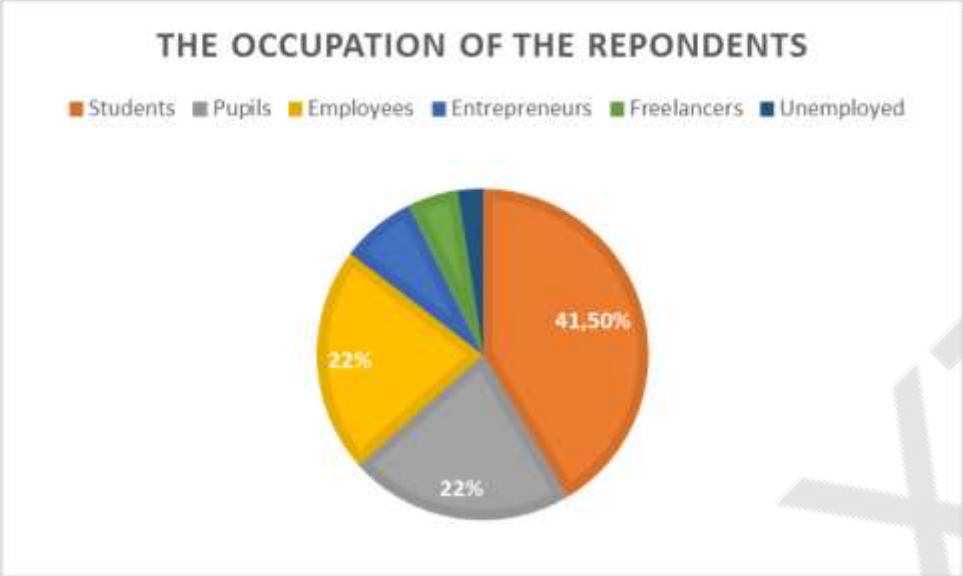

Fig. 13. Online questionnaire – the occupation of the respondents on questionnaire

Source: Online questionnaire – Intelllectual property (Moldova)

The proportion of students who answered the questionnaire predominates (41,5 %). Most stuudents know what means IP and heard about the State Agency of Intellectual Property, at least once they have tangents with it. According to the employees and pupils, the proportion is equal (22 and 22 %), probably intellectual property is increasingly discussed in the academic environment.

Conclusions and recommendations

It's important to know that the concepts of know – how, patent, copyright, trademarks, industrial design, trade secrets, entrepreneurship and innovation are included in the definition of intellectual property rights.

All the trends used in the IP talk about the development and growth of innovations, inventions, patents in each country metioned. The world is advancing and big companies adapt to trends with amazing speed.

In terms of intellectual property, Republic of Moldova and Ukraine are situated almost at the same position in top 15 countries. This talk about future efforts that will be directed to IP development.

For the Republic of Moldova, it's advisable to be done the following efforts by the authorities to protect and promote the IP rights:

- improving the strategic and operational cooperation between various institutions responsible by the protection of intellectual property rights;
- elaboration of a strategy regarding the identification of local products that can obtain intellectual property titles and trainings for producers in the field of intellectual property;
- legislative harmonization in the field of intellectual property inspired by international practice.

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HTEOHAT

FEATURES OF SUSTAINABLE DEVELOPMENT STRATEGIES FOR UKRAINIAN AGRICULTURAL BUSINESS HOLDINGS

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Abstract*. In the work the essence and features of the application of the sustainable development strategy for Ukrainian agricultural holdings are investigated. The prerequisites for the emergence of the sustainable development concept, the main goals and directions of the sustainable development strategies for agricultural holdings are highlighted.*

A study of the activities of ten leading Ukrainian agricultural holdings (according to the Landlord agribusiness rating) on the implementation of the sustainable development concept was carried out, as well as an analysis of the compliance of the sustainable development directions of Ukrainian agricultural holdings with the strategic goals of Ukraine until 2030. The agricultural holdings that most systematically and actively implement the sustainable development principles are identified.

Based on the analysis done, it was found that attention is not paid to such goals as overcoming poverty, inequality, creating a healthy lifestyle and overcoming gender inequality.

Therefore, taking into account the features of the agricultural holdings development, the need to implement clearly formulated and structured sustainable development strategies at the enterprises of Ukrainian agro-industrial holdings is emphasized.

Key words: *development, sustainable development, agro-industrial holding, strategy, food security, agrarian sector.*

I. Introduction

The relevance of the work's topic is that the prevention of the negative consequences of human activity and the implementation of preventive measures to create a safe existence of the population and the environment today are the most important tasks facing our society, government and relevant state bodies. Sustainable economic development over the past 2-3 decades requires serious organizational and managerial expenses for this purpose, both from the state and the enterprises themselves. And therefore, the study of the features of the sustainable development strategies implementation at the enterprises in modern conditions is relevant and important.

In general, the development of the "sustainable development" category is fairly connected with the Club of Rome, namely with reports that were presented by Donella and Dennis Meadows, J. Randers, E. Pestel, A. King and, of course, with its founder, Aurelio Peccei. In these reports the ideas of the civilization transition to the "global dynamic equilibrium" state were formulated. However, the concept of sustainable development has a long history of formation.

Starting from the scientific works of V. Vernadsky on the noosphere (the beginning of the last century); the declaration of the first UNO conference on the environment (Stockholm, 1972) which indicated the connection of economic and social development with environmental problems; scientific reports of the Club of Rome (1972, which have already been mentioned); to the report of the UNO World Commission on the Environment and Development in 1987; the UNO conference on the environment and development in Rio de Janeiro (1992); the World Summit on sustainable development in Johannesburg (2002) and up until now.

II. Analytical review of the literature

The works of such national scientists as S. Podolynskyi, V. Vovk, I. Hrabynskyi, L. Melnyk, Yu. Tunytsia, V. Budkin, O. Veklych, B. Danylyshyn, B. Burkynskyi, O. Balatskyi and others, as well as of many foreign scholars, including J. Grosman and A. Krueger, G. Daly, D. Meadows, B. Copeland, C. Taylor, P. Rao, J. Frankel, K. McAsland, and R. Petig, are devoted to the study of various aspects of the correlation between the economy and the environment.

III. Object, subject and methods of research

The aim of the work is to conduct research on existing sustainable development strategies for agro-industrial holdings and to identify their specific features.

The object of research is agro-industrial holdings of Ukraine, namely: "Nibulon", "Kernel", "Myronivskyi Khliboprodukt", "UkrLandFarming", "Astarta", "T.B.Fruit", "Ukrprominvest Agro", "Agroprosperis", "Allseeds Group", "ViOil".

The subject of research is the features of the implementation and use of the sustainable development strategy at the agricultural enterprises.

The key objective of the work is to study the correspondence between the goals of sustainable development and their implementation in the development strategies of Ukrainian agricultural enterprises.

In order to achieve this aim, the methods of comparison and matching were used.

IV. Results of the work

Humanity's awareness of the real danger of environmental disaster which threatens the existence of civilization has led to the beginning of the development of the sustainable development concept. Increasing consumption of natural resources has led to environmental degradation and negatively impacted on human health. The international community has admitted that balanced development "should be a priority on the agenda of international cooperation". It is generally accepted that balanced development is a harmonious combination of economic, social and environmental components of development. Only achieving a balance between the two will provide the opportunity to move to a social development that does not deplete natural and human resources, and therefore will be able to last long enough.

An important feature of sustainable development is its manageability based on the use of a systematic approach and modern information technologies which allow modeling and forecasting the results of different options of economic system development.

Sustainable development of an enterprise in the current period should be considered as its ability to carry out economic activities at any given time under the

conditions of uncertainty of environmental influences that violate its normal functioning and development [3, p. 87].

An important scientific task is to study the features of implementing the sustainable development concept at different levels. If at the macro level the state adopted a sustainable development strategy with specific goals, then it is necessary to analyze how much the achievement of the above goals is reflected in the strategic directions of development of the country's leading agricultural enterprises.

Over the past ten years there has been a significant increase in the number of agricultural holdings in Ukraine, as well as an increase in their role. For an instance, in 2007 there were 18 agro-holdings in Ukraine that owned land with a total area of 1.7 million hectares, that is 8% of the land used by agricultural enterprises. And in 2017 there were already 93 agricultural enterprises that cultivated more than 10 thousand hectares – they possess 29% of the land used by agricultural enterprises, i.e. 6.25 million hectares of the arable land [6].

Agricultural holdings provide a significant share of the production and export of agricultural products, primarily cereals and oilseeds. They attract financial resources, introduce innovative technologies and enter new markets more effective than farms and small agricultural enterprises [5].

Some large companies in Ukraine have earlier formulated and successfully implement now their own sustainable development strategies. Of particular interest is the study of the features of sustainable development strategies of agricultural holdings in Ukraine which, on the one hand, are the main driving force for the development of the agricultural sector of Ukraine and, on the other hand, are constantly accused by society and the scientific community of violating the principles of balanced and harmonious development of the agri-food sector.

Information on the activities of ten leading agricultural holdings in Ukraine, according to the rating of Landlord Agroportal [17], for the implementation of the sustainable development concept was analyzed. As information sources, data from official websites of companies, as well as publications on this topic in scientific and specialized publications was used.

The study showed that some agro-industrial holdings have formulated and structured strategies for sustainable development, which are posted on the official websites of companies along with annual reports on their implementation: “Astarta-Kyiv”, “Kernel”, “Myronivskyi Khliboprodukt”, “UkrLandFarming”. This is due primarily to the fact that the shares of these companies are placed on EU stock exchanges, and the presence of such strategies is almost mandatory for them.

These enterprises are the example of introducing the sustainable development concept not only for Ukraine, but also for the world community.

Other agricultural holdings do not have their own sustainable development strategies. However, they are working to ensure balance within the framework of corporate social responsibility programs: “Nibulon”, “Ukrprominvest Agro”, “Allseeds Group”.

The third group of leading agricultural holdings does not even have a formulated social responsibility policy – they carry out certain social measures, however, such actions are not systematized: “Agroprosperis”, “ViOil”, “T.B.Fruit”.

On the other hand, the absence of a formalized strategy does not prevent the active implementation of the principles of balanced harmonious growth – "Nibulon" is working on the achievement of 11 of Ukraine's 17 sustainable development goals by 2030 as part of its corporate social responsibility program [10].

Table 1

Analysis of the activities of the leading Ukrainian agro-industrial holdings in the implementation of the sustainable development concept*

Name of agro-industrial holding	Field of activity	Sustainable Development Policy	Number of sustainable development goals [10] that the company is working on
Nibulon	Crop production, grain trade	Corporate social responsibility program	11
Kernel	Oil production, cereals	Sustainable development strategy	8
Myronivskyi Khliboprodukt	Poultry and crop production, meat processing	Sustainable development strategy	8
UkrLand-Farming	Production of eggs, egg products, cereals	Sustainable development strategy	7
Astarta	Sugar, milk and grain production	Sustainable development strategy	6
T.B.Fruit	Production of juice and juice concentrate	No formalized strategy	6
Ukrprominvest Agro	Crop producton; sugar production; grain processing	Social responsibility program	5
Agroprosperis	Cereal cultivation	No formalized strategy	4
Allseeds Group	Oil production	Corporate social responsibility program	3
ViOil	Oil production	No formalized strategy	2

* Compiled by author based on open source data

What's more, the most active in ensuring sustainable development are "Kernel", "Myronivskyi Khliboprodukt", "UkrLandFarming", "Astarta" and "T.B. Fruit". The most attention the companies, which were studied, devote to the goal of "overcoming hunger, achieving food security, improving nutrition and promoting sustainable agricultural development". This is logical because they are leading food producers and provide food to millions of people around the world (Table 2).

Also, 8 out of 10 agro-industrial holdings are focused on "promoting full and productive employment and decent work for all" (which consists in creating decent working conditions and promoting employment) and "strengthening the means of implementation and intensifying work in the framework of the global partnership for sustainable development" (which consists in developing partnerships with local communities and financial assistance to them).

Table 2

Analysis of sustainable development areas compliance of 10 Ukrainian agricultural holdings with the strategic goals of Ukraine in 2030*

Sustainable Development Goals of Ukraine until 2030	Number of agro-industrial holdings declaring this goal
1) overcoming poverty;	0
2) overcoming hunger, achieving food security, improving nutrition and promoting sustainable agriculture;	10
3) ensuring a healthy lifestyle and promoting well-being for all at any age;	3
4) ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all;	3
5) ensuring gender equality, empowerment of all women and girls;	1
6) ensuring accessibility and sustainable management of water resources and sanitation;	1
7) ensuring access to affordable, reliable, sustainable and modern energy sources for all;	7
8) promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;	8
9) creating sustainable infrastructure, promoting inclusive and sustainable industrialization and innovation;	2
10) reducing inequality;	0
11) ensuring openness, security, resilience and environmental sustainability of cities and other settlements;	3
12) ensuring the transition to rational patterns of consumption and production;	1
13) urgent action to combat climate change and its consequences;	1
14) conservation and rational use of oceans, seas and marine resources for sustainable development;	1
15) protecting and restoring land ecosystems and promoting their rational use, rational forest management, combating desertification, terminating and reversing (reversing) the process of land degradation and stopping the process of biodiversity loss;	6
16) the promotion of a peaceful and open society for sustainable development, access to justice for all and the creation of effective, accountable and participatory institutions at all levels;	5
17) strengthening the means of implementation and revitalization of the global partnership for sustainable development.	8

* Compiled by author based on open source data

At the same time, the least attention is paid to such sustainable development goals as:

1) overcoming poverty – 0 out of 10;

2) ensuring gender equality, empowerment of all women and girls – 1 in 10 (“Kernel”)

3) ensuring accessibility and sustainable management of water resources and sanitation – 1 out of 10 (“Nibulon”);

4) reducing inequality – 0 out of 10;

HPOHAT

5) ensuring the transition to rational patterns of consumption and production – 1 out of 10;

6) urgent action to combat climate change and its consequences – 1 out of 10 (“Myronivskyi Khliboprodukt”);

7) conservation and rational use of oceans, seas and marine resources for sustainable development – 1 out of 10 (“Nibulon”).

The lack of attention to gender equality can be explained by the fact that this problem is not acute in Ukraine as a whole and in the agricultural sector in particular, because in most companies women work in leadership positions, their rights and opportunities are expanding.

Neglect of the problems of sustainable water resources management and rational use of oceans, seas and marine resources is explained by the fact that these companies conduct their activities mainly on the land – except for “Nibulon”.

Ensuring the transition to rational patterns of consumption and production, as well as the problems of global warming are probably not very relevant for agricultural holdings, since they are global tasks that must be addressed at the state level.

At the same time, in our opinion, it seems incomprehensible why the leading agricultural companies of Ukraine do not direct their efforts to overcoming poverty and reducing inequality – at least, such goals were not declared directly from any of the agricultural holdings that were studied. These problems are extremely important for Ukraine and negatively affect the development of all areas of life. Therefore, in our opinion, strategies for sustainable development of agro-industrial companies should be supplemented with an inclusive component – measures developed to overcome poverty and inequality in the country.

V. Conclusions

The study showed that some agro-industrial holdings have formulated and structured sustainable development strategies. They are posted on the official websites of companies along with annual reports on their implementation: “Astarta-Kiev”, “Kernel”, “Myronivskyi Khliboprodukt”, “UkrLandFarming”.

In general, the sustainable development strategies of the four leading agro-industrial holdings of Ukraine operate on nine global goals: the development of agriculture; quality education; clean water and proper sanitation; accessible and clean energy; decent work and economic growth; industry, innovation and infrastructure; sustainable development of cities and communities; responsible consumption and production; partnership for sustainable development.

Other agricultural holdings do not have their own sustainable development strategies, however, they are working to ensure balance within the framework of corporate social responsibility programs: “Nibulon”, “Allseeds Group”, “Ukrprominvest Agro”. However, this does not prevent “Nibulon” from being the most active in implementing the principles of sustainable development.

The third group of leading agricultural holdings does not even have a formulated social responsibility policy – they carry out certain social measures, however, such actions are not systematized: “Agroprosperis”, “ViOil”, “T.B. Fruit”.

Analysis of the compliance of the sustainable development areas of 10 agro-industrial holdings of Ukraine with the strategic goals of Ukraine until 2030 showed

that studied companies most of all are focused on the goals of "overcoming hunger, achieving food security, improving nutrition and promoting sustainable agricultural development". Practically no attention is paid to such goals as overcoming poverty, inequality, creating a healthy lifestyle, overcoming gender inequality and caring for water resources.

Given the specifics of the development of agricultural holdings, we noted the need to direct their efforts to overcome poverty and reduce inequality. In our opinion, sustainable development strategies of agro-industrial companies should be complemented by an inclusive component – measures developed to overcome poverty and inequality in the country at the company level.

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3. INFORMATION TECHNOLOGIES, AUTOMATION AND ROBOTICS

НТБ ОГАХТ

RESEARCH ON THE POSSIBILITY OF THE BEE COLONY ALGORITHM FOR DETERMINING THE TOPOLOGY OF THE WIRELESS NETWORK AT THE MARSHALLING YARD

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Supervisor: Victoria Pakhomova
Dnipro National University of Rail Transport Named After V. Lazaryan (Ukraine)

Abstract. *For railway marshalling yards of different power (low, medium, high), an optimal number of wireless base stations and their location were determined on a Python program based on a bee colony algorithm. Program input: marshalling yard parameters (area, number of clients); wireless network parameters (coverage radius and number of base station clients); parameters of the algorithm (number of bees, number of attempts). For example, to connect 300 clients at the medium-power marshalling yard, 93 base stations with a coverage radius of 50 m are required. The quality of solutions depends heavily on the choice of parameters of the bee colony algorithm. It is determined that increasing the number of bees (from 10 to 50) and the number of attempts to find the optimal bee solution (from 10 to 50) leads to an improvement in the quality of the optimal solution (reducing the number of base stations by an average of 6.5% and 9.3%, respectively). In addition, increasing the number of bees by 5 times leads to a decrease in the search time of the bee optimal solution by an average of 1.8 times, while increasing the number of attempts to find the optimal bee solution by 5 times will increase the search time of the solution by an average of 2.14 times. In particular, for the high-power marshalling yard, when the base stations coverage radius is doubled (from 50 to 100 m), their number decreases approximately twice (from 136 to 64), while the search time for the bee optimal solution is increased by 2.5 times (from 8.4 to 20.6 s).*

Keywords: *marshalling yard; wireless network; base station; coverage radius; bee colony algorithm.*

INTRODUCTION

A wireless network is a combination of computers and other devices to exchange information without the use of wires; the connection is made through radio channels. The establishment of the wireless network is necessary when deployment of a cable system is impossible or economically impractical, in particular at railway marshalling yards, which confirms **the relevance of the project theme**.

The purpose of the project is to investigate the effect of the number of base stations and their coverage radius on the quality of the wireless network at the railway marshalling yard using the bee colony algorithm. According to the purpose of the project, **the following tasks** have been set:

1. Perform an analytical review of scientific sources on the topic.
2. Create a program to determine the number of wireless base stations at the marshalling yard and their location.
3. Determine the optimal number of wireless base stations for marshalling yards of different power.

4. Conduct research parameters of the bee colony algorithm for marshalling yards of different power in the created program.

The object of study is the process of functioning of the wireless network at the marshalling yard under various conditions of changing its parameters.

The subject of study is the influence of the number of base stations and their coverage radius on the quality of the wireless network.

The research method is an intelligent multiagent optimization method (bee colony algorithm) to determine the optimal number of wireless network base stations under given constraints, as a software implementation - Python language with a wide range of modern standard tools.

The presented project consists of an introduction, three mandatory sections, conclusions and a list of references. The first section presents the main findings of the analytical review of scientific sources on the subject of the project: classification and advantages of wireless over wired networks; choice of intelligent multiagent optimization method; current state (foreign and domestic) of development of wireless networks on the railway transport. The second section presents the formulation of the problem, the reasoned choice of the topology and methodology of wireless networks deployment, the general characteristic of the created program in the Python language according to the bee colony algorithm for determining the number of wireless base stations for marshalling yards and their location. In the third section for marshalling yards of different power, the optimal number of wireless base stations is determined under given restrictions using the created program. The implementation of the project is based on the use of 19 main sources, among which about 50% of scientific articles in the last 5 years.

Theoretical significance. The study was made of the number of wireless base stations and the search time for bees solution by different numbers of bees and the number of attempts to find the bee optimal solution for marshalling yards of different power. It was determined that increasing the number of bees (from 10 to 50) and the number of attempts to find the optimal bee solution (from 10 to 50) leads to the specification of the optimal solution (reducing the number of base stations by an average of 6.5% and 9.3%, respectively. In addition, increasing the number of bees by 5 times leads to the decrease in the search time of the bee solution by an average of 1.8 times, while increasing the number of attempts to find the optimal bee solution by 5 times leads to increasing search time of the optimal solution by an average of 2.14 times.

Practical importance. The algorithm and its software implementation have been developed, which allow determining the required number of wireless network base stations and their placement at the marshalling yard of different power.

Results were tested at the XIII International Scientific and Practical Conference "Modern Information and Communication Technologies on a Transport, in Industry and Education" held at the Dnipro National University of Railway Transport named after academician V. Lazaryan in December 2019.

1 ANALYTICAL REVIEW OF LITERATURE

1.1 Wireless networks as an alternative to wired networks

Wireless networks have significant advantages over wired networks [2-4]: they allow deploying the network where it is impossible to use wires while maintaining

sufficient data rates. Wireless networks also provide easy connectivity, user mobility, rapid fault detection and network equipment availability.

Wireless networks can be classified into four specific groups (Fig. 1.1) [2-4]: Wireless Personal Area Networks (WPAN) - up to 10 m; Wireless Local Area Networks (WLAN) - up to 100 m; Wireless Metropolitan Area Networks (WMAN) - up to 50 km; Wireless Wide Area Network (WWAN).

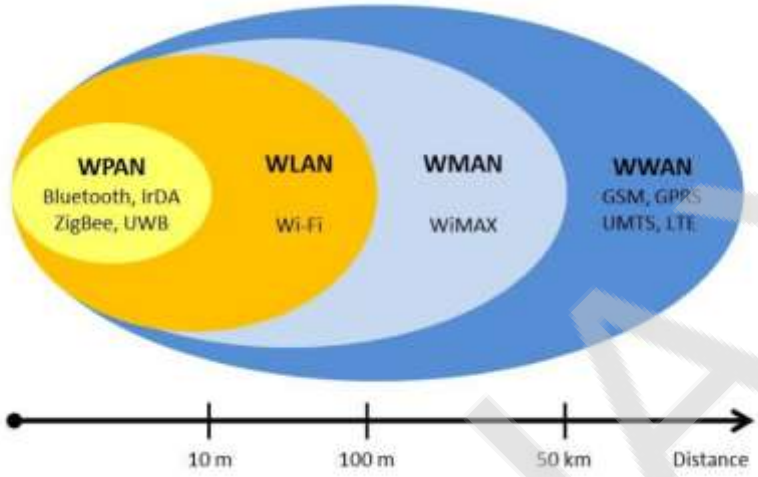

Figure 1.1 - Wireless networks classification

By topology, wireless LANs are divided into: Ad-Hoc (Independent Basic Service Set, IBSS) temporary networks; dependent networks (Basic Service Set, BSS); Extended Service Set (ESS) [2-4]. According to the IBSS topology (Fig. 1.2, a) [11, 18], the client stations interact directly with each other without an access point. Ad Hoc mode requires a minimum of hardware - a wireless adapter. This configuration does not require the creation of any network infrastructure. In this mode, each node participates in routing by forwarding data to other nodes, so determining which nodes send data is dynamically based on the network connection and the routing algorithm used. Ad-Hoc mode is mainly used to create temporary networks.

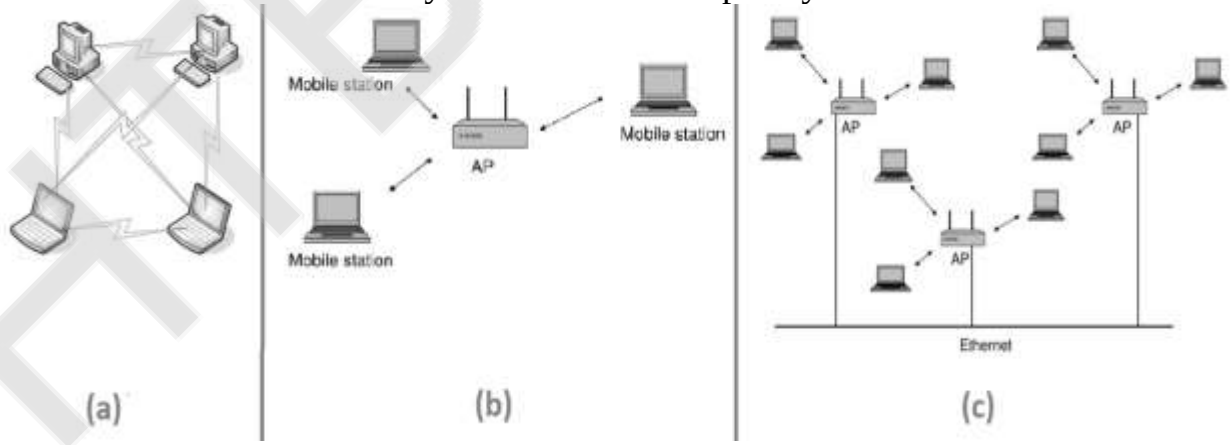

Figure 1.2 – Topology: (a) – IBSS; (b) – BSS; (c) – ESS

According to the BSS topology (Fig. 1.2, b) [11, 18], network nodes do not interact with each other directly but through an access point (Access Point, AP), which can act as a bridge to connect to an external cable network. All the base stations of the

network are interconnected by means of a Distributed System (DS), which can be used as radio or infrared waves.

The ESS topology (Fig. 1.2, c) [11, 18] allows to combine several access points, that is, to integrate several BSS networks. In this case, access points can interact with each other. Such the topology is convenient when you need to combine multiple users into one network or connect multiple wired or wireless networks.

There are two main WLAN deployment methodologies available: wireless LANs with maximum service area; wireless LAN with maximum bandwidth [11, 18], Fig. 1.3. Service-oriented WLANs are designed with the emphasis on providing maximum coverage with as few access points as possible. A typical network-centric service provides a ratio of users to 25:1 access points. Some typical features of service-oriented WLANs are: the use of pulsating-type applications with a low packet rate, such as applications that query databases; low bandwidth requirements so that data rates can be reduced to as low as 1 and 2 Mbps; providing ease of maintenance as the WLAN service staff is small. [18]

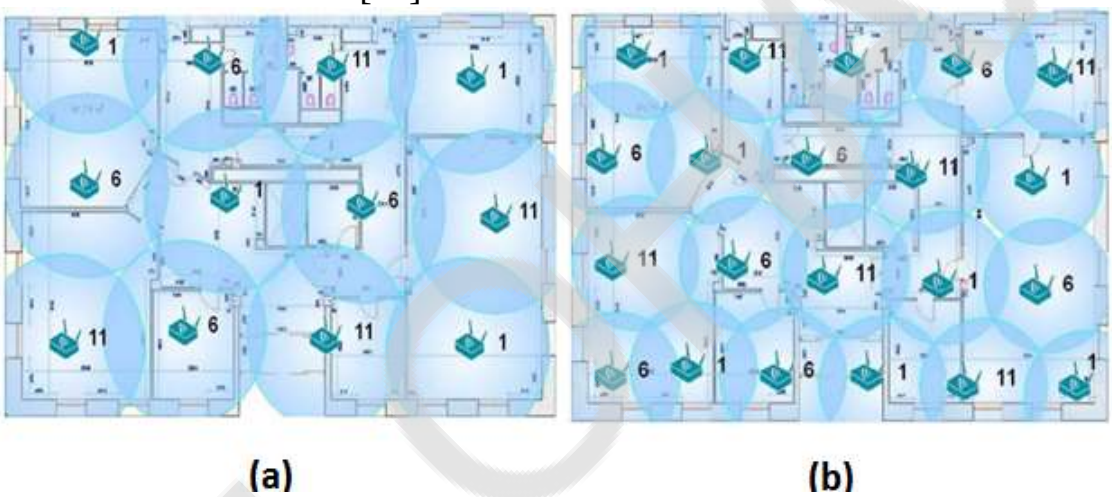

Figure 1.3 – WLAN:
(a) – Bandwidth Oriented Networks; (b) – Service Oriented Networks

In service-oriented networks, typical applications have a low packet rate and have low bandwidth requirements. This approach allows many users to immediately access WLAN services while retaining the latest sufficient features. Such options are common to small or medium-sized business affiliates when WLAN is selected as an alternative to Ethernet. Easy-to-deploy WLANs provide the basic LAN connections needed to share files and printers. Each WLAN access point serves approximately 25-30 users. [18]

High bandwidth-oriented WLANs are required when: applications that require high packet speed are used; Delay-sensitive applications are used; smaller subnets are deployed (or multiple subnets are in the same service area); there is a high density of user placement. On such networks, the number of access points is several times the number of service-oriented WLANs. The service area of each access point is much smaller than when building a network focused on the maximum service area. Each access point serves about 12 users. [18]

1.2 Choosing a method for organizing a wireless network

Nowadays, there are many different swarm algorithms [1, 8], which can be divided into: swarm algorithms based on the behavior of insects and animals; swarm algorithms based on bacterial behavior and inanimate nature. The first algorithms include: particle swarm algorithm; ant algorithm; bee colony algorithm; firefly algorithm; cuckoo search; bat algorithm. The second are: gravitational search algorithm; intelligent water drops algorithm; stochastic diffusion search; bacterial foraging optimization. It was determined [7] that the bee colony algorithm is most suitable for solving the problem of placement of wireless base stations. It should be noted that the bee colony algorithm is a new algorithm for finding global extrema of complex multidimensional functions. The advantages of the algorithm include: the ability to effectively allocate to parallel processes; high speed of work. The bee colony algorithm has some modifications [14], one of which is BCOi (Bee Colony Optimization based on the improvement concept), the peculiarity of which is that it deals with working with complete solutions of an optimization problem and not with partial ones, as in the classical BCO method [7].

Consider the biological basis of the bee colony algorithm. Bees in nature search for food by exploring the space around their hive (Fig. 1.4) [16]. As a rule, at the initial stage, several bee-scouts are exploring the environment. Upon completion of the search, the scout bees return to the hive and inform other swarm members about the location, quantity and quality of available food sources that they have found.

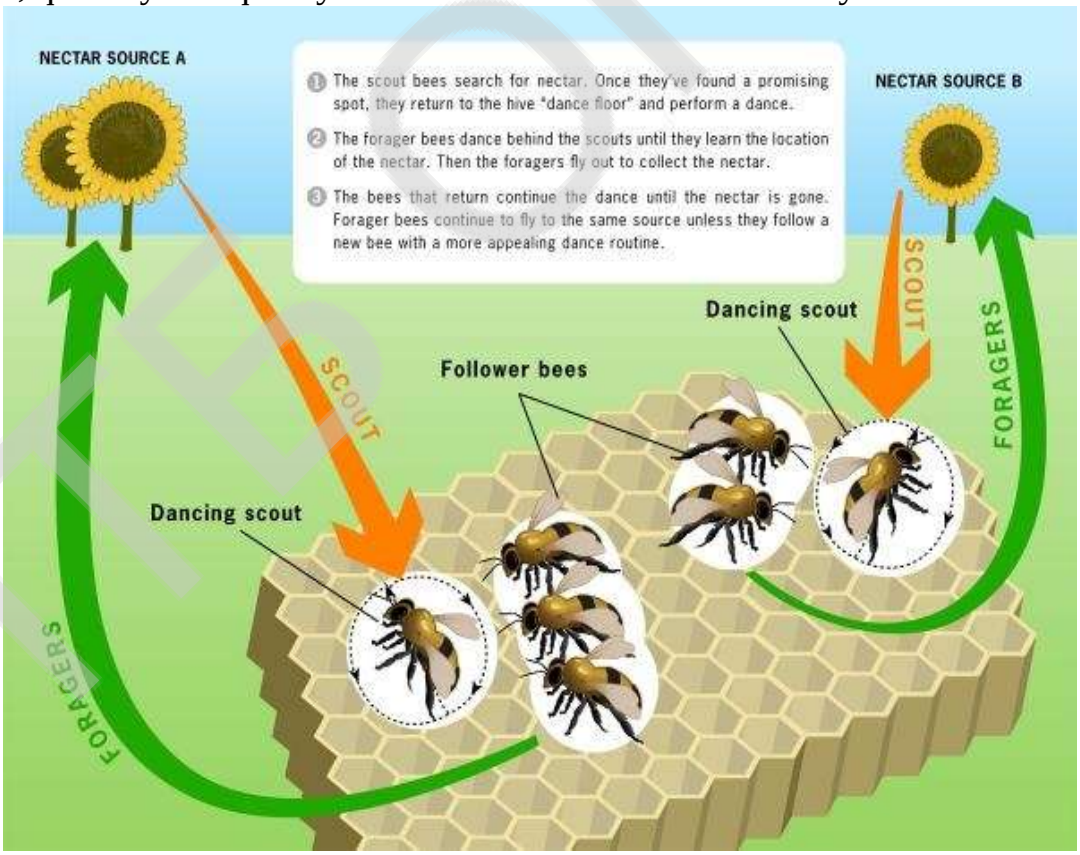

Figure 1.4 – Natural analogue

A review of sources [7, 13-14, 16] shows that bees share information through the waggle dance at a designated area. If a scout-watching bee decides to leave the hive and collect nectar, it will follow one of the scouts to one of the previously

identified food sources. Such a bee becomes a busy forager, it deals with the collection of nectar, while specifying information on the amount of nectar in the vicinity of the source found. After collection, the forage returns to the hive and leaves the collected nectar there. He can then do one of the following things: Become an unoccupied forager by leaving his current source of nectar; continue to obtain nectar from its source without recruiting idle bees through dance; continue to extract nectar from its source while recruiting idle bees. The described process continues continuously, while the hive accumulates nectar and explores new areas with potential food sources.

1.3 The current state of the railway

Railways in Europe have been using the GSM-R (Global System for Mobile Communications - Railway) standard since 2008 to provide secure wireless communication between rail services and trains [9, 15]. The GSM-R network is used to provide the European Train Control System (ETCS) [9]. In the UK, the GSM-R network has been operational since 2015 [10]. To date, Europe is moving towards more advanced technologies such as 4G / LTE and 5G [17]. In the future, the following new services are expected on the railway: on-board and off-road HD video surveillance, multimedia control video streams, sensory information from the railway infrastructure, including bridges, viaducts, tunnels, road defects and more. With the help of infrared, sound and temperature sensors, information is collected and sent to a data center [12].

At the present stage, Ukraine is conducting research on the information and telecommunication system (ITS) of railway transport using artificial intelligence methods: neural and neural fuzzy networks, ant and genetic methods, in particular, at the marshalling yard [19]. However, the results of the implementation of wireless networks on the railway transport are not yet sufficiently presented. In [5-6], the authors considered the possibility of using WLAN technology for the implementation of mobile communication at railway stations, compiled a diagram of the states of the base station in the mode Distributed Coordination Function (DCF), which is mandatory and based on the protocol providing Carrier Sense Multiple Access with Collision Avoidance (CSMA / CA) multiple access. It is advisable to conduct an investigation of the optimal number of wireless network base stations, in particular, at the marshalling yard that reaches the lower level (linear enterprises) of the Ukrainian Railways.

2 OBJECT, SUBJECT AND METHODS OF STUDY

2.1. Formulation of the problem

The railway marshalling yard (Fig. 2.1) includes an arrival park, a marshalling park and a hump, a departure park. The most important part of the technological object is the hump, whose capacity (small, medium, large and high) depends on the number of humps (2, 3, 4, 6-8, respectively). Various technological sections are located at the investigated site: turn, speed and acceleration measurements in the area of 1-2BP (brake position) and 3-4BP, measurement of the parameters of the split, control of the cleavage, measurement of the mass of the split with various terrestrial equipment: travel sensors and photo sensors; rail circuits; weights; radar speedometers and others.

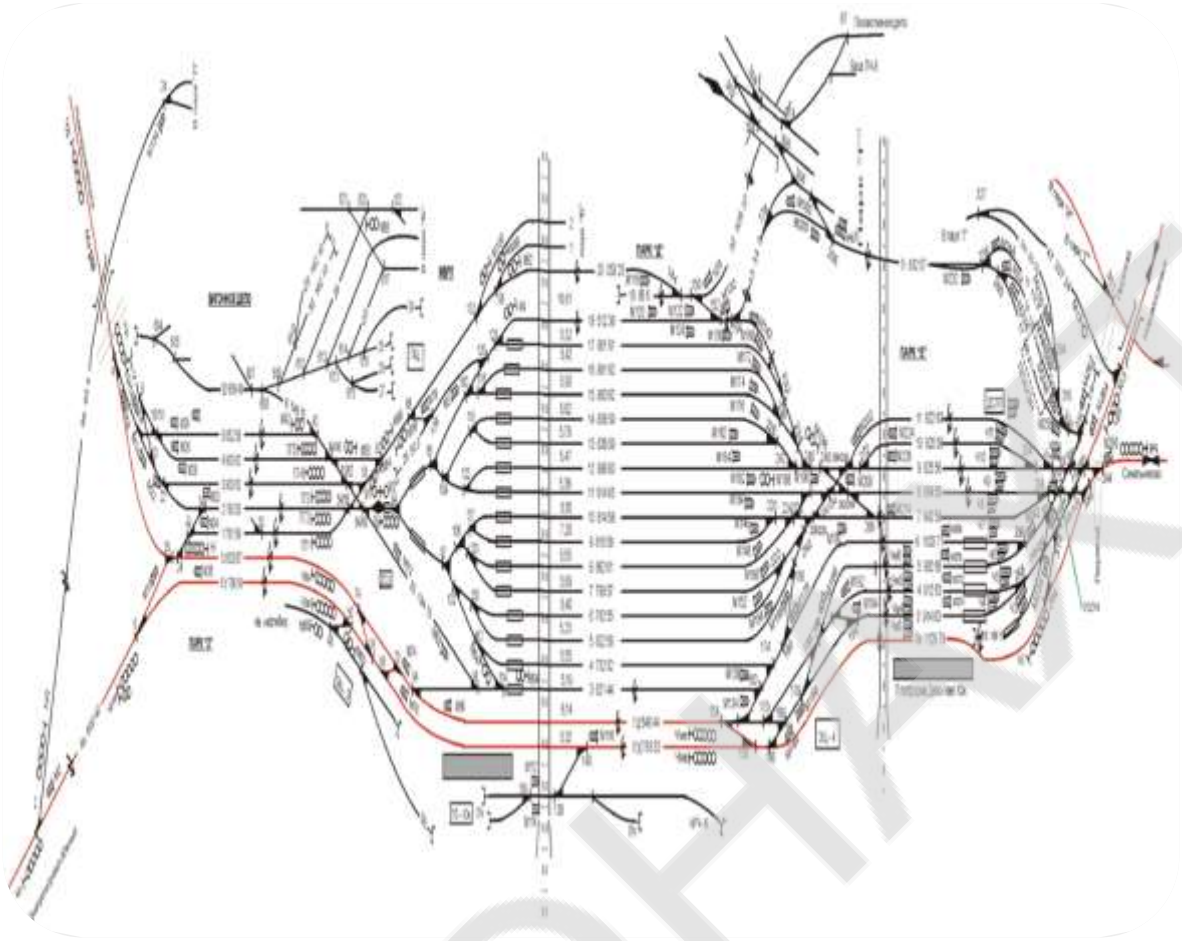

Figure 2.1 – Layout of the marshalling yard

Let L be the set of clients (terrestrial marshalling yard equipment) that need to be connected to the WLAN base station at the marshalling yard. Known M - candidate places where base stations can be installed. In addition, all clients must be connected to base stations.

Introduce the notation $BS_i(r)^k$ – the *i*-th wireless base station with the coverage radius r to which *k*-clients are connected, where i ∈ [1; M]; k ∈ [1; *L*]. If $BS_i(r)^k = 1$, then the *i*-th wireless base station with *k*-clients connects to the wireless network, otherwise $BS_i(r)^k = 0$.

As a target function, consider the following function:

$$F = \sum_{i=1}^{M} BS_i\ (r)^k\ \rightarrow min, \qquad (2.1)$$

Moreover, there are following restrictions:

$$r \leq r_{max},\ \ k \leq k_{max.}, \qquad (2.2)$$

r_{max} – the maximum coverage radius of the WLAN base station; k_{max} – the maximum number of clients that connect to the WLAN base station.

2.2. Deploying the wireless network at the marshalling yard

Based on a survey of scientific sources and subject topology (railway marshalling yard), it is appropriate to investigate an ESS network that uses multiple access points that interact with each other. In addition, there are wired networks at the marshalling yard that need to be exchanged, so it makes sense to use a WLAN deployment methodology that is focused on maximum bandwidth. The size of the cell-oriented WLAN bandwidth is smaller than that of the WLAN, which is focused on the maximum service area, respectively, the density of placement of access points above.

2.3. Bee colony algorithm

An enlarged scheme of the bee colony algorithm is presented in Fig. 2.2 [13]. Initially, the colony is initialized, followed by a search for a solution, after which the bees exchange information in the hive via dance, and then colony initializes again until an algorithm stop criterion is detected, and then the search for the optimal solution is performed.

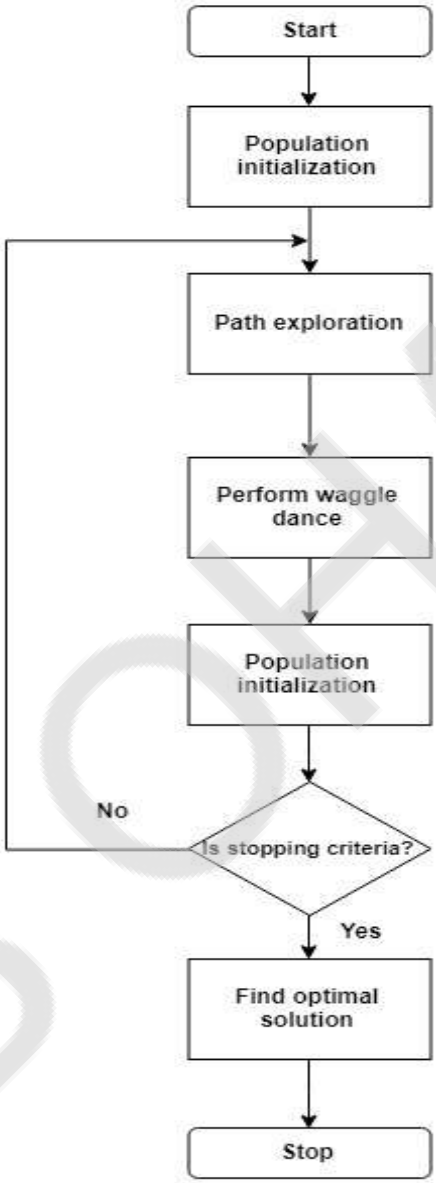

Figure 2.2 – Artificial Bee Colony Algorithm Flowchart

2.4. Short description of the created program

Software implementation of the bee colony algorithm is executed in Python language using standard libraries: Os - is responsible for interaction with the OS; Sys - responsible for system functions; Random - responsible for random number generation; Math - is responsible for mathematical operations; Datetime - Responsible for time conversion; Matplotlib - responsible for charting.

The following classes of user are included in the program structure (Fig. 2.3): Log - used for debugging the program and displaying results, it is the parent for all classes; Field is a class for representing the marshalling yard where the location of the base stations is searched; Hive is the hive class where scout bees share information and

choose the best solution; the parent class is Field; Bee is a reconnaissance class of bee-scouters looking for coordinates to house base stations, the parent class being Hive.

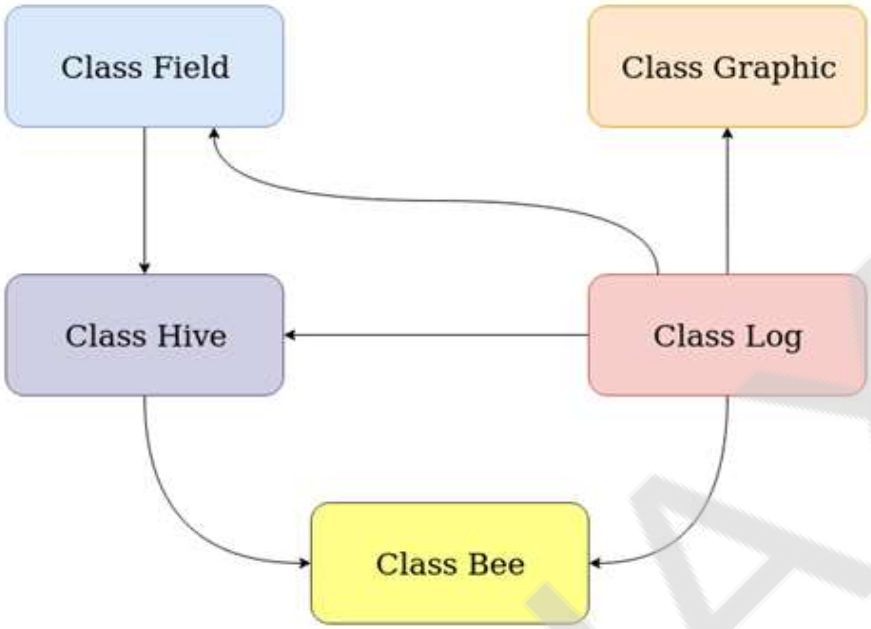

Figure 2.3 – Interaction of main classes of the program

The location of the WLAN base stations (BS) on the marshalling yard is based on the bee colony algorithm. Firstly, all classes are initialized, the main variables include: bees_count - number of bees; max_retries_count - number of attempts to find the best solution; clients_count - number of clients; clients_list - a list of client coordinates; bs_max_clients_count - the maximum number of clients that can be connected to one station; bs_area_radius - base station coverage radius; field_width - the width of the marshalling yard field; field_height - the length of the marshalling yard field.

As an example in Fig. 2.4 shows a snippet of the program. The For loop (line 28) creates the required number of bees, according to the initial conditions. After creating everything you need for the program, the implementation of the algorithm begins. Line 30 starts the While loop until all clients are connected to the wireless base stations. Inside, a For loop (line 32) is performed, in which the values of the extremes and positions for each of the bees are cleared (lines 33-35). After specifying a search field (line 36), each bee makes a specified number of attempts to find the optimal location solution for the base station (line 37). As a result of the loop iteration, a global extremum may be found, where it is more expedient to place the base station, in which case it will be installed (line 40). Then client numbers that connected to the base station (lines 41-42) is deleted from the general client list and the loop is repeated.

```
bees = [bee(hive, log) for i in range(bees_count)]
iter_count = 0
while len(hive.clients_list) > 0:
log.stat("run".upper(), "### Iteration #"+ str(iter_count) +" started. ##
#")
for bee in bees:
bee.local_extremum = {}
bee.location = []
hive.global_extremum = {}
scouting_area = hive.set_scouting_area(field, bs_area_radius)
for _ in range(max_retries_count):
for bee in bees:
bee.scout(scouting_area)
bee.set_bs_location(hive.global_extremum)
for key, value in hive.global_extremum["clients_in_area_list"].items():
hive.modify_clients_list({key: value})
iter_count += 1
```

Figure 2.4 – Snippet of the program

3 RESEARCH RESULTS

3.1. Determining the number of base stations (BS) and their location

Determination of the number of BS at the low power marshalling yard. Input parameters of the program: number of bees (bees_count) = 10; maximum number of attempts to find the optimal solution (max_retries_count) = 10; number of clients (clients_count) = 250; maximum number of clients covered by one base station (bs_max_clients_count) = 12; coverage radius (bs_area_radius) = 50; field width (field_width) = 2000; field height (field_height) = 400. The results of the program are shown in fig. 3.1.

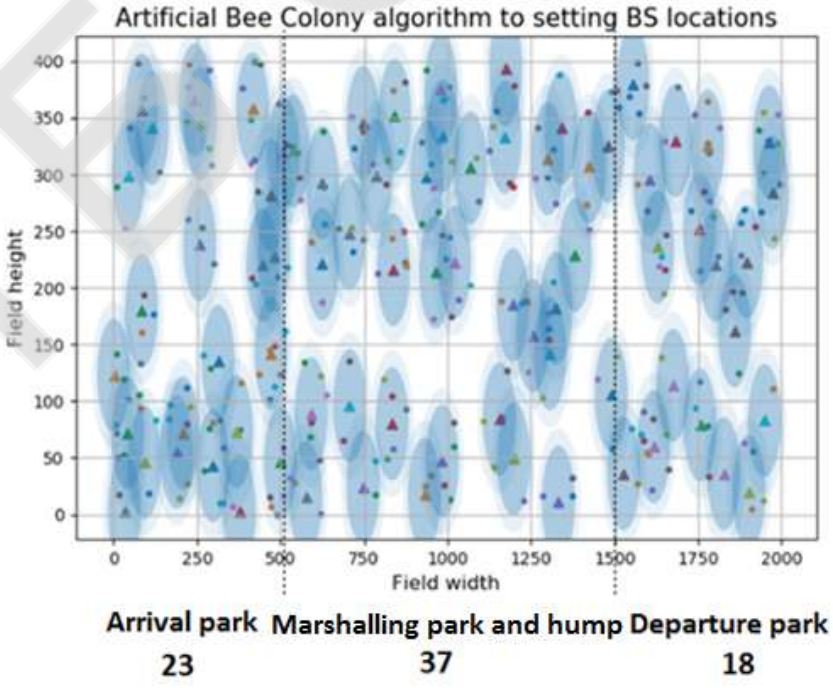

Figure 3.1 – BS location at the low power marshalling yard

Determination of the number of BS at the medium power marshalling yard. Input parameters of the program: number of bees (bees_count) = 10; maximum number of attempts to find the optimal solution (max_retries_count) = 10; number of clients (clients_count) = 300; maximum number of clients covered by one base station (bs_max_clients_count) = 12; coverage radius (bs_area_radius) = 50; field width (field_width) = 2500; field height (field_height) = 500. The results of the program are shown in fig. 3.2.

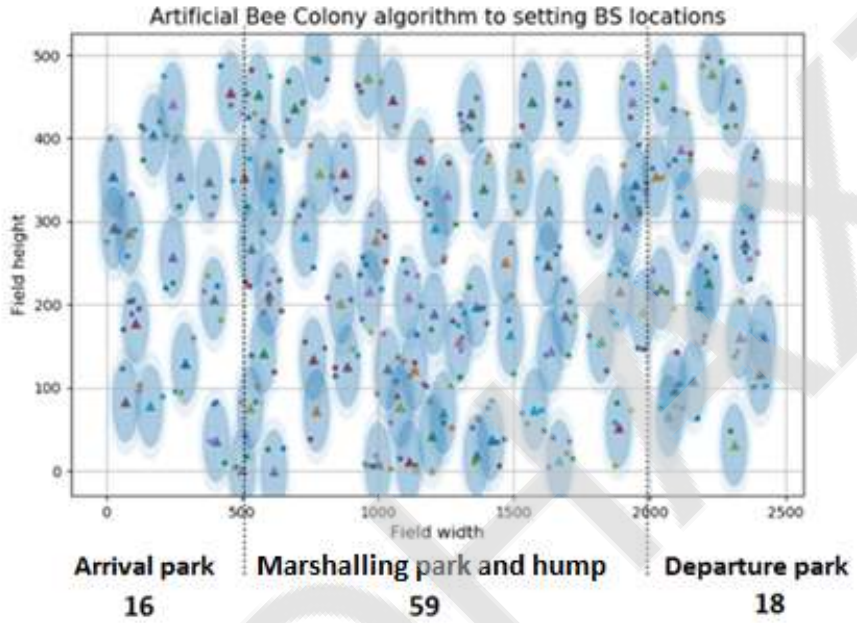

Figure 3.2 – BS location at the medium power marshalling yard

Determination of the number of BS at the high power marshalling yard. Input parameters of the program: number of bees (bees_count) = 10; maximum number of attempts to find the optimal solution (max_retries_count) = 10; number of clients (clients_count) = 350; maximum number of clients covered by one base station (bs_max_clients_count) = 12; coverage radius (bs_area_radius) = 50; field width (field_width) = 3000; field height (field_height) = 600. The results of the program are shown in fig. 3.3.

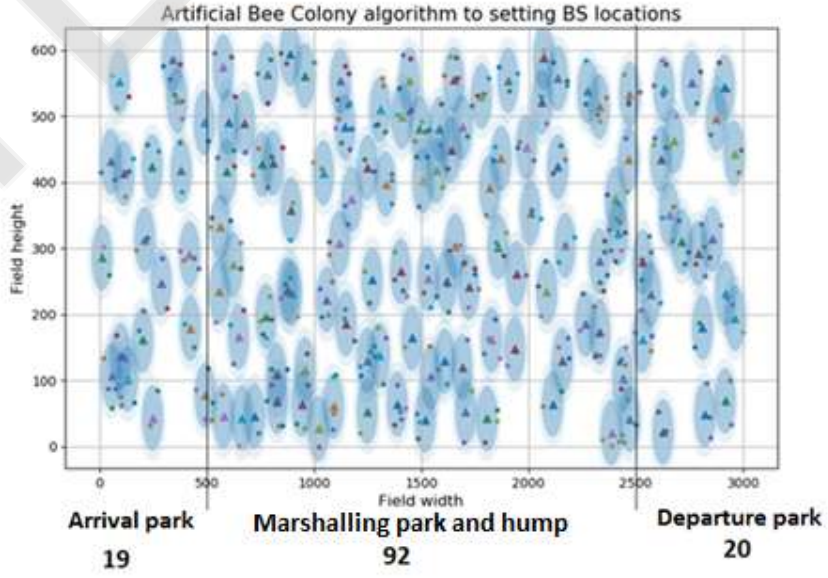

Figure 3.3 – BS location at the high power marshalling yard

3.2. Investigation of parameters of the bee colony algorithm

The quality of the obtained solutions depends on the choice of algorithm parameters. In addition, the speed of the algorithm depends on this choice. Therefore, a study was conducted to find out the dependencies of the optimization results (the number of BS of the wired network) and the time to find the optimal solution for low, medium and high power marshalling yards with different number of bees and the maximum number of attempts to find the optimal solution for each bee. The results are shown in Fig. 3.4-3.5.

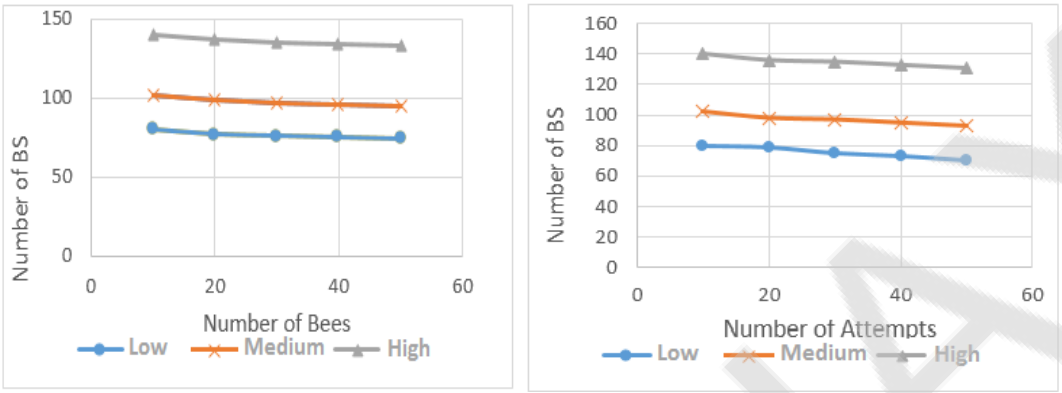

Figure 3.4 – Dependence of optimization results (number of BS) on different number of bees and attempts for different power marshalling yards

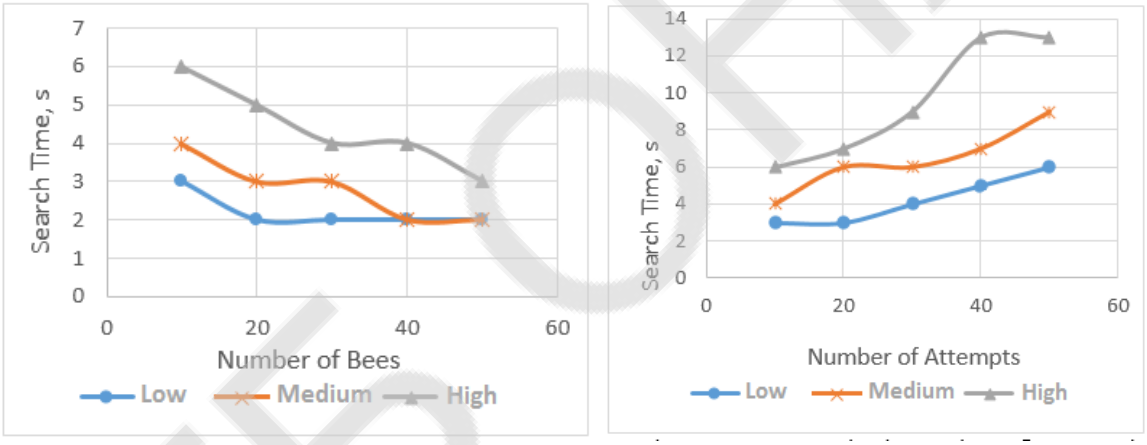

Figure 3.5 – Time dependency of finding the optimal solution for different number of bees and attempts for different power marshalling yards

From fig. 3.4 it can be seen that increasing the number of bees (from 10 to 50) and the number of attempts to find the optimal bee solution (from 10 to 50) leads to the decrease in the number of WLAN base stations by an average of 6.5% and 9.3%, respectively.

Increasing the number of bees (from 10 to 50) leads to the decrease in the search time of the bee solution by an average of 1.8 times, while increasing the number of attempts to find the optimal bee solution (from 10 to 50) will increase the search time of the solution by an average of 2.14 times (Fig. 3.5).

3.3. Investigation of base station coverage radius

An appropriate study was conducted for the high-power marshalling yard with the following parameters: number of bees (bees_count) = 10; maximum number of attempts to find the optimal solution (max_retries_count) = 10; number of clients (clients_count) = 350; maximum number of clients covered by one base station

(bs_max_clients_count) = 12; field width (field_width) = 3000; field height (field_height) = 600. The results obtained in the program are summarized in table. 3.1.

Table 3.1 – Research results

Experiment №	BS Coverage Radius, m	Number of BS	Search Time, s	BS Coverage Radius, m	Number of BS	Search Time, s
1	50	135	22	100	67	8
2		135	20		61	7
3		133	19		62	9
4		140	22		63	9
5		138	20		66	9
Average:		136,2	20,6		63,8	8,4

The table shows that, when the WLAN base stations coverage radius is doubled (from 50 to 100 m), the number of BS decreases approximately twice (from 136 to 64), while the search time for the optimal bee solution is increased by 2.5 times (from 8.4 to 20.6 s).

CONCLUSIONS

1. To determine the optimal number of wireless base stations and their location at the marshalling yard, the bee colony algorithm was used, the advantages of which include the ability to effectively allocate to parallel processes and high speed of operation.

2. The Python program was created based on the bee colony algorithm, the input of which is: marshalling yard parameters (area, number of clients to be connected to the base stations); WLAN parameters (maximum coverage radius and maximum number of clients of base station); parameters of the bee colony algorithm (number of bees, maximum number of attempts to find the optimal solution for the bee). For example, to connect 300 clients at the medium-power marshalling yard with an area of 2500x500 m^2, 93 base stations with the coverage radius of 50 m are required.

3. The quality of solutions depends heavily on the choice of bee colony algorithm parameters. The number of WLAN base stations (time to find the optimal solution) was investigated by different number of bees (number of attempts to find the optimal bee solution) for marshalling yards of different power. It is determined that increasing the number of bees (from 10 to 50) and the number of attempts to find the optimal bee solution (from 10 to 50) leads to increasing the quality of the optimal solution (reducing the number of base stations by an average of 6.5% and 9.3%, respectively). In addition, increasing the number of bees (from 10 to 50) leads to decreasing the search time of the bee solution by an average of 1.8 times. Increasing the number of attempts to find the optimal bee solution (from 10 to 50) leads to increasing the search time the bee optimal solution by an average of 2.14 times.

4. For the high-power marshalling yard, when the wireless base stations coverage radius is doubled (from 50 to 100 m), their number decreases approximately

twice (from 136 to 64), while the search time the bee optimal solution is increased by 2.5 times (from 8.4 to 20.6 s).

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НТБ ОНАХТ

INTELLIGENT URBAN TRAFFIC

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Abstract*. This investigation aims to create the algorithm that allows to find optimal routes for vehicles in cities where traffic jams are an acute problem. It's necessary to consider that an urgency of the problem is increased day by day. The situation is exacerbated in connection with the constant increasing of the cars number on the city streets. In the meantime, streets and intersections throughput stay virtually unchanged. To solve the formulated problem, logistic software algorithms are used to find the best routes. In this respect the most acceptable for decision of formulated problem is A*-algorithm.*

Technically, the flows` control process of vehicles can be done by obtaining information from sensors that are mounted at city intersections. Based on the collected data, a real-time interactive interplay between the Traffic Management Center (TMS) and each vehicle is carried out. The TMS transmits to each driver voice commands regarding the route to the destination, specified by the driver, as in normal GPS navigation. However, the main difference consists in choice of a criterion for optimality – our program chooses as such criterion a time of trip (t-optimality criterion), but usual GPS navigator takes into consideration geometrical factor (g-optimality criterion). The t-optimality criterion is realized by introducing special dynamic scales for the edges of the multigraph that simulates the city's transportation network.

Therefore, the main purpose of this investigation is to lay out t-optimal routes for all vehicles who had ordered such routes. As a result, it will lead to optimization of used transport arteries throughout the city and to a decrease congestion numbers, to synchronization of the vehicles` flows – traffic will move to a new quality level.

Keywords*: traffic management center, multigraph, A*-algorithm, t-optimality criterion, g-optimality criterion, GPS navigation.*

I. INTRODUCTION

Traffic problem in every metropolis in the world is extremely typical today, but unfortunately is still not resolved. The problem is far from new, but there are no real prospects for solving it. That`s why the author focused on the aim to create the algorithm, which will really give possibility to improve the quality of traffic in cities.

The algorithm is tuned to work in real-time mode, tracking traffic changes and responding appropriately to them when laying t-optimal routes. Laying out such routes works according to the following scheme:

1. Every city intersection will equipped with special sensors – input and output ones. The first sensors are registered cars driving on the road between adjacent intersections; the second type of such devices are registered cars, which leave it. In consequence of this process the entire transport network is under the control of TMS.
2. The interaction between TMS and driver, who uses GPS navigator, is implemented by means of GPS-trackers and as a result, the vehicle driver receives instructions as to choosing of the best route taking into account the latest traffic

situation. In other words, car drivers obtain information in regime of real time. On the contrary, in the case with modern GPS navigation drivers obtain the information behind time, when traffic jams on cities streets are already exist.

II. ANALYTICAL REVIEW OF THE LITERATURE

The study [1] is an overview fundamental work concerning an analysis of modern types of intelligent transportation systems. A wide variety of issues related to the visualization of urban traffic data is addressed. One of the most significant methods of visualizing such data is to use graphs that give possibility to visually represent the topology and geometry of urban areas (in our study the use of graphs and related algorithms there is just the main method of research). The authors also conduct a generalized analysis of a dynamic urban flows mobility, which is as follows:

- Urban traffic flows and their monitoring;
- Human dynamics in an urban environment;
- Road traffic incidents;
- Air pollution.

A striking example of visualization is Fig. 1, where traffic congestion levels is shown – red color represents the highest congestion of the urban network [1].

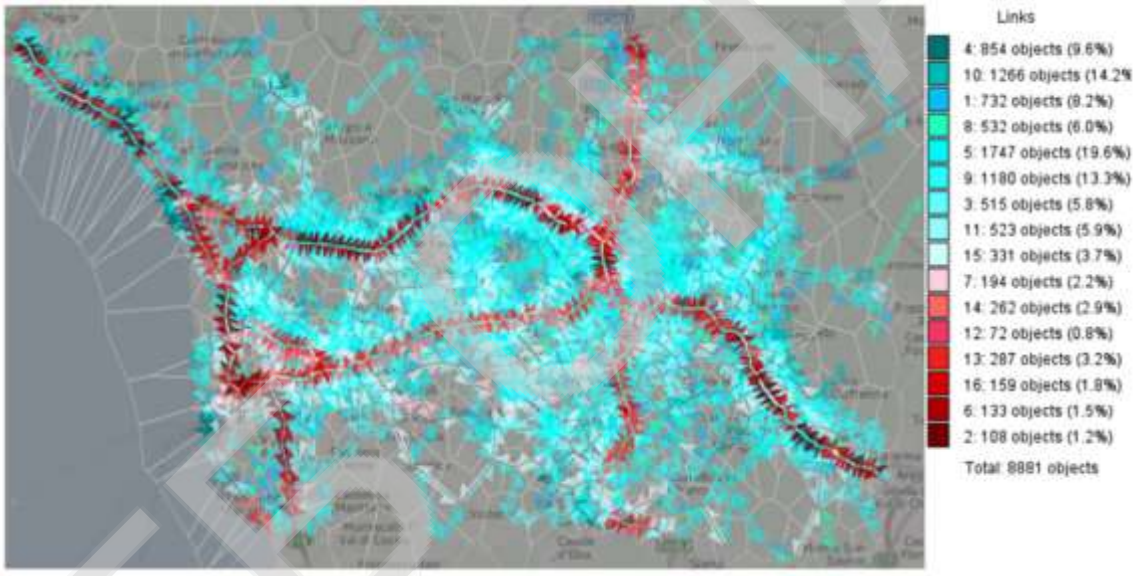


Fig. 1. Visualization of the traffic flows in terms of the vehicle speed value on urban roads (red colors correspond to the transport highways, where the speed is the lowest [1]).

A characteristic feature of urban transport network research is using of Vehicular Ad-hoc Networks (VANETs) technology, described in detail in [2]. This technology is used to collect traffic congestion data and transmit it to the TMS. An important applying of VANETs technology is feedback-based navigation. It uses special cars (sensors vehicles) to collect information about the situation on the city's roads and transmits this information to the TMS.

The range of works is devoted to use of the neural networks for an analysis and forecasting of the traffic situations on the transport arteries of cities. In this respect, the authors of work [3] had developed a model that allows to do short-term forecasts (depth of the forecast consists of 5-10 minutes) regarding the behavior of traffic flows on city highways. The study uses the sorting genetic algorithm of type II (NSGA-II), which

exploits two important factors – traffic estimation and optimization parameters. A similar previous study had been conducted in [4]. Here Kalman filter is used to predict congestion of urban transport arteries. The technology of "connected cars" is used – such modern vehicles, on which special devices is installed that allow them to interact with urban roadside infrastructure. As a result of such "cooperation" it is possible to estimate various parameters of traffic flows – average speed of traffic, idle time at crossroads, travel time, etc. The algorithm does not use data obtained from other similar techniques from looped detectors and video cameras, but only data from "connected cars", which proves the cost-effectiveness of this approach.

Effective use of the data collected from various types of road sensors is a significant problem in connection with the loss of some data transmitted to the TMS. This problem is described in an article [5] that proposes a method of data transmission with a high degree of reliability and efficiency. Compared to other technologies of this kind, the quality of data transmission is increased by 87%. The authors introduce a special decomposition matrix that uses the data flow compression principle to calculate traffic metrics.

Traffic forecasting is an important aspect in many areas related to city traffic. The authors of an investigation [6] pay attention to the topic, where three models are selected by analyzing the huge number of methods that make short-term forecasts about the traffic situation. Italian transport networks are investigated using a nonparametric K-neural regression model. Weekly and monthly variations of traffic parameters based on averaged data of this type were studied. Article [7] investigates a problem of integrated traffic control over transport networks by using a macroscopic model, which is a mathematical model of the traffic flow of a vehicle. The density, intensity and speed of the car flow are analyzed. An integrated control algorithm is proposed to solve the problem. The essence of the algorithm is to choose the best routes in the urban transport network.

International inventions, to which the author of this investigation pays great attention, plays a significant role in the problem of solving the fundamental issues of road traffic. In this regard, the prototype of our study is the invention [8], which is a technology related to a use of the mobile phones by drivers of vehicles. At the intersections of a city special devices are installed to record traffic flows and transmit the collected information to the TMS. The information then will sent to each driver via the Internet in order to choose the best route for them. The invention is solved the problem of traffic optimization by estimating a flow of vehicles through each city intersection [9]. The system operates in real time mode and therefore dynamically controls and regulates traffic on urban routes by creating a green wave mode. In [10] the method of time-series analysis of Markov hidden chain is applied. As the main criteria are used optimizing travel time and vehicle speed, that as a result leads to finding the best option trip.

Interaction between cars on urban routes (and not only) plays an important role in organizing of a coordinated behavior of a large number of dynamic objects, especially when they are crowded, as is a case in metropolis cities. The problem of such interaction based on the standard IEEE 802.11p is considered in [11]. «Car-to-

Car» interaction should be provided by a reliable communication system, which is the standard mentioned above.

Transport networks work in different modes [12]. Knowledge of these modes and transitions between them is an important factor that determines an essence of the transport network operation. Overload of city road network leads to congestion. In order to avoid such problems, it is necessary to study in detail the principles of the transport network operation. This work examines the statistical and dynamic transitions between different modes of traffic. Investigation [13] is addressed to the specific problem of improving traffic in an urban environment, where congestion is often happened due to bad traffic management. A similar problem is addressed in the study [14], which is an element of technology suitable for practical use. An emphasis has been done on four areas – graph theory, intellectual A*-algorithm, information technology and technical means of the vehicles registration (sensors). A combination of these components makes a real step in a solving of a major problem of each big city – the problem of traffic jams. A real technology for solving the mentioned problem provide authors of an invention [15] too. This innovation relates to an intelligent control system of traffic lights by bilateral exchange of information with TMS.

III. OBJECT, SUBJECT AND METHODS OF RESEARCH

This investigation is focused on solving of significant problem of big cities – the problem of traffic jams. Therefore, the object of this study is the transport networks of the megapolis cities. The problem to be solved – the subject of this study – is congestion on urban transport networks. Creating an algorithm for laying t-optimal routes for each vehicle involved in traffic is the main goal of the work. Research methods: 1) methods of theory for modeling of the complex systems; 2) methods of a graph theory; 3). Java technologies; 4). optimization methods and A*-algorithm.

IV. WORK RESULTS

Let`s consider part of Toledo (Canada) transport network, which is presented in Fig.2. It is necessary to create a transport network model for this part of the city, taking into account number of lines on each section of the road. All this have been done in Fig. 3.

Fig. 2. A microdistrict of Toledo (Canada). The dotted line highlights a part of the area modeled by the graph shown in the following figure.

As can be seen (Fig. 3), the presented graph simulates not only the road between adjacent intersections, but also individual lines, that is fundamentally significant point, since a congestion of the different lines is usually essentially different. Therefore, it is need register them separately. The multigraph presented in Fig. 3 is weighted – each edge receives a changing weight (this will be discussed further). The nodes of the graph simulate the roads intersections, and the directed arcs (edges) symbolize lines.

Labels “START” and “FINISH“ symbolize the starting and ending positions of the car that had ordered a route between the indicated positions. In the center of Fig. 3 there is designations of type b7_6, a7_6, a6_7, b6_7 and c6_7. How such designations should be understood? First, the traffic lines are denoted by a, b, c, d,…, starting from a center of the road, as shown in Fig. 4.

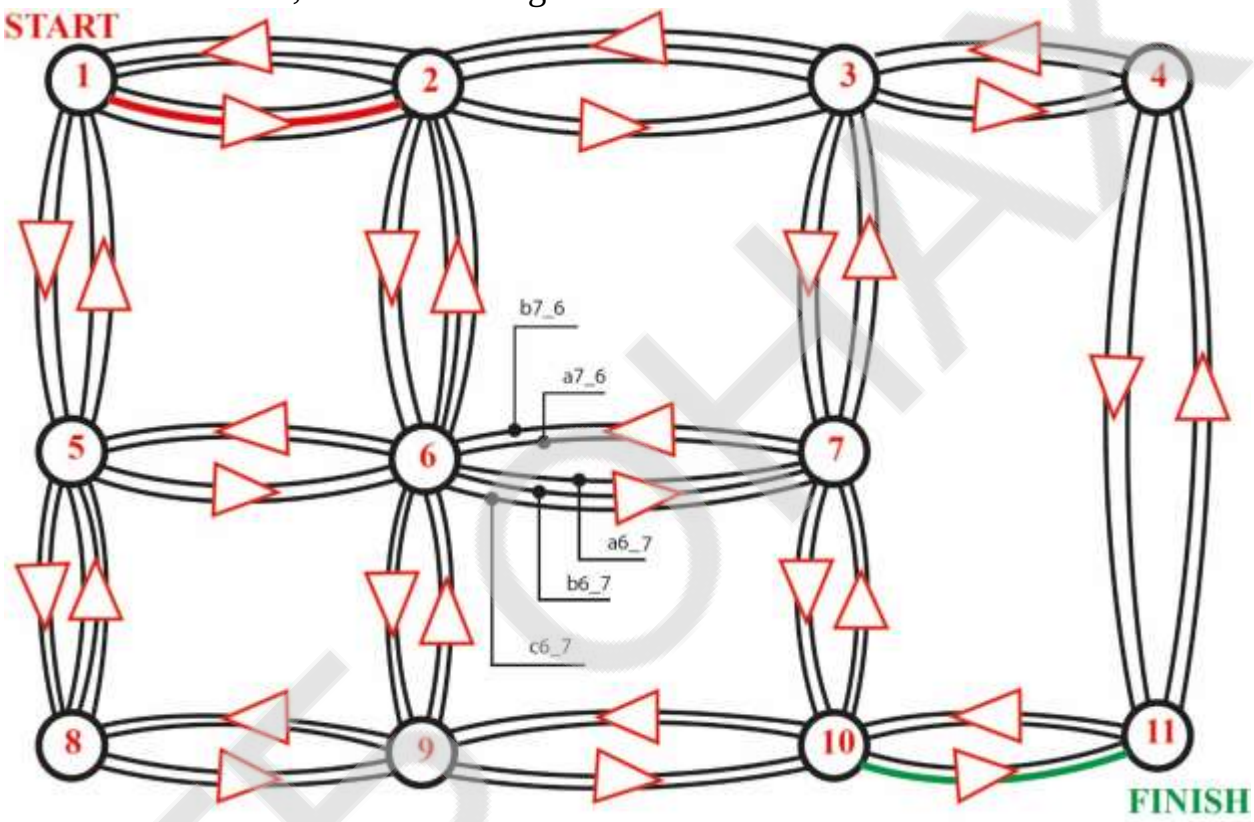


Fig. 3. A weighted planar oriented multigraph that simulates the city's transportation network.

So, in particular, the entry b7_6 denotes the middle line extending from node (intersection) 7 to node 6. Record c6_7 represents the extreme right line (with only three lines in one direction of the road) extending from intersection 6 to the intersection 7. Similarly, other inscriptions of this type are deciphered.

To plot t-optimal route in graph presented in Fig.3, it is necessary to register the vehicles located on each of the lines. The process of such registration can be understood by looking at Fig. 4.

The key item on Fig.4 is the presence of two types of sensors – input and output ones. These are so-called piezoelectric sensors, such as the Roadtrax BL type [13]), which respond on pressure caused by wheeled couple of vehicle. These sensors are mounted in a roadway perpendicular to the longitudinal axis of the road immediately behind the stop line. The received impulses are received for registration at the

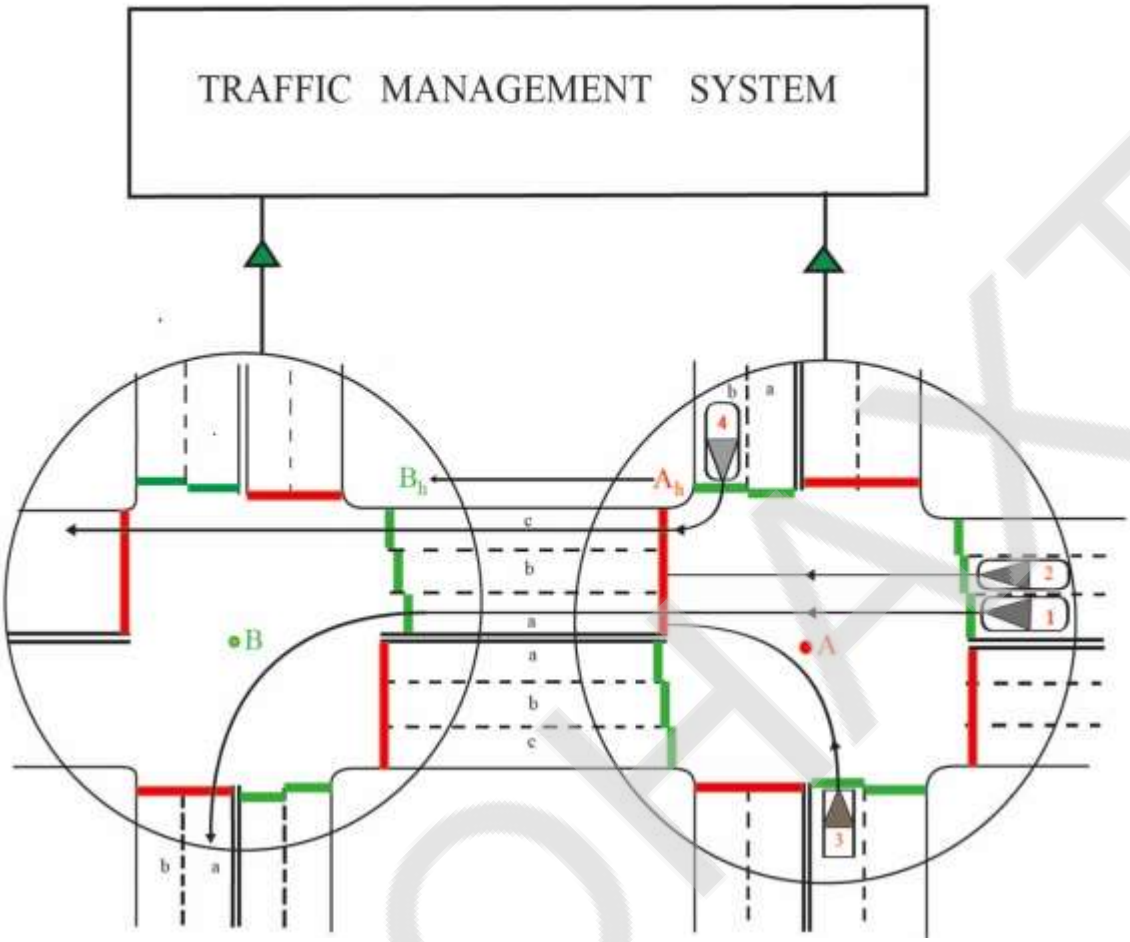
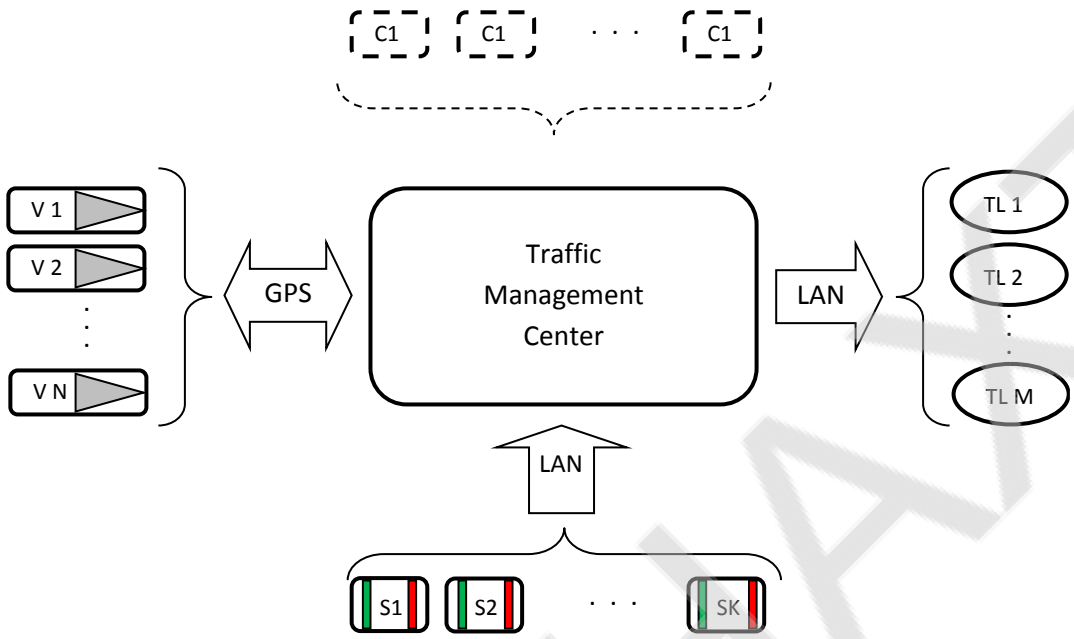


Fig.4. Two adjacent crossroads – A and B. The vehicles driving to the section of the road between these intersections are shown. The red bars are the input sensors. The output sensors are represented as three green stripes in a row – each strip is equipped with its own sensor. It is shown the routes of the vehicles at number 1 and 4. The data from input and output sensors is coming to TMS.

measuring and computing complex (MCC) and then to TMS. In this way, lines between adjacent intersections are under control. Input sensors register all vehicles as a whole, driving to the lane A_h ® B_h from all possible directions of the intersection A, that is, the total number of the vehicles. These sensors also play a fundamental role in the transmission of updated routes to cars – as soon as the vehicle has crossed the input sensor, the program at the TMS calculates and transmits a new vehicle route. The output sensors register the cars separately, that is, for each individual line of the road. Following, the number of output sensors is equal to the number of lines of the carriageway in one direction. The presence of input and output sensors, makes possible fully register the transport flows. In order to regulate such flows, the t-optimal routes are laid for all vehicles involved in traffic. In large cities, the number of cars on the streets at peak hours can reach up to a million. This means that their flows must be reconciled, synchronized, by the way of finding the optimal route for each vehicle.



V – vehicle,

TL – traffic lights,

S – road sensors,

LAN – local area network (f.e. LoRaWAN),

C – camera.

Fig. 5. An interaction scheme of the TMC with cars, traffic lights at intersections and sensors. Video cameras are also shown as an additional source of cross-traffic information.

In Fig. 5 schematically presented the processes of interaction between TMS and traffic components – cars, road sensors, traffic lights. Video cameras are used as an additional source of information on urban network congestion.

Technically, the process of optimizing traffic flows consists in transferring data from the MCC to the TMC, where, based on a special program, t-optimal routes of traffic for each vehicle are calculated. Then, the traffic routes are transmitted to each driver on the GPS navigator. As the data is constantly updated, the program, which will be presented below, is constantly searching for t-optimal routes for all vehicles in a metropolis. Here, optimality is determined by fulfilling the following condition:

$$\sum_{h=1}^{f} (N^{i}_{A_hB_h} / (n^{i}_{A_hB_h}))l_{A_hB_h} \to min. \qquad (1)$$

Here $N^{i}_{A_h B_h}$ – the number of cars driving on a line i of the road section A_h ® B_h; $n^{i}_{A_h B_h}$ – the number of cars leaving the line i; h – an index numbering the sections of the road that make up the whole route. Number f – is the number of sections of road that form the route; $l_{A_h B_h}$ – length of the road section h.

In the Listing 1 the instruction

```
double ra2_1 = (1 + (double) k.nextInt(5)) * L2_1,
```

corresponds presented up condition (1), where `ra2_1` is an attitude with the number of vehicles driving on a road between adjacent intersections and those who leaving it.

In expression (1) time t is clearly not included! The question then is: why does this condition correspond to the optimality condition over time? In this connection it is need to consider the relation appearing in the multiplication of the expression (1):

$$N^{i}_{A_h B_h} \Big/ n^{i}_{A_h B_h} \quad . \qquad (2)$$

The magnitude (2) has a great influence on a duration of a trip. Suppose that the relation (2) is equal three in the middle. This actually means that at each intersection the car is delayed for three periods (cycles) of traffic light switching. If one cycle of the traffic light switching is approximately 70 s, then the delay at each intersection will be 210 s, and we will get a very significant value along the whole route. Ideally, the value (2) should be within a unit: in such case trip time will be reduced by three times! Our algorithm, using (1), searches such route for which value (2) is approximately equal unit. That is why condition (1) is a criterion for optimality over time.

In general, the value of the relation (2) for each section of the road can take a wide range of values. Consider two extreme options:

$$N^{i}_{A_h B_h} / (n^{i}_{A_h B_h}) \; \square \; 1, \qquad (3)$$

$$N^{i}_{A_h B_h} / (n^{i}_{A_h B_h}) \gg 1. \qquad (4)$$

In the case of condition (3), the edge of a graph (in other words, the traffic line between adjacent intersections) is closed to traffic, since cars drive on the line of the road, but they are delayed for a long time on this line (the wait time exceeds several switching cycles traffic light). In fact, this means that such line of the road is closed for traffic, and therefore the program will bypass it laying the optimal route and redirects cars to less load directions. As already mentioned, the other point in case (4) – the corresponding lines of the road are free for traffic, the dynamics of car on them is maximum (or close to that), and therefore the corresponding links of the road between the intersections will be included in the calculated t-optimal route.

The computer program below (Listing 1) implements an A*-algorithm which is inherently optimization one. The program contains three classes – Astar, Node and Edge. In the field of the first of the named classes all constructors of the nodes of the

graph presented in Fig. 3 are implemented. The initGraph () method of the same class contains the Random () constructor, which is used to generate car line downloads. The parameters of this constructor are chosen in such way that the traffic congestion (values of type ra2_1) lie within $1 \div 10$, which corresponds to the real situation on city streets. Type constructors

```
b1_2.adjacencies = new Edge[]{
new Edge(a2_3, ra2_3),
new Edge(b2_3, rb2_3),  };
```
(5)

describes the interaction between the edges of a graph (in other words, between lines). It is noteworthy that it adheres to the traffic rules (TR). Indeed, if we analyze (5), it can be seen that from the line b1_2, that is, the middle line, it is possible to cross the intersection 2 only directly (see Fig. 3), to get into the lines a2_3 and b2_3, but not to turn left or right. And in such manner throughout the graph for all lines. Thus, the program completely reproduces the real situation on the city roads and can serve as a guide for drivers. It is need to note that the initGraph () method of the Astar class includes all constructors of type (5). However, the number of such constructors is equal to the number of edges in the graph (last number is equal 65). Accordingly, the length of this method is quite large and therefore we cannot give it completely. We give only constructors for two nodes. It is important to note that A* algorithm operates on quantities $f(n)=g(n)+h(n)$, where $g(n)$ is a distance in the graph from the starting vertex to the current one. The $h(n)$ is so called heuristic distance, measured in a straight line from the current vertex n to the end (in the Astar class field, the node constructors include as arguments the heuristic spectrum measured with respect to the specified starting and finishing positions shown in Fig. 3).

Listing 1.

```
import java.util.*;
public class Astar {
        static Node a1_2 = new Node("a1_2-Liberty avenue", 962);
        static Node b1_2 = new Node("b1_2-Liberty avenue", 962);
        static Node c1_2 = new Node("c1_2-Liberty avenue", 962);
        static Node a1_5 = new Node("a1_5-Freedom street", 1002);
        static Node b1_5 = new Node("b1_5-Freedom street", 1002);
        static Node a2_1 = new Node("a2_1-Liberty avenue", 962);
        static Node b2_1 = new Node("b2_1-Liberty avenue", 962);
        static Node c2_1 = new Node("c2_1-Liberty avenue", 962);
        static Node a2_6 = new Node("a2_6-Heroes street", 733);
        static Node b2_6 = new Node("b2_6-Heroes street", 733);
        static Node a2_3 = new Node("a2_3-Broad street", 753);
        static Node b2_3 = new Node("b2_3-Broad street", 753);
        static Node a3_2 = new Node("a3_2-Broad street", 753);
        static Node b3_2 = new Node("b3_2-Broad street", 753);
        static Node c3_2 = new Node("c3_2-Broad street", 753);
        static Node a3_4 = new Node("a3_4-Short street", 658);
        static Node b3_4 = new Node("b3_4-Short street", 658);
        static Node a3_7 = new Node("a3_7-Valley street", 504);
        static Node b3_7 = new Node("b3_7-Valley street", 504);
        static Node a4_3 = new Node("a4_3-Short street", 658);
        static Node b4_3 = new Node("b4_3-Short street", 658);
        static Node a4_11 = new Node("a4_11-Long street", 325);
        static Node b4_11 = new Node("b4_11-Long street", 325);
        static Node a5_1 = new Node("a5_1-Freedom street", 1002);
        static Node b5_1 = new Node("b5_1-Freedom street", 1002);
```

HK Draft

```
        static Node a5_6 = new Node("a5_6-Middle street", 777);
        static Node b5_6 = new Node("b5_6-Middle street", 777);
        static Node a5_8 = new Node("a5_8-Victory street", 887);
        static Node b5_8 = new Node("b5_8-Victory street", 887);
        static Node a6_5 = new Node("a6_5-Middle street", 887);
        static Node b6_5 = new Node("b6_5-Middle street", 887);
        static Node a6_2 = new Node("a6_2-Heroes street", 733);
        static Node b6_2 = new Node("b6_2-Heroes street", 733);
        static Node c6_2 = new Node("c6_2-Heroes street", 733);
        static Node a6_7 = new Node("a6_7-Happy street", 523);
        static Node b6_7 = new Node("b6_7-Happy street", 523);
        static Node c6_7 = new Node("c6_7-Happy street", 523);
        static Node a6_9 = new Node("a6_9-Joy street", 569);
        static Node b6_9 = new Node("b6_9-Joy street", 569);
        static Node a7_6 = new Node("a7_6-Happy street", 523);
        static Node b7_6 = new Node("b7_6-Happy street", 523);
        static Node a7_3 = new Node("a7_3-Valley street", 504);
        static Node b7_3 = new Node("b7_3-Valley street", 504);
        static Node a7_10 = new Node("a7_10-Trump street", 289);
        static Node b7_10 = new Node("b7_10-Trump street", 289);
        static Node a8_5 = new Node("a8_5-Victory street", 887);
        static Node b8_5 = new Node("b8_5-Victory street", 887);
        static Node c8_5 = new Node("c8_5-Victory street", 887);
        static Node a8_9 = new Node("a8_9-Lincoln street", 713);
        static Node b8_9 = new Node("b8_9-Lincoln street", 713);
        static Node a9_6 = new Node("a9_6-Joy street", 569);
        static Node b9_6 = new Node("b9_6-Joy street", 569);
        static Node b9_8 = new Node("b9_8-Lincoln street", 713);
        static Node a9_8 = new Node("a9_8-Lincoln street", 713);
        static Node a9_10 = new Node("a9_10-Kennedy street", 400);
        static Node b9_10 = new Node("b9_10-Kennedy street", 400);
        static Node a10_7 = new Node("a10_7-Trump street", 289);
        static Node b10_7 = new Node("b10_7-Trump street", 289);
        static Node a10_9 = new Node("a10_9-Kennedy street", 400);
        static Node b10_9 = new Node("b10_9-Kennedy street", 400);
        static Node a10_11 = new Node("a10_11-Apple street", 125);
        static Node b10_11 = new Node("b10_11-Apple street", 125);
        static Node a11_10 = new Node("a11_10-Apple street", 125);
        static Node b11_10 = new Node("b11_10-Apple street", 125);
        static Node a11_4 = new Node("a11_4-Long street", 325);
        static Node b11_4 = new Node("b11_4-Long street", 325);
        static Node nodes[] = new Node[]{
a1_2, b1_2,c1_2, a1_5, b1_5, a2_1, b2_1,c2_1,a2_6,b2_6, a2_3, b2_3,
a3_2, b3_2,c3_2,a3_4, b3_4,a3_7,b3_7,a4_3,b4_3,a4_11,b4_11,a5_1,
b5_1,a5_6,b5_6,a5_8,b5_8,a6_5,b6_5,a6_2,b6_2,c6_2,a6_7,b6_7,c6_7,
a6_9,b6_9,a7_6,b7_6,a7_3,b7_3,a7_10,b7_10,a8_5,b8_5,c8_5,a8_9,
b8_9,a9_6,b9_6,b9_8,a9_8,a9_10,b9_10,a10_7,b10_7,a10_9,b10_9,a10_11,
                b10_11, a11_10,b11_10,a11_4,b11_4  };
        public static void initGraph() {
            Random k = new Random();
            int L2_1 = 320;
            double ra2_1 = (1 + (double) k.nextInt(5)) * L2_1;
            double rb2_1 = (1 + (double) k.nextInt(5))  * L2_1;
            double rc2_1 = (1 + (double) k.nextInt(5)) * L2_1;
            a1_2.adjacencies = new Edge[]{
                    new Edge(a2_1, ra2_1),
                    new Edge(b2_1, rb2_1),
                    new Edge(c2_1, rc2_1),};
                      int L2_3 = 340;
            double ra2_3 = (1 + (double) k.nextInt(5)) * L2_3;
            double rb2_3 = ((1 + (double) k.nextInt(5))  * L2_3;
            b1_2.adjacencies = new Edge[]{
                    new Edge(a2_3, ra2_3),
                    new Edge(b2_3, rb2_3),
```

After that, in the main method of the program and in the classes Node and Edge the route between the lines b1_2 and b10_11 (in Fig. 3 these lines are highlighted) is implemented.

```
            public static void main(String[] args) {
            initGraph();
            AstarSearch(b5_6, b10_11);
            List<Node> path = printPath(b10_11);
            System.out.println("Path: " + path);
            while (path.size() > 1) {
                Node node = path.get(1);
                node.parent = null;
                for (Node n : nodes) {
                    n.parent = null;
                initGraph();
                AstarSearch(path.get(1), b10_11);
                path = printPath(b10_11);
                System.out.println("Path: " + path);
            }
                    }
        public static List<Node> printPath(Node target) {
            ArrayList<Node> path = new ArrayList<Node>();
            for (Node node = target; node != null; node = node.parent) {
                path.add(node);
            }
            Collections.reverse(path);
            return path;
        }
        public static void AstarSearch(Node source, Node goal) {
            Set<Node> explored = new HashSet<Node>();
            PriorityQueue<Node> queue = new PriorityQueue<Node>(100, new
Comparator<Node>() {
                //override compare method
                public int compare(Node i, Node j) {
                    if (i.f_scores > j.f_scores) {
                        return 1;
                    } else if (i.f_scores < j.f_scores) {
                        return -1;
                    } else {
                        return 0;
                    }
                }
            });
            source.g_scores = 0;
            queue.add(source);
            boolean found = false;
            while ((!queue.isEmpty()) && (!found)) {
                Node current = queue.poll();
                explored.add(current);
                if (current.value.equals(goal.value)) {
                    found = true;
                }
                    for (Edge e : current.adjacencies) {
                    Node child = e.target;
                    double cost = e.cost;
                    double temp_g_scores = current.g_scores + cost;
                    double temp_f_scores = temp_g_scores +
child.h_scores;
                      if ((explored.contains(child)) &&
                            (temp_f_scores >= child.f_scores)) {
                        continue;
                    } else if ((!queue.contains(child)) ||
                            (temp_f_scores < child.f_scores)) {
```

```
                    child.parent = current;
                    child.g_scores = temp_g_scores;
                    child.f_scores = temp_f_scores;
                    if (queue.contains(child)) {
                        queue.remove(child);
                    }
                    queue.add(child);
                }
            }
        }
    }
}
class Node {
    public final String value;
    public double g_scores;
    public final double h_scores;
    public double f_scores = 0;
    public Edge[] adjacencies;
    public Node parent;
    public Node(String val, double hVal) {
        value = val;
        h_scores = hVal;
    }
    public String toString() {
        return value;
    }
}
class Edge {
    public final double cost;
    public final Node target;
    public Edge(Node targetNode, double costVal) {
        target = targetNode;
        cost = costVal;
    }

    public String toString() {
        return "Edge(" + target + ", " + cost + ")";
    }
}
```

Running the program, we can get the result below (another program launch usually gives other data due to the action of the random numbers generator):

Path1: [b1_2-Liberty avenue, **b2_3-Broad street**, b3_7-Valley street, a7_6-Happy street, a6_9-Joy street, b9_10-Kennedy street, b10_11-Apple street]
Path2: [b2_3-Broad street, **b3_7-Valley street**, a7_6-Happy street, a6_9-Joy street, b9_10-Kennedy street, b10_11-Apple street]
Path3: [b3_7-Valley street, **a7_6-Happy street**, a6_9-Joy street, b9_10-Kennedy street, b10_11-Apple street]
Path4: [a7_6-Happy street, **a6_9-Joy street**, b9_10-Kennedy street, b10_11-Apple street]
Path5: [a6_9-Joy street, **b9_10-Kennedy street**, b10_11-Apple street]
Path6: [b9_10-Kennedy street, **b10_11-Apple street**]
Path7: [b10_11-Apple street]

The result of the program has a row of specific features. The calculated route is a set of steps of type Path1 –Path7. Particularly note that the transitions from one step to another are interconnected and are carried out using the calculation result in the previous step – the program intercepts the second position of the previous calculated route (these key lines are highlighted) and starting from this position calculates a new route. It is implied that the route calculated in the first step will be preserved only

during the journey by the driver of only one line – due to the high dynamism of urban traffic. As soon as the vehicle has crossed the intersection, the program calculates a new route, starting each time from the second pre-calculated position. For example, Path2 uses the b2_3-Broad street as a starting position (which stands second in Path1) to calculate a new route. The program then uses b3_7-Valley street as the starting position for calculation of Path3. The following routes are similarly calculated until the final position is reached (in this case, the b10_11-Apple street line). As emphasized above, the transmission of the updated route is initiated by the input sensors – as soon as the car crosses the input sensor, the program on the TMS calculates and transmits a new path to the GPS navigator. Thus, thanks to constantly updated routes, the traffic software has a high degree of dynamism and at the same time is very comfortable for every driver *because the driver is able to adjust to the desired line, as every new instruction comes to him immediately after crossing the intersection.*

As all cars (or the vast majority of them) will move along t-optimal routes, complete synchronization of traffic flows will occur, resulting in fundamentally new quality and, as a consequence, to the disappearance of traffic jams (or their abrupt reduction) in the city transport networks. This circumstance will allow each driver to arrive at his destination in a shortest possible time. Thus, urban traffic has transformed into a fundamentally new state.

Testing of Listing 1 program had been performed on graphs with vertices up to 165 and edges up to 445. It is need to note that the complexity of the A*-algorithm is linear O (n), which makes it quite efficient for the tasks with a large amount of input data.

The testing of the described algorithm was carried out by modeling the transport network with the help of the highly efficient AnyLogic 8.5.1 simulation program [16]. The simulation results show a significant increase in the capacity of urban transport networks compared to the standard mode when using conventional GPS navigation.

V. CONCLUSION

The work has practical nature and aims at a real solution of traffic problem in big cities. According to the results of the investigation, an article [14] had been published.

Model experiments show the full acceptability of the algorithm for the purposes of technical implementation. This circumstance will help get rid of the problems of every major city – congestions – and it will make easier for drivers to follow along stated route. The traffic climate on cities` streets will improve significantly – congestions will not be a great problem!

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MEASURING SYSTEM TO MONITOR DEFORMATION OF LARGE SIZE STRUCTURE MEMBERS

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Abstract. *About 250,000 bridges in use in the world require inspection and repair, monitoring and control of the condition of the structure. External conditions such as daily change in temperature, change in wind force and direction, rainfall, seismic shocks, and traffic load (number, weight, and speed of motor vehicle traffic on the bridge) are the most significant factors that influence the deformation of the bridge structure. The purpose of this article is to identify the most effective methods and measurement system for monitoring deformations of large structural elements. For the technical realization of this task it is necessary to develop a measuring system that will provide control of the deformation parameters of the bridge structures within the automated deformation monitoring system (ASDM). The use of a measuring system, which includes a laser beam scanner and analog-to-digital converters (ADCs), allows all measurements of deformations of objects of various lengths to digitize the ADCs "linear displacements - time - code", after which the converted information enters the computer. for further processing and storage, or for use in ASDM and others. And the use of ASDM, in turn, will allow you to quickly control the condition of the bridge structures, deflections resulting from the influence of external climatic influences, as well as intensive transport load. The developed methodology and the proposed system of measurement of deformations of large structures are proposed for the first time.*

Key words: *laser, laser beam sweep unit, photodetector, analog-digital converter.*

Introduction

Modern long length bridges can bear huge loads and strain partly because of their capacity to be slightly deformed under external conditions. The most considerable external factors that bring about the deformation of a bridge structure are the changes of external conditions such as daily air temperature, direct sunrays, wind force and direction, precipitation, wave motion, seismic shocks and traffic (intensity, weight and speed on a bridge). Even the most developed countries face problems in terms of bridges. For instance, in 2005 the Federal Highway Administration (FHWA) of the U.S. Department of Transportation established that about 15 % of 595000 American bridges do not meet design standards. In Europe about 10 % of bridge structures have defects and discrepancies between projects and bridges. All over the world about 250000 bridges in operation need inspection, repair, monitoring and control [1].

Literature review

It is necessary to periodically monitor the bridge structure making the set of the geodetic measurement of its parameters to forecast the state of a bridge structure in order to be warned in advance about the tendencies of the changes of structure geometric parameters. However, in a critical situation the measurement does not enable us to get updated information and it does not contain enough information to calculate

the real current dynamic characteristics of a structure to compare with design parameters. Therefore, at present, the task of topical interest is to develop a currently operating system that can collect, systematize, store, analyse, transform, display and disseminate the spatial coordinate data of a structure elements, which are monitored, during operation. In addition, the monitoring of such structures as bridges, having piers as high as some hundreds metres, has to be performed during construction. The monitoring of piers has to be performed before the project is implemented as the structure starts reacting to loads due to the changes of temperature, wind and increasing own weight per se during construction. It, in turn, can cause both the spatial deformation of the structure and the deviation from the project [1].

During the construction of bridges it is necessary to carry out periodical and permanent monitoring. However, as the construction process is coming to its completion, the permanent monitoring will grow in significance. The monitoring of a bridge state has to be fully performed during the construction as well as maintenance of bridge.

The use of the automated system of deformation monitoring (ASDM) for a bridge enables us to efficiently monitor the state of a bridge structure, its displacement and deflection that come into existence as a result of external natural and climatic factors as well as intensive traffic [1].

The indisputable advantages of the ASDM over the traditional methods of deformation monitoring are as follows:

• measuring of deformation values and their permanent comparison with permissible (design) deformation values in real time;

• possibility to monitor objects 24 hours, 365 days with specified resolution;

• high precision and uniformity of measuring, operator's error elimination;

•remote control of the ASDM. Automatic data collection, the preliminary analysis of the information and sending it to any terminal using the Internet or other communication channels are carried out;

•the ASDM can be designed in such a way that, when critical values or dangerous tendencies (speeding up) of deformation processes are detected in an object, an alert with automatic notification of authorities is triggered using communication links to make an urgent decision, avoid accidents and save people.

The automated system of deformation monitoring allows us to measure non-stop the deformations (displacements) of object structure elements. Digital monitoring sensors help us detect object deformations if they are beyond standards. It guarantees pinpoint accuracy in real time using the appropriate specification and configuration of the ASDM. The results of measurement from various gauges provide information about the conditions of object operation and their impact on geometric stability and durability of objects. So, the ASDM enables us to analyse deformations and model the forecast of an object behaviour in general and its structural components in particular [2].

To control and forecast the state of a bridge structure with the ASDM, optical methods to measure deformation are widely spread. Due to various optical systems, practically all images, starting with medical papers on a cell level, the pictures of the surface of nuclear reactor fuel elements and ending with cartographic data and the measurements of the deformation of various length objects, have high precision and

clearness. Then the images are digitized with the help of analog-digital converters (ADC) and enter a computer to be further processed and stored or used by the ASDM, an automatic control system to control a technological process etc. To convert measured information about object parameters into digital form, the analog-digital converters “analog – time – code”, “analog – frequency – code” and “analog – phase – code” are used. An analog-digital converter engineering approach to convert information came into existence in the 70s–80s of last century [3].

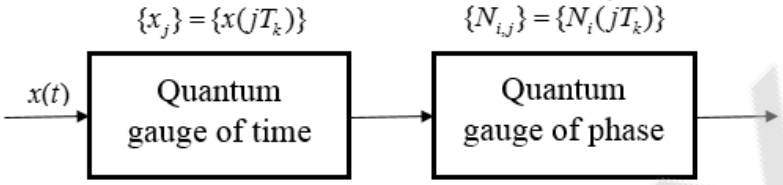

Fig.1. Functional scheme of ADC

The ADC receives the input analog signal $x(t)$ that, having passed through a sampler, is converted into the sequence of samples $x(jT_k)$. A quantizer converts the sequence of samples into the sequence of codes $N_i(jT_k)$ where the index *i* corresponds to the *i*-th level.

At present the ADC continues developing and improving in terms of operation speed, noise immunity, precision and microminiaturization [4]. For example, in a device to measure deformation, a multielement photodetector, which is designed as a matrix, detects the quantity and direction of deformation. If a narrow-beam light pulse simultaneously comes to several photocells of a multielement photodetector, deformation distance and direction are calculated as arithmetical mean value of the quantity of all lighted photocells [5].

Geometric scanning systems, similar to that described in [6], can form the basis for the measurement of the deformation of long length objects.

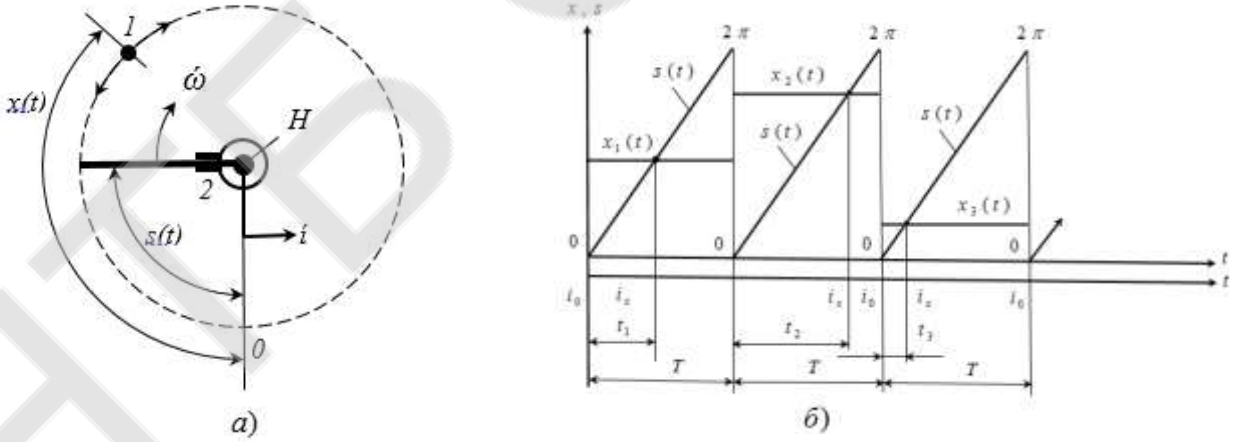

Fig.2. Geometric scanning system

In a geometric scanning system (Fig. 2, a), the parameter, which is scanned, is an angle *x(t)* that determines the location of object 1 on a circular trajectory. The scanned element 2, which is in the centre of a circle, is a prism or mirror. They are located on an engine shaft at an angle of 45° with a laser beam. During uniform rotation with angular velocity $\omega = const$ element 2 periodically meets zero sign 0 and object 1 at angles $s = 0$ and $s = x$. At the same time the zero control *H* of on-off action generates pulses i_0 and i_x that on a geometric or temporal scale correspond to instant angles s_0

and s_x. These pulses can be transmitted at distance or used at the spot to monitor and control [5].

The process of scanning in Fig. 2, b has a sawtooth function $s = \omega \cdot t$ over a period of $T = 2 \cdot \pi / \omega$ and current time $t = s / \omega$. The diagram shows three angular positions x_1, x_2 and x_3 that correspond to the points of time t_1, t_2 and t_3, the meeting of elements and the generating of pulses i_x. Time is calculated from the beginning of each cycle [5].

These systems are the basis to design some equipment that contain *n* sequentially allocated strain gauges, which are rigidly fixed on a structure in deformation; each of them has a semi-reflecting mirror, cross mark, light source, light receiver, focusing unit and scanning light unit that are located sequentially along an optical axis between a light receiver and semi-reflecting mirrors. At the same time, *n* light sources and *n* cross marks are also located along the optical axis of each gauge that is perpendicular to a main optical axis between a semi-reflecting mirror and a light source. In addition, the gauge has a detector and a switching unit whose input is linked to a light receiver and outputs are linked to a focusing unit, *n* light sources and a detector that contains a measuring circuit and a computing unit [7, 8].

Aim and problem statement

The aim of this paper is to determine the most effective methods and a measuring system to monitor the deformation of large size structure elements. In order to technically perform this task, it is necessary to design a measuring system that guarantees the monitoring of bridge structure deformation parameters when using the ASDM.

Design of measuring system

As part of the ASDM, the measuring system of bridge structure deformation, which consists of a laser, optical collimator, unit of laser beam sweep, *n* photodetectors, switching unit, converter "linear displacements – time – code" and detector, is proposed. All *n* photodetectors are *n* sequentially located strain gauges that are horizontally positioned on supports at an equal distance from one another along a structure and rigidly fixed on the structure in deformation. They can be, for instance, electric poles to light a road on a bridge (Fig. 3) or special supports, which are in Fig. 4.

Fig. 3. Electric lighting of roadway on the bridge

Fig. 4. Special supports to fix strain gauges-photodetectors.

The output of every *n* photodetector is connected to the inputs of a switching unit and its output – to the input of the converter "linear displacement – time – code", which output is connected with the input of a recorder; every consecutive photodetector, which is fixed to a pole, is located at a certain equal distance from one another vertically, and the first and *n*-th photodetectors, laser, optical collimator and a unit of laser beam sweep are located beyond the bounds of the structure in deformation.

The system operates as follows. To measure the deformation of a large size structure, *n* photodetectors 3_1, …, 3_n are used. They are *n* consecutively located strain gauges, which are fixed to supports 2_1, …, 2_n that are at a certain equal distance d from one another horizontally along structure 1 and rigidly fixed to the structure (Fig. 5). The first and *n*-th photodetectors are located beyond the bounds of the structure. In addition, laser 4, optical collimator 5 and a unit 6 of laser beam sweep 7 are located beyond the bounds of the structure. The gauge uses a laser that continuously radiates a beam of a certain wavelength. The optical collimator, which consists of a lens, which has the output of a laser beam in its focal plane, is located in series with the laser. Optical collimator 5 guarantees a parallel laser beam and due to practically zero divergence all the energy of a laser beam is focused on the sensitive surface of each photodetector, which is made of a special material that creates no obstacle for a laser beam.

The *n* photodetectors contain a photodiode or photoelectric multiplier. A sensitive surface and an optical filter, which let the beam of a certain wavelength pass, are positioned before a photoelectric multiplier. All the elements of a photodetector are in a hermetic container. The unit 6 of laser beam sweep, for example, is a motor which shaft houses a

mirror or a prism having a mirror face, which are located at an angle of 45° with a laser beam, or a rotary optical wedge due to which a laser beam sweeps in the vertical plane.

The optical signal, which sweeps, from a unit 6 of laser beam sweep sequentially passes the sensitive surface of every 3_1, …, 3_n photodetector of a certain length *h* (Fig. 5, Fig. 6).

An electric signal from a photodiode or photoelectric multiplier goes to the electric signal amplifier of a photodetector and after amplification it goes to a switching unit 8. The time span of an electric pulse coming from the output of a photodetector is determined by the beam transmission rate along the sensitive surface of a photodetector. The rate will, in turn, be determined by both the angular velocity $\dot{\omega}$ of the motor of a sweep unit and the distance *R* between a sweep unit and a photodetector (Fig. 5, Fig. 6).

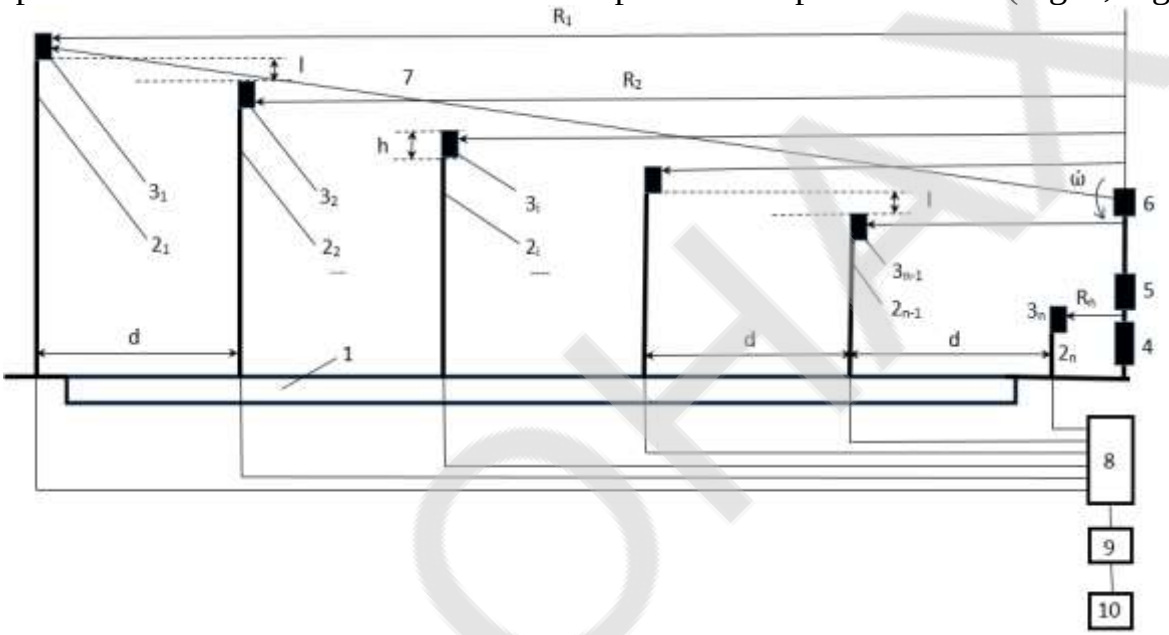

Fig. 5. General view of device and position of photodetectors on a structure without deformation.

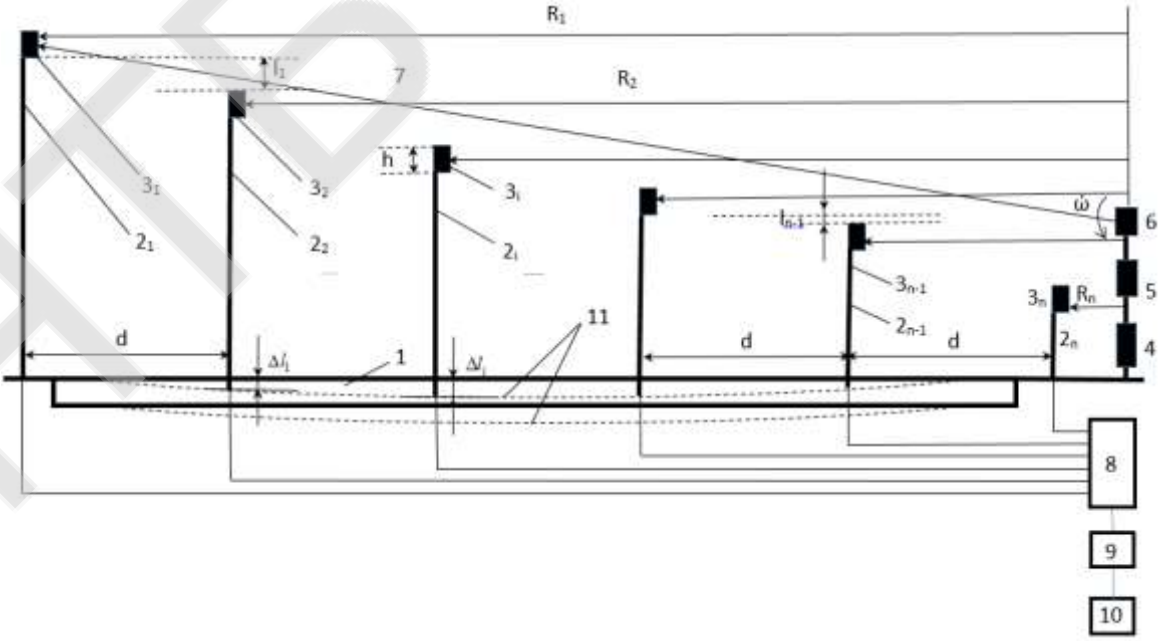

Fig. 6. General view of device and position of photodetectors on a structure with deformation.

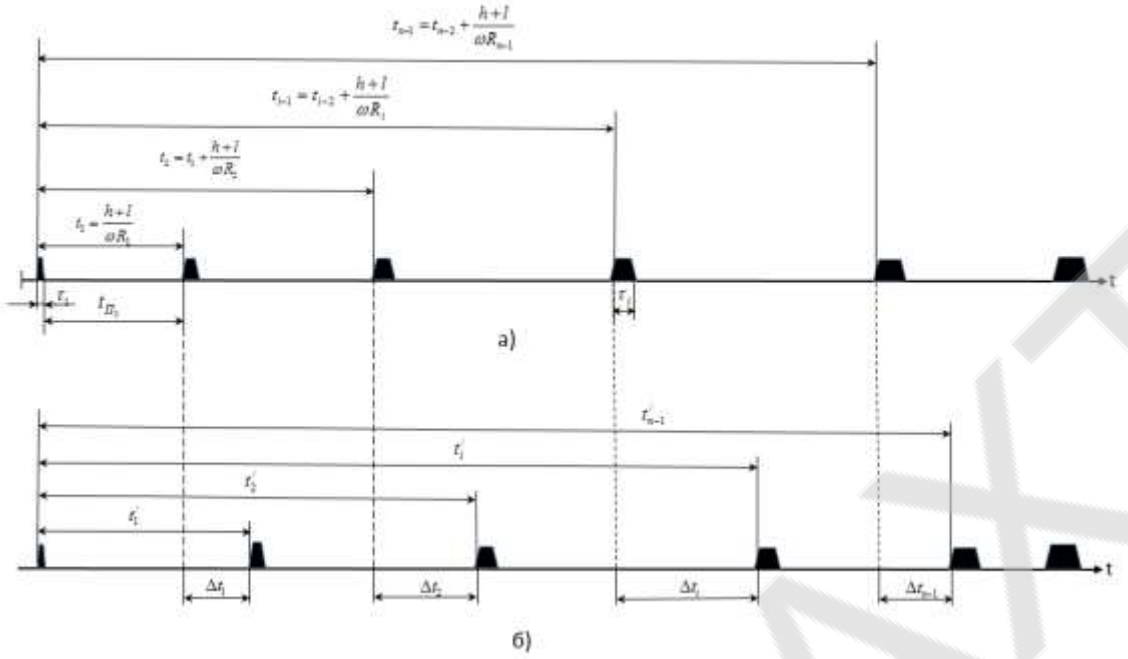

Fig. 7. Time chart of device operation without structure deformation (a) and with structure deformation (b).

So the time span of pulses from a photodetector will vary; it will be increasing when a photodetector is approaching a sweep unit (Fig. 7 a, b)

$$\tau_1 = \frac{h}{\omega R_1}, \tag{1}$$

where $\omega = 2 \cdot \pi \cdot f$ is the angular velocity of motor rotations; R_1 is the distance between the sweep unit of a laser beam and the first photodetector.

Then for the i of the photodetector, the pulse time span will be

$$\tau_i = \frac{h}{\omega R_i}, \tag{2}$$

where $i = 1 \ldots n$.

The distance l between photodetectors is the same in the vertical plan (Fig. 5), the distance (pause) between electrical pulses will be increasing as photodetectors are approaching a sweep unit (Fig. 7, a).

$$t_{П_i} = \frac{l}{\omega R_i}, \tag{3}$$

where $t_{П_i}$ is the distance between the electrical pulses of two photodetectors; l – the distance (pause) between photodetectors; $i = 1 \ldots n\text{-}1$.

As the first 3_1 photodetector is beyond the structure in deformation, the calculation of deformation Δl_i is made relative to the first photodetector (Fig. 7, a). So

$$t_1 = \tau_1 + t_{П_1} = \frac{h+l}{\omega R_1},$$

$$t_2 = t_1 + \frac{h+l}{\omega R_2}, \tag{4}$$

$$t_i = t_{i-1} + \frac{h+l}{\omega R_i},$$

$$t_{n-1} = t_{n-2} + \frac{h+l}{\omega R_{n-1}}.$$

If the structure is deformed (dotted line 11 in Fig. 6), the vertical distance between photodetectors will change from l_1 to l_{n-1} respectively (Fig. 6). So the time span of pulses will be similar to the structure before deformation (Fig. 5) but the time span between pulses and the period of pulse-passing time will change respectively and depend on Δl_i

$$\Delta l_i = l_i - l, \quad (5)$$

where Δl_i – deformation value; $i = 1 \ldots n\text{-}1$.

Analogous (4) calculation $t_1^{/}, t_2^{/}, \ldots, t_i^{/}, \ldots, t_{n-1}^{/}$ is made for a deformed structure too (Fig. 7, b).

Then

$$\frac{t_i}{t_i^{/}} = \frac{l}{l_i}, \quad (6)$$

therefore

$$l_i = \frac{l \cdot t_i^{/}}{t_i}. \quad (7)$$

Then, taking into consideration (5), equation (7) has a form

$$l + \Delta l_i = \frac{l \cdot t_i^{/}}{t_i}. \quad (8)$$

Therefore

$$\Delta l_i = \frac{l \cdot t_i^{/} - l t_i}{t_i} = \frac{l \cdot (t_i^{/} - t_i)}{t_i}, \quad (9)$$

but $\Delta t_i = t_i^{/} - t_i$ (Fig. 5, b).

So equation (9) has a form

$$\Delta l_i = \frac{l \cdot \Delta t_i}{t_i}. \quad (10)$$

Signals from photodetectors $3_1, \ldots, 3_n$ through switching unit 8 go to converter 9 ADC "linear displacement – time – code", then they go to recorder 10 after having been converted and calculated. The calculation of t_i and $t_i^{/}$ in equation (9) is made using either the traditional method, for instance, of the filling of the intervals between two rising edges of the pulses of two corresponding photodetectors with the pulses of a stable frequency clock generator or the nonius method using a shock-excited oscillator, which are in converter 9, and l is known beforehand.

Conclusions

The deformation measuring system can be used in the ASDM of bridge structures and other members of large size structures. It enables us to efficiently monitor their state, displacement and bend that come into existence as the result of external natural climatic impacts as well as intensive traffic.

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HARDWARE-SOFTWARE COMPLEX TO RESTORE FINGER MOVEMENT COORDINATION AND COLOR PERCEPTION

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Abstract*. After the damages of the cervical-thoracic spine and hand nerves, the motor and/or sensory functions are impaired, especially fine motor skills of each finger individually or a group of fingers. The results of injuries in the cervical spine can also lead to atrophy of the optic nerve. In this case, it becomes quite difficult to distinguish colors, color perception is distorted. This is especially true of red color. The work presents the results of the development and testing series of diagnostic and training (DT) devices "Reflex-Txx" for the physical rehabilitation program (therapy) of these patients. As a working element of the device, a movable zone, rotating on a servo drive, with Hall sensors or touch buttons for contact with hand fingers in different DT device models of the series "Reflex-Txx" has used. The electronic components and architecture of the developed devices are described as the minimal cost of hardware implementation. For this purpose, an Arduino platform is used in the developed DT devices. The average-moving method was used to research the effectiveness of training techniques. The statistics of a current training session is displayed on the LCD screen of a DT device. The total results are accumulated, displayed and analyzed on the microservices of the developed hardware and software complex. The mobile application was developed to visualize training data on the user's gadgets in real-time.*

Keywords*: cervical-thoracic spine/hand damages, diagnostic-training devices, Arduino, microservice architecture*

1. INTRODUCTION

In accordance with the Classification of American Spinal Injury Association Impairment Scale motor and/or sensory functions are impaired after spinal injuries [1]. In this case, muscles and joints are lost strength and mobility. Damage to the fingers of the hands can also occur as a result of congenital anomalies, office work, strokes, etc. For example, carpal ("tunnel") syndrome can begin with a decrease in the motor functions of the fingers, muscle weakness, etc. [2].

Rehabilitation programs have to combine physical therapies with exercises toward muscle strengthening and redeveloping fine motor skills. According to medics, strategies for recurring episodes of spasticity are very important. Post-stroke spasticity of the limb is one of the most frequent motor disturbances. Spasticity is reported in more than 12 million people worldwide [3]. The most common are lesions from injuries of the upper extremity (UE) pains with a rate of 26% to 96% [4].

Therapeutic exercises and a gradual increase in motion, including apparatus treadmill, loads play a leading role in the treatment of spasticity [5]. Adaptive devices also may help people with spinal cord injury and hand nerve damage to regain independence and improve mobility and quality of life. Such devices may include computer adaptations and other computer-assisted technology.

2. ANALYTICAL REVIEW OF THE LITERATURE

It is important in time, before the development of contractures ("clawed paw", "monkey paw"), to identify affected fingers (Fig. 1) and to provide the necessary hardware to carry out the training programs to overcome muscle weakness and to develop fingers.

It is advisable to follow the Management of carpal tunnel syndrome evidence-based clinical practice guidelines, adopted by the American Academy of Orthopaedic Surgeons (AAOS) in 2016 [2]. In addition to medical tests and health surveys using sophisticated equipment (Ultrasound scan, CT or MRI, X-rays, etc.), these Recommendations also provide for special simple mechanical tests. These recommendations also give examples of strong evidence that supports no benefit to routine postoperative immobilization (splinting). It says about the effectiveness of short-term difference in regards to grip strength, pinch strength, and range of motion up 17.5 months via the 4-week courses of sensory and therapy motion exercises relearning home program. Such an approach calls simple exercises running on simple, inexpensive devices. A treatment with allowing an early range of motion exercises has contributed to the improvement in motion in the short 2-week term in 2-point and 3-point pinch strength. This effect was not present follow-up ordinary immobilization even at the 3-month [2].

Fig. 1. Fingers (groups of fingers) to be diagnosted/trained

Thus, it is important not only to localize the problem, but also to contribute to the decision to train the finger (in case of muscle weakness) or to solve about immobilization the finger to reduce the risk of further complications ((in case of injury or inflammation). For some diagnoses, the doctor may also recommend doing some gentle exercises to stretch the fingers, which may help reduce stiffness and improve mobility even to participants with rheumatoid arthritis [6], [7]. This is possible with the help of special devices for practicing individual movements with your fingers.

The results of injuries in the cervical spine can also lead to atrophy of the optic nerve and as a result, it becomes quite difficult to distinguish colors, color perception is distorted, and the field of vision sharply narrows to red color [8]. Therefore, in diagnostic and training (DT) devices for detecting dichromasia, it is also advisable to include components associated with the determination of the base colors (RGB).

Specific training can improve function, coordination of fine muscle movements, and overall strength and health. Scientists note the relative effectiveness of an intensive task-specific motor training program added to standard rehabilitation compared with standard rehabilitation alone for improving hand function [9]. Early rehabilitation is

important to prevent joint contractures of the hand and fingers, as well as the loss of muscle strength [10].

Worldwide, hardware methods for the treatment of degenerative-dystrophic diseases of articular or periarticular tissues are being studied and successfully applied. the extracorporeal shockwave therapy of fingers flexor muscles in poststroke patients [11], phototherapy [12], etc.

However, it should be borne in mind that the above devices are full-scale, designed to treat all parts of the spine and joints, and therefore are characterized by large dimensions and cost. For the sake of this, it's relevant to develop small-sized low-cost DT devices, which you need to use regeneration-stimulating the regrowth of axons and targeting their connections appropriately by repeating the coordinated motions with particular fingers and finger groups.

It is also important to accumulate the results of training each individual in the database of the hardware-software complex (HSC) to adjust training regimes and achieve the best possible results. It should be noted that the transfer of a patient's personal data from the DT device to the servers occurs, mainly through the open communication channels. Based on this, vulnerabilities of wireless networks introduce additional risks to ensure the confidentiality and integrity of transmitted data [13]. As a result, the data of diagnosis and testing of patients may be distorted. If dangerous factors cannot be eliminated from communication channels, it is advisable to use methods and tools that indicate error positions in the message and focus on implementation on hardware platforms used in the HSC development [14].

JWT (JSON Web Token) technology is required to authenticate when data processes by HSC microservices. You can also use the Google Firebase Authentication Service to simplify the development process. But it should be borne in mind that in this approach, personal data of users (IP-address, e-mail, user IDs on social networks and other systems, etc.) become partially accessible to third-party service.

3. OBJECT, SUBJECT AND METHODS OF RESEARCH

The object of the research is a process for improving the coordination of finger movement through hardware training, as well as data processing on microservice platforms.

The subject of the research is the DT devices, based on information technology, for diagnostic and rehabilitation the patients with damages of cervical-thoracic spine and hand nerves.

The aim of this study is hardware and software implementation of assistive movement technology and training of color sensitivity of patients with damage of the cervical and thoracic spine and hand nerves, as well as the study of the effectiveness of use in the rehabilitation the movements of the hands and fingers of participants.

The tasks for the development of the hardware and software complex (HSC) are:

1. The development of hardware and software for DT devices and microservices.
2. Data collection from sensors in the training complex (from several types of workplaces with developed DT devices or IoT devices of industrial production).
3. View metrics in real-time.
4. Analysis of data collected over a period of time.

The average moving method was used to evaluate the effectiveness of training with the use of DT devices. This allows you to determine the degree of improvement or deterioration of patient outcomes already during training.

4. RESULTS OF WORK

4.1. Development of Diagnostic-Training Devices and Hardware-Software Complex

4.1.1. Development of Hardware

Considering the recommendations made above, a series of diagnostic and training devices "Reflex-Txx" was developed. Each device model has a movable working area, in which 3 LEDs (RGB) and sensors under them are mounted (Fig. 2). The LEDs light up alternately in random order. The patient should touch the colored area near the illuminated LED before the next light signal.

In this way, the patient's perception of RGB colors, the reaction time to the LED flash and coordination of movements are evaluated. Considering that fingers from the 1st to the 4th may need diagnostics and training (see Fig. 1), it is planned to touch the area near the flashed LED by a finger or a magnet, which is held by a pinch of 2-, 3- or 4 fingers (Table 1).

Fig. 2. Diagnostic and training devices of the "Reflex-Txx" series

Table 1 shows that for diagnosing the degree of spasticity of one finger, for example, according to Modified Ashworth Scale (MAS) of muscle spasticity [3], a touch sensor, for example, TTP223, can be placed under the disk working area. At the top, such a touch button on the "Reflex-TT3" ("Training Touch 3 Sensors") is marked with a circle of the same color as the LED next to it. (see column 3 in Table 1).

If we are talking about the damage of several fingers and the need to train them with 2-point, 3-point and 4-point pinch strength, then it is advisable to use the Magnetic holder as a tool for touching the working area (see columns 2–4 in Table 1). In this case, 3 Hall sensors are attached under the working area, for example, A3144 – one sensor near each LED (Fig. 3). The upper surface of the working area of such a "Reflex-TN3" ("Training Hall 3 Sensors") device is marked with RGB rectangles.

Arduino software implements an algorithm of a random flash of different colors on each LED, which provides training of the concentration of attention of the patient and promotes the treatment of optic atrophy.

TABLE I. Fingers (groups of fingers) to be trained

The count of training fingers	**1**	**2**	**3**	**4**
Fingers position during training				
Magnetic pinch holder	Not required			
Sensor Type	Touch	Hall	Hall	Hall
Start Score on the MAS	2–3	1–2	1–2	From 1+ up to 2
Finish Score on the MAS	1+	0	0	1

The hardware platform for the developed devices is the widespread Arduino platform. Despite the rapid departure of the microelectronics market towards the STM32 platform, the Arduino platform still holds a fairly strong position in the segment of devices for home use. These include, among others, small-sized finger training devices according to the recommendations of AAOS [2].

The convenience of Arduino for development home training programs is due to the presence of its own ecosystem of the platform, knowledgebase, C ++ programming environment, wide software functionality, accessible shields, ease of use. When equipped with high-quality electronic components from the original vendors, devices based on the Arduino platform can well satisfy the needs of the market of biomedical electronic devices for monitoring, diagnostics and treatment.

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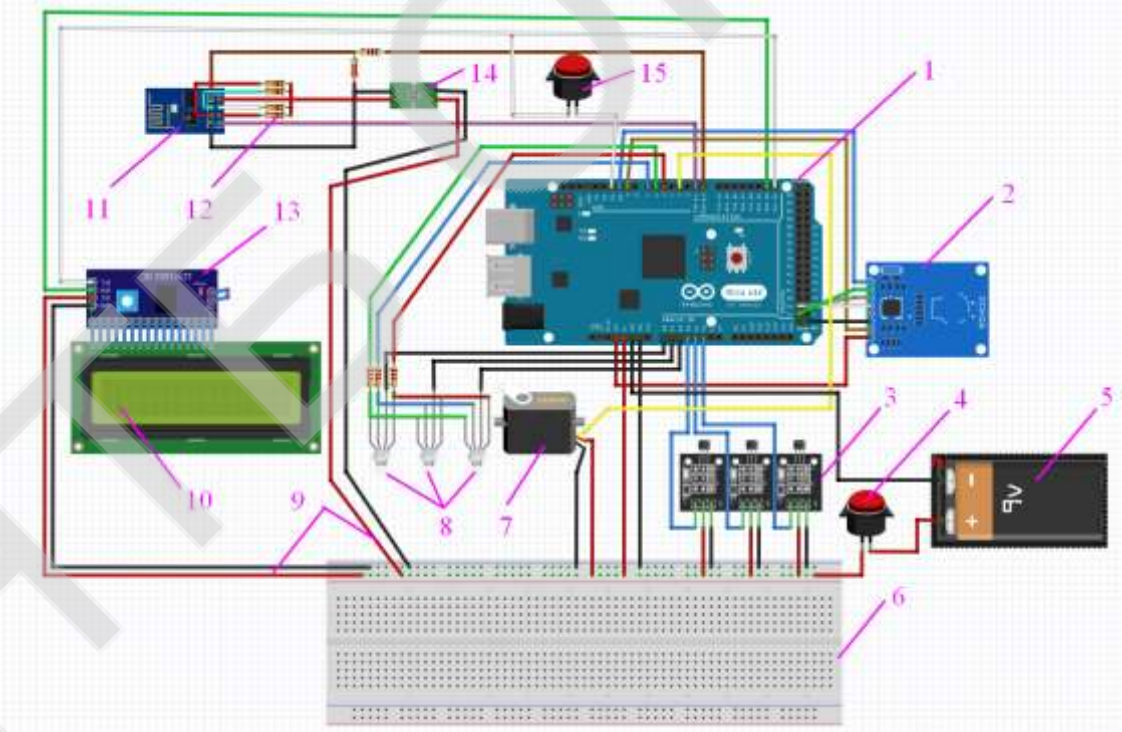
Fig. 3. Hall sensors on the working area of the DT device "Reflex-TH3" (bottom view)

An open-source software tool Fritzing v. 0.9.3 has been used to layout electronic components and document developed prototypes (Fig. 4).

The device "Reflex-Txx" rotates the work zone over a range of 30 degrees while vibrators via servomotor, for example, SG-90. The patient's task is to track the device working area movement turning own hand.



Legend: 1 – microcontroller board (central control) Arduino; 2 – RFID module; 3 – sensors (Hall or touch);4 – power button; 5 – Li-Po Battery 9 V; 6 – circuit board; 7 – servo motor; 8 – LED (RGB); 9 – breadboard Dupont jumper wires; 10 – LCD screen; 11 – Wi-Fi module; 12 – resistors; 13 – I2C module; 14 – DC converter 3V/5V; 15 – start button.

Fig. 4. Wiring diagrams of the modules in "Reflex – Txx" series DT device

Interaction of the DT of the device with the computer or the patient's own gadget is carried out using a Wi-Fi module, for example, ESP-01 of the ESP8266 series via UART using a set of AT commands.

4.1.2. **The Architecture of Hardware-Software Complex**

Developed DT devices of the “Reflex-Txx” series and industrially produced monitoring IoT devices could be considered as the Internet-of-Things nodes for Home Area Network (HAN) [15]. Such devices can connect different sensors that can be substituted further according to the medical recommendation for the patient. In comparison with known solutions, the proposed approach does not require a reprogramming device in case of sensor type has been changed.

The data received from each DT device is transmitted to the services of the developed HSC via a wireless network with the distribution of the data flow separately for each task in the context of each of 5 attempts to complete it [16].

To accomplish the tasks of research, HSC is divided into several services, each of which performs a specific task throughout the system. That is, an approach called service-oriented architecture is used during development [17].

In this case, data is exchanged, for example, between:

– DT devices that collect primary sensors data.

– Monitoring Service for HSC based on Redis Database Management System (DBMS).

– Data Analysis and Storage Service based on WebSocket technology and MongoDB DBMS.

– Single Page Application (SPA) Data Visualization Service [18] and others (Fig. 5).

Messages are JSON files, the structure of which is agreed for each pair of participants in the communication protocol.

Because HSC provides real-time metrics monitoring and long-term data storage for further analysis, it has been decided to create two separate user interfaces. To accelerate the development process for both interfaces, open Nuxt.js framework and open Vuetify component library are used.

The Nuxt.js framework, which contains libraries for Vue.js, was used to build web-based interfaces and a web server with server-side rendering, automatic routing configuration, and state management internal data.

The Vue.js framework was used to create user interfaces and to create sophisticated one-page applications (SPA) in combination with modern tools and support libraries [19].

The monitoring interface solves the problem of displaying real-time data, namely, workload schedules for each DT device and patient, coordination status metrics, and color perception of the user in the last hours of use of the system.

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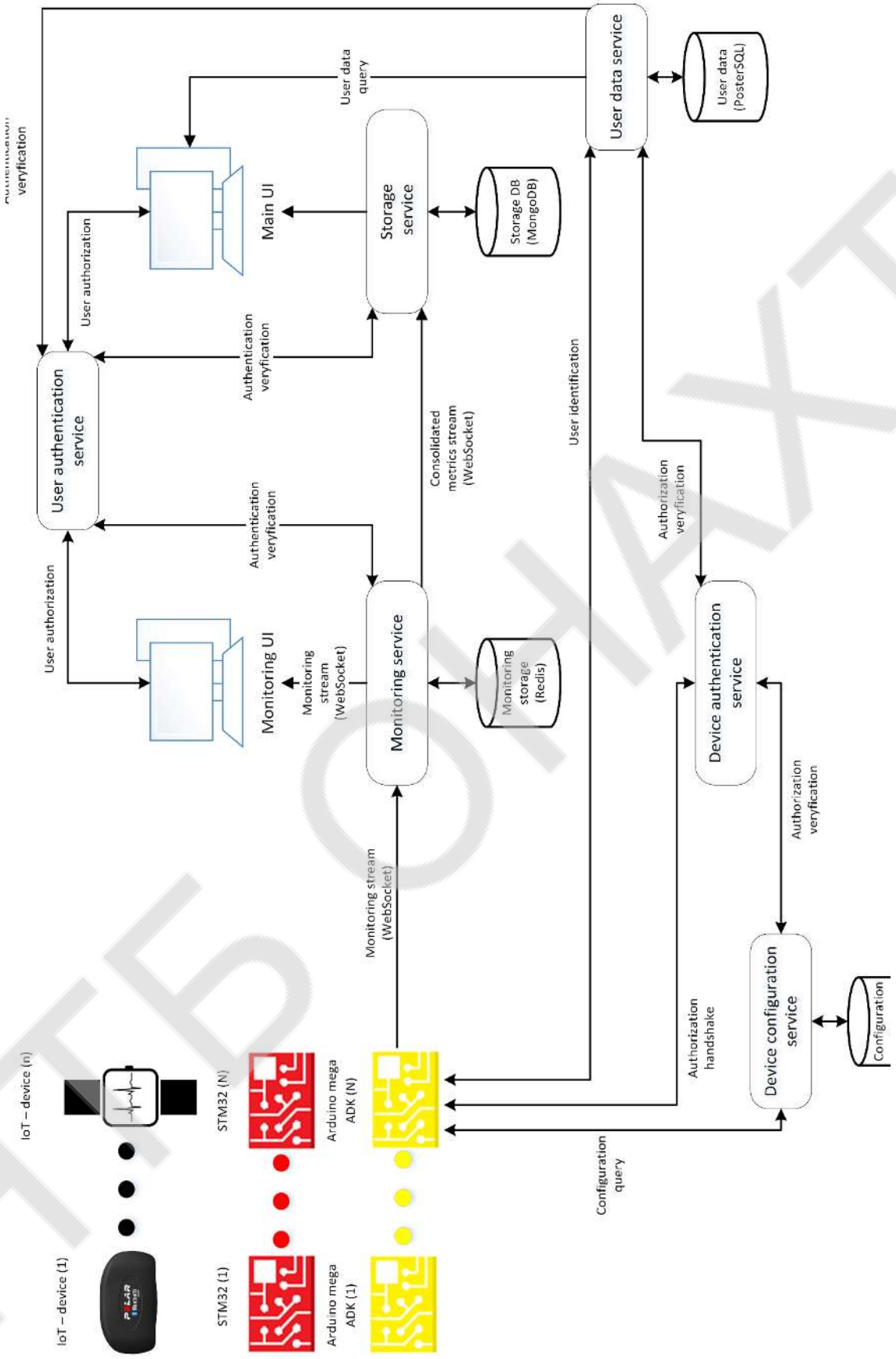

Fig. 5. The architecture of hardware-software complex to diagnostic and rehabilitation the patients

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4.2. Prepare Exercises and Measurement

4.2.1. Training mode

Following the medical advice to hold the pinch for up to 30 s before releasing it [20]. One attempt time on "Reflex-Txx" has selected 30 s divided into 20 actions. The attempt repeats up to 5 times with 10-second breaks in between.

Thus, the developed hardware-software complex supplies a series of 20 light flashes with an interval of 1.5 s to the working area of the "Reflex-Txx" device. In the case of a high level of spasticity by MAS and as a result of a slower patient reaction, this interval may be increased.

4.2.2. Data Visualization and Processing

During the work of patients with "Reflex-Txx" devices, for each of 5 attempts of a piece of training series, an oscillogram is recorded showing the patient's reaction speed to the light-emitting diode of a certain color, and average values of training indices are calculated. All results can be seen on the smartphone using the developed mobile application (Fig. 6).

Using the average moving method allows you to determine the degree of improvement or deterioration of results already during training. In this case, at first, the average value of the reaction time AVG_i is calculated as:

$$AVG_i = \frac{1}{CurCoAc} \sum_{n=1}^{Att} \sum_{i=1}^{CoAc} TR_{i,n}, \quad (1)$$

where $CoAc$ – the total number of actions in the attempt Att_n (supposed that is performed $CoAc$ = 20 actions in each attempt); $CurCoAc$ – the number of actions performed at the current time from the beginning of the attempt; $TR_{i,n}$ – reaction time on the RGB LED flash; Att – the number of attempts in session (Att = 5).

To evaluate the effectiveness of training over the course of training, the average moving time MOV_AVG_i is calculated by some neighboring actions NMA in an attempt (in example NMA = 3):

$$MOV_AVG_i = \frac{1}{NMA} \sum_{i=NMA}^{Ai=NMA} TR_i. \quad (2)$$

If the training is successful, then with its current MOV_AVG_i becomes smaller than AVG_i. that is, reaction time decreases during training time (Fig. 6).

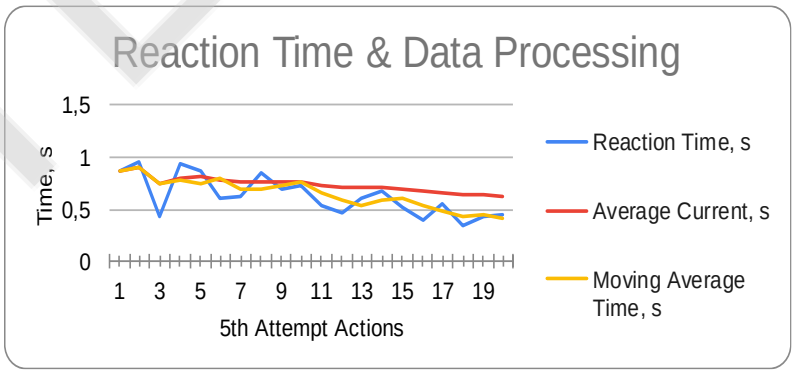
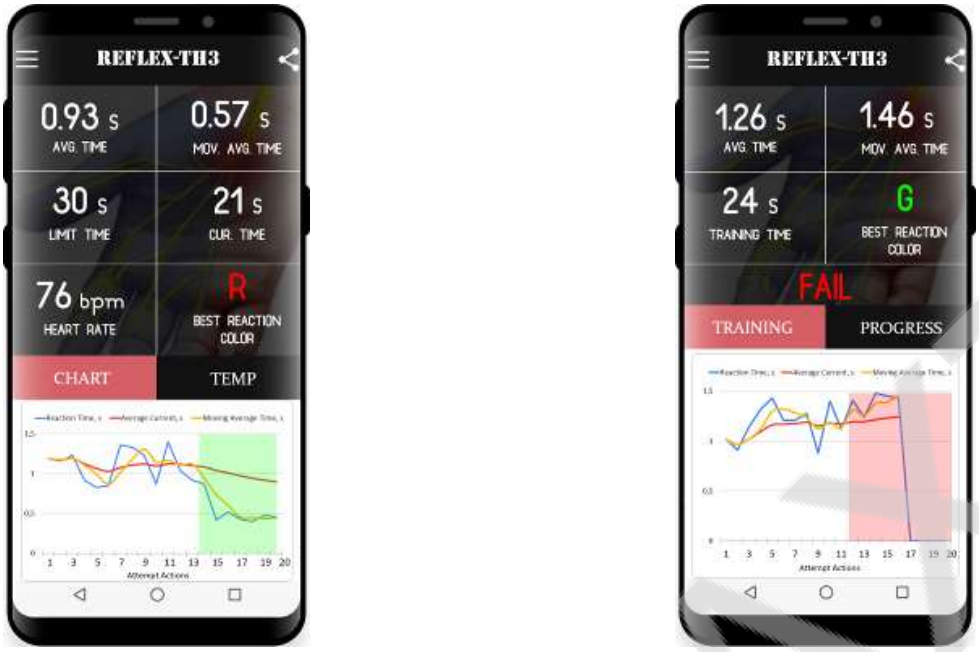


Fig. 6. The training with improving outcomes over time

On the mobile interface, this transition of training to the phase of improving results is marked as "Green Zone" (as in Fig. 7,a).

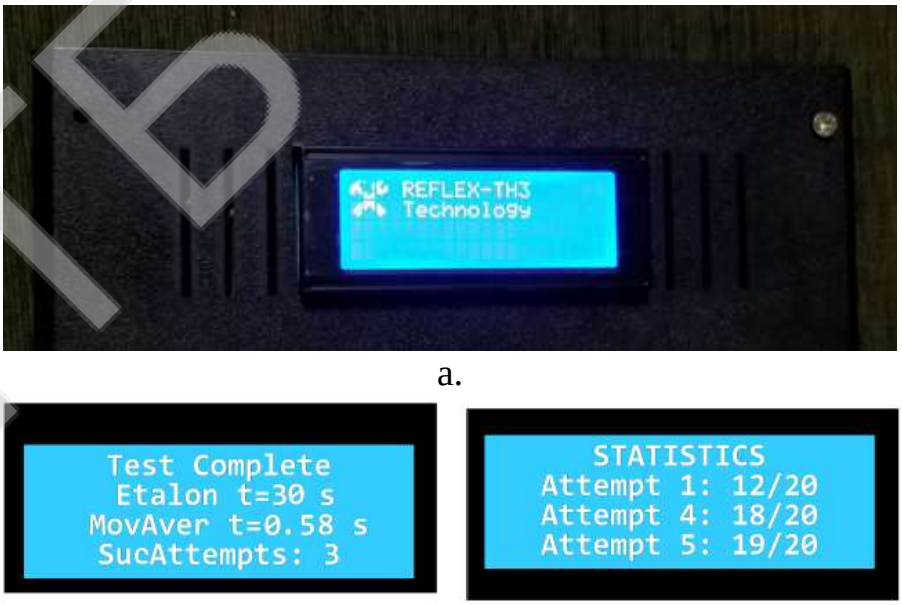


a. b.

Fig. 7. The visualization of the successful training (a) and failed training (b) results on mobile interface

If it is difficult for the patient to complete the task on time, then the average reaction time AVG_i overrun the moving average, and training should be interrupted ("Red Zone" on Fig. 7,b). In this case, it is advisable to increase the interval between flashes of LEDs or to change a number of application points of pinch strength.

At the same time, after successful completion of the test on the DT device "Reflex-Txx" the sound will be accompanied and the message "Test Complete" will be displayed on the LCD screen. The DT device name, main characteristics and statistics of successful attempts during the session will be shown up (Fig. 8).



a.

b. c.

Fig. 8. Device Logo (a) and test results after training: b – move average time; c – test statistics (unsuccessful / successful actions of each attempt)

4.2.3. **Data analysis on a specialized microservice**

Based on the data obtained from the long-term storage service, it is possible to analyze the work of the complex and some users for a certain period of time, using the obtained metrics (Fig. 9).

a.

b.

Fig. 9. Analysis of the usage efficiency in the HSC of two models of "Reflex-Txx" series devices: a – time load monthly, b – success of training of users

For example, from the analysis of Figs. 9, and it can be concluded that the "Reflex – TH3" DT devices are used more efficiently than the "Reflex – TT3" devices. The TH3 DTs have trained 443 users (Visits) more than the TT3, and they have opened on the TH3 for 681 sessions (Sessions) more than the TT3. That is, patients showed a greater interest in devices in which the work area based on Hall sensors than in devices with touch buttons.

In addition, the number of attempts for TH3 during the analyzed period is reduced compared to the allowed maximum of 1622 attempts (Attempts), i.e., training to obtain the desired result was faster. It should be noted that patients of TH3 DTs exhibited greater DT devices interest, as there are new users (Unique Users) 522 fewer than TT3 patients. That is, patients did not leave the training site until testing was

completed with a positive result. Thus, it can be noted that the workloads and training regimes at NTC are selected correctly. Also, from Fig. 9,a, it is possible to estimate the monthly number of users on the TH3 and TT3 DTs separately.

From Figs. 9,b shows that the performance of patient PVH-13-408 from December 16 to December 22 was 18% higher than that of patient HMD-04-408. During the specified training period, the first user showed a 12% shorter average time to complete the tasks. In addition, its average sliding time was 16% better. That is, over the course of training, his speed of PVH-13-408 reaction to the random inclusion of RGB LEDs and movement coordination has improved significantly. From Fig. 9,b it could also be concluded that such positive training results are achieved by greater persistence, since PVH-13-408 has opened for 42 sessions more than the HMD-04-408 during the analyzed time period.

The main argument in favor of using the developed "Reflex-Txx" series is that as a result of increasing the intensity of motor loads with the involvement of gripping movements of the fingers in the patients trained on the DT devices, by 3rd week there was observed a decrease in spasticity of the hand by 2 points according to the MAS of muscle spasticity [3].

5. CONCLUSIONS

Thus, medical studies and training on the developed "Reflex-Txx" series indicate that passive therapy with robotic devices for rehabilitation of the stroke and spinal trauma requires further analysis and cost-effectiveness compared to standard therapy. It is proven that such treatment is well tolerated without side effects. The use of diagnostic training devices, in addition to conventional physiotherapy, gives positive shifts in treatment after a total of 150 minutes of the entire trial.

In the absence of positive changes in the developed hardware and software complex (HSC), reprogramming of intervals between light flashes, the pauses between attempts to rest the patient according to medical recommendations is provided. The HSC also provides for connection to the IS of personal IoT devices to monitor the general condition of the patient to prevent overloading his.

As your skills grow, muscle strength increases, and patients' response rates increase, you will find that the Arduino platform will no longer cope with the amount of computing you want to get from it. It may be corny to lack performance in calculations, updating information on displays, sending data and other resource-consuming actions, and it may just run out of memory. In this case, you can upgrade to a more advanced STM32 platform. However, it should be noted that improving the hardware resources of devices will entail a significant increase in the cost of devices, as well as a significant increase in their power consumption. Therefore, we consider it appropriate to first of all pay attention to optimizing the program code directly for the components of the Arduino platform: analysis of the use of variables of the corresponding types, transition from actions with floating-point numbers to an integer type, replacement of division to multiplication, replacement of the Arduino-function to work with ports, etc.

This approach will save the minimum cost of hard and thus spend on expanding the device fleet. Thereby can be increasing the number of patients who can be assisted

with home programs in the course of rehabilitation after cervical spine injuries and damage to the nerves of the hand and fingers.

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METHOD AND MODEL FOR A HIGHLY REALISTIC RENDERING OF A THREE-DIMENSIONAL IMAGE

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Abstract. *The formation of color components of face images is a complex computational task, since for each pixel of a surface it is necessary to calculate the color intensity, for which it is necessary to determine the unit vectors to the light source and normal to the surface. Therefore, the urgent task is to simplify the coloring procedure without losing the realism of the final image. It is suggested to use second-degree and third-degree polynomials to adapt to painting, depending on the surface curvature. For the third degree polynomial, an approximation formula is obtained to determine the diffuse and specular color components. The hardware for determining the coefficients and the approximation polynomial is proposed.*

Keywords*: rendering, diffuse and specular color components, 3D imaging, plastic surgery, face image*

I. INTRODUCTION

Spatial imaging [5, 7, 13, 14, 15-18] is a complex computational process. This is due to the multistepness and complexity of geometric transformations, the use of complex models of lighting and over-painting. The final rendering (rendering) stage [1, 7] is one of the most time consuming, as each intensity point determines the color intensity and the screen coordinates. It is important not only to accurately reproduce the shape of the object and its design features, but also to correctly convey the gradation of colors, since this is crucial in creating the illusion of three-dimensional volume on a two-dimensional flat screen.

In determining the intensity of the coil color of the pixels, the location of the light source and the observer, the optical properties of the material, the spectral characteristics of the light source, and the curvature of the surface are taken into account. In this regard, the final visualization is characterized by significant computational costs, which necessitates the development of methods and tools to improve the productivity of its implementation.

At the present stage of development of three-dimensional graphics the question of dynamic graphic images formation in real time and in interactive mode is urgently raised, when it is assumed that the trajectories of motion of objects are not predetermined but determined by the actions of the user in the process of interaction with the system. Visualization of three-dimensional scenes for such modes imposes strict requirements on methods and means of forming three-dimensional graphic scenes, which creates the task of increasing their productivity.

Today, the growth rate of geometric complexity of 3D images exceeds the growth rate of graphics performance [7]. Insufficient graphics performance is also a hindrance to modeling in physical process scenes and increasing the number of dynamic objects.

Since the final visualization stage is the most time-consuming stage of 3D

modeling and accounts for 60-80% [15] of the total amount of calculations, it is advisable to develop methods and models that would improve the performance and achieve the desired dynamics of realistic images.

The purpose and objectives of the study. The purpose of the work is to increase the productivity of 3D image formation by using new models and the painting method.

The object of study – the process of finally rendering three-dimensional graphic objects in computer graphics systems.

Subject of study – methods and tools for improving productivity of final visualization of three-dimensional objects.

Research methods. In the course of the study applied: theory of numbers and numerical methods; theory of algorithms; theory of interpolation of functions; methods of analytical geometry, linear algebra, differential and integral calculus; computer simulation to analyze and verify the validity of theoretical findings

Scientific novelty of the results.

1. The method of painting is developed, the peculiarity of which is the adaptive use for determining the intensities of color in different parts of the surface of the polynomials of the second and third degrees, which allowed to increase the productivity of forming a three-dimensional image, and, as a consequence, to provide a dynamic mode of display.
2. New modifications of the Cook-Torrence and Vard models are proposed, which differ from the known ones when calculating only one function and smaller degrees of polynomials, which makes it possible to improve the performance of three-dimensional image formation taking into account the offset properties of surfaces.

The practical significance of the obtained results is that, on the basis of theoretical studies and scientific results obtained, software and hardware for the formation of three-dimensional images have been developed.

Publications. Subjects of the research are published: scientific work, of which 1 monograph; articles included in Scopus international scientific base; articles in publications included in the list of professional publications; certificates for registration of copyright on computer programs.

II. ANALYTICAL REVIEW OF LITERATURE

Diffuse reflection is characteristic of matte and rough surfaces with chaotic irregularities whose dimensions are comparable to or exceeds the wavelength. Diffuse reflection determines the visibility of surrounding bodies because each point of the illuminated surface emits reflected rays in all directions. In the presence of a point light source in the scene, the intensity of the diffuse reflection is proportional to the cosine of the angle between the normal to the surface and the direction to the light source [3, 7, 13, 14]. In this case, the Lambert cosine law is used to calculate the diffuse reflection intensity [7]

$$I_d = I_0 \cdot k_d \cdot \cos\varphi,$$

where I_0 - the intensity of the light source, $k_d \in [0,1]$ - diffuse reflection coefficient, φ - the angle between the vector $\vec{L}$ and the normal $\vec{N}$ to the surface (Fig. 2.1).

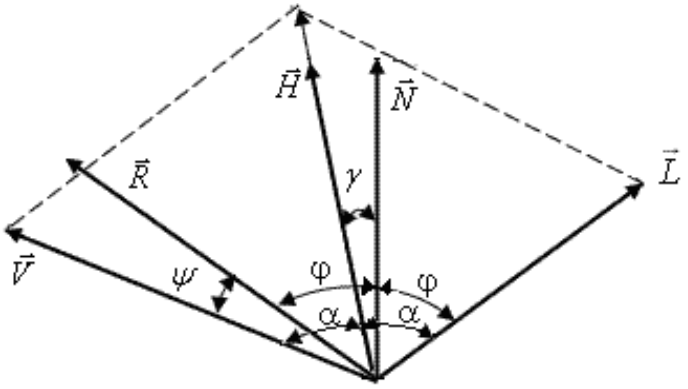


Fig. 2.1 The normal vector to the surface point

Computer graphics most often use the model of determining the speculative component of Phong color [3, 7, 13, 14], which has the form

$$I_s = I \cdot \varpi(\varphi,\ \lambda) \cdot \cos^n \psi ,$$

where $\varpi(\varphi,\ \lambda)$ - reflectance curve, which determines the ratio of mirror reflected light to the incident as a function of the angle of incidence θ and wavelength λ, n - surface speculation coefficient.

Function $\varpi(\varphi,\lambda)$ is complex complex, so in most cases it is replaced by a constant k_s which is determined experimentally or chosen for aesthetic reasons. In Phong BRDF [1, 3, 7] $\cos\psi = \vec{V} \cdot \vec{R}$ where $\vec{R} = 2 \cdot (\vec{L} \cdot \vec{N}) \cdot \vec{N} - \vec{L}$. Vector $\vec{R}$ called specular reflection. [7] In the distributive function of Blin which historically was later Phong BRDF instead $\cos\psi$ use $\cos\gamma = \vec{N} \cdot \vec{H}$ where $\vec{H} = (\vec{L} + \vec{V}) / \left|\vec{L} + \vec{V}\right|$.

In most cases, when painting by Phong, models of Blin and Phong lighting are used [3, 7, 13, 14]. This is due to the fact that the specified BRDF are derived from the cosine of the angle between vectors that are easily found through their scalar product. When the light source and the observer are at a sufficient distance from the object (the most common case in a computer graphic), the vector $\vec{H}$ of Blin model calculated once for each triangle. In connection with this, in most cases for painting surfaces by Phong method is used lighting model of Blin.

Determining diffuse and specular color components is a complex computational task [2], which involves the development of new methods and tools.

III. MODIFICATION OF EXISTING METHODS OF VISUALIZATION OF OFFSET FACE SKIN STRUCTURE

Testing [4, 9, 10, 11] with subsequent illumination is most often used in the formation of images of a person's face for surgical interventions. In this case, the surface area of the image obtained from patients' photographs is used as texture. This approach best conveys the relief character of the skin, its specific micro-features [7,13].

The surfaces of virtually all materials have the property of anisotropy, that is, the reflectivity of the material depends on the angle of view of the object by the observer relative to the normal to the surface.

As the skin belongs to rough surfaces, it is often advisable to use lighting models that take into account the offset structure of the surface and, as a consequence, are more

physically correct. Such models include the Cook-Torrence model and the Vard model [7,13,14].

It was found [2] that the Cook-Torrence model better models the spectral component of color, and the Vard model diffuses.

In these models, the surface roughness distribution is used to account for surface roughness.

Consider the Cook-Torrence model [7, 14], the bend with which the calculation of reflected light is carried out by the formula

$$\frac{F \cdot G \cdot D}{(\vec{V} \cdot \vec{N}) \cdot (\vec{L} \cdot \vec{N})},$$

where F - coefficient of Frenel G - an option that allows self-shading fields, D - a parameter that determines the rms slope of the microgranes.

Microgranes have the greatest impact if they are directed along the vector $\vec{H}$. Parameter D determined by the following formula

$$D = \frac{1}{4 \cdot m^2 (\vec{H} \cdot \vec{N})^4} e^{\left(\frac{(\vec{H} \cdot \vec{N})^2 - 1}{m^2 \cdot (\vec{H} \cdot \vec{N})^2}\right)}.$$

where m - an average slope of the microgranes. m is selected in the range from 0.2 to 0.6.

Calculation D is difficult as it involves the use of two functions - exponential and cosine. We will express D through one function that will simplify the computational process.

Write parameter that determines the degree exponent in the formula for calculating D in this form

$$\frac{(\vec{H} \cdot \vec{N})^2 - 1}{m^2 \cdot (\vec{H} \cdot \vec{N})^2} = \frac{cos^2 - 1}{m^2 \cdot cos^2} = \frac{-sin^2(\gamma)}{m^2 \cdot cos^2(\gamma)} = -\frac{tg^2(\gamma)}{m^2}.$$

With this in mind, the following formula can be written to determine D

$$D = \frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 (\vec{H} \cdot \vec{N})^4}.$$

Decompose $e^{-\frac{tg^2(\gamma)}{m^2}}$ in Taylor, limited to two terms

$$e^{-\frac{tg^2(\gamma)}{m^2}} \approx 1 - \frac{x^2}{m^2}.$$

Approximate $e^{-\frac{tg^2(\gamma)}{m^2}}$ by function $cos^{\cdot\frac{a}{m^2}}$.

Decompose $cos^{\cdot\frac{a}{m^2}}$ in Taylor, limited to two terms.

$$\cos^{\cdot\frac{a}{m^2}} = 1 - \frac{a}{2 \cdot m^2} \cdot x^2.$$

Equating the right parts of the two schedules to the Taylor series, we obtain this equality

$$1 - \frac{x^2}{m^2} = 1 - \frac{a}{2 \cdot m^2} \cdot x^2.$$

From the last equation we find that $a = 2$.

As follows,

$$e^{-\frac{tg^2(\gamma)}{m^2}} \approx \cos^{\cdot\frac{2}{m^2}}(\gamma) .$$

Considering

$$D = \frac{1}{4 \cdot m^2 (\vec{H} \cdot \vec{N})^4} e^{\left(\frac{(\vec{H} \cdot \vec{N})^2 - 1}{m^2 \cdot (\vec{H} \cdot \vec{N})^2}\right)} = \frac{1}{4 \cdot m^2 (\vec{H} \cdot \vec{N})^4} \cos^{\cdot\frac{2}{m^2}}(\gamma)..$$

Given that the scalar product of vectors $\vec{H}$ and $\vec{N}$ is $\cos\gamma$, we write the following expression for D

$$D = \frac{1}{4 \cdot m^2 \cdot (\vec{H} \cdot \vec{N})^4} \cos^{\cdot\frac{2}{m^2}}(\gamma) = \frac{1}{4 \cdot m^2 \cdot \cos^4(\gamma)} \cos^{\cdot\frac{2}{m^2}}(\gamma) = \frac{\cos^{\cdot\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2}.$$

Fig. 3.1 shows a graphic $\frac{\cos^{\cdot\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2}$ and $\frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 \cos^4\gamma}$.

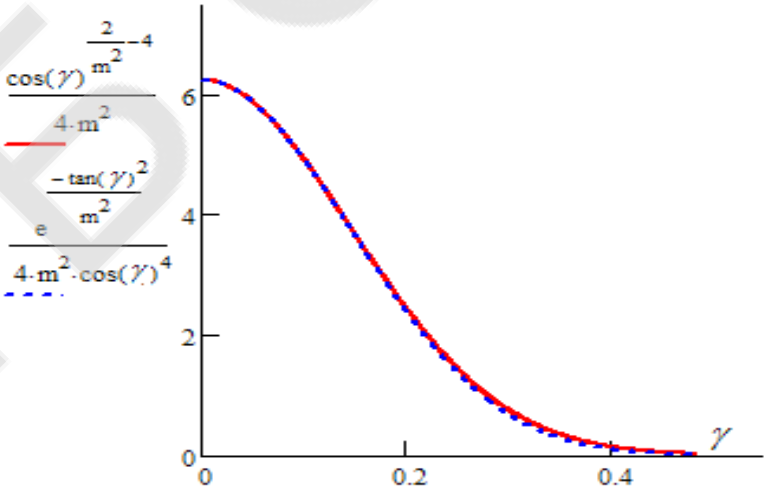
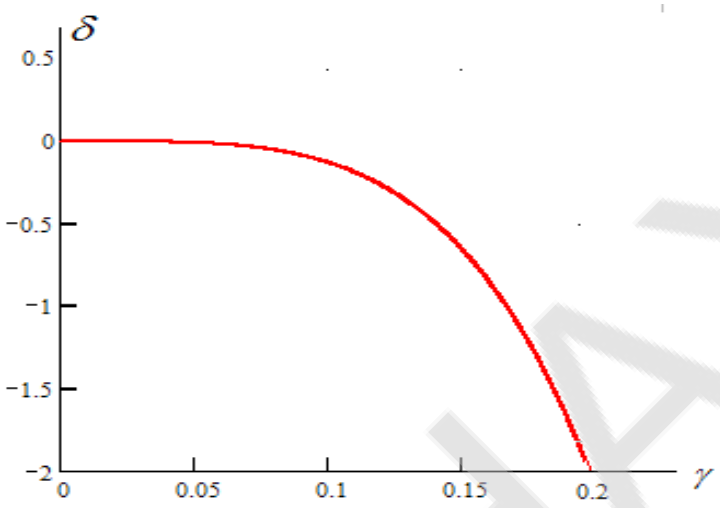


Fig. 3.1 - Graphic of functions $\frac{\cos^{\cdot\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2}$ and $\frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 \cos^4\gamma}$.

The graph shows that the proposed function has a good convergence of the original.

Fig. 3.2 shows a graph of the relative approximation error function $\frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 \cos^4 \gamma}$ function $\frac{\cos^{\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2}$ the angle γ.



is

Fig. 3.2 - The graph of change of relative error of approximation of function $\frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 \cos^4 \gamma}$ by function $\frac{\cos^{\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2}$ from the angle γ

The graph above shows that high approximation accuracy is achieved for a significant change interval of the original function.

We got function $\cos^n \gamma \approx \left(\frac{n}{g}(\cos\gamma - 1) + 1 \right)^g$.

Use this function to approximate D:

$$\frac{\cos^{\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2} \approx \frac{1}{4 \cdot m^2} \cdot \left(\frac{\frac{2}{m^2}-4}{g} \cdot (\cos\gamma - 1) + 1 \right)^g .$$

After simplification we get that $\frac{\cos^{\frac{2}{m^2}-4}(\gamma)}{4 \cdot m^2} = \frac{1}{4 \cdot m^2} (\cdot(\cos\gamma - 1) + 1)^g$

For $g = 4$ $D4 = \frac{1}{4 \cdot m^2} \cdot \left[\left(\frac{1}{2m^2} - 1 \right) \cdot (\cos\gamma - 1) + 1 \right]^4$,

For $g = 8$ $D8 = \frac{1}{4 \cdot m^2} \cdot \left[\left(\frac{1}{4 \cdot m^2} - \frac{1}{2} \right) \cdot (\cos(\gamma) - 1) + 1 \right]^8$,

For $g = 16$ $D16 = \frac{1}{4 \cdot m^2} \cdot \left[\left(\frac{1}{8 \cdot m^2} - \frac{1}{4} \right) \cdot (\cos(\gamma) - 1) + 1 \right]^{16}$.

Fig. 3.3 shows a graph of changing D, $D4$, $D8$, $D16$. Function $D16$ provided high accuracy of approximation as for the epicenter of the bell-shaped D, and for its blooming zone (Fig. 3.4).

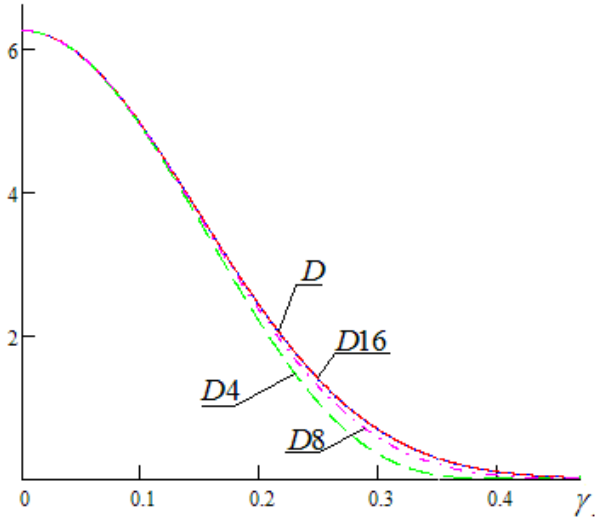


Fig. 3.3 - Graph of changing D, $D4$, $D8$, $D16$

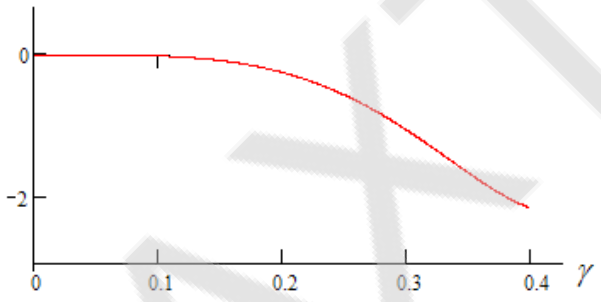


Fig. 3.4- Graph of changing relative error approximation function D by $D16$

According to the Vard model, the color intensity is determined by the following formula

$$I_w = \frac{k_d}{\pi} + k_s \cdot \frac{1}{\sqrt{\vec{V}\cdot\vec{N} + \vec{L}\cdot\vec{H}}} \cdot \frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4\cdot\pi\cdot\alpha^2}.$$

where α - correction coefficient that depends on the curvature of the surface,

The difference between the Vard model and the Cook-Torrance model is the absence of the Fresnel factor [] and the self-shadowing factor. It is believed that Vard in his model has reached the most accurate fit of this model to the experimental data.

Replace $e^{-\frac{tg^2(\gamma)}{m^2}}$ on $cos^{\frac{2}{m^2}}(\gamma)$. Using these in the second chapter we can rewrite dependence $cos^n\gamma \approx \left(\frac{n}{g}(cos\gamma - 1) + 1\right)^g$ as

$$I_w \approx \frac{k_d}{\pi} + k_s \cdot \frac{1}{\sqrt{\vec{V}\cdot\vec{N} + \vec{L}\cdot\vec{H}}} \cdot \frac{cos^{\frac{2}{m^2}}(\gamma)}{4\cdot\pi\cdot\alpha^2} = \frac{k_d}{\pi} + k_s \cdot \frac{1}{\sqrt{\vec{V}\cdot\vec{N} + \vec{L}\cdot\vec{H}}} \cdot \frac{cos^{\frac{2}{m^2}}(\gamma)}{4\cdot\pi\cdot\alpha^2} =$$

$$= \frac{k_d}{\pi} + k_s \cdot \frac{1}{\sqrt{\vec{V}\cdot\vec{N} + \vec{L}\cdot\vec{H}}} \cdot \frac{\left(\frac{2}{g\cdot m^2}(cos\gamma - 1) + 1\right)^g}{4\cdot\pi\cdot\alpha^2}.$$

The analysis showed that a sufficient approximation accuracy achieved with $g = 16$. In this case

$$I_w = \frac{k_d}{\pi} + k_s \cdot \frac{1}{\sqrt{\vec{V} \cdot \vec{N} + \vec{L} \cdot \vec{H}}} \cdot \frac{\left(\frac{1}{8 \cdot \alpha^2} (\cos\gamma - 1) + 1 \right)^{16}}{4 \cdot \pi \cdot \alpha^2}.$$

The relative error of approximation $e^{-\frac{tg^2(\gamma)}{m^2}}$ does not exceed 1.3%.

The proposed expressions have significantly less computational complexity than the original expressions by using only one function, and to a lesser extent. Figure 3.5 shows examples of image formation using the developed Cook-Torrence and Vard models.

a b

Fig. 3.5 – examples of face images rendering using the developed modified models a – Cook-Torrence model, b – Vard model.

Research results. A modification of the Cook-Torrence model is proposed by using a new formula to determine the parameter used to calculate the rms slope of the microgranes. The analysis showed that when using the parameter $D = \frac{1}{4 \cdot m^2} \cdot \left[\left(\frac{1}{8 \cdot m^2} - \frac{1}{4} \right) \cdot (\cos(\gamma) - 1) + 1 \right]^{16}$ against $D = \frac{e^{-\frac{tg^2(\gamma)}{m^2}}}{4 \cdot m^2 (\vec{H} \cdot \vec{N})^4}$ allowed to increase the productivity of its calculation by 4.34 times. For the Varda model, productivity gains are more than twice.

IV. DEVELOPMENT OF AN ADAPTIVE METHOD OF DETERMINING THE DIFFUSE AND SPECULAR COMPONENTS FOR RENDERING [2]

Today surgeries during plastic surgery can be estimated by constructing 3D models. This makes it possible to reduce differences and dissatisfaction on the part of patients and reduce the risk of such transactions to the lowest level .. have a unique opportunity ahead of time to see how a person will look after the work of plastic surgeons

[9, 11]. In forming the 3D image rights should be as accurately reproduce real face. It is important to convey realistic colors. Therefore, the formation of diffuse and specular color components put forward higher requirements. Formation diffuse color component images of areas face a complex computational problem, since each pixel must calculate surface color intensity, which is necessary to define the inner product unit vectors to the light source and the normal to the surface. Determination unit vectors involves normalizing output vector that require labor-intensive operations perform multiplication, division and square root of. Therefore, the actual problem is facilitation of procedures diffuse color component without substantial loss of realism of the final image.

In [7] for finding the diffuse color component offered rasterization line break at intervals, except for the last, each of which use linear interpolation [6]. The proposed method is highly effective only for surfaces with small curvature. Failing to provide acceptable accuracy must break line rasterization on a large number of intervals, which significantly reduces the efficiency calculations. In addition, the appearance of artifacts within at intervals not considered as differentiation curve for color intensity.

The use of quadratic interpolation [4] to find intensity of color components makes it possible to increase the size ranges, but use as a parabola curve color intensity can distort the real curve and consequently lead to low precision calculations.

Intensity of use for the current color component range line rasterization a polynomial of the third degree,

$$I_{i,t} = A_i \cdot t^3 + B_i \cdot t^2 + C_i \cdot t + D_i$$

where t - parametric variable A_i, B_i, C_i, D_i - unknown to be found by determining the color intensity interval at four points, which is broken line rasterization. Find the unknown A_i, B_i, C_i, D_i, $I_{i,t}$ - the intensity of the diffuse or specular color component.

Obviously, when $t = 0$ $I_{i,l} = D_i$. At the end point of the interval $t = 1$. Ago $I_{i,p} = A_i + B_i + C_i + D_i$. At the midpoint of the interval $t = 1/2$, ago $I_{i,c} = \frac{A_i}{8} + \frac{B_i}{4} + \frac{C_i}{2} + D_i$. At the point $t = 1/4$ $I_{i,c} = \frac{A_i}{64} + \frac{B_i}{16} + \frac{C_i}{4} + D_i$.

Thus, to find unknown A_i, B_i, C_i, D_i you can create a system of equations

$$\begin{cases} I_{i,l} = D_i, \\ I_{i,p} = A_i + B_i + C_i + D_i, \\ I_{i,c} = \frac{A_i}{8} + \frac{B_i}{4} + \frac{C_i}{2} + D_i, \\ I_{i,c2} = \frac{A_i}{64} + \frac{B_i}{16} + \frac{C_i}{4} + D_i. \end{cases}$$

Solution reduced system of equations gives the following formula to determine the unknown coefficients:

$$A = \frac{8(I_2 + 8 \cdot I_4)}{3} - 8(I_1 + 2 \cdot I_3) \quad B = 2(7 \cdot I_1 - I_2 + 10 \cdot I_3 - 16 \cdot I_4)$$

$$A = \frac{I_2 + 32 \cdot I_4}{3} - 7 \cdot I_1 - 4 \cdot I_3 \quad D = I_1,$$

We use to compile a system of equations such point interval: $t=0,\ t=\frac{1}{2},\ t=\frac{3}{4},\ t=1$. We obtain a system of equations

$$\begin{cases} I_{i,1} = D_i, \\ I_{i,p} = A_i + B_i + C_i + D_i, \\ I_{i,c} = \frac{A_i}{8} + \frac{B_i}{4} + \frac{C_i}{2} + D_i, \\ I_{i,c2} = \frac{A_i \cdot 27}{64} + \frac{B_i \cdot 9}{16} + \frac{C_i \cdot 3}{4} + D_i. \end{cases}$$

The solution is a system

$$A = 8\cdot(I_2 + 2\cdot I_3) - \frac{8\cdot(8\cdot I_4 + I_1)}{3},\ B = 2\cdot(3\cdot I_1 - 5\cdot I_2 - 14\cdot I_3 + 16\cdot I_4),$$

$$D = I_1,\quad C = 3\cdot(I_2 + 4\cdot I_3) - \frac{13\cdot I_1 + 32\cdot I_4}{3}.$$

In these formulas are many factors to power of two, which simplifies hardware implementation, as in this case, micro-multiplication can be replaced by micro assembly shift. In addition, many factors can set the amount of values that are equal degree two, for example, $10\cdot I = 8\cdot I + 2\cdot I$. It also replace micro multiplication by addition and shift. Given this is the first time the most appropriate.

Division 3 can also be implemented using shift and add. For example,

$$\frac{1}{3} \approx \frac{1}{2} - \frac{1}{8} - \frac{1}{32} - \frac{1}{128}.$$

In this case, the relative proportion of error of no more than 0.79%.

Fig. 4.1 shows a functional block diagram of the portion $I/3$.

Fig. 4.2 shows an example hardware implementation factor B_i without operations of multiplication and division by adding operands shifted towards senior level.

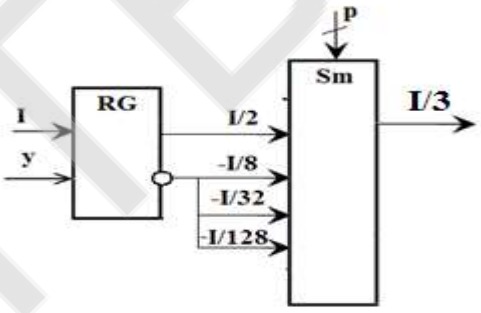


Fig. 4.1 Functional block diagram of the portion $I/3$.

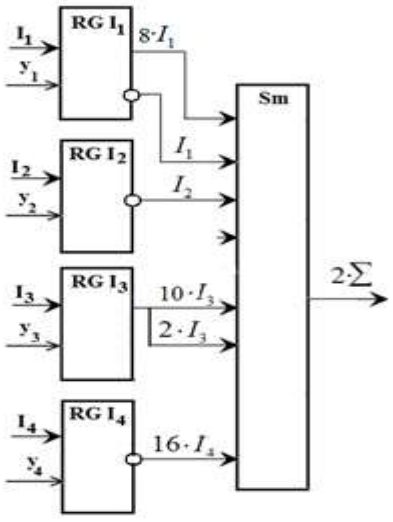


Fig. 4.2. A functional block diagram of armatures determining factor B_i

Similar is the construction unit to determine other factors.

Fig. 4.3 shows a functional block diagram for determining the color intensity using a polynomial of the third degree. For this uses the relationship.

$$I_{i,t} = A_i \cdot t^3 + B_i \cdot t^2 + C_i t + D_i = t \cdot (t \cdot (A_i \cdot t + B_i) + C_i) + D_i.$$

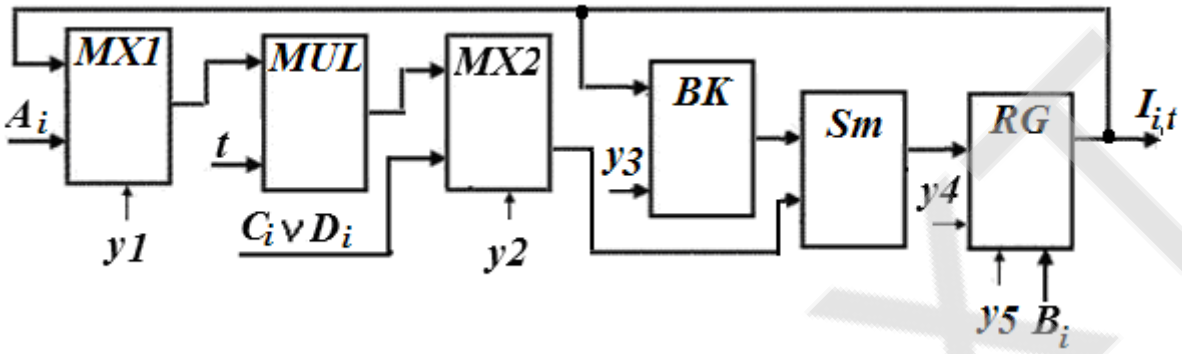


Fig. 4.3 - A functional block for determining the color intensity using a polynomial of the third degree

In registry RG entered value B_i, and input $MX1$ submitted values A That the block MUL multiplied by the value t. Therefore, the output of the adder Sm determined value $(A_i \cdot t + B_i)$ Which is stored in the register RG. This iteration of block valves BK operates in transmit mode operand.

Block key switch reset mode operand. Value $(A_i \cdot t + B_i)$ multiplied by t and recorded in the register RG. The output of the adder Sm formed importance $(A_i \cdot t + B_i) \cdot t$.

The input multiplexer $MX2$ submit value C_i Because the output of the adder Sm formed importance $(t \cdot (A_i \cdot t + B_i) + C_i)$ Be entered in the register RG. To block this key switch the transmission mode operand.

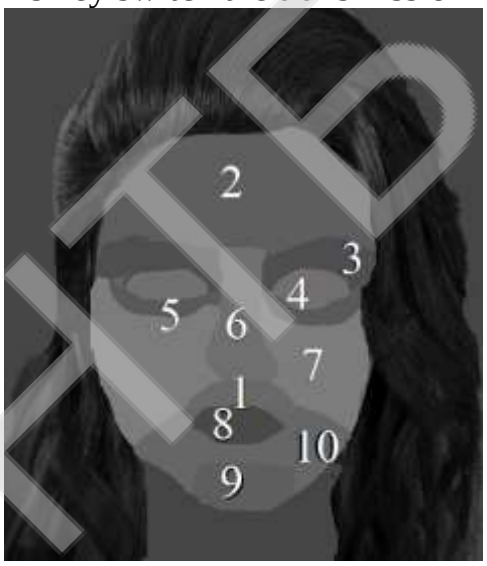


Fig. 4.4 – Distinguish of face for specific areas

Subsequently, the resulting value is multiplied by t. In this case, block key resets value stored in the register RG. Block key switch in transmission mode operand. Subsequently, the input multiplexer $MX2$ submit value D_i That is added to the operand $t \cdot (t \cdot (A_i \cdot t + B_i) + C_i)$ That gives a output register RG value $I_{i,t}$.

Fig. 4.4 shows the splitting image of a human face on specific areas. The analysis showed that for lots 2, 4, 7 expedients to use for determining the diffuse and specular components approximating polynomial of the second degree, but for others - the third degree.

The figure 4.5 shows an example of forming a three-dimensional image of the face using the adaptive method of painting.

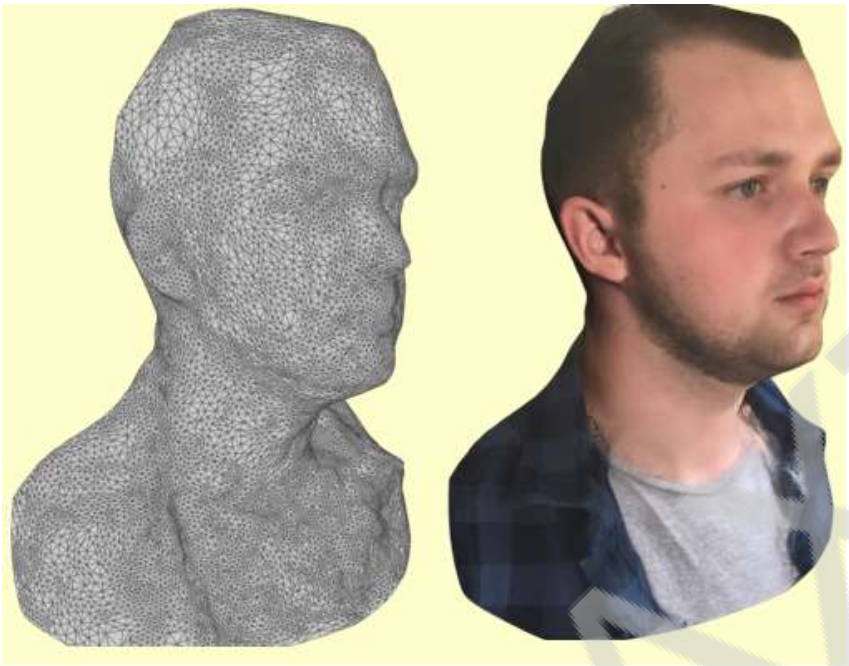


Fig. 4.5 – Example of forming a three-dimensional image of the face using the adaptive method of painting.

Research results. Analysis of the complexity of imaging the human face under the proposed method showed that compared with Phong achieved by increasing productivity up to 3 times by reducing the number of long-term operations and multiplication and division of the square root. Adaptive use of polynomials of second and third degrees possible to achieve normalized mean square error (NMSE) not more than 0.0001, which means that the image formed face of visually indistinguishable relative image formed by the method Phong.

The proposed method and models can be used in highly realistic computer graphics systems.

V. CONCLUSIONS

The paper proposes a new method and models for high-performance face rendering.

Scientific novelty of the obtained results.

1. The method of painting is developed, the peculiarity of which is the adaptive use for determining the intensities of color in different parts of the surface of the polynomials of the second and third degrees, which allowed to increase the productivity of forming a three-dimensional image, and, as a consequence, to provide a dynamic mode of display.
2. New modifications of the Cook-Torrence and Vard models are proposed, which differ from the known uses when calculating only one function and smaller degrees of polynomials, which makes it possible to improve the performance of three-dimensional image formation taking into account the offset properties of surfaces.
3. Expressions for approximating polynomials to determine the speculative and diffuse color components are proposed, which made it possible to improve the productivity of face imaging.
4. Hardware has been developed to determine the color intensities, which

makes it possible to implement a high-speed specialized device.

5. The areas of the face are selected for the adaptive use of approximating polynomials, which makes it possible to increase the realistic formation of graphic images.

The practical significance of the obtained results is that, on the basis of theoretical studies and scientific results obtained, software and hardware for the formation of three-dimensional images have been developed.

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SEO - EDUCATIONAL SITE ANALYSIS

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Abstract*. What is SEO and what does it eat? Description of the importance and difficulty in mastering.*

Keywords*: SEO optimization, training material, work with a search engine.*

Introduction

To help users navigate the Internet in a huge variety of online resources, there are specialized arrangements - search engines. Each search engine such as Google or Yandex, have their own search engine to query received from the user. Through this mechanism, the search engine selects the most appropriate search resources and gives them a list of the user. But somehow one site gets the first position and the second, exactly the same topics and close to content not included even in the top hundred.

Search engines regularly index sites on the Internet. In addition, each resource is given a rating index and relevance. Based on ongoing indexing search engine instantly produces a list of results, most closely matching the key request.

Every website owner would like to get into the top ranks of the list, but few people know that in the top position of search engine can be controlled. A set of actions aimed at improving life in the top positions of search, called SEO-optimization.

1. Analytical review of the literature

Keyword selection is one of the most important stages of SEO. From what the "right" key phrases will be selected for optimiztsii, determine the fate of the site. Research popular search need not only of semantic core site, but also to study the target audience.

A well-chosen keywords not just attract traffic to the site - they attract targeted traffic. The benefits of properly folded semantic difficult to overestimate. It can be predicted jumps in demand, respond to changing market conditions and offer consumers goods, services and content they need. In the history of marketing there was no better way of studying the target audience than working with keywords.

There are many methods for determining keywords. Here are some tips:

- Viewing the source code of web pages of competitors;
- Choosing low keywords that have less competition;
- Using Google Trends, which analyzes of user queries to Google and calculates the number of times searched word;
- Do not use a single word. The phrases rather than words;
- Choose for words that often seek, but have weak competitiveness;
- To control the density of keywords in the text;
- Relevance. It is necessary to ensure that the site description reflects exactly what is offered;
- Not included in the kernel requests correctly. Similar searches automatically correcting system, and issue goes completely different. Also misspelled

keywords should not be used when writing text, as this may damage the company's reputation;

- Watch for a keyword. Best Places in HTML - tag <title>, header tags <h1>, <h2>, alt-tags, text, links, tags, bold / italics, URL-addresses, meta tags and comments;
- Locate keywords: to use its geographical position, but should avoid using too specific words;
- Do not use unnatural queries that will be difficult to fit into the content of the site;
- You must use the tools available to search keywords: keywordtool [1].

This site uses keywords and phrases: moodle, Distance Learning Center ONAFT.

Fig. 1.1 -Output site code moodle.onaft.edu [2]

2. The object, subject and research methods

Indexing in search engines - the process of gathering information about the site bots. The search robot avoids site and adds to its database all the information, text, pictures, videos, links, etc). This database is called the index of a search engine. If the site is added to the index database, it means the search engine knows about it. After that, other algorithms are tested on the site subject to the license search and ranking make a decision on the site of delivery.

Accordingly, that would get referrals from search engine on the page that you want to promote, they should all be in the search engine index. Simply put - be indexed. But if you hit the index page, it does not mean that it appears in the search for this it is necessary to optimize and promote. It is also clear that if a page does not hit the aircraft code, it does not appear in the issue.

The conclusion is obvious - the total pages indexed in major search engines

Yandex and Google is an essential process of moving. The faster proindeksuyetsya new site in search engines, the better.

The site is not included in the top 10 sites for different keywords on the subject site in the search engine Google, Yandex apart - in this search engine site occupies 7th place for «moodle». Results "Distance Learning Center ONAFT" site is headed by top 10, taking first place in search engines Yandex and Google, region of Ukraine. Positions are determined by the site seogadget [3].

Анкор	Яндекс	Google
moodle	7 http://moodle.onaft.edu.ua/	17 http://moodle.onaft.edu.ua/

№	Ссылка / ИКС
1	https://moodle.org/
2	https://moodle.znu.edu.ua/
3	https://moodle.com/
4	http://moodle3.chmnu.edu.ua/
5	https://uk.wikipedia.org/wiki/Moodle
6	https://moodle.kdpu.edu.ua/
7	**проверяемый сайт**
8	https://moodle.mnau.edu.ua/
9	https://moodle.oa.edu.ua/
10	http://moodle.bsmu.edu.ua/

№	Ссылка / ИКС
1	https://moodle.oa.edu.ua/
2	https://uk.wikipedia.org/wiki/Moodle
3	https://moodle.org/?lang=uk
4	https://moodle.org/course/view.php?id=17...
5	https://moodle.org/mod/page/view.php?id=...
6	https://moodle.donnu.edu.ua/
7	http://moodle.nuxa.edu.ua/
8	http://moodle.bsmu.edu.ua/
9	http://www.dut.edu.ua/ua/1035-pro-sistem...
10	https://moodle.tdmu.edu.ua/

Анкор	Яндекс	Google
центр дистанційного навчання онахт	1 http://moodle.onaft.edu.ua/	1 http://moodle.onaft.edu.ua/

№	Ссылка / ИКС
1	**проверяемый сайт**
2	http://moodle.onaft.edu.ua/login/index.p...
3	https://www.onaft.edu.ua/dlc
4	http://moodle.onaft.edu.ua/course/
5	https://www.onaft.edu.ua/ru/dlc
6	http://www.dlc.onaft.edu.ua/
7	https://cdn.snau.edu.ua/moodle/
8	http://elr.tnpu.edu.ua/
9	http://dl.oneu.edu.ua/
10	http://dl.nasoa.edu.ua/

№	Ссылка / ИКС
1	**проверяемый сайт**
2	https://www.onaft.edu.ua/dlc
3	http://dlc.onaft.edu.ua/
4	http://dlc.onaft.edu.ua/index.php/sistem...
5	https://www.onaft.edu.ua/ru/dlc
6	http://dlc.onaft.edu.ua/index.php/sistem...
7	http://www.otk.od.ua/news/Distancijne_na...
8	http://www.otk.od.ua/
9	https://knutd.edu.ua/university/institut...
10	http://kntiis.od.ua/uk/distanciyne-navch...

Fig. 2.1 - The position of the site in comparison with competitors

3. The results

The model involves the creation of contextual advertising classifieds linked to certain keywords. When a user enters any of these keywords into the search box, along with the results for the issuance, he served ads and advertisers.

If the user turns on any ad, with a business owner will be charged for a click is made.

For each search set certain price based competition among advertisers. Accordingly, in the first place will ads from an advertiser who set the highest price per click.

Competitor moodle.org [4] ranks first in the keyword search.

Keywords competitor: moodle, Moodle - Open-source learning platform, Moodle.org.

Advertisements missing.

Fig. 3.1 - Keywords moodle.org site

4. Main material

The benchmark shows derivative is the visibility of the site. In contrast, there is no absolute and relative value. Site Visibility is calculated as the ratio of effective website shows the total number of searches for a given query. The value of visibility is expressed as a percentage.

Visibility of the site can be considered as impression share (from all possible content in this section) that could get a site on their positions in the search results. Visibility is close to 100% means that users of search engines see links on this site almost any inquiry on this subject. Visibility is less than 100% indicates that only some users, giving requests given topic, see the site in search results. If the site and its mirrors occupy several positions in the search results, the visibility of the site drawn up more than 100%.

Increased visibility - one of the main prerequisites for increasing site traffic.

With site megaindex [5] an analysis of site visibility moodle.onaft.edu., As shown in the figure.

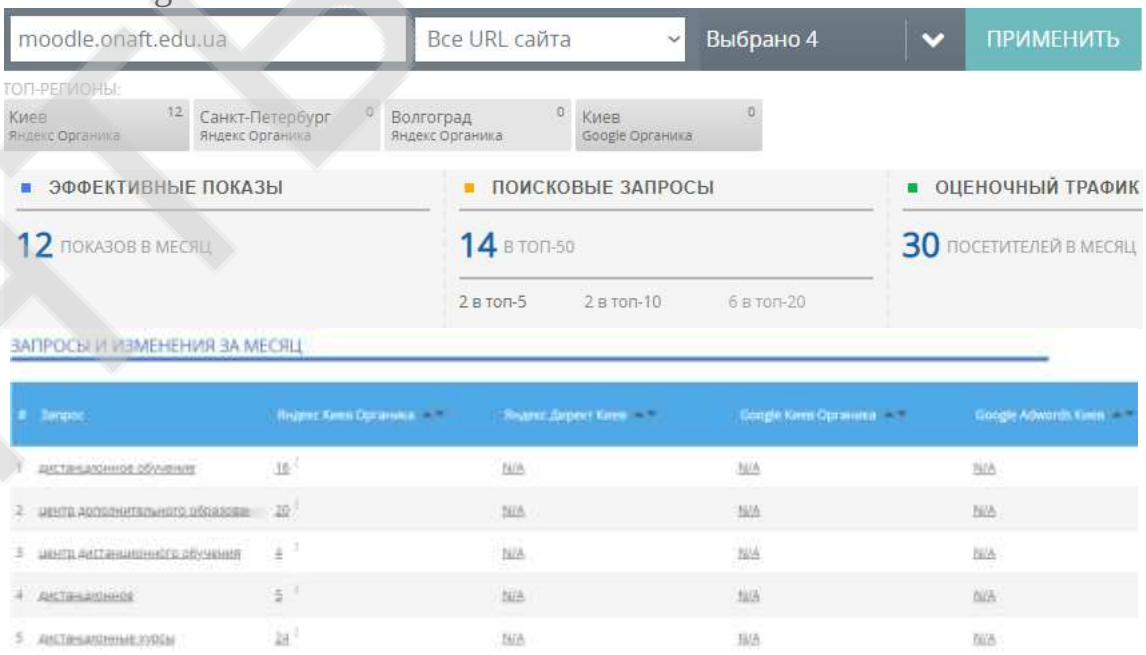

Fig. 4.1 - Site Visibility moodle.onaft.edu.ua

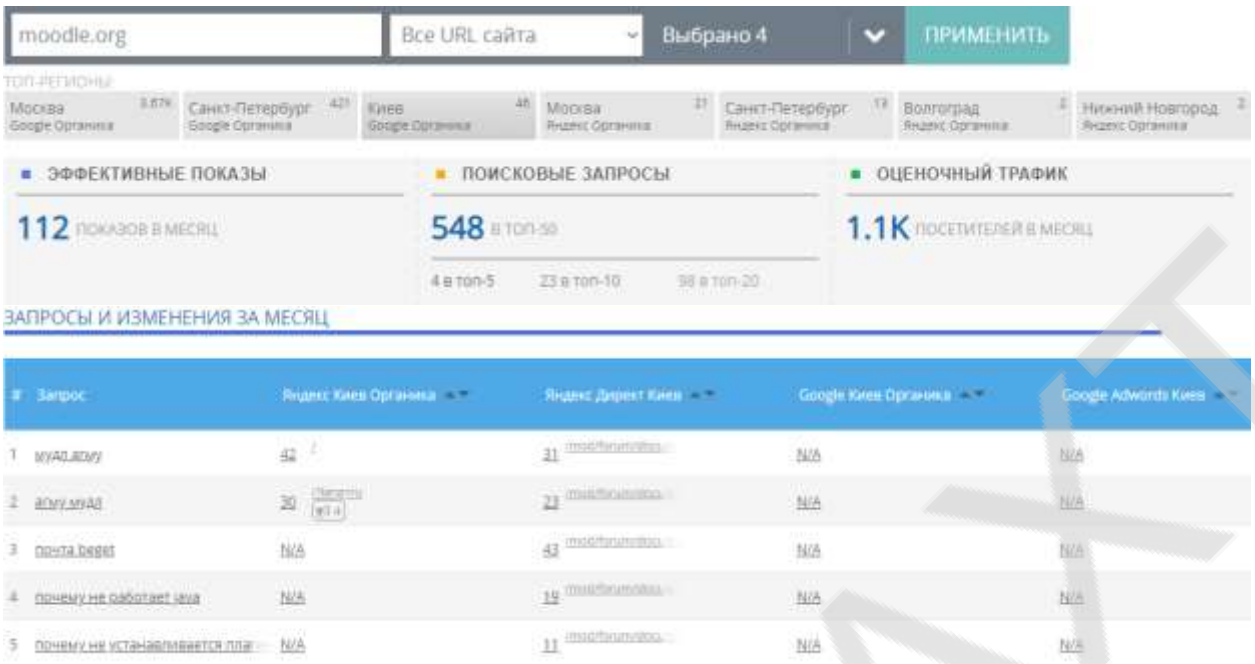

Fig. 4.2 - Visibility competitor moodle.org

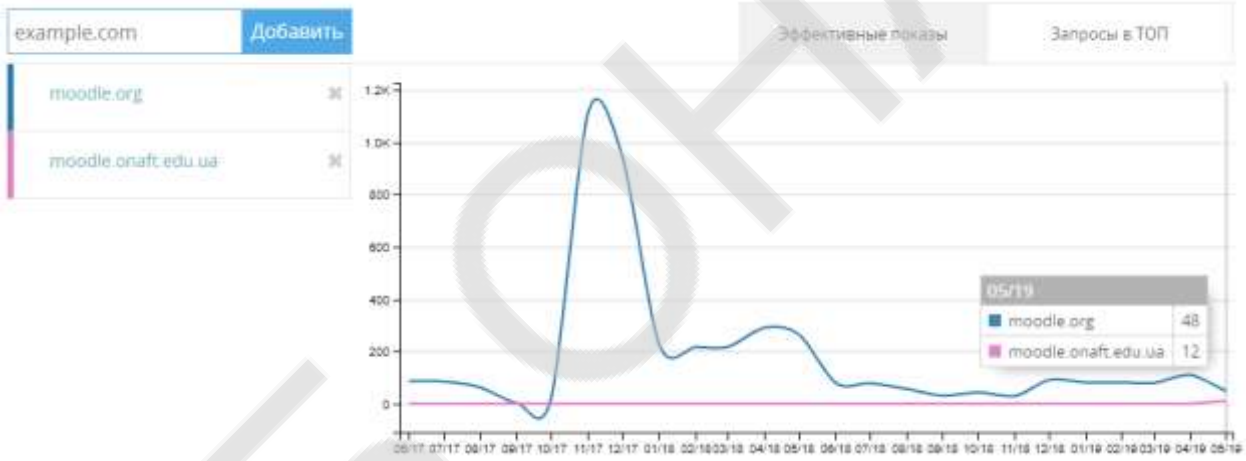

Fig. 4.3 - Schedule of sight

- Analysis of statistics on the site

Enrollments particular resource - is not just numbers, which you can find active site. This is very useful information for the owner of the site and for its competitors or interested people. For quantitative audience research site has appeal to search engines, directories, counting time spent online and other technical means. These data are summarized Special service site traffic analysis such as Google Analytics.

Among the enrollments accounted site visits, unique visitors, the number of new visitors and audience behavior parameters such as the average length of visits, average depth of view and so on. In most studies, online marketing audience the notion of permanent or regular users. Detection constant audience inaccessible log analyzer, due to the fact that no cookie-files (that log analyzer to set users can not) user identification extremely difficult.

So, for this kind of analysis requires the use of special software and accounting stamped cookie-files. Depending on the method, subjects online resource and frequency of renewal of its approaches to the selection of user groups that are returned to the site with some frequency may vary.

Target domain statistics analyzed and designed website pr-cy.ru [6].

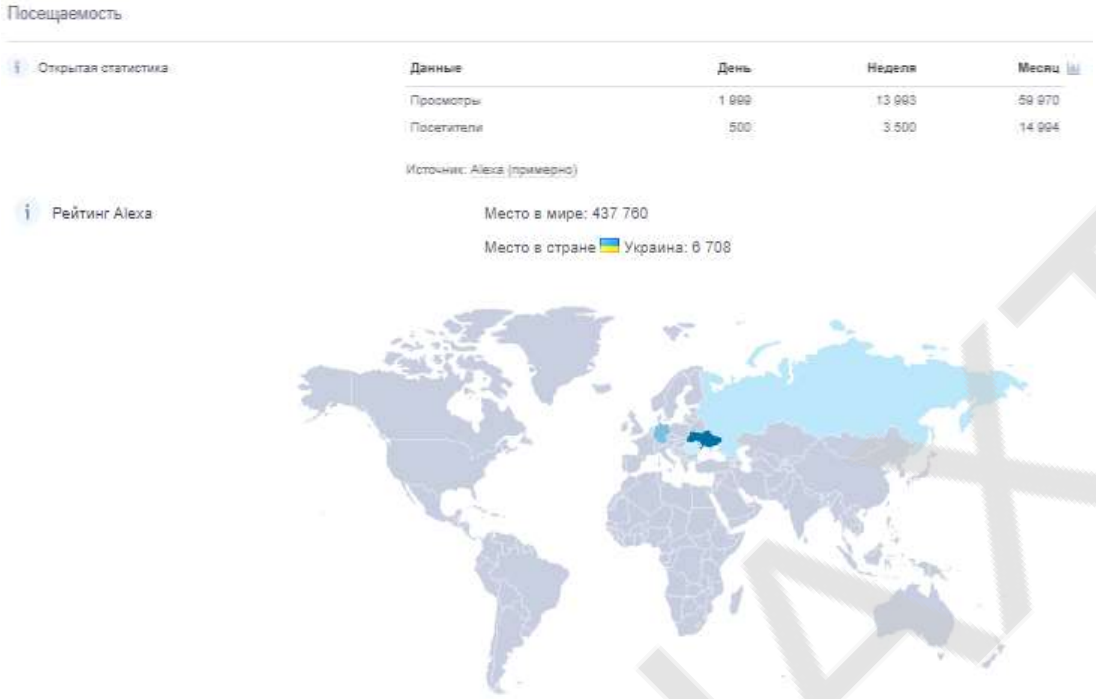

Fig. 5.1 - statistics destination domain

With site serpstat.com by most visited site:

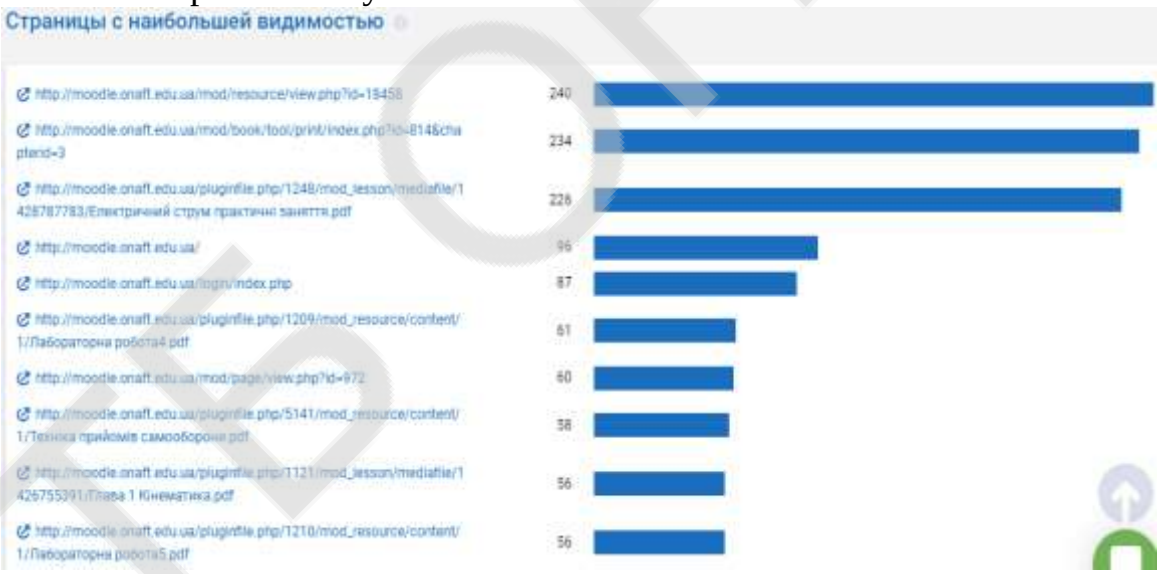

Fig. 5.2 - Pages naybolshoyu attendance

Analysis of external and internal site error

Technical optimization every year plays an increasingly important role in search engine optimization. Correction of errors on the site can provide a significant increase in positions with little or no significant infusion of funds. Well, considering that a reference impact factor is constantly decreasing, then check website for errors and correct them is a must.

With sites varvy.com, a.pr.-cy.ru, seop.ru and seowarlock.ru revealed the following errors:

- No description page;

- Redirection is not configured;
- Used headers H1 - 1, H 2 - 1, H 3 - 0 H4 - 0 H5 - 0 H6 - 0. On present selected items that are rarely found in the text of the page is hardly reasonable to use the allocation for irrelevant words. It is frequently used tags allocation B, STRONG, EM and I elements in the text of the page;
- The site is located 3 images, but alt-attributes not found. Adding alternative text search operations will better understand the content of the image;
- Not all links are clear and easy to understand user;
- No site map sitemap.txt;
- The robots.txt file is not found;
- Speed HTML 3,17 c .;
- A low brake words, less than 3%;
- Mikrorozmitky Open Graph and Schema.org not found

Fig. 6.1 - Bugs Online

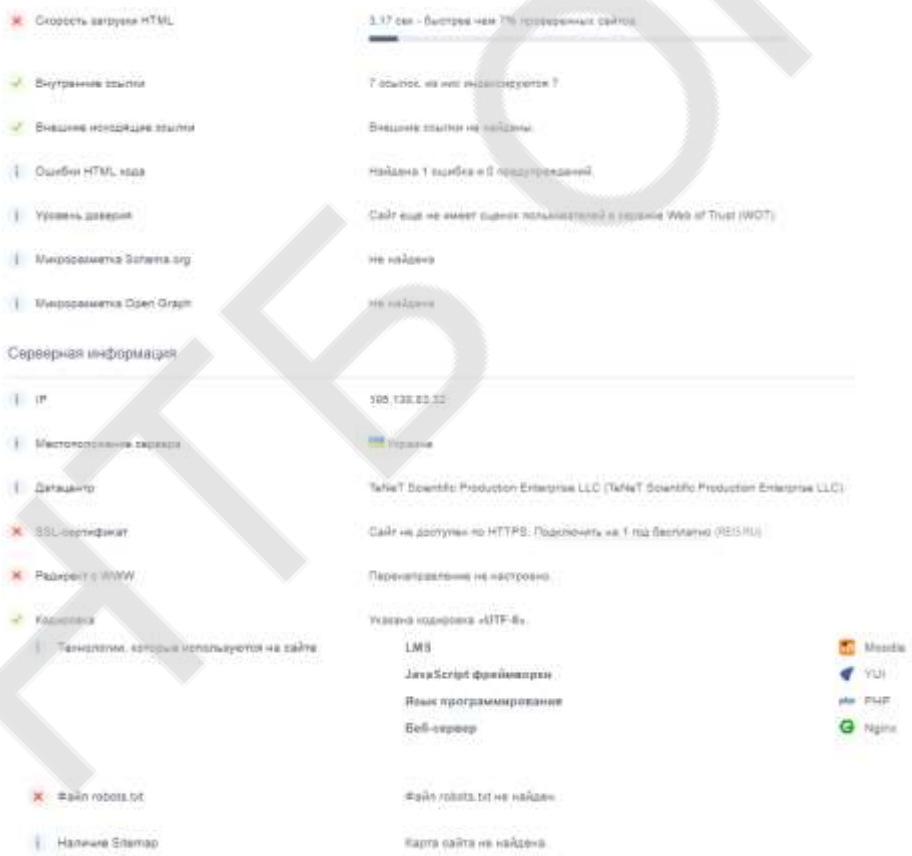

Fig. 6.2 - Bugs Online

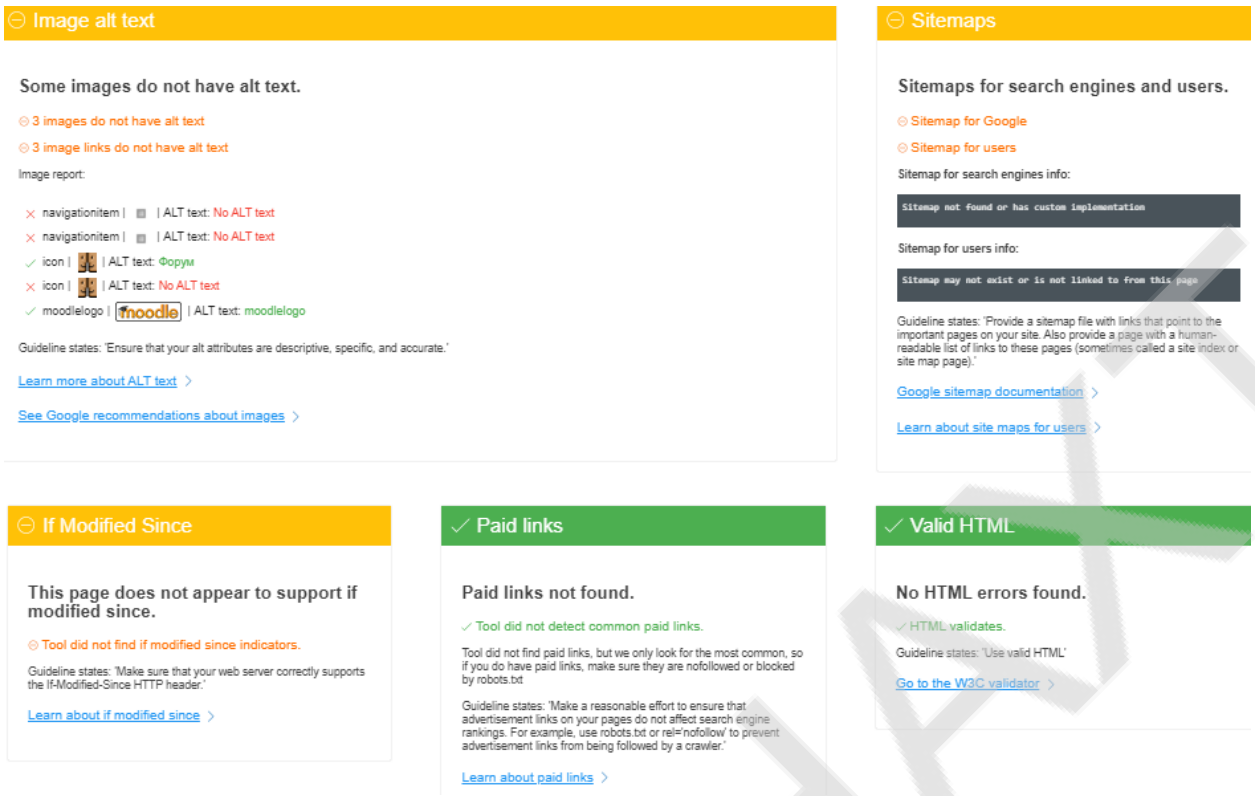

Fig. 6.3 - Bugs Online

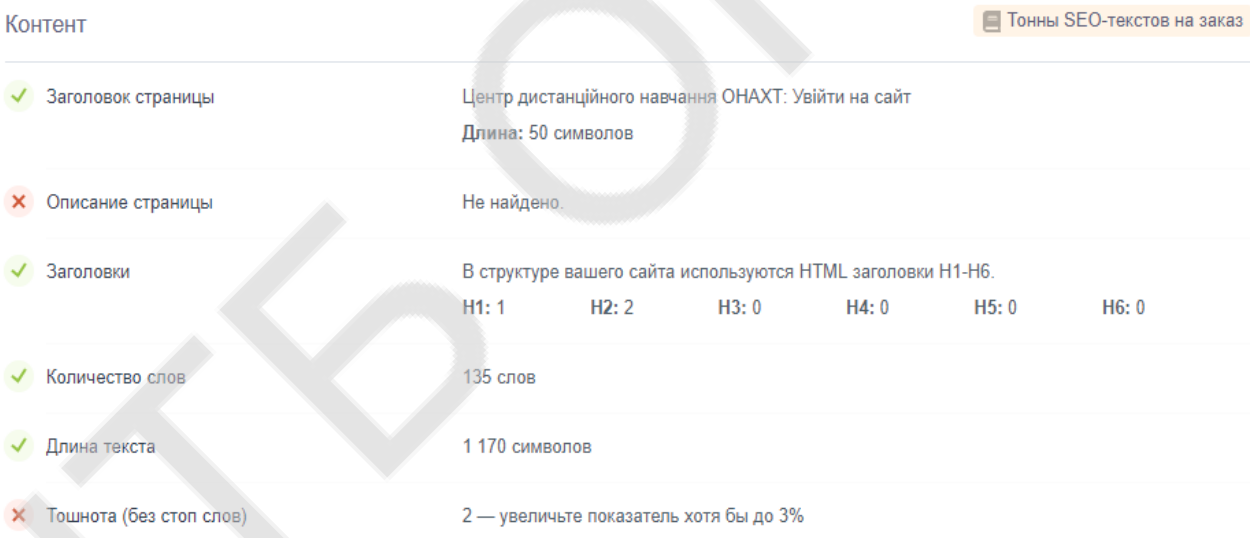

Fig. 6.4 - Errors in content site

- Analysis of the presence of internal and external links

Be sure to pay attention to the internal and external links. It is worth to take care of the proper organization of internal links. It is also important to periodically analyze internal and external links to keep the situation under control. The internal reference is a reference to another material, which is also located on site. Thanks to an internal reference content is linked together, placed on the site. External links are yet another resource that the site it might just go away. This means that some traffic from the site will be free to move to another.

Typically, webmasters hide from indexing external links using special tags. But

there are exceptions. You can not hide external links that lead to your other resources. So just traffic will be redistributed between sites, almost anything without losing.

Analysis of inbound links to the site is also very important to do, to see the whole situation and in case of mistakes promptly correct them. Links can be divided into ankornyy and bezankornyy. Encore - a reference that hidden under the word or phrase with a special tag. That same address in the text is not visible, hidden under some reference word, clicking on which she works. Bezankorni reference is not hidden, are in normal text in a website address. Better use Encore, they look much nicer and not scare visitors.

With site pr-cy.ru/link_extractor[7] on this site was discovered 7 internal links, all of them indexed and external links does not.

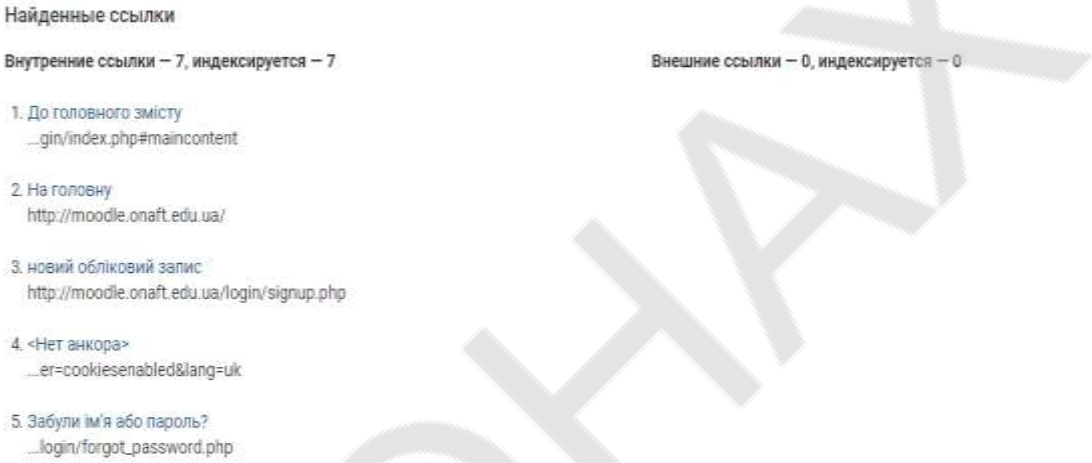

Fig. 7.1 - External and internal links Site

On the site link 900 pages and 7 domains. There is low activity in social networks.

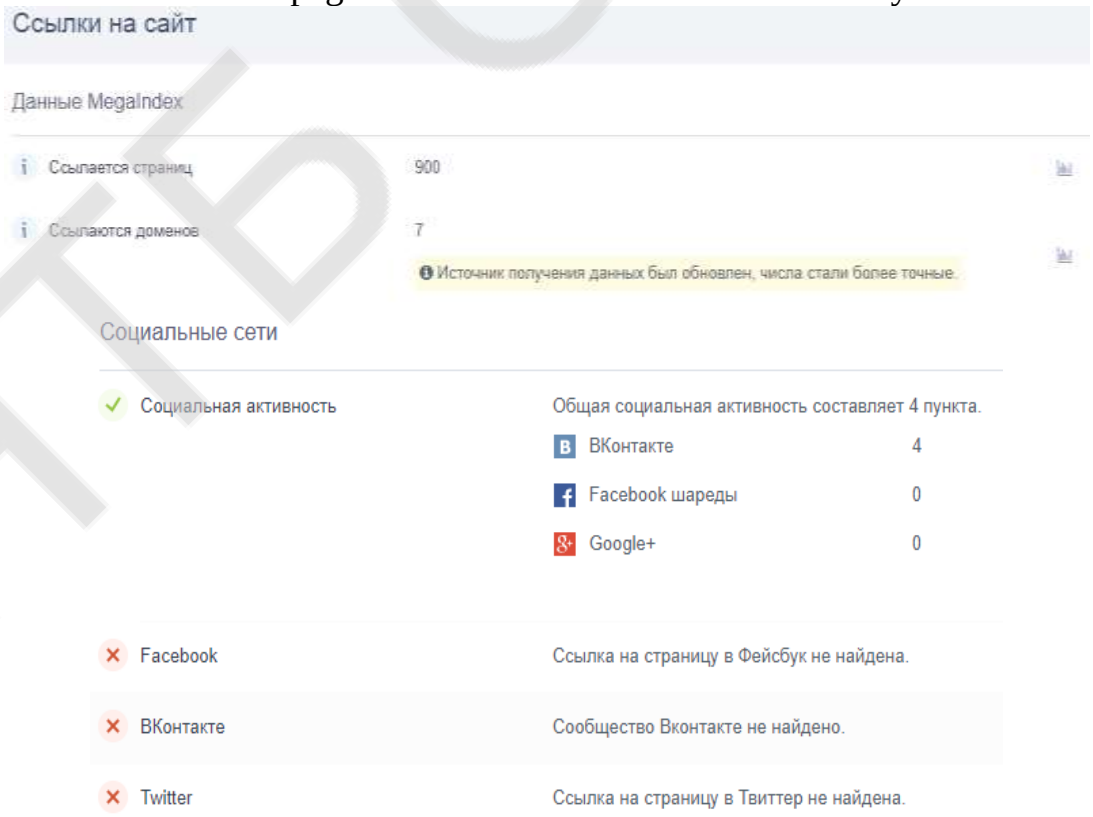

Fig. 7.2 - Analysis sitelinks

- Performance Analysis Site

Page Speed is a very important signal to search engines. And for users is a significant factor that is difficult not to pay attention if problems with it. Improving site speed can not only obtain advantages in ranking but also gain more trust and conversion rate.

The analysis results a.pr-cy.ru sites and varvy.com revealed the following problems in performance:

- Render blocking CSS and / or JS;
- There is no link from page 404;
- CSS is not minimized. Large files css. One of the points of optimization is to minimize the code that is transmitted by the browser at the opening of the site. This includes content CSS-files. These measures can significantly reduce the size of the final bit of code and speed up the download site. Minimization is due to remove extra spaces, tabs, and blank lines.

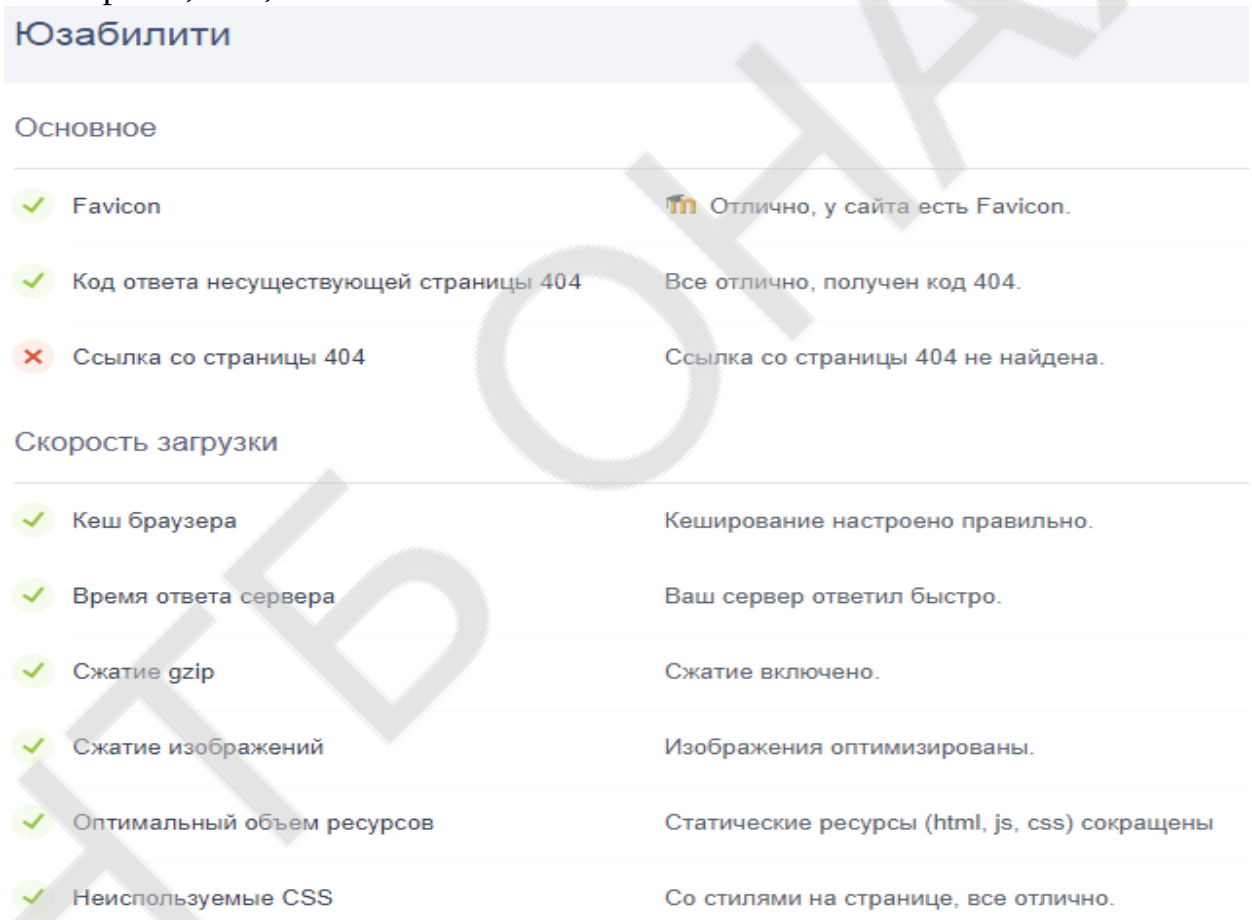

Fig. 8.1 - Site Usability

НТБ ОНАХТ

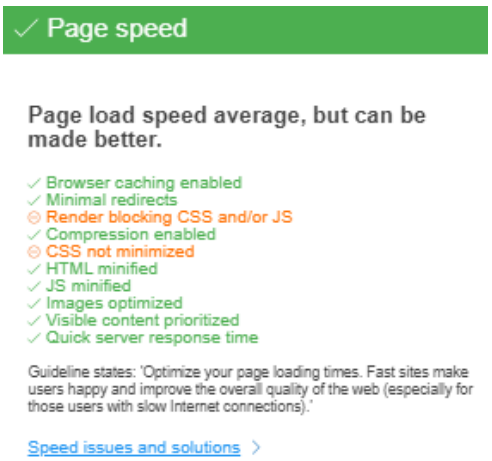

Fig. 8.2 - speed page

- Check optimization for mobile and desktop devices

Nowadays more and more people prefer to go to the Internet via mobile devices and tablets. So today, designers and developers far more important to think about how their sites will be presented on these devices. In April 2015 held updates search algorithm Google during the informal name "Mobilegeddon", and in February 2016 Yandex announced similar work algorithm called "Vladivostok". Their essence is similar - in mobile search preference to those sites that are adapted for viewing on mobile devices. This means that mobile adaptation ignored no longer.

The site is not well adapted for mobile devices that do not allow them easy to use on any device. The analysis indicates that:

- pressing the small area, but it does not prevent them completely use;
- font size on small sites;
- viewport not set

The analysis was conducted using site varvy.com [8].

Fig. 9.1 - Analyze your site's mobile

Fig. 9.2 - The site on a mobile device

5. Conclusions

In general, the site was created at a level that allows users without a separate major flaws they use. But most of this site with quite a lot of flaws and errors. Most serious mistakes and shortcomings were the lack of a site map, a low download speed, no Russian and English languages and lack lokalizatsiyiyi by robots.txt. All work on optimization should not take more than one or two months.

What you need to fix:

- Add keywords;
- Add Russian and English versions localization pages. To solve this problem, each executing a file, you need to connect additional libraries responsible for localization. Or place the additional features that are the same character;
- Add your robots.txt file;
- Add sitemap.xml. You can do it yourself or using a resource https://www.xml-sitemaps.com/;
- Reduce the size of css files. Minifikatsiya CSS files includes removing any unnecessary characters from the file to reduce its size and thereby speed up downloads. That removed during minifikatsii file: space characters; comments; line breaks; separators blocks. In most cases the process does not affect minifikatsii file and optimize it for download. Especially useful minifikatsiya CSS, JS and HTML-files. In addition, Google takes into account when ranking the performance of resource and minifikatsiya helps speed up your site. To distinguish minifitsirovannye files, their names are added to expand .min;
- Add alt text to images. This alternate text that displays the browser if for some reason he can not download the image (if the image has been deleted from the server or by off images in the browser). Bots have not yet learned to "read" images, but because of this attribute can tell the job that is this picture that her name and that it is

written. Previously, W3C standards having this attribute was optional;

- In this site a low level of confidence. You'll need to assess service users in the Web of Trust (WOT);
- Increase the rate of stop words, more than 3%;
- Need to add a description page

6. References

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3. Indexing [electronic resource] - Access to the resource: www.seogadget.ru/serppos[3];
4. Moodle [electronic resource] - Access to the resource: https://moodle.org [4];
5. Analysis visibility domain [electronic resource] - Access to the resource: megaindex.ru [5];
6. Analysis of statistics [electronic resource] - Access to the resource: pr-cy.ru [6];
7. Analysis of the presence of internal and external links [electronic resource] - Access to the resource: http://pr-cy.ru/link_extractor[7];
8. Analysis of external and internal errors [electronic resource] - Access to the resource: https://varvy.com [8].

НТБ ОНАХТ

ADAPTIVE MOBILE APPLICATION FOR THE CATS LEARNING SYSTEM

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Abstract*. Using mobile devices around the world has already become commonplace. There are a huge number of applications that greatly simplify everyday life: from simple planning of actions and events to paying for goods by simply touching the terminal with a mobile device. That is why the problem of integration a mobile learning application into the educational process is quite relevant. The purpose of this study is to increase the efficiency of the learning process through using CATS adaptive mobile application. During the study, existing learning systems were examined, their advantages and disadvantages were determined, requirements for the development of a new mobile application for the adaptive training system CATS were developed. The implementation of the mobile application is made in the environment of Microsoft Visual Studio Community (Mac), the programming language is C#. The proposed development has been integrated into the educational process of the Belarusian National Technical University.*

Keywords*: adaptive learning system, LMS, mobile application, Xamarin, adaptive learning, knowledge control, electronic training complex.*

Introduction

In the information technology environment, the term “adaptive system” refers to a process in which an interactive system changes its behavior for specific users based on information received about users, circumstances of use, and the environment.

In our days one of the most popular types of adaptability is the adaptability of learning systems, which makes e-learning possible. The following types of adaptability of such systems are distinguished:

- adaptive navigation, leading to a change in the layout of the screen;
- learning-oriented adaptability: the learning method is dynamic and individualized for each student;
- content-oriented adaptation, which can lead to dynamic content changes. For example, course information is divided into three levels of detail, and the level is displayed based on the value of a certain coefficient;
- interactive support to solve a problem that helps students to find the right solution in the next step;
- flexible information filtering, which helps to provide students with only the information they need.

Therefore, we can say that the system adapts the level of presentation of educational material to the personal abilities and capabilities of the student.

Since mobile devices are currently gaining great popularity, it seems urgent to develop a mobile client for the adaptive learning system CATS, developed and used by the Belarusian National Technical University.

Analytical literature review

The presence of demand for Learning Management Systems (LMS), naturally, gives rise to many offers, creating the problem of choosing the best. According to the Edutechnica team, the most common in the world are Blackboard, Moodle and Sakai [1]. Due to the specifics of the educational system, which differs from the more individual western, as well as in terms of cost characteristics, in the higher educational institutions of the Republic of Belarus, the most widely used systems are Moodle, Prometheus, e-University (the current name is e-Uni) and SharePoint LMS.

Moodle (Modular Object-Oriented Dynamic Learning Environment), known as a virtual learning environment or as a tool of creating dynamic websites for students, is primarily focused on the organization of interaction between professor and students, suitable for organizing traditional distance learning courses and full-time support. Moodle LMS is a free, open source software product. This fact is both an advantage of this system and its disadvantage, since, on the one hand, it allows you to create any training courses and classes, and on the other hand, it requires special knowledge in their development. As a result, the system is quite difficult to configure, and for a professor who does not know the basics of programming, it's not easy to figure it out. There are even textbooks for learning how to work with Moodle, which once again emphasizes the difficulty in mastering it. It should also be noted the unfriendly system interface, overloaded links and a lot of unnecessary information [2].

Prometheus LMS is a Russian software allows you to organize learning courses, learning materials, tests with 10 types of questions, chat, forum, messages and much more. Unfortunately, the system does not provide for the possibility of supporting course and diploma design, and there is no learning adaptability to the student's current knowledge and its psychophysiological characteristics.

E-University LMS was created by belarussian developers and used at several faculties of the Belarussian State University. The system provides the possibility of learning courses creation and tests creation for them. However, due to the fact that the system is no longer supported by the developer, its interface and set of functionalities is significantly outdated. Currently, the e-Uni system, which is more focused on the corporate sector, has replaced this software product.

SharePoint is a collection of software products and components from Microsoft for website development. Thus, the development of LMS using these products requires separate skills that are unlikely for professors. Some website developers have taken advantage of this moment and offer their services using SharePoint. Therefore, the completeness of the functionality of the LMS designed in this way will depend on the developer's imagination, and the ease of configuration will depend on his skill.

It should also be added that the Prometheus, e-University and SharePoint systems described above are paid developments and have the same disadvantages: high cost and lack of flexibility, i.e. the purchased product is a "thing in itself" and cannot be modified by other developers, but only for an additional payment.

Taking into account the shortcomings of the available paid and free learning management systems, as well as wishing to take into account their own specifics, many educational institutions resort to the independent development of such automated systems or make an individual order for development. This was done, for example, at

Harvard University and the Massachusetts Institute of Technology (USA), at the Russian Economic University named after G.V. Plekhanov, at the Higher School of Economics (HSE, Russia), at St. Petersburg State Medical University named after I.P. Pavlova and in many others. It can be noted that recently there has been a tendency for such orders, since the finished systems, although they claim the term "universality", do not always implement it [2].

It should be noted that recently there has been a shift from LMS to intelligent or adaptive learning systems (ALS) [3]. Adaptive learning systems analyze the student's knowledge at each stage of the study of the material and allow you to build an individual learning path. The psychophysical characteristics of individuals can also be considered. It should be noted the complexity of developing such systems and not always high accuracy. This is primarily due to the difficulties of formalizing knowledge. In this case, the student acts as a control object (CO), and the ALS acts as a control device (CD). In Figure 1, the following notation is adopted: Ψ - state of the environment; *Y* is the state of the student; I_Ψ, I_Y - corresponding meters; Ψ ', Y' - measurement results for Ψ, *Y*; *X* - control actions; D_X - resources (control restrictions); *Z** is the control goal, which consists in transferring the student to the required state *Y** [1].

In the designations introduced, the general rule for the functioning of ALS is presented in the following form: ALS, receiving information on the state of the environment Ψ 'and the state of the student Y', as well as information on the purpose Z* and resources D_X, gives out an acceptable control:

$$X = A(\Psi', Y', Z^*) \in D_X,$$

transferring the student from the current state to a state close to *Y**. Here A is the learning management algorithm. It is assumed that the student model connecting the observed inputs and outputs has the form $Y'=M_L(\Psi',X)$. The synthesis task of the optimal control *X** taking into account μ(*), as a symbol of some measure of proximity, is written as:

$$\min_X \mu\big(Y - M_L(\Psi', X)\big) = \mu\big(Y - M_L(\Psi', X^*)\big),\ X \in D_X.$$

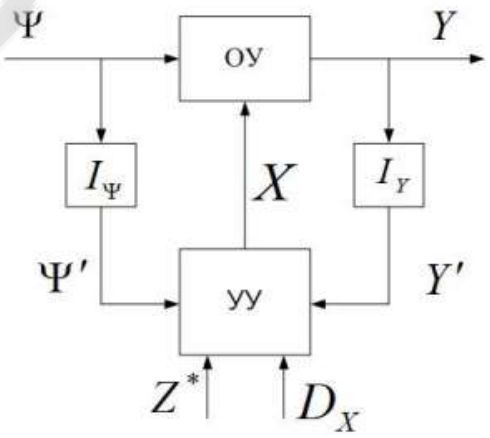

Figure 1 – General structure of ALS [1]

Despite the complexity of developing adaptive learning systems, this approach is extremely relevant in our days due to the development of continuing education. A person exists in this process throughout his life, he wants to study in any place

convenient for him, in any free time for him, as soon as possible, without spending any extra money.

The adaptive learning system called CATS (Care About The Student) is developed and used at the Faculty of Information Technologies and Robotics of the Belarussian National Technical University [4]. As mobile devices are currently gaining popularity, a mobile client has been developed for this system. Thus, a student can receive all the necessary information for the educational process, including class schedules, news, assignments, track their performance and attendance in subjects, pass through tests, work with electronic educational and methodical complexes, and also use an adaptive learning module.

Object, subject and methods of the study

The object of the study is the adaptive mobile application of the CATS learning system.

The subject of the study is the adaptability of a mobile application and its impact on the learning process.

In the course of the study, the following theoretical and empirical methods were used:

- analysis of scientific publications;
- analysis of the basic concept of adaptability;
- methods of quantitative and qualitative processing of factual data;
- a method of secondary analysis of the study results;
- conducting experimental work on the implementation of adaptive mobile applications at the department of a higher educational institution;
- analysis of the received results.

The study results were integrated into the educational process at the Software of Information Systems and Technologies department of the Faculty of Information Technologies and Robotics of the Belarusian National Technical University for the software engineers learning as part of the disciplines “Unit Testing”, “Software Testing and Debugging”, “Software Reliability”. There is an act of implementation.

Study results were reported at Republican scientific conferences. There are three publications.

Study results

To implement the adaptability of the mobile application of the CATS learning system for various platforms, the Xamarin framework was chosen, which allows developing the application for two operating systems iOS and Android at once [5-6]. The mobile application was developed using the architectural pattern Model-View-ViewModel, the development environment is Microsoft Visual Studio Community (Mac), the programming language is C#.

Currently, for free download on the Internet, an Android version of the mobile application is available at https://educats.bntu.by by selecting the appropriate link at the bottom of the welcome page. On the first application launch, user will have two main modules available: the authorization page (Figure 2) and the settings page (Figure 3).

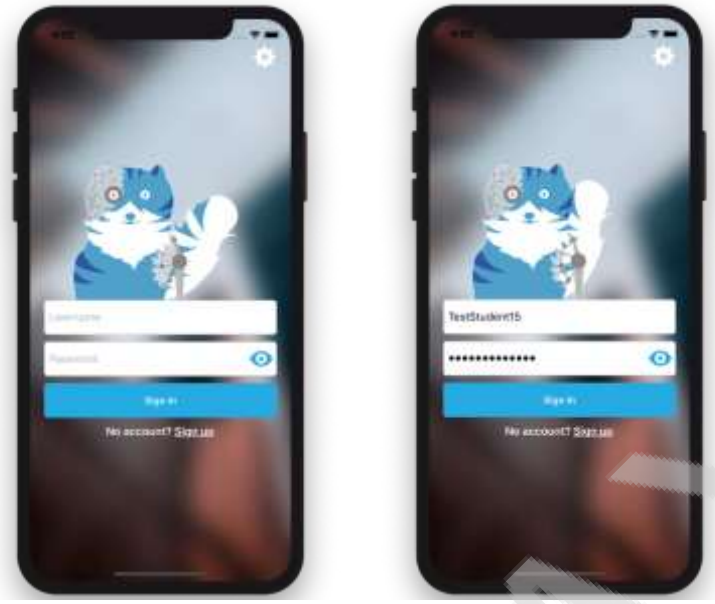

Figure 2 – Mobile app authorization page

The authorization page (Figure 2) assumes a student account in the CATS learning system. To test the application, six test entries were created with the logins TestStudent10, TestStudent11, TestStudent12, TestStudent13, TestStudent14, TestStudent15. Passwords for these credentials are the same as logins.

On the settings page, at the moment you can select the necessary server (stable, test and local university server), since the system is deployed on two servers. It is also possible to run the application on the university's local network via internal Wi-Fi without using Internet traffic. The interface language is provided in English and Russian. By default, the system language of the device is set.

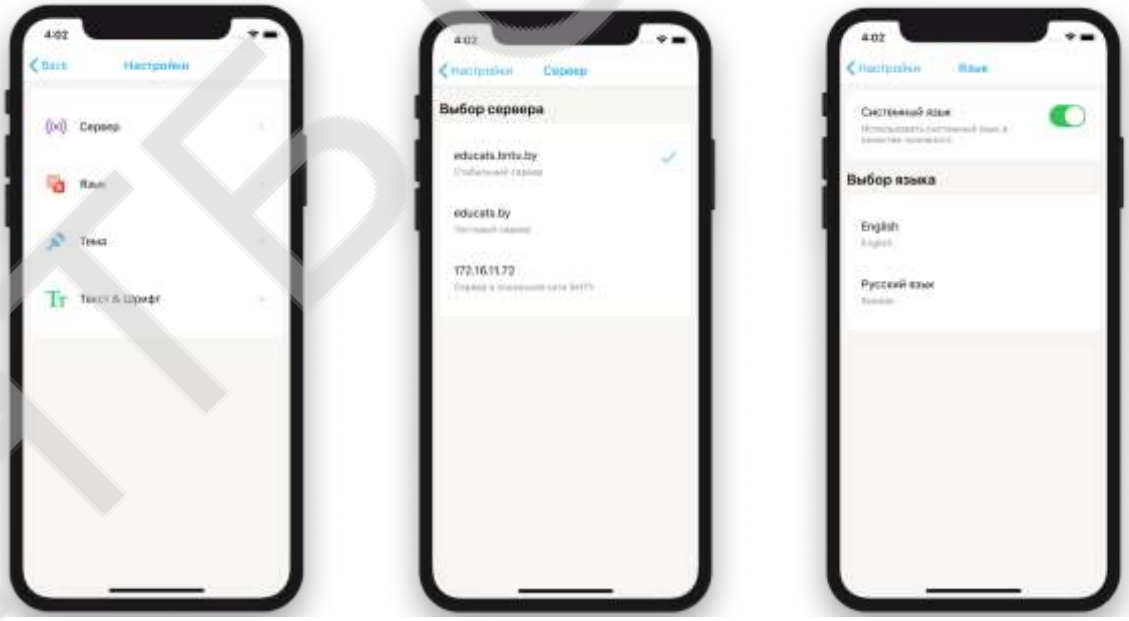

Figure 3 – Mobile app settings page

After authorization in the mobile application of the CATS learning system, you can see the main page, which is called Today (Figure 4). At the top of the screen is a calendar with the current date highlighted. In the middle part of the screen are the news, as well as the names of subjects, if there are learning sessions on them on the current

day (Figure 5). At the bottom of the screen is a menu of a mobile application, consisting of four items: Today, Learning, Statistics and Settings. By clicking on each of the proposed menu items, a transition to them will occur.

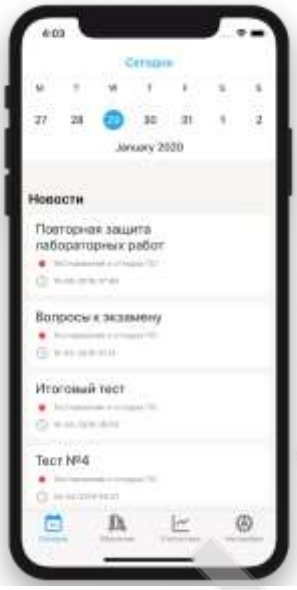

Figure 4 – Mobile app home page

As indicated above, the Today page (Figure 5) includes a horizontal calendar of classes and the latest news on subjects studied. The calendar is interactive and updates the news and the list of items for the selected date (Figure 6).

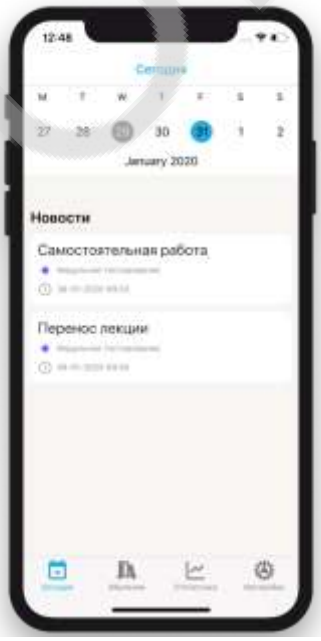

Figure 5 – Today page with a selected date without subjects

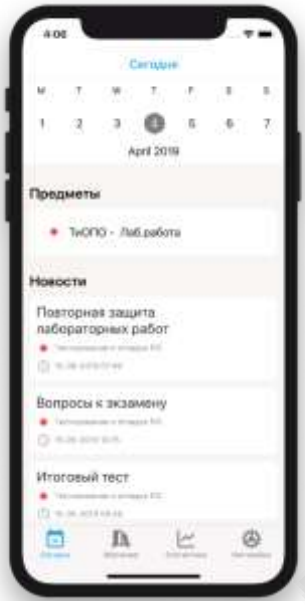

Figure 6 – List of subjects by a given date

The Learning page contains four modules: Tests, EEMC (electronic educational-methodical complex), Files and Adaptive learning (Figure 7).

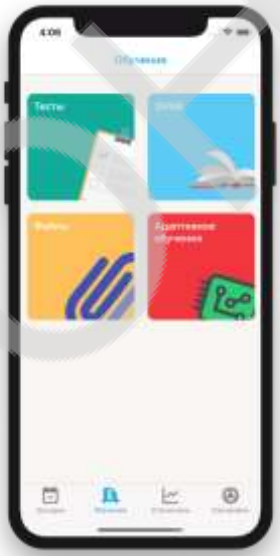

Figure 7 – Screen of the Learning page

When choosing the Tests module, the student has a list of tests that he can pass (Figure 8). It can be both tests for self-study, which can be taken many times and the rating is not counted for them, and tests for the control of knowledge used by professors to control the student's knowledge [7].

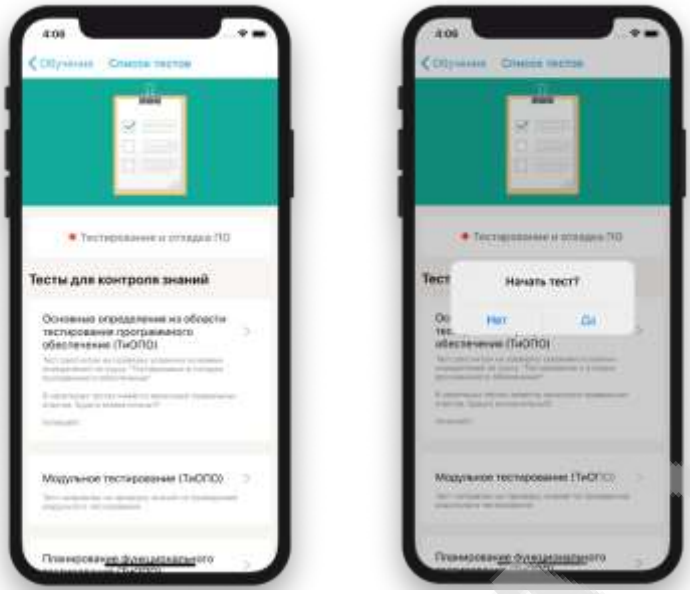

Figure 8 – Tests page

Each test can have several types of questions: with one correct answer, with the correct sequence of answers, with several correct answers, and also to enter the correct answer from the keyboard. Figure 9 shows the first three types of questions.

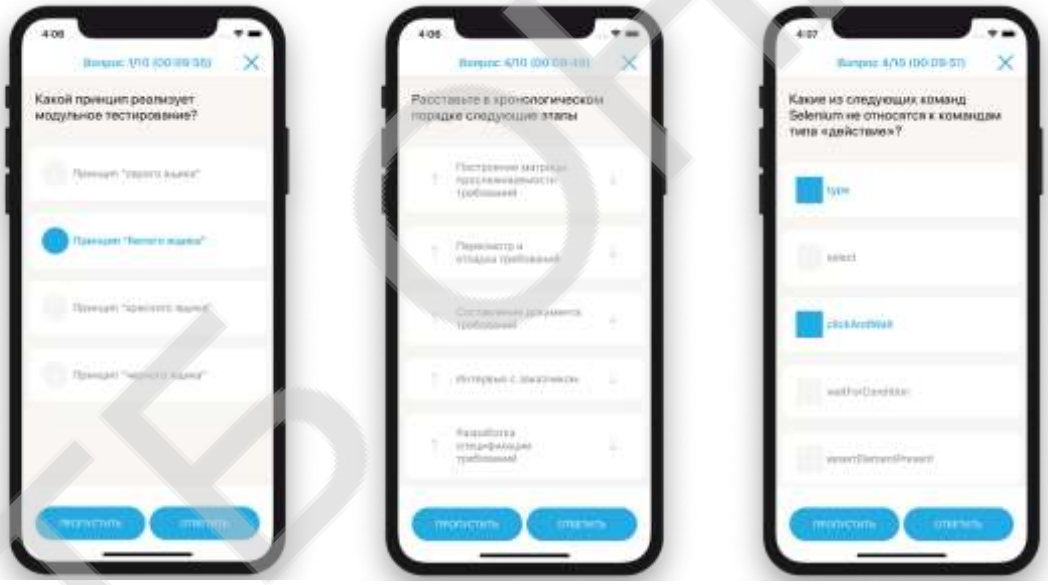

Figure 9 – Types of questions in the test

As a result of passing the test, the obtained mark is displayed for it indicating which questions were answered correctly and which are not (Figure 10).

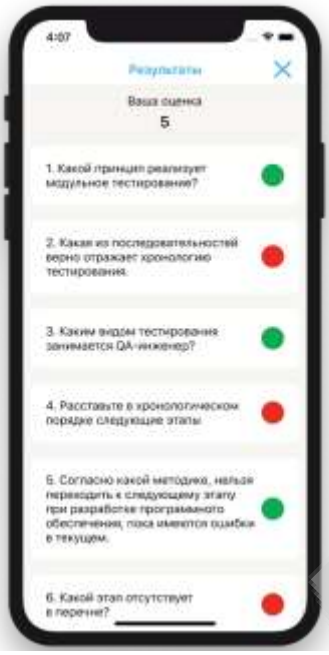

Figure 10 – Test results

The EEMC module is an interactive book (Figure 11). In the Republic of Belarus, electronic educational and methodological complexes are the main component of e-learning. The process of developing EEMC, its structural elements and sections are regulated by the relevant Regulation approved by the Ministry of Education of the Republic of Belarus [8]. According to paragraph 7 of the above document, EEMC, as a rule, includes sections: theoretical, practical, knowledge control and auxiliary. So, figure 11 shows the EEMC for the academic discipline " Software Testing and Debugging " with the required components and a cover page. Choosing the right section, information for reading will be opened, and when choosing a knowledge control unit, a transition to the test module will be implemented.

Figure 11 – Electronic educational-methodical complex

The Files module provides the ability to download files attached by the professor (Figure 12). For example, it can be questions for the exam, lecture notes, recommended

list of literature, guidelines for practical and laboratory works, course projects, task texts for these works and other information. Figure 12 shows the list of files for the discipline "Testing and debugging software", which can not only be downloaded, but also shared.

The Adaptive Learning module connects the EEMC and Tests modules. The idea behind this approach is to identify gaps in student knowledge. Each topic for study (or concept) is associated with a certain test. Passing the test, a list of questions is formed to which the student answered incorrectly, therefore he did not study a certain topic. Therefore, this topic should be offered for reading, and then a test to verify the material studied. The algorithm will continue its work until the correct answers are received to all questions of the required topics for study.

Adaptive learning begins with passing a pre-test throughout the course, the results of which will form the first list of materials for study (Figure 13).

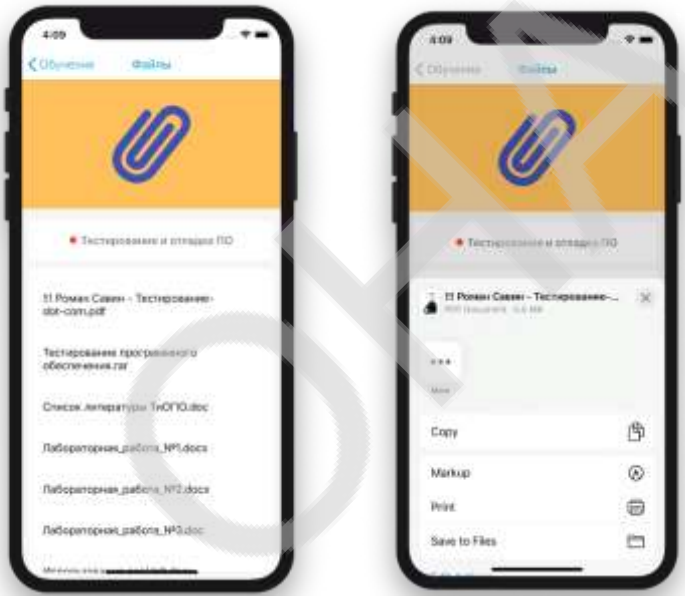

Figure 12 – Files to download from a mobile application

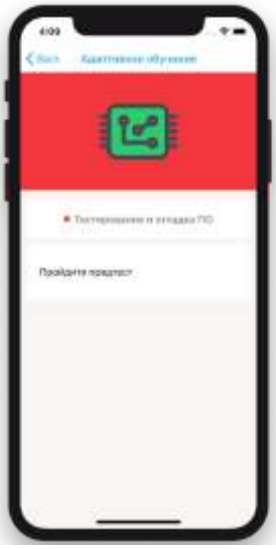

Figure 13 – Adaptive learning start

Figure 14 shows the first pre-test question for adaptive training in the discipline "Software Testing and Debugging". At the top of the screen you can see that this is the

first question out of thirty-six. It displays the timer remaining time for passing the test. You can answer the question right away or skip it and return to it later. The figure shows a question with one correct answer.

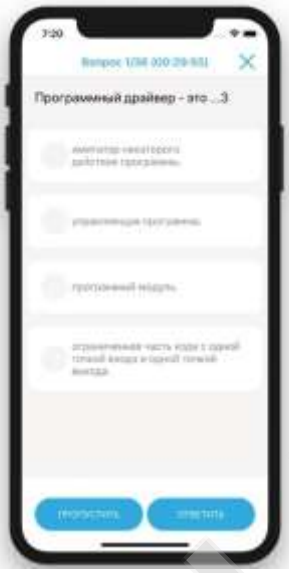

Figure 14 – Questions from the pre-test

After passing the pre-test on the Adaptive learning page there are two links Recommended reading material and Take the test (Figure 15).

Figure 15 – Updated adaptive learning list

If you click on the Recommended Reading Material, the EEMC will open right on the necessary page of that topic, the questions to which were answered incorrectly (Figure 16). After reading the proposed material, you should pass a test on the topic.

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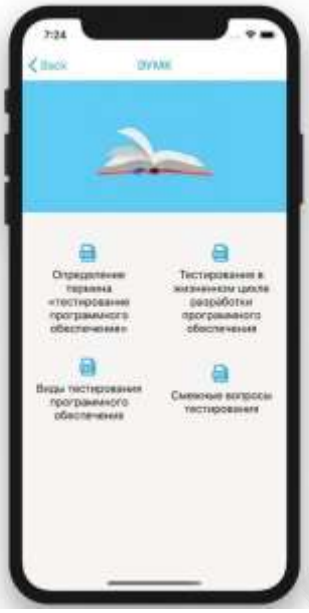

Figure 16 – Recommended reading material

The Statistics page contains information about the student's academic performance in laboratory studies, as well as about his omissions from laboratory work and lectures (Figure 14).

Figure 14 – Statistics page

The student is only available information about his own grades and passes (Figure 15), while the professor can view information about all students in the groups in which he conducts classes (Figure 16).

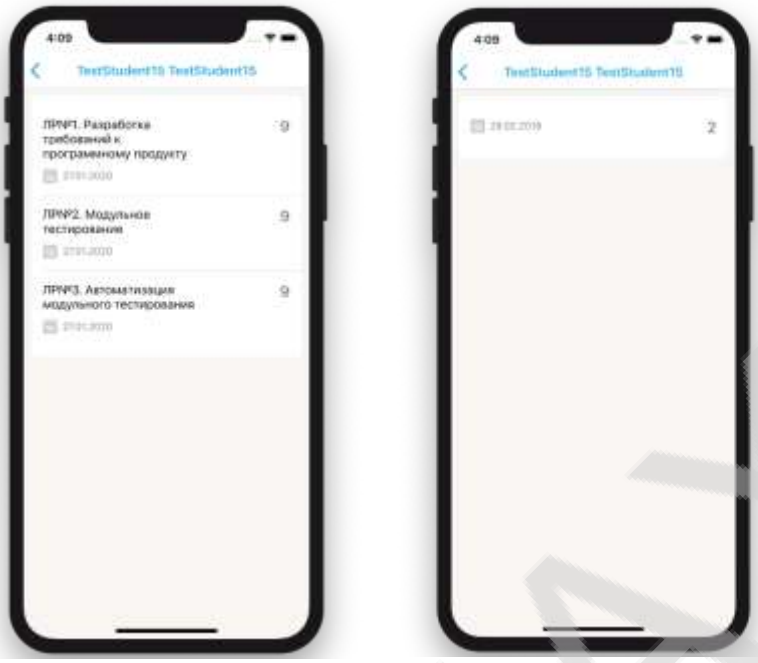

Figure 15 – Information about student's academic performance and skipping classes

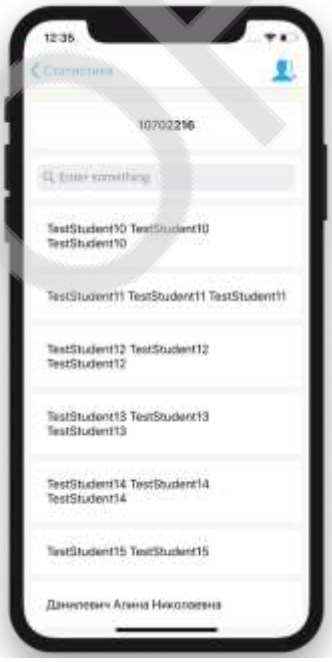

Figure 16 – List of students visible from the professor's role

The Settings page was described above, however, it is worth mentioning that after authorization the full name of the student and his group will be visible in a separate block. An exit button also appears, which redirects the user to the authorization page and clears all current authorization data (Figure 17).

Figure 17 – Settings page after authorization

Conclusion

The current trend towards lifelong education creates a promising environment for promoting the proposed mobile application of the CATS adaptive learning system.

The considered mobile application has the following features:

- covers all the main components of the learning process, including working with electronic educational and methodological complexes, passing tests, downloading the required information;
- informs participants of the educational process about their performance and absences;
- takes into account the characteristics of each student, realizing the possibility of adaptive learning;
- allows to adapt to various sizes of devices;
- implemented using modern technologies for the Android and iOS operating systems;
- available on the Internet, as well as on the local network of the Belarusian National Technical University via Wi-Fi;
- the proposed system has been tested on several academic disciplines of the university;
- the mobile application is constantly being improved, updated and is a platform for generating new ideas;
- the functionality of the CATS adaptive mobile application can significantly increase the efficiency of the learning process.

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НТБ ОНАХТ

MEASURMENTS FROM HIVE PREVENTS THE EXTINCTION OF BEES BASED ON IOT TECHNOLOGY

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Lodz University of Technology (Poland)

Abstract: *European plant cultivation depends on bees' participation in pollinating flowers. Colony Collapse Disaster and "Empty Hives Syndrome" is still growing. The aim of this article is proposing technological solutions for prevention of bee's colony reduction based on own research and temperature measurements from hive. A survey of beekeepers was conducted for better understanding beekeeper's problems. The electronic equipment developed for the study by student confirmed presumed objectives and the effectiveness of the proposed algorithms for detecting anomalies inside the hive. Presented result can help prevent the extinction of bees using IoT Technology.*

Keywords: *IoT, Bees, Algorithms, Swarming Detector, Machine Learning*

Introduction

Bees are treated as a deity, are considered exceptional, marvellous and wonderful creatures. In Poland, beekeeping is associated primarily with family tradition, continued for by next generations. Bees provide us with healthy and natural products, such as: honey, pollen and propolis. The main benefits of food produced by bees are antioxidants contained in it and antibacterial properties. Furthermore, EU parliament noted in resolution T6-0579/2008 that 79% of the world's food supply is dependent on honeybees while Great Brittany beekeepers say that this number exceeds over 80%.

Over the past 20 years, there has been a dramatic decline in the honeybee population (Apis Mellifera), in most countries of the world. The sudden decline in the population of bees - both breeding and wild - has far-reaching consequences. Pollination by bees ensures the reproduction of many plant species, especially crops that are the basis of nutrition for the world's population, which is why authors of article Intelligent Hives project focuses on reducing the risk of extinction of the bee population. One of the main factors causing the reduction of bee populations are like late detected disease, thefts, time-consuming maintenance or lack of technology development.

The aim of this article is to develop knowledge and show result of study that will be able to remotely monitor bee family and notify about anomalies based on temperature measurements to prevent bees from extinction. Solution of this problem will have an impact on an important part of the environment and will increase the awareness of people about data collection and analysis.

World agriculture problem

Bees are key pollinators for European agricultural crops, not only from economic perspective. It is estimated that over 35% of human food consumption depends on insect directly or indirectly [1]. The worldwide economic value of pollination amounted to €153 billion, which represented 9.5% of the value of the world agricultural reduction used for human food in 2005 [2]. Food would become a very scarce resource, in a situation when bees become extinct.

Solutions for beekeepers, which help bees

At this moment, beekeepers support their work with manual measurements, that is a worrying process for life of bees. Several companies provide single sensors that could be implemented in hives, however there is no a complex solution on the market yet.

There is a product on Polish market, called ControlBee, which provides only a location tracking and temperature monitoring, however with not precise results. This system does not possess the ability to monitor the hive in order to prevent the loss of bees. The ULmonitor is the next device on the Polish market, which is worth investigating. This system consists of periodical recording of humidity and temperature information by sensors placed in hives, transferring data to a phone. Unfortunately, like first product, the second product do not make analysis and is complicated for a beekeeper, who is not familiar with electronic system.

Survey among beekeepers

Beekeepers have been gathering knowledge for centuries. Traditions is passed on by generation to generation and own observations and practical experience. Beekeeper's knowledge is a good resource of bee protection, which is why survey was conducted among beekeepers to check beekeepers' awareness of hazards for bees, awareness of ways to protect bees and for the determination of important parameters for monitoring beehives. It was carried out on the 10th June 2018 and forty-four beekeepers took part in presented survey. Among the respondents were both experienced beekeepers who have been running their apiaries for many years, but also the less experienced ones. This cross-section of the beekeeping community also affected the number of hives owned by one beekeeper. The number ranged from 3 to over 90 hives per person.

The results of this survey indicate not only that beekeepers are aware of the dangers that could happen to them, but also most of them have lost their bee families at least once. Over 90% of beekeepers have heard about Empty Hives Syndrome and as much as 72.7% of the respondents recorded a loss of family in their apiary.

According to the beekeepers' answers, the loss of a colony is not only very costly, but it is also connected with a long time of reconstruction of a bee colony. Less than 91% of the respondents answered that this type of loss is expensive and the rest of them answered that it may be so. None of the respondents answered this question in the negative. When asked about the time of reconstruction of the lost family, two answers received a total of less than 80% of votes. It was "3 to 6 months" and "6 to 12 months". It follows that in such a situation a beekeeper must reckon with a smaller profit from his activity for several to even several months.

Thanks to the survey presented above and the conversations conducted with beekeepers we were able to deduce what an average beekeeper need. Our device and its functionality are created based on consultations with customers. This can be proved by the functions available in various BeeHUB variants. The basic version focuses on humidity and temperature measurements, while we are currently developing and testing further products that would allow, among other things, sound analysis that helps to detect swarm and the addition of a scale that would not only meet the greatest need of beekeepers, but would also be cheaper than other scales for hives available on the market.

Internet of Things

The Samsung Techonomic research presented that over 80% of Europeans has no idea about Internet of Things really is. This may seem strange as statistically in each home on our continent there are 19 electronic devices on average. Internet of Things is a collection of technological solutions that are designed to home automate, an office or a whole city! It's not only for fun, most of all means for solutions that translate into effective time, security and space management.

Idea of Intelligent Hive, which can monitor bee's family is a perfect example of a system utilizing the features of IoT. Simple implementation of the low power consumption device for monitoring hives, turns an average hive into an Intelligent Hive. User can place the device into the hive, distributes the sensors and turns it on, which is sending valuable data gathered by these sensors with low latency. Data is processed in the cloud and advanced data analytical solutions with embedded artificial intelligence mechanism, combined with machine learning, is conducting analysis of variety of IoT data.

To create system based on IoT, it is necessary to expand, choose or create main components:

- Hardware - electronic components, which are the source of data;
- Middleware - accountable for storage and data analysis;
- Presentation – presentation and visualization of data.

Fig 1. Concept of IoT system structure.
Source: Sebastian Górecki

Based on a conceptual structure, prototype of system was created. This model was designed as a prototype of an actual device for prevent bees' diseases with a simple Internet interface for a beekeeper, with possibility of data download with idea for prediction anomalies.

The Wi-Fi network is widely available and quite cheap for beekeepers to create and maintain easily accessible environment for test device to cloud. For this reason, prototype electronic equipment was based on this network in the conceptual version of the project. Using Wi-Fi, data from the device was sent to the cloud - in this case to open source database. It would be worth to utilize the LoRaWAN network in the future or the 5G network for data transfer, due to the relatively large range of the sending device. Expanding listed networks allow cheap data transfer at long distances, with small delays and a stable link.

Fig 2. Data downloaded from prototype device, presenting variation in temperature from 10/09/2018 to 16/09/2018.
Source: Sebastian Górecki

Temperature inside hive

The data taken from the test equipment from the study for all 2018 beekeeping season, where example of short period is presented in Fig. 2. confirmed that each bee family creates own environment in a hive. In swarming period exposes a specific temperature in the beehive. Despite changing external conditions, bees can maintain their optimal temperature in the nest the best for the brooding. in a range of 33-36 °C. In winter season, bees maintain a temperature around 25 °C in the centre of the withers.

Observing the temperature in the nest, it can be determined at what stage the bee family is. For example, in the cold weather, the temperature under the coating will increase, when food intake increases. During late autumn or winter the temperature in the beehive may be equal to the outside temperature, which may be caused by underfeeding. However, swarm extinction is usually the result of a disease, not a lack of supplies. When you see a cooled beehive, you can eliminate it in advance, so that the disease does not spread to other bees.

Presented identification algorithm of Fig. 3. algorithm which was made by scientists from Latvia was tested on historical temperature data of honeybee colonies gathered from prototype devices and successfully identified all swarming events. An algorithm should be included in the software, to detect swearing period. In the period of warm-up for final take-off of bees, the temperature above upper hive body rises by 1.3-3.5° C from normal brood rearing temperature 34- 36 °C to 37 °C. In observed swarming events, it was found out that a bee colony needs around 14 min to warm up before final take-off [3].

Fig 3. Activity diagram of one iteration of swarm identification algorithm.
Source: Remote detection of the swarming of honeybee colonies by single-point temperature monitoring

Machine learning implementation

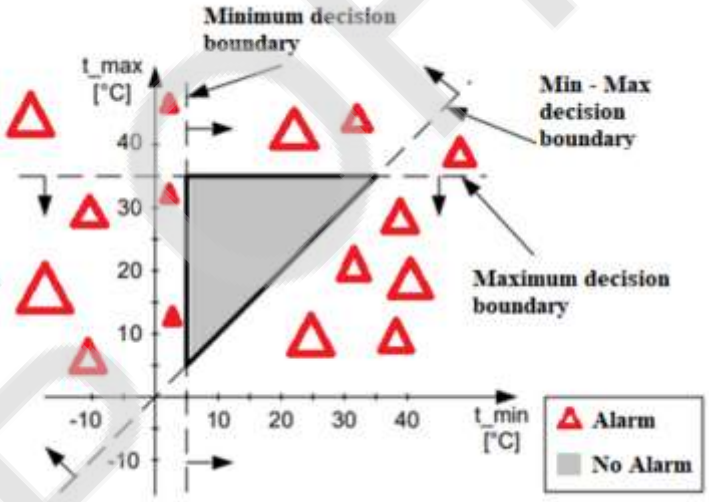

Fig 4. Activity diagram of one iteration of swarm identification algorithm.
Source: Sebastian Górecki

Usage of machine learning should concentrate on the idea [4] contained on Fig. 4. which shows classification set of training data with minimum and maximum temperature boundaries and minimum-maximum boundary. Temperature readings, which are placed outside boundary triangle are extreme for beehive colony and cause sending an alarm message to the beekeeper, when diseases or swarm period occur.

This temperature classification will be tested for anomaly detection in the next season 2020. However, tasted on the collected data from the past years, it is accurate and effective.

Summary

Colony Collapse Disaster and so-called "Empty Hives Syndrome", particularly in North America and most of Europe is still growing. Intelligent Hive is a solution,

enabling analysis of the alarm state, by monitoring such parameters as temperature inside the hive. The idea of basing the bees' state of health anomalies detection system on IoT technology promises to be very fast, accurate and efficient. Data collected using a dedicated circuitry, software and machine learning algorithms, with a combination of gathered knowledge for one season, based on existing scientific research and analysis affirmed that the temperature analysis have been conducted properly. Investigated activity diagram of one iteration of swarm identification algorithm and the proposed temperature classification that can be used in machine learning algorism to detect bad health bees' condition. System with the solutions quoted will be developed and tested further. Presented ideas and result can help prevent the extinction of bees using IoT Technology.

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REMOTE TEMPERATURE AND HUMIDITY MEASUREMENT SYSTEM

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Abstract*. The relevance of the study lies in high-quality remote measurement of temperature and humidity in compliance with the requirements for the safety of transmitted data.*

The purpose of this study is to measure temperature using indirect features, i.e. the difference in the speed of sound for agriculture and industry.

The studywas made on 20 pages of printed text, contains 1 drawing and a list of references, which consists of 10 sources. The study was done in English.

Key words*: temperature measurement, humidity measurement, the speed of sound, the remote measurement.*

I Introduction

The main directions of our state's policy in the field of environmental protection and use of natural resources include the creation of conditions for the environmentally safe existence of the environment. The main criteria for environmental conditions are atmospheric pressure, humidity, and temperature. There are weather stations around the world that regularly measure temperature and humidity in order to detect changes in a timely manner, assess, prevent and eliminate the consequences of negative processes.

Unfortunately, the accuracy of temperature measurement by weather stations cannot be 100% accurate. This is affected by direct sunlight, precipitation, and other weather conditions. Also, weather stations make measurements only at a certain point and because of this, a large number of them are required. Our offer allows you to make accurate measurements of temperature and humidity in all the necessary space from any point.

The relevance of the study, in connection with the above, consists in high-quality remote measurement of temperature and humidity in compliance with the requirements for the safety of transmitted data. To know exactly what to measure, you need to have knowledge about the temperature measurement process and its main characteristics.

Air temperature describes the thermal state of the atmosphere and is measured in degrees Celsius (°C) and Kelvin (K). It determines the conditions of formation and the nature of the weather depends on the angle of incidence of sunlight. The temperature is affected by the transparency of the atmosphere, cloud cover, wind direction, precipitation, and the like. The difference between the highest and lowest air temperatures is called the amplitude of temperature fluctuations.

To study the weather, it is necessary to observe all its elements: air pressure, temperature, humidity, cloud cover, wind direction and its strength. Weather observations are made at weather stations using special devices.

However, all of the weather stationshavethe same drawback – measurement of temperature and humidity. Currently, it is important to measure the temperature on the

field area. This problem is solved by increasing the measurement points followed by averaging.

We proposed to measure the average temperature and humidity by measuring the difference in the speed of sound.

II Analytical review of the sources

Agricultural production depends mostly on the weather and climate. In General, the possibility of growing certain types of crops is determined by the necessary amount of heat and light, and their yield is determined by the amount of precipitation and moisture reserves in the soil. [9]

In our country, about 70 % of the areas occupied by agricultural crops are located in areas of insufficient and unstable moisture. The choice of optimal sowing dates, the feasibility and timing of applying mineral fertilizers, carrying out various agrotechnical and reclamation activities-all of the above mentioned is determined by meteorological conditions. Conditions for sowing, tillage, and harvesting determine the productivity of agricultural machines and ultimately affect crop yields.

Temperature and humidity monitoring data are used to warn about adverse weather events for the national economy, to study the climate and its changes, as well as to directly provide information about the weather to service organizations.

We can assign a number (with dimension) to each body that characterizes the temperature of this body, and the higher the temperature, the greater the number.

To do this, you need to select a temperature standard, that is, a body that under certain conditions, equilibrium and fairly easy to reproduce, would have a certain temperature number. This temperature number is the reference point of the corresponding temperature scale – an ordered sequence of temperature numbers that allow you to quantify the temperature of a particular body. [1]

The temperature scale allows you to indirectly measure the body temperature by directly determining a physical parameter that depends on the temperature.

The most famous example of a temperature reference is water. The melting and boiling points of water at normal atmospheric pressure are selected as reference points in modern (but not necessarily native) temperature scales proposed by Anders Celsius (1701-1744), Rene Antoine fershaw Reaumur (1683 – 1757), and Daniel Gabriel Fahrenheit (1686 – 1736). The latter created the first practically usable alcohol and mercury thermometers, widely used until now.

Reomur and Fahrenheit temperature scales are currently used in the United States, great Britain, and some other countries.Introduced in 1742, the temperature scale of Celsius, which proposed a temperature interval between the temperatures of ice melting and water boiling at normal pressure (101325 PA) divided into one hundred equal parts (degrees Celsius), is widely used today, although in a refined form, when 1°C is equal to 1 K. The boiling point of water becomes approximately equal to 99.975°C. These corrections are usually not significant, since most used alcohol, mercury, and electronic thermometers do not possess (since this is not necessary) high enough accuracy to take them into account.

After the introduction of the International system of units (SI), two temperature scales are recommended for use. The first scale is thermodynamic, which does not depend on the type of thermometric substance and is introduced using the Carnot cycle.

[7] the unit of temperature measurement in this temperature scale is 1 Kelvin (1 K), one of the seven basic units in the SI system. This unit is named after Lord Kelvin (W. Thompson), who developed this scale and kept the value of the temperature unit the same as in the Celsius temperature scale. The second recommended temperature scale is the international practical one. [8] This scale has 11 reference points – the temperatures of phase transitions of a number of pure substances, and the values of these temperature points are constantly updated. The unit of temperature measurement in the international practical scale is also 1 K.

In addition to setting reference points that are determined using the temperature standard, you must select a thermodynamic property of the substance that depends on the temperature (a sign of temperature), which should be easily reproduced. This allows you to get a set of temperature points that are intermediate with respect to the rapper points.

For the numerical characteristic of temperature, you must select a sign of temperature change (thermometric property-a physical property of a substance that depends on temperature), which is also easily reproduced, which allows you to get an ordered set of temperature numbers.

Such signs are, for example: the change in volume during heating, a change in the electrical resistance of bodies, the occurrence of an electric current in bodies, etc. Corresponding to these signs, temperature measuring devices (thermometers) will be: gas and mercury thermometers, thermal resistance, thermocouple.

By bringing the thermometer into a state of thermal equilibrium with the body whose temperature is to be measured, it can be stated on the basis of the zero beginning of thermodynamics that their temperatures are equal. This allows you to assign the body the same temperature number (temperature value) that the thermometer has. Another method of measuring temperature is implemented in pyrometers-devices for measuring the temperature of bodies by the intensity of their thermal radiation. In this case, the equilibrium state of the thermodynamic system is reached, from the pyrometer itself and the thermal radiation received by it. More information about this will be provided in the section of the course devoted to the quantum properties of equilibrium thermal radiation. Now we only note that optical pyrometry (non-contact temperature measurement methods) is used in metallurgy to measure the temperature of the melt and rolled products, in laboratory and production processes where it is necessary to measure the temperature of heated gases, as well as in plasma studies.

Constant volume gas thermometer: a thermometric body is a portion of gas enclosed in a balloon with a process. The basis for measuring temperature (thermometric sign – - gas pressure at a certain fixed volume. The constancy of the volume is achieved by moving the right tube level in the left tube of the pressure gauge is brought to the same level (reference mark) and at this point, measurements are made of the difference in the height of the liquid levels in the pressure gauge. Taking into account various corrections (for example, thermal expansion of glass parts of the thermometer, gas adsorption, etc.) allows you to achieve the accuracy of measuring the temperature of a gas thermometer with a constant volume equal to one thousandth of a Kelvin.

Gas thermometers have the advantage that the temperature determined with their help at low gas densities does not depend on the nature of the gas used in a wide range, and the scale of the gas thermometer-well coincides with the absolute temperature scale (it will be written below). In the second Chapter, we will describe in more detail the ideal gas thermometer that determines the absolute temperature scale.

Gas thermometers are used for calibration of other types of thermometers, such as liquid thermometers. They are more convenient in practice, however, the scale of the liquid thermometer, which is graded according to the gas one, is usually uneven.

A liquid thermometer is the most commonly used thermometer in everyday life, based on changes in the volume of a liquid when its temperature changes. In a mercury-glass thermometer, the thermometric body is a glass balloon with a capillary and mercury placed in it. A thermometric feature is the distance from the mercury meniscus in the capillary to an arbitrary fixed point. Mercury thermometers are used in the temperature range from – 39 ° C to several hundred degrees Celsius. At high temperatures (more than 300 ° C), nitrogen is pumped into the capillary (pressure up to 100 ATM or 107 PA) to prevent the mercury from boiling. By adding a waist, the lower temperature measured by a mercury thermometer can be reduced to – 59 ° C.

Other types of widely used liquid thermometers are alcohol (from – 110 ° C to + 50 ° C) and pentane (from – 200 ° C to + 20 ° C). Note that water can not be used as a thermometric body in a liquid thermometer: the volume of water with an increase in temperature first falls, and then increases, which makes it impossible to use the volume of water as a thermometric feature.

However, due to the development of measuring technology, the most convenient technical types of thermometers are those in which the thermometric feature is an electric signal. These are thermal resistances (metal and semiconductor) and thermocouples.

Metal resistance thermometer: the temperature measurement is based on the phenomenon of metal resistance increasing with temperature. For most metals near room temperature, this dependence is close to linear, and the temperature coefficient of resistance for pure metals has a value close to 4.10-31 / ° C. the Thermometric characteristic is the electrical resistance of a thermometric body – a metal wire. Most often, platinum wire is used, as well as copper wire or their various alloys. The range of application of such thermometers is from hydrogen temperatures (~ 20 K) to hundreds of degrees Celsius. At low temperatures in metal thermometers, the dependence of resistance on temperature becomes significantly nonlinear and the thermometer requires careful calibration.

Semiconductor resistance thermometer (thermistor): temperature measurement is based on the phenomenon of reducing the resistance of semiconductors with increasing temperature. Since the temperature coefficient of resistance of semiconductors in absolute value can significantly exceed the corresponding coefficient of metals, the sensitivity of such thermometers can significantly exceed the sensitivity of metal thermometers.

Specially manufactured semiconductor thermal resistances can be used at low (helium) temperatures. However, it should be noted that in conventional semiconductor supports, defects occur due to the influence of low temperatures, which leads to a lack

of reproducibility of the measurement results. Most often, germanium and carbon (coal) are used as the material for the thermistor.

A thermocouple is a junction of two metal wires at a measured temperature and the other two ends of these wires at a known temperature. The resulting closed electric circuit includes a measuring device. The electromotive force (thermo-EMF) that occurs in such a circle depends on the temperature difference between the two junctions – the measuring and the free one. Thus, the thermometric body is a junction of two metals, and the thermometric sign occurs in the thermo-EMF chain. The sensitivity of thermocouples ranges from units to hundreds of mV / K, and the range of measured temperatures from nitrogen to one and a half thousand degrees Celsius (for noble metal thermocouples). Greatest use is made of thermocouples: copper-constantan, chromel-alumel, platinum-rhodium, iridium-rhodium.

It should be noted that the thermocouple can only measure the temperature difference between the measuring and free welding. The free junction is usually possible innormal room temperature. Therefore, to measure the temperature with a thermocouple, you must use an additional thermometer to determine the room temperature or a system to compensate changes in the temperature of the free junction. [2]

In the radio often apply the concept of noise temperature equal to the temperature to which must be heated resistor, consistent with an input resistance of electronic devices to the capacity of the thermal noise of this device and resistor was equal to a certain frequency band. The possibility of introducing such a concept is due to the proportionality of the average noise power (the average square of the noise voltage on the electrical resistance) to the absolute temperature of the resistance. This allows you to use the noise voltage as a thermometric indicator for measuring temperature. Noise thermometers are used to measure low temperatures (below a few Kelvins), and in radio astronomy to measure the radiation temperature of space objects.

Measurement error is a value that characterizes the deviation of the measured physical quantity from its actual (true) value. The actual (true) value of the measured physical quantity is the value obtained using an exemplary (reference) device. [3]

When you repeatedly measure a value, it is easy to make sure that the measurement result changes all the time, that is, in each case, there is a deviation of the measurement result from the average value of the measured value. In addition, taking measurements of the same value in a different time interval gives not only other deviations from the average value, but also a different average value of the measured value.This is due to the fact that the measured physical quantity of the body under study, as well as the measure used, changes during the measurement time. These changes are caused by the influence of external factors: changes in ambient temperature, atmospheric pressure, air humidity, room vibration, electrostatic charges, stray currents, and so on. So, it is not possible to accurately determine the measured value, that is, without the appearance of any deviations during multiple measurements.

As a result of a large number of random and deterministic factors that occur during the manufacture, storage and operation of measuring instruments, the nominal values of measures and readings of measuring instruments differ from the true values of the measured values. These deviations characterize the errors of the measuring tools.

The practical usefulness of any measurement is determined by indicating its error, that is, the quantitative characteristic of the deviation of the measurement result from the true value of the measured physical quantity. The occurrence of measurement errors is due to the influence of various physical factors that accompany the measurement.

The traditional analytical approach to determining errors is to divide them into components, each of which is determined by certain factors. This allows us to investigate the sources of the error components, conduct the necessary experiments, including auxiliary measurements, and, as a result, determine the properties of the error and evaluate its components with the necessary accuracy. Knowing the properties and estimates of the components, you can correctly take them into account when evaluating the total error, and if necessary, enter an amendment to the measurement result and (or) organize a measurement experiment so that the individual components, and with them the total error, are reduced to an acceptable value. To improve the objectivity of the assessment of measurement errors and determine ways to reduce them, in order to improve the quality of measurements, it is necessary to know the sources (causes) of the various components of the total measurement error and the patterns of their change.

Mercury or alcohol thermometers are used to measure air temperature under normal conditions. When measuring temperatures above 00C, you should use mercury thermometers, because mercury expands evenly when heated, and alcohol-unevenly. At temperatures below 00C, mercury thickens, so it is recommended to use alcohol thermometers.

The traditional analytical approach to determining errors is to divide them into components, each of which is determined by certain factors. This allows us to investigate the sources of the error components, conduct the necessary experiments, including auxiliary measurements, and, as a result, determine the properties of the error and evaluate its components with the necessary accuracy. Knowing the properties and estimates of the components, you can correctly take them into account when evaluating the total error, and if necessary, enter an amendment to the measurement result and (or) organize a measurement experiment so that the individual components, and with them the total error, are reduced to an acceptable value. To improve the objectivity of the assessment of measurement errors and determine ways to reduce them, in order to improve the quality of measurements, it is necessary to know the sources (causes) of the various components of the total measurement error and the patterns of their changes.

To measure humidity, psychrometers are used, which consist of two mercury thermometers: dry and wet. The reservoir of the wet thermometer is wrapped in gauze or other hygroscopic cloth, the end of which is lowered into the water. Due to the evaporation of moisture, the temperature on the wet thermometer decreases. The difference in the readings of wet and dry thermometers is greater, the lower the relative humidity and is due to the removal of heat from the wet thermometer due to moisture evaporation. Only when the relative humidity is 100%, the thermometer readings are the same.[4]

Cause of errors: imperfection of traditional measurement methods.

III Object, subject and research methods

The object of the study is the development of a measuring device.

The subject of the study is a method for measuring temperature and humidity without using weather stations.

The novelty of the study consists in creating a software and hardware complex that allows you to obtain data using indirect measurements; determining the accuracy of the information received from the monitoring system and checking the reliability of the data; developing a device that uses sensors to capture the data necessary for monitoring.

Currently, it is important to measure the temperature on the field area. This problem is solved by increasing the measurement points followed by averaging. We proposed to measure the average temperature and humidity by measuring the difference in the speed of sound [11].

Statistical quality analysis requires obtaining various correlation characteristics. These characteristics include mutual, partial, and multiple correlation coefficients. [5]

The mutual correlation coefficient rxy of random variables x and y that acquire values x = {x1, x2,..., xn}, y = {y1, y2, ..., ym}, where in General n = m ≥ 100 values, is called the mathematical expectation of the product of standardized (normalized) deviations of random variables:

$$r_{xy} = \frac{\Sigma_{i=1}^{n}(x_i - mx) * (y_i - my)}{\sqrt{\Sigma_{i=1}^{n}(x_i - mx)^2 * (y_i - my)^2}}$$

(1)

where mx and my are mathematical expectations. The rxy characteristic is dimensionless.

For a system of random variables {X1, X2, ..., Xn} get a normalized matrix of mutual correlation coefficients of the form:

$$\|r_{ij}\| = \begin{vmatrix} 1 & r_{12} & r_{13} & \cdots & r_{1n} \\ r_{21} & 1 & r_{23} & \cdots & r_{2n} \\ r_{31} & r_{32} & 1 & \cdots & r_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & r_{n3} & \cdots & 1 \end{vmatrix}.$$

(2)

The mutual correlation coefficient characterizes the tightness of the linear relationship between random variables and has the following properties:

1) change Limits 1 ≤ rxy ≤ +1.

2) the Equality |rxy| =1 indicates a functional relationship between the random variables X and y. the Converse is incorrect: in a nonlinear functional relationship, the correlation coefficient may be less than one and even equal to zero.

3) If the random variables X and Y are independent, then rxy = 0. The opposite is not true: for rxy = 0, random variables can be either independent or dependent. If rxy = 0, random variables are called incoherent or uncorrelated.

4) the rxy > 0 Inequality indicates a positive correlation between the random variables X and Y: when one of them increases, the other tends to increase on average.

At rxy < 0, a negative correlation is indicated: when one of the random variables increases, the other tends to decrease on average.

The multiple correlation coefficient is used to describe a system of random variables {X1, X2, X3, ..., Xn}. It is a characteristic of the correlation between the value X1, on the one hand, and the entire set of values {X1, X2, X3, ..., Xn} with another. [6] Numerical values of this coefficient, which is also called the summary correlation coefficient X1 and {X2, X3, ..., Xn}, found by the formula:

r_(x_1 (x_2, x_3,...,x_n))=√(1-P/P_11) (3)

where P=det (rij) is the determinant of the square matrix of mutual correlation coefficients; P11 is the minor of this determinant (obtained by crossing out 1 row and 1 column).

The significance of the coefficients is checked using a system of values of gradations of tightness of connection:

0 < / r|<0.2 – very weak
0 < / r|<0.4-weak
0 < / r|<0.7-average
0 < / r|<0.9-strong
0 < / r|<1.0 – very strong

Small values of coefficients suggest that one or more random variables that are analyzed are uninformative and can be deduced from further consideration. In addition, according to the third property of the multiple correlation coefficient, the original matrix of cross-correlation coefficients can be simplified by deleting one or more rows.

Since this paper studies the propagation of sound waves in the air, we will focus in more detail on issues related to the speed of sound. The velocity of the longitudinal wave propagation in an elastic medium is expressed by the formula:

$$\upsilon = \sqrt{\frac{E}{\rho}}, \quad (4)$$

Where E is the volume elasticity modulus of the medium or the inverse of the compressibility of the medium:

$$\frac{V - V_0}{V_0} = -kF; \quad k = \frac{1}{E}. \quad (5)$$

For the propagation velocity of small perturbations in a gas, in particular for the speed of sound, the ratio is valid

$$\upsilon = \sqrt{\frac{dp}{d\rho}}. \quad (6)$$

If the process of sound propagation is considered adiabatic, then

$$pV^{\gamma} = C; \quad p = C\rho^{\gamma}. \quad (7)$$

Then

$$\frac{dp}{d\rho} = \gamma c \quad \rho^{\gamma-1} = \gamma\frac{p}{\rho}. \quad (8)$$

Substitute (8) in (4) and get

$$\upsilon = \sqrt{\gamma \frac{p}{\rho.}} \quad (9)$$

Using the Clapeyron formula, we rewrite (9) as

$$\upsilon = \sqrt{\gamma \frac{RT}{\mu}} \quad (10)$$

For air

$$V = 20{,}1\sqrt{T}, \quad (11)$$

That is, the speed of sound is proportional to the square root of the absolute temperature.

IV. Results of the study

We decided to develop software for firmware of the Arduino Uno R3 Board using specialized Arduino software.

The collected information is displayed on the built-in display (Fig. 2), after which it is written to the repositories and sent to the server for post-processing and archiving. The data obtained using a special program is presented in the form of graphs and forecasts for their changes based on the analysis of tracking dynamics.

Pic. 2. The device to be monitored (top view)

Components used for creating a monitoring device:

* Arduino UNO R3 - 1 PC.
* Layout Board – 2 PCs.
* Ethernet shield w5100 - 1 PC.
* MQ-2 gas sensor-1pc.
* Humidity/temperature sensor DHT-22-1pc.
* Pressure/temperature sensor BMP-180-1pc.
* LDR light sensor-1pc.
* Soil moisture sensor FC-28 - 1 PC.
* Real time clock Tiny RTC V1. 1-1 piece.
* 4x40 display-1pc.
* Power module-1 piece.
* LEDs – 5 PCs.
* Shift register-74HC595 - 1 PC.
* Capacitors
* Resistors

When transmitting received data from sensors to a remote server, there may be a situation where the information may become corrupted or not be transmitted at all.

This can happen for several reasons:

- the cable is damaged in some place;
- there was a data transfer conflict.

When transmitting data over a long distance via a cable, it should be taken into account that it must pass in a place that is difficult to reach for an ordinary person or animal (on poles or under the ground). It is also worth taking into account the weather conditions and the state of the environment where the cable will pass. First of all, it must be shielded so that external electronic fields cannot distort the original signal. Second, it must be very well insulated (protected by a plastic shell). Third, it does not often bend over 90 degrees. Due to frequent and severe bends in the cable may be damaged. And even if this is not visible from the outside, it does not mean that the conductors are not broken off inside.

If the connection between the client (device with sensors) and the server is made using a wi-fi connection, it is reasonable to encrypt the data to protect it from interception. You can use one of the most common algorithms – WPA2. [10]

WPA2 uses a stronger AES encryption algorithm, which is very difficult to break, but not impossible. The wireless network transmission rate is reduced when WPA2-PSK (AES) is enabled, because encryption and decryption take some time. This encryption algorithm is not ideal, but it is the best choice for this case. If you use a more powerful encryption algorithm, it can significantly slow down the monitoring process.

V Conclusions

As a result of this work, we developed software that allows us to determine the accuracy of the information received from the monitoring system and check the reliability of the data. The developed software meets the requirements set in the terms of reference.

Created software performs the following functions:

* Processing a differential signal;
* Determination of the reliability of the received data;
* Storing data on external files.

The software fully meets the requirements for organizing input and output data, reliability requirements, and other requirements specified in the terms of reference

Working with the software is carried out using a convenient interface, and is designed to work in a dialogue mode with a user who is not a programmer.

The developed software takes up 617 KB of disk space (only *.exe file). The maximum size of the product together with log files can reach several gigabytes (when using the program for more than a year).

The following set of hardware and software tools with minimal parameters is recommended for software operation:

* Intel Pentium IV processor 1 GHz or later;
* RAM: from 512 MB;
* minimum disk space of 10 GB;
* screen with a resolution of at least 800x600 pixels;
* OS: Windows XP and higher.

Description of the equipment used

The device is based on the Arduino Uno R3 controller with an ATmega 328 chip and an extension for working with the network. The necessary environmental parameters are collected by reading data from humidity, temperature, atmospheric pressure, illumination, and precipitation sensors.

The system has several humidity sensors: atmospheric – installed on the surface; ground-directly into the ground. Thermosensors are placed on a similar principle, the air temperature sensor can be placed next to the humidity sensor and barometer, and the sealed thermocouple can be placed in the ground. The light sensor is installed at a distance from objects that may interfere with direct sunlight falling on the sensor. The precipitation detector is located in the open air for timely response during precipitation in the form of rain or snow. The sensor also responds to dew, which may appear early in the morning on the device.

The paper defines the basic principles of measuring air temperature and humidity; a device has been developed that takes the necessary data and transmits it to the server.

The following tasks were solved:

- analysis of the process of measuring air temperature and humidity;
- the main research directions are defined;
- a device has been developed that uses sensors to capture the necessary data for monitoring;
- analyzed and defined methods for protecting data transmitted from the device to the server.

With the help of the developed device, you can accurately and correctly remove such indicators: temperature, humidity. It is made of sensors that transmit data to a small screen. This data can also be transmitted remotely. The cable connection between the device and the server must be well protected from external stimuli and collisions. The wireless connection will be encrypted using the WPA2 encryption algorithm.

The implementation was completed and showed full functionality of the proposed method.

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НТБ ОНАХТ

INFORMATION MODEL OF THE APPLICATION OF A HELLIOSYSTEM FOR THE NEEDS OF STUDENT DORMITORY IN THE BLACK SEA REGION

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Abstract*. The paper investigates the possibility of using solar energy in the hot water system, using the example of the Odessa Technical College of the Odessa National Academy of Food Technologies dormitory, for improve living conditions. The needs student dormitory in hot water at a confidence interval of 95 ± 5% is confirmed by the results of a poll in a representative sample of students living in a dormitory.*

The paper identified requirements (quantitative characteristics) of thermal energy for the needs of a typical student dormitory (corridor type) in the Black Sea region, the optimal angle of inclination of the solar collectors installation is determined, the type and the required amount of solar system equipment are calculated. According to the results of the study, the optimal variants of the number of vacuum solar collectors at the implementation site are determined, which differ significantly by seasons.

Generalization, mathematical and computer modeling techniques were used in writing of the information model study. Computer simulation is done by tabulating functions in MS Excel and plotting 3D graphs in Matlab.

As a result of the research, it was found that the use of solar energy in the student dormitory can provide it with hot water in the spring and autumn period of the year.

Key words*: Information Model, Computer Modeling, Solar System, Vacuum Solar Collectors, student dormitory (corridor type) of the Black Sea region.*

I. INTRODUCTION

Theme actuality:

The functioning and procedure of settlement of persons in dormitories during studies in Ukraine is governed by the Housing Code of Ukraine (Housing Code, Article 127), the Student Dormitory Regulations developed by the educational institution in accordance with the Model Regulations and the Dormitory Rules and Conditions [1]. As a rule, the supply of hot water for domestic needs of students living in a student dormitory in the Black Sea region is interrupted between April and September and is renewed from October of the current year. This is due to the existing integrated gas heating system and hot water supply.

According to the results of a sociological survey among students residing in the dormitory of the Odessa Technical College of the Odessa National Academy of Food Technologies (OTC ONAFT), the need to improve the living conditions, namely the need to supply hot water throughout the year was determined (see Fig.1). Alternative renewable energy sources (RES) are proposed to meet domestic hot water requirements.

One of the most promising types of RES is solar energy. Due to this, it is possible to fully satisfy the demand for hot water in the spring-autumn period of time.

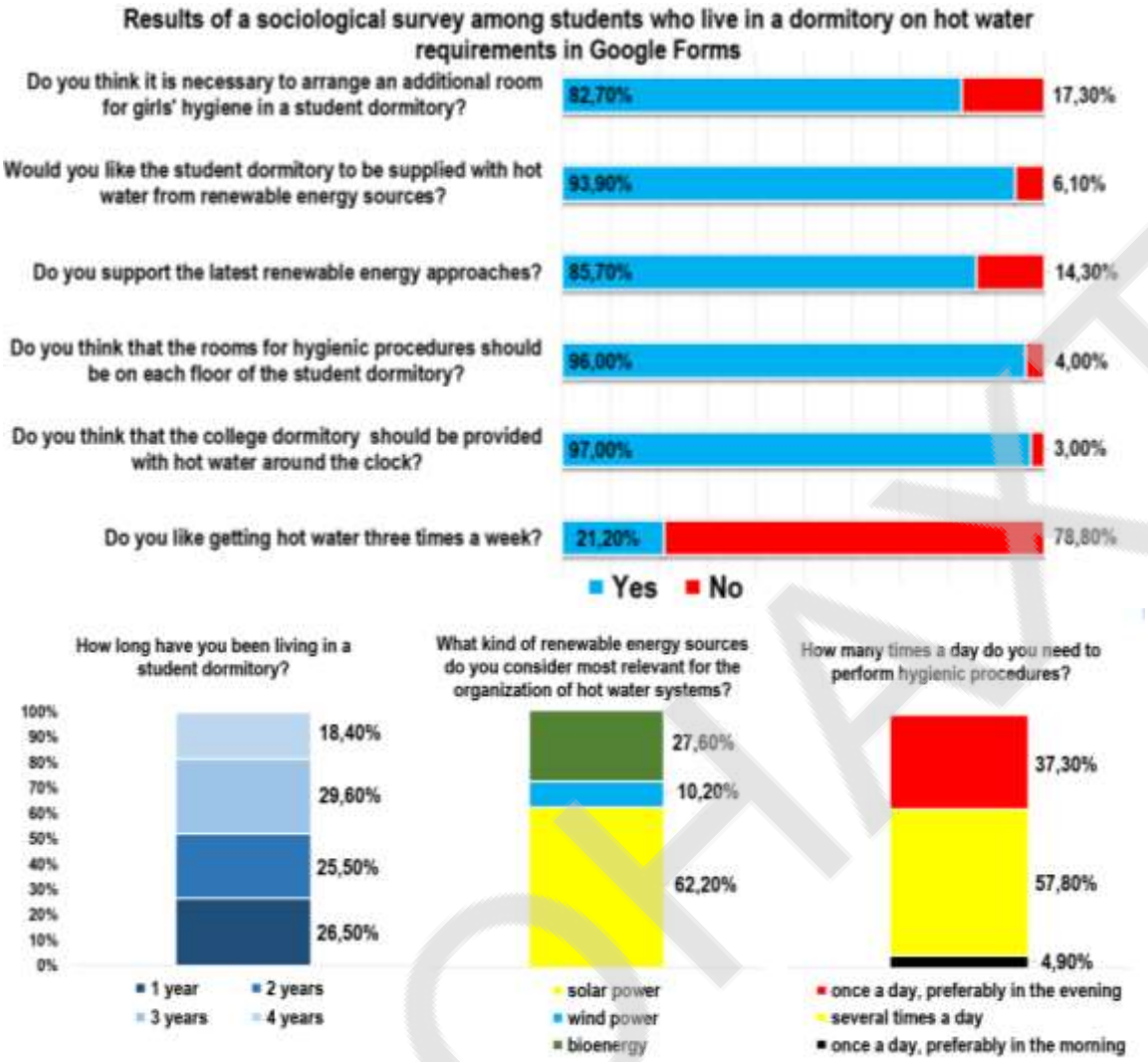


Figure 1 – Results of a sociological survey among students who live in a dormitory on hot water requirements in Google Forms

The most efficient use of solar energy is possible when using solar collectors. It is the absorbing panel of the solar collector that under the influence of solar radiation (infrared component) transforms solar energy into thermal, for the subsequent heating of domestic water. Modern solar systems allow you to save up to 60% of the energy required to heat water per year.

Research methods:

Generalization, mathematical and computer modeling techniques were used in writing of the information model study. Computer simulation is done by tabulating functions in MS Excel and plotting 3D graphs in Matlab.

Scientific novelty of the work:

- identified requirements for thermal energy for the needs of a typical student dormitory (corridor type) in the Black Sea region;
- determined the optimal tilt angle of the installation of solar collectors and the estimated amount of necessary equipment for the solar system.

Practical value:

As a result of a conducted research it was found that the use of solar energy in a student dormitory will allow to provide hot water in the spring and autumn periods of the year.

Structure of the research paper:

The research paper consists of an introduction, two sections and a conclusion.

The first section provides an overview of current solar energy technologies. Presented variants for using solar energy for hot water supply.

The second section describes the development of an information model of a hot water supply system utilizing a solar energy for a typical floor of a student dormitory in the Black Sea region.

The conclusion provides suggestions for the practical implementation of the selected solar system equipment.

II. Analytical review of the literature

Increasing the use of energy from renewable sources and alternative fuels is considered an important part of Ukraine's strategy to conserve traditional fuel and energy resources and reduce the associated environmental impact. The adopted Law of Ukraine "On Alternative Energy Sources" defines legal, social, economic, environmental and organizational principles of the use of alternative energy sources, as well as encouraging increase of their use [2].

The problems of the use of alternative energy are covered in the works of leading domestic scientists, namely: S.O. Kydria, I.V. Bondarenko, H.B. Varlamova, I.A. Volchyna, O.V. Zur'yan, A.K. Shyndlovskyi, V.F. Shinkarenko etc. [4-7]

Renewable energy sources in Ukraine are well studied and described, but it is difficult to determine their economic potential. In 2001, at the request of the State Committee for Energy Conservation, a group of Ukrainian scientists created the Ground Atlas of the Energy Potential of Renewable Energy in Ukraine [8]. The Atlas provides information on the territorial distribution of various renewable energy sources and the calculation of their physical, technical and economic potential. The Atlas certifies that Ukraine has a large enough potential of all types of RES, outlines the overall picture of existing RES implementation and recommendations for further development. For example, it is recommended to use flat solar collectors in the southern regions of Ukraine.

Modern technologies for the production of alternative energy sources include:

- use of solar energy for heat supply systems by means of collectors and passive solar heating systems;
- use of geothermal water for heat supply;
- use of heat pumps of small and medium capacity for heat supply of individual houses and utilization of thermal emissions, and high power - in heat pumping stations for replacement of small and medium-sized boilers;
- use of agricultural waste to produce biogas as fuel;
- other energy sources.

Let's take a closer look at the benefits of using helliosystems for domestic use. The task of solar energy is to heat water for domestic use during the warm season, where it is economically justified.

A helliosystem (solar collector or solar system) is a device for effectively converting solar energy into thermal energy and heating water. A solar thermal system typically consists of a solar thermal collector, a water storage system (a tank) for a control system and a pump system.

There are a large number of solar systems in the world that are structurally different from one another. The classification of the solar heat supply system is shown on Fig. 2.

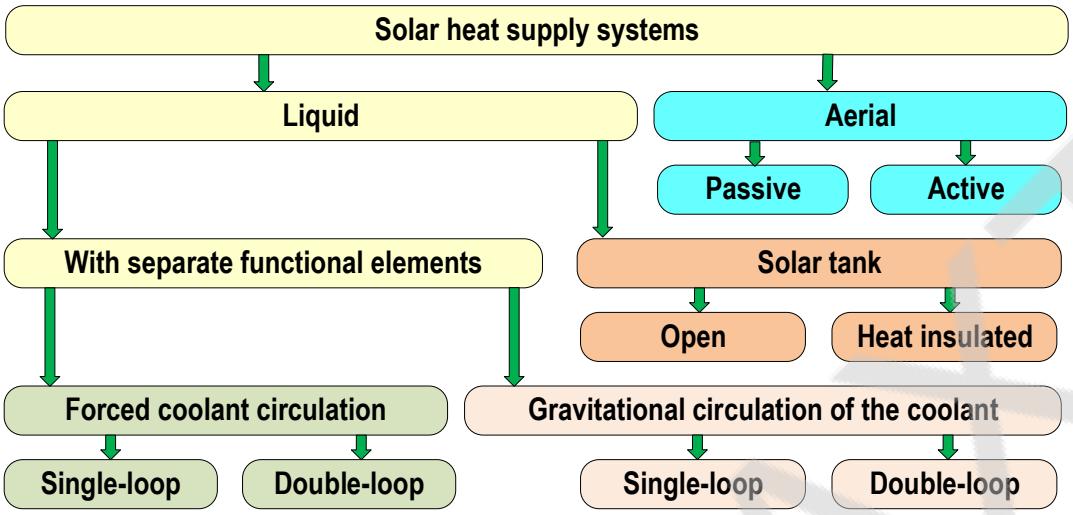


Figure 2 – Classification of solar heat supply systems

The most efficient use of solar energy is possible when using solar collectors. It is the absorbing panel of the solar collector that under the influence of solar radiation (infrared component) transforms solar energy into thermal, for the subsequent heating of domestic water. Modern solar systems allow you to save up to 60% of the energy required to heat water per year.

The amount of solar energy that reaches the surface of 20,000 km^2 can be used to supply the population of the globe.

The use of solar energy in many countries is beginning to take an important place. Water heating in household appliances is widespread in Australia, Greece and the Mediterranean East. Several million dollars worth of solar energy produced annually in the USA and Japan. In Ukraine the highest energy of solar radiation is in the Black Sea region (Fig. 3).

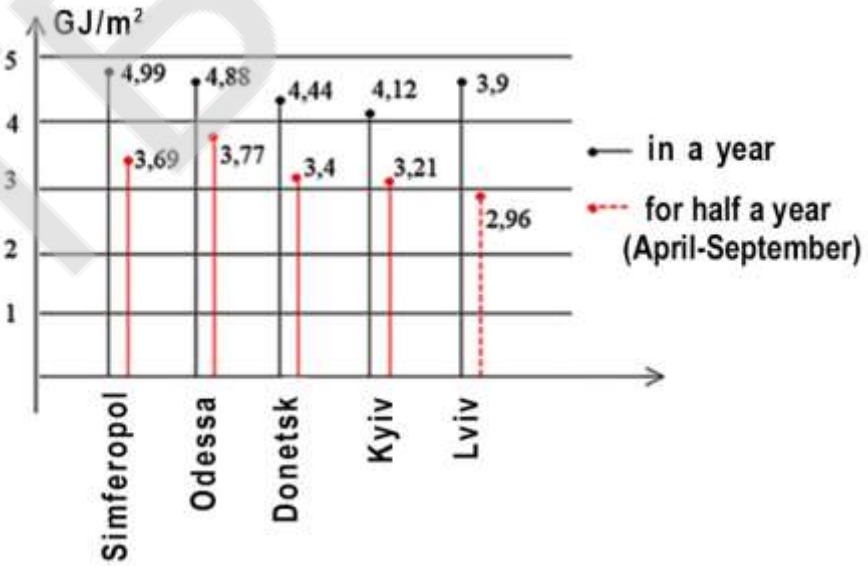


Figure 3 – Solar radiation energy reaching the surface of the land in Ukrainian cities

Solar installations (solar power plants) convert solar radiation into thermal (for heating water to 50-60°C in baths, laundries etc.) or electrical (photoelectric, thermoelectric and thermodynamic) energy. A solar installation with a machine cycle is called a solar power station.

The collector most effectively manifests itself in the southern region of Ukraine in the summer with good sunny weather, but can successfully work even on sunny winter days. For example, the efficiency of vacuum collectors averages 65-70%. It should be also considered that the vacuum collector absorbs not only direct but also scattered sun rays, and works successfully even at negative ambient air temperatures [9].

III. Object, subject and methods of research

Characteristics of the object of study

The purpose of the study is to investigate the possibility of using solar energy in the hot water system, using the example of the Black Sea OTC ONAFT dormitory. Figure 4 shows the layout of the premises with the requirement for hot water in the student dormitory.

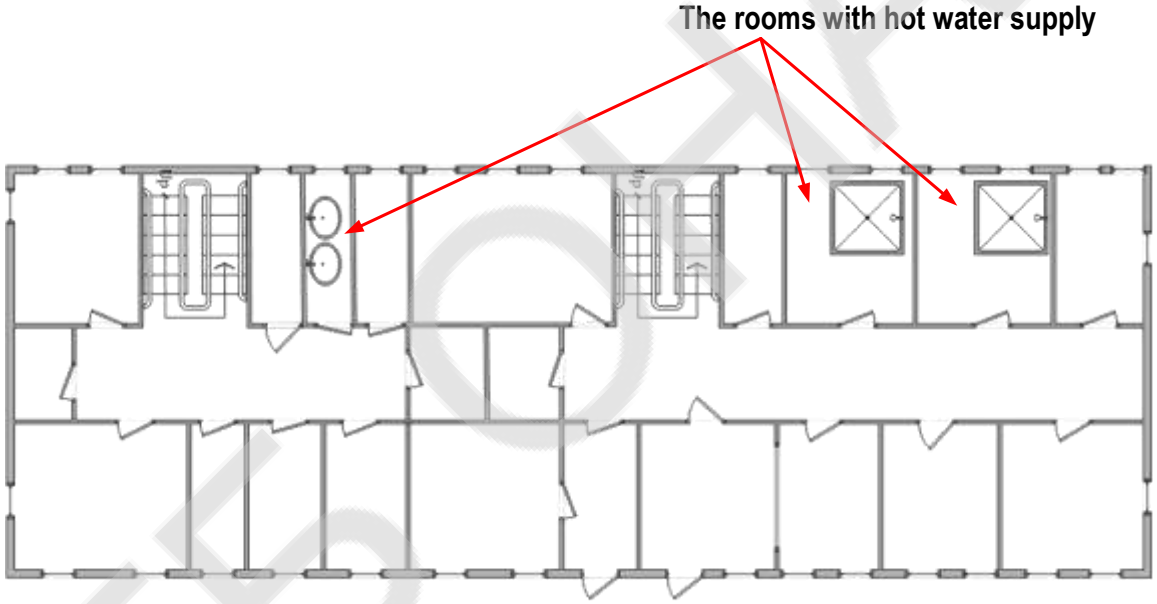


Figure 4 – Floor plan of a student dormitory with rooms with hot water supply

Most solar collectors have the elements shown on fig. 5.

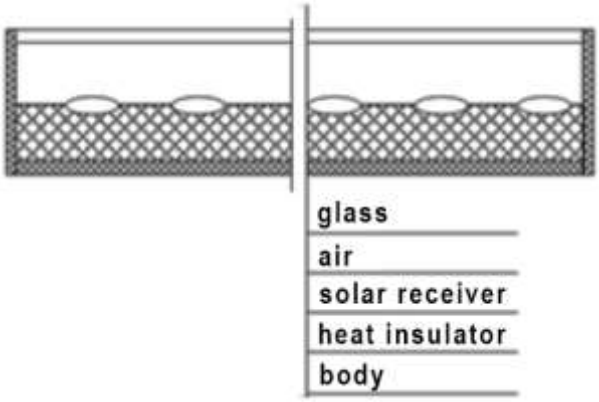


Figure 5 – Elements of solar collectors

The most efficient solar collectors are made with an aluminum housing, two layers of glass and a solar collector, which has a coating that provides minimal heat losses to the collector during radiation heat exchange. Such collectors are expensive enough, and this is not always justified by their additional thermal conductivity. Therefore, cheaper collectors with steel housings and solar collectors that are protected by a single layer of glass are often used. The scheme of the simplest solar installation is shown on Fig. 6.

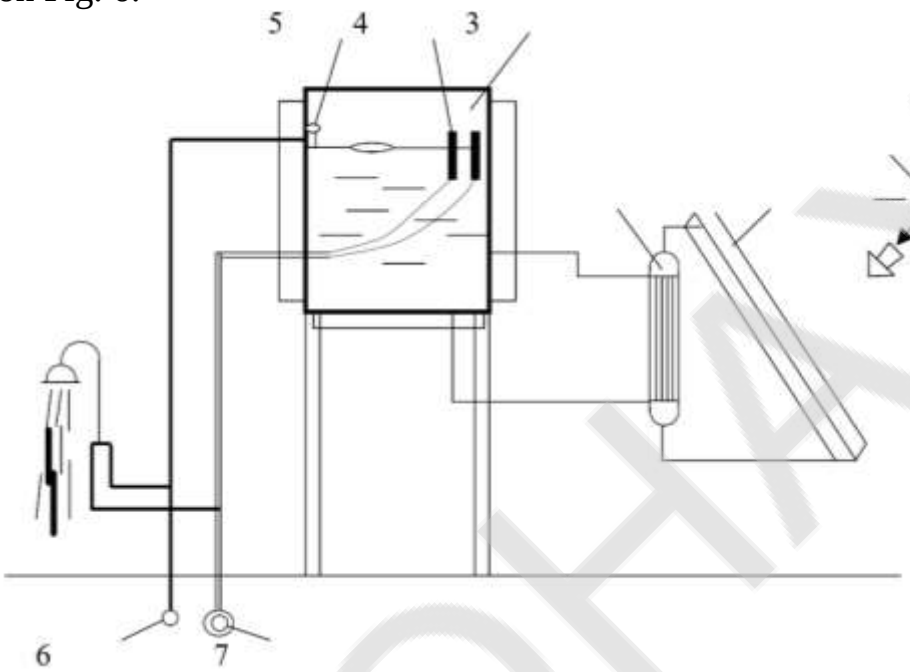


Figure 6 – **Scheme of solar installation for hot water supply**
1 – solar boiler; 2 – heat exchangers; 3 – storage tank;
4 – float; 5 – float valve ; 6 – water supply system;
7 – hot water supply line.

The scheme consists of two circuits of circulation. The first circuit is a solar boiler 1, which has pipelines connected by solar collectors, where water circulates during natural excitation. Water that is heated in solar collectors under the influence of gravitational pressure is directed to a heat exchanger 2, where the heat is transferred to the tap water that is filled in thermally insulated storage tank 3. As a result of stratification, the water temperature in the tank will be the same. The highest water temperature will be reached in the upper zone of the tank. In order for the hot water supply network to receive the highest temperature water, the shut-off pipe is attached to the float 4. The tank is filled through a float valve 5, which is connected to the water supply system 6, and the heated in solar installation water is directed to the consumers via the hot water supply line 7.

Solar systems for hot water supply are widespread in recreational facilities, in residential areas where facilities can be used to reduce the cost of purchasing fuel or paying for the heat in summer.

A patent review of works in the field of solar energy has shown that currently the largest number of new patents among various types of "green" energy technologies are issued in the field of solar generation. This was reported by WIPO (World Intellectual Property Organization) experts at a seminar held at the Europe-Asia Forum (ASEM).

Computer model of the solar system for domestic heat supply

Let's look at the results of modeling the solar system in Matlab and the MS Excel spreadsheet based on a symbolic linear programming model for the student dormitory system of the Odessa Technical College of the Odessa National Academy of Food Technologies (OTC ONAFT).

Solar water heating system for household needs is planned in Odessa Technical College, which is located at latitude 46.47 NN. The system has to meet the needs of N = 38 consumers, each one daily use V = 30 liters of hot water at a temperature of $T_{h.w.}$ = 55°C. Temperature of cold water in the water supply system of Odessa city $T_{c.w.}$ = 10°C. Collectors set at an angle of 45° to the horizon and oriented south. Volume of water in the storage tank $V_{s.t.}$ = 300 liters.

To calculate the heat capacity of the solar collector we need to determine the monthly average daily amount of solar energy, MJ/(m^2·day) which enters the collector surface. It's determined by the formula:

$$E_k = E \cdot R \quad (1)$$

where E is the average monthly total solar radiation on a horizontal surface, R is the ratio of average daily quantities solar radiation coming to the surface at an inclined and horizontal surface.

$$R = \left(1 - \frac{E_D}{E}\right) \cdot R_d + \frac{1+\cos\beta}{2} \cdot \frac{E_Д}{E} + \rho \cdot \frac{1-\cos\beta}{2} \quad (2)$$

where E_D *is* the average monthly amount of solar energy that is dissipated

(diffused) arriving on a horizontal surface, MJ/(m^2·day), R_d – direct radiation conversion factor from horizontal to the surface inclined, β – the angle of the collector to the horizon, deg.; ρ – the reflection coefficient for the surface of the land: in summer it's 0.2, and in winter at snow – 0.7.

The monthly average value of the coefficient is determined by the formula:

$$R_d = \frac{\cos(\varphi-\beta)\cdot\cos\delta\cdot\sin\omega_3' + \frac{\pi}{180}\cdot\omega_3'\cdot\sin(\varphi-\beta)\cdot\sin\delta}{\cos\varphi\cdot\cos\delta\cdot\sin\omega_3 + \sin\varphi\cdot\sin\delta\cdot\frac{\pi}{180}\cdot\omega_3} \quad (3)$$

where φ – is the latitude, deg.; δ – declination of the Sun, deg.; ω_3 and ω_3' – sunset angle on horizontal and inclined surfaces, deg.

The angle of inclination of the Sun in every day n is equal to:

$$\delta = 23{,}45 \cdot \sin\left(360 \cdot \frac{284+n}{365}\right) \quad (4)$$

The load of hot water supply is determined by the formula:

$$L_{\text{нw}} = M \cdot N \cdot 1000 \cdot (T_{avg} - T_{cold}) \cdot \rho \cdot \mathrm{C_p} \quad (5)$$

where M is the number of days in a month, N is number of people – 38, T_{avg} – average temperature of hot water – 55°C, T_{cold} – temperature of cold water – 10°C, ρ is the density of water – 1 kg/l, $\mathrm{C_p}$ is the heat capacity – 4190 J/kg·K.

The amount of heat coming from the heat sink to 1 solar collector is determined by the formula:

$$Q_{us} = F_R' \cdot \lfloor E_k \cdot (\tau\alpha) - U_L \cdot (T_T - T_a) \rfloor \quad (6)$$

де Q_{us} – where is the useful thermal power of the solar collector, W/m^2, E_k – is the density flow of total solar radiation in the area of reservoir, kW/(m^2·day), τ – bandwidth of transparent insulation, α is the panel absorbency of the collector, U_L is the total coefficient of thermal losses, W/(m^2·K); T_T is the average temperature of the

coolant in the collector, K; T_a is the ambient air temperature, K, F_R' – is the coefficient of efficiency of the absorbing panel, that takes into account that the average panel temperature is always above the average liquid temperature.

There are several varieties of complexes with alternative energy sources used for hot water supply. After analysis of the object of study and its hot water operating system we decided that using the vacuum solar collector ATMOSFERA SVC-NANO with 30 tubes that is certified in Ukraine is more rational and efficient [10]. That model uses high-performance "3-hi solar" vacuum tubes with system "heatpipe" (capacitor diameter 14mm).

The SVC-Nano collector is effective for year-round use. Collector efficiency - up to 92%. It has steady performance in cloudy weather.

The aluminum frame of collector reduces the load on the carrier roof of a construction. The frame construction is designed to install a manifold on a sloping surface. Thermal insulation of heat exchanger is 45 mm.

Calculations were made for the hardware and software complex parameters of vacuum solar collectors, namely the load of hot water supply for each month, the thermal capacity of the solar collector, the volume of the battery tank and its selection.

The calculation is made for ATMOSFERA SVC-NANO (30 tubes), with the following characteristics:

– absorption coefficient of panel F_R'= 0,77;

– total coefficient of heat loss U_L= 0,8 W/(m^2·K);

– $(\tau\alpha)$ = 1,08;

– average coolant temperature in the collector T_T= 328 K.

The desired area of collectors A (m^2) is selected on a clear day of the warmest month of the year (August):

$$A = \frac{V_{h.w.}}{Q_{day}} \quad (7)$$

where $V_{h.w.}$ is daily consumption of hot water, l.; Q_{day} is the daily productivity of 1m^2 solar collector, which is determined by the formula, l/m^2·day:

$$Q_{day} = \frac{Q_{us}}{m \cdot c \cdot (T_{avg} - T_{cold})} \quad (8)$$

where Q_{us} is the amount of useful heat produced by the collector, kW·h; m is the specific gravity of water, kg/l ; c – heat capacity of water, kWh/ m^2·°C; c = 0,001 kW·h/m^2·°C; T_{avg} is the average temperature of hot water – 55°C, T_{cold} is the temperature of cold water – 10°C.

$$Q_{day} = \frac{4752}{1 \cdot 0{,}001 \cdot (55-10)} = 105{,}6 \text{ (l/m}^2\text{·day)}$$

Required area of solar collectors:

$$A = \frac{1710}{11{,}63} = 16{,}2 \text{ m}^2$$

Number of vacuum collectors:

$$K_{v.c} = \frac{A}{S_{absorb.}} \quad (9)$$

where $S_{absorb.}$ – where is the absorber area defined in the technical specifications of the solar collector – 2,41 m^2.

The optimum variant of the parameters of the hot (domestic) water supply system was calculated in accordance with the model of thermal balance of the solar heat supply system based on computer simulation of technical systems using the MS Excel spreadsheet and Matlab.

Computer simulation is done by tabulating functions in MS Excel and building 3D graphs in Matlab in three stages: the first step is to create a tabular model of linear programming; the second stage investigates the model performance, which depends on the angle of inclination of the solar collectors installation in the Odessa region; in the third stage, a symbolic model of linear programming creates its representation in the MS Excel spreadsheet.

VI. Results of paper

Based on the obtained solar system data, a framework model was created in the Matlab system in 3D on the base of two-dimensional function using a coordinate grid, where in the space (x, y, z) on the axes *ox/oz* the counts correspond to the sequence of months in the current year and on the axis *oy* the time angle of sunset / sunrise on an inclined surface is displayed, affecting the average monthly values of the direct radiation conversion factor from horizontal to inclined surface.

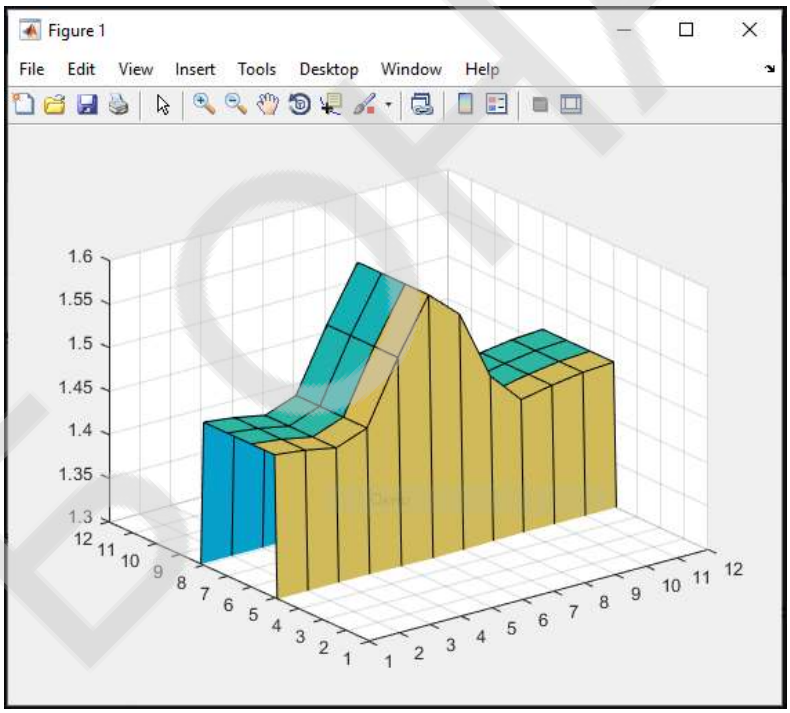
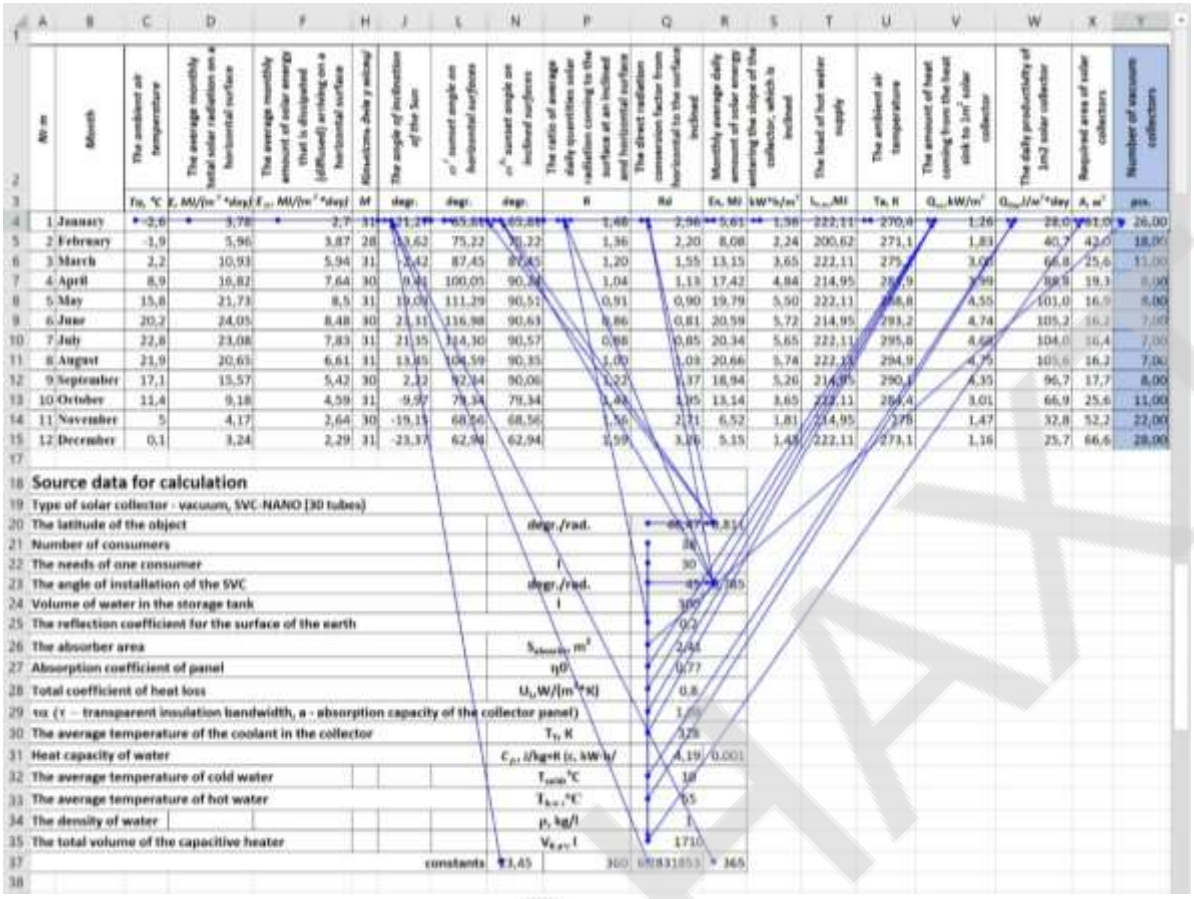


Figure 7 - Model of the ratio of the average monthly amounts of solar radiation arriving at the inclined surface and the horizontal surface by months of the year

Using the developed model it is possible to calculate the characteristics of the ATMOSFERA SVC-NANO 30 solar system for different angles of inclination, namely 35, 45, 55 degrees, by months of the year.

Figure 8 presents the results of the model parameters calculation in MS Excel.

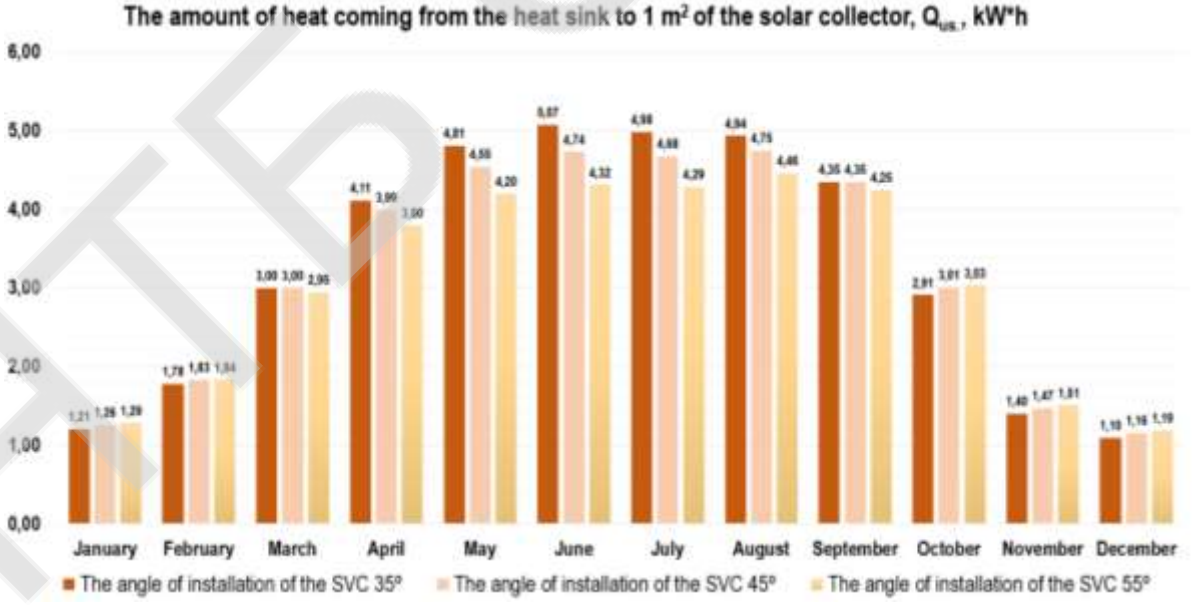


№ m	Month	The ambient air temperature	The average monthly total solar radiation on a horizontal surface	The average monthly amount of solar energy that is dissipated (diffused) arriving on a horizontal surface	Kilometric (body y-axis)	The angle of inclination of the Sun	α° sunset angle on horizontal surfaces	α° sunset angle on inclined surfaces	The ratio of average daily quantities solar radiation coming to the surface at an inclined and horizontal surface	The direct radiation conversion factor from horizontal to the surface inclined	Monthly average daily amount of solar energy entering the slope of the collector, which is inclined	The load of hot water supply	The ambient air temperature	The amount of heat coming from the heat sink to 1m² solar collector	The daily productivity of 1m2 solar collector	Required area of solar collectors	Number of vacuum collectors
		Tm, °C	$\bar{E}$, MJ/m²*day	$\bar{E}_{dif}$, MJ/m²*day	M	degr.	degr.	degr.	R	Rd	Es, MJ	kW*h/m²	$t_{c.w}$,MJ	Ta, K	Q_{UR}, kW/m²	Q_{day},J/m²*day	A, m²	pcs.
1	January	-2,6	3,78	2,7	31	-21,29	65,88	65,88	1,48	2,56	5,61	1,56	222,11	270,4	1,26	28,0	41,0	26,00
2	February	-1,9	5,96	3,87	28	-13,62	75,22	75,22	1,36	2,20	8,08	2,24	200,62	271,1	1,83	40,7	42,0	18,00
3	March	2,2	10,93	5,94	31	-2,42	87,45	87,45	1,20	1,55	13,15	3,65	222,11	275	3,00	66,8	25,6	11,00
4	April	8,9	16,82	7,64	30	9,41	100,05	90,36	1,04	1,13	17,42	4,84	214,95	281,9	3,99	88,9	19,3	8,00
5	May	15,8	21,73	8,5	31	19,09	111,29	90,51	0,91	0,90	19,79	5,50	222,11	288,8	4,55	101,0	16,9	8,00
6	June	20,2	24,05	8,48	30	23,31	116,98	90,63	0,86	0,81	20,59	5,72	214,95	293,2	4,74	105,2	16,2	7,00
7	July	22,8	23,08	7,83	31	21,15	114,30	90,57	0,88	0,85	20,34	5,65	222,11	295,8	4,68	104,0	16,4	7,00
8	August	21,9	20,65	6,61	31	13,45	104,59	90,35	1,00	1,03	20,66	5,74	222,11	294,9	4,75	105,6	16,2	7,00
9	September	17,1	15,57	5,42	30	2,22	92,14	90,06	1,22	1,37	18,94	5,26	214,95	290,1	4,35	96,7	17,7	8,00
10	October	11,4	9,18	4,59	31	-9,97	79,34	79,34	1,48	1,95	13,14	3,65	222,11	284,4	3,01	66,9	25,6	11,00
11	November	5	4,17	2,64	30	-19,15	68,56	68,56	1,56	2,71	6,52	1,81	214,95	278	1,47	32,8	52,2	22,00
12	December	0,1	3,24	2,29	31	-23,37	62,94	62,94	1,59	3,16	5,15	1,43	222,11	273,1	1,16	25,7	66,6	28,00

Source data for calculation			
Type of solar collector - vacuum, SVC-NANO (30 tubes)			
The latitude of the object	degr./rad.	46,47	0,811
Number of consumers		86	
The needs of one consumer	l	30	
The angle of installation of the SVC	degr./rad.	45	0,785
Volume of water in the storage tank	l	100	
The reflection coefficient for the surface of the earth		0,2	
The absorber area	S_{absorb}, m²	2,03	
Absorption coefficient of panel	η0	0,77	
Total coefficient of heat loss	U_L,W/(m²*K)	0,8	
τα (τ – transparent insulation bandwidth, a - absorption capacity of the collector panel)		1,65	
The average temperature of the coolant in the collector	T_T, K	329	
Heat capacity of water	$c_{p.t}$ J/kg•K (c, kW·h/	4,19	0,001
The average temperature of cold water	T_{water},°C	10	
The average temperature of hot water	$T_{h.w.}$,°C	55	
The density of water	ρ_t, kg/l	1	
The total volume of the capacitive heater	$V_{k.p.t}$ l	1710	
	constants	3,45	360 0,0833333 365

Figure 8 – Results of the model parameters calculation

Below are the results of calculating the parameters of the model of the solar system, depending on the angle of inclination by months of the year in infographics (see Fig. 9) and tabular form (see table 1).



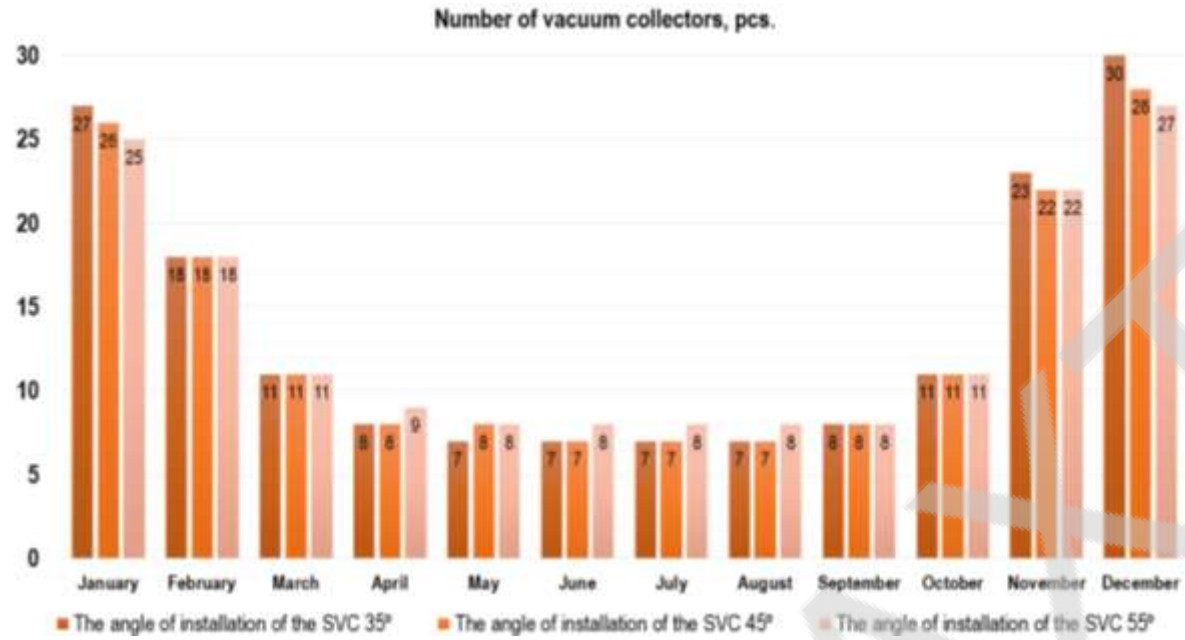


Figure 9 – The main indicators of the use of the solar system of ATMOSFERA SVC NANO 30 by months of the year in a student dormitory of the Black Sea region.

Table 1

Specifications for the relationship of the number of solar collectors from the angle of inclination

нм №	Month	Number of vacuum collectors, pcs.			The amount of heat coming from the heat sink to 1 m^2 of the solar collector, Quse, kW*h		
		The angle of installation of the SVC 35°	The angle of installation of the SVC 45°	The angle of installation of the SVC 55°	The angle of installation of the SVC 35°	The angle of installation of the SVC 45°	The angle of installation of the SVC 55°
11	**January**	27	26	25	1,21	1,26	1,29
22	**February**	18	18	18	1,78	1,83	1,84
33	**March**	11	11	11	3	3	2,95
44	**April**	8	8	9	4,11	3,99	3,8
55	**May**	7	8	8	4,81	4,55	4,2
66	**June**	7	7	8	5,07	4,74	4,32
77	**July**	7	7	8	4,98	4,68	4,29
88	**August**	7	7	8	4,94	4,75	4,46
99	**September**	8	8	8	4,35	4,35	4,25
110	**October**	11	11	11	2,91	3,01	3,03
111	**November**	23	22	22	1,4	1,47	1,51
112	**December**	30	28	27	1,1	1,16	1,19

V. CONCLUSIONS

The relevance of the study of the information model of the solar system for the needs of the Black Sea student dormitory in hot water at a confidence interval of 95 ± 5% is confirmed by the results of a poll in a representative sample among students living in the OTC ONAFT dormitory.

Thus, according to the results of the study, the optimal variants of the number of vacuum solar collectors at the implementation object, which differ significantly by

seasons, are calculated in the MS Excel spreadsheet and Matlab. The option "the more the better" in this case is not suitable, because in summer you need to dump unused hot water into the sewerage. Given the uneven use of hot water in the dormitory by month, we recommend 8 solar systems ATMOSFERA SVC-NANO 30 with a capacity of 300 liters per day.

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НТБОНАХТ

VICTORY MANIPULATOR UNIVERSAL ROBOTS IN THE LINE SORTING OF FINISHED PRODUCTS OF THE WINE INDUSTRY

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Abstract*. The work considers the introduction of collaborative robots (manipulators) into the line of the technological process for the bottling, drying and packaging of sparkling wines, for safer work of people with manipulators and to reduce accidents at the plant itself.*

Key words: *collaborative robots, industrial manipulators, production safety, technological process, engine failure.*

Introduction

Production safety - to this day they are striving for this. Initially, the human muscle was replaced by mechanical, which simplified the work of man. For example, turning a part on a lathe, a turner - in this case operates with a process, since all the work on rotating the part is performed by an electric motor. But even this work is not completely safe, there are many accidents during such work.

As a result of scientific and technological progress, the mechanical work of man was replaced by automation, that is, the cleansing abilities were performed by program-logic controllers, and not the human mind, where he was in the operator's room and controlled the technological process through a computer.

How many methods are used for the safety of production, for example, at elevators (cereals, sunflower seeds, corn) and flour mills, since a large amount of dispersed dust is released, an explosion occurs when a spark appears. This is avoided by removing dust from the walls of the enterprise. By similar parameters, in chemical plants where vapors can explode, they are also diverted from the process itself. In addition to such productions, use pneumatic or hydraulic actuators, since they do not give a spark.

Most enterprises use conveyors, like other moving elements, they can easily tighten the limbs of a person who, in turn, did not adhere to safety precautions, so that as soon as possible to stop the conveyor, a cable is attached to its base, if it is pulled, it will trigger the end a switch that will operate as a lock and the conveyor will stop.

The use of manipulators in industry is very common, for example, in automobile manufacturing, without them large-scale production of products did not exist. Also, manipulators can be used in the food industry.

Analytical analysis of the literature

We have considered a large number of publications by various authors exploring this issue.

The production line and its sparkling wine champagne process are discussed below[1, 2, 3].

Object, subject and research methods

Field of application of "Universal Robots" collaborative manipulators in the wine industry. Let us single out a section of technological production for the use of

collaborative manipulators (robots). By those. The process will be a sparkling wine production site.

General process analysis

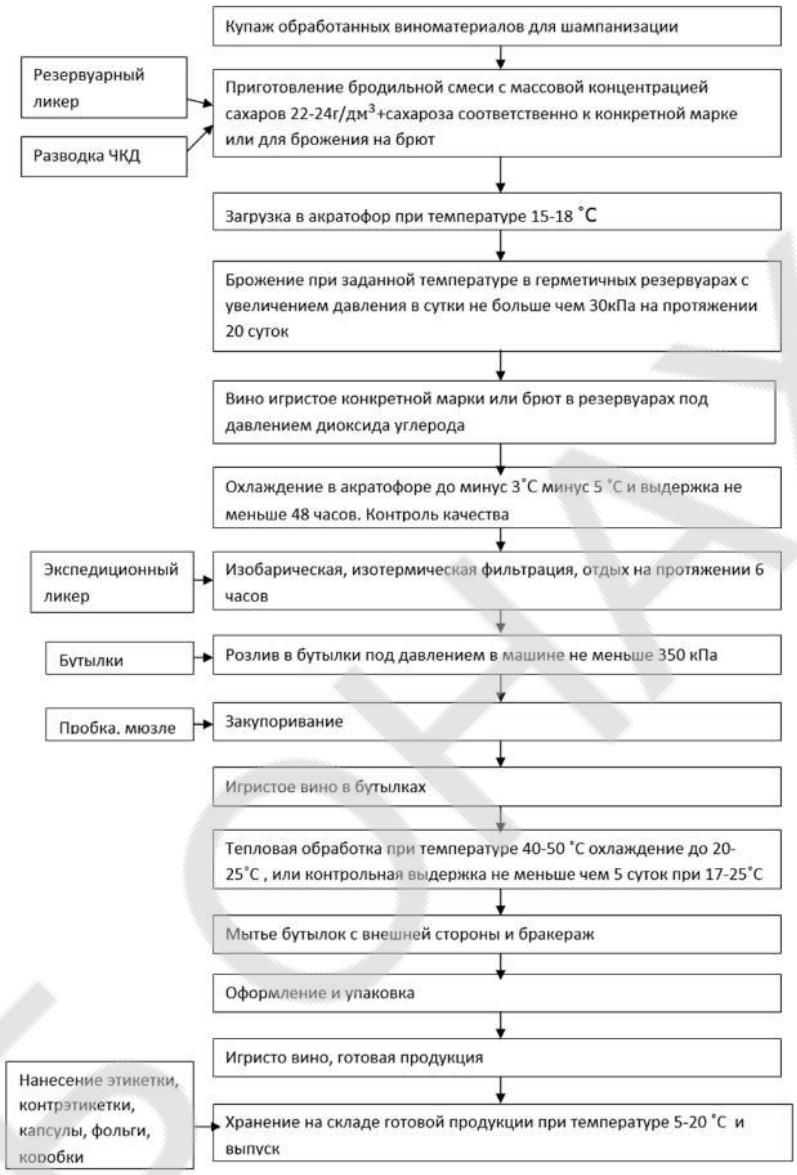

Image 1. The technological process of champagne wine

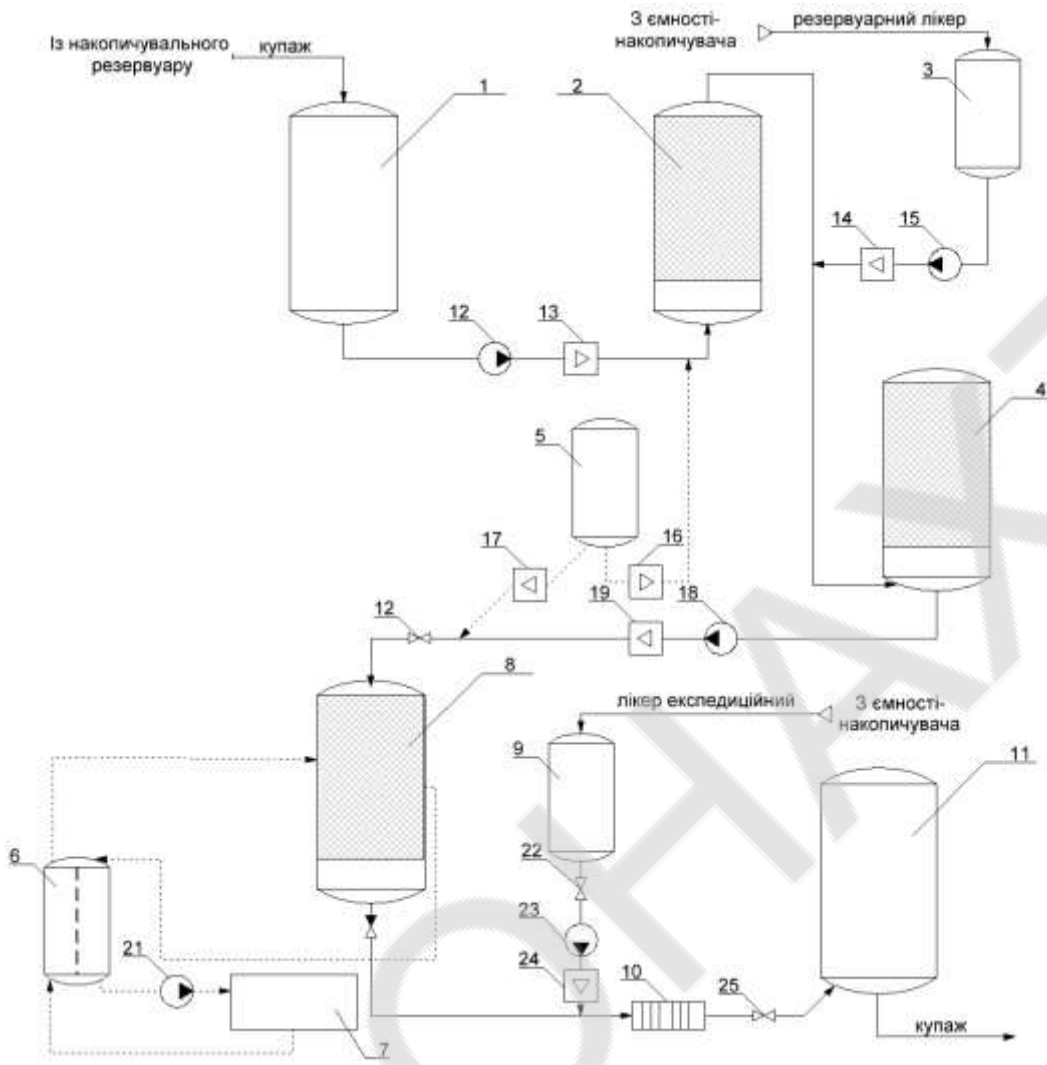

Image 2. Flow diagram of a section of a line for production of sparkling wines

The blending from the reservoir (1) by the pump (12) through the flow meter (13) is supplied to the apparatus (2) with the filler. Simultaneously with the blend, yeast wiring with dispersed mineral and yeast-growing apparatus is injected into the stream (5).

In the apparatus (2), processes of deoxygenation, stabilization and filtration of the blend occur.

Further, the worked blend is fed into the storage tank (4) for preparing the fermentation mixture by supplying the land (3) to the tank liquor stream using a pump (14) through a flow meter (15).

The fermentation mixture is pumped with a batcher (18) through a flow meter (19) and stop valves (20) into the acratophore (8) with a filler for the process of champagne. The fermentation mixture is dosed yeast wiring cultured with dispersed mineral.

At the end of the secondary fermentation, the sparkling wine is cooled, dispensed in the stream by expeditionary liquor from the tank (9), by opening the shut-off valves (22) of the pump (23) and the flow meter (24). It is filtered on the filter (10), through the stop valves (25) it enters the receiving unit (11) and enters the bottling.

The refrigerant from the tank (6) is pumped to the refrigeration machine (7) by a pump (21). It cools, enters the reservoir (6) and enters the pipe system, which are connected with the acratophore jacket (8), the spent refrigerant returns to the reservoir (6).

The use of cobots "Universal Robots"

After bottling and corking the bottles, they move along the conveyor to the sink and sent to the packaging. On the way to the packaging, filled bottles with sparkling wine are checked for defects, that is, they are illuminated by a laser with a special sensor on the one hand, and on the other hand, the receiving part of the sensor analyzes the density of the signal beam from the laser, if the signal is weak, then the bottle filled with wine, but suddenly the signal turns out to be stronger, then the density is lower, which in turn means that the bottle is empty, maybe the dispenser did not fill it. In any case, it is impossible to pack a defective product with a full one.

It is necessary to eliminate it from the conveyor, for this the manipulator (robot) "Universal Robots" of the UR10e model series is suitable, since they are safe when working with people. Since there is a washing, a marriage check, a label sticker and the packaging itself, which most people can do, is located in the workshop. The use of conventional manipulators can lead to injuries to people at work in cramped workshops, as they do not provide protection.

In cobots "Universal Robots" protection is provided for working with people, for example, when it is working, it accidentally touches a person, the robot instantly stops and will wait for some time according to the algorithm or already an operator's command to continue working, which will give time to a person , which hit, leave this place.

Consider a line of collaborative robots, which consists of four instances (shown below).

A brief description of the line e-series: created with a view to the future, the e-Series line allows you to expand your business, is a springboard to improving quality and increasing productivity, helping you always get ahead of your competitors. With an intuitive programming option, versatile use and an endless list of accessories, the e-Series line fits harmoniously into production regardless of industry, company size or product nature.

Universal Robots "UR3e"

Image 3. Universal Robots UR3e

Specification

- Radius – 500 mm / 19.7 inch
- Payload – 3 kg / 6.6 lbs
- Footprint – ø 128 mm
- Weight – 11.2 kg / 24.7 lbs

Universal Robots “UR5e”

Image 4. Universal Robots UR5e

Specifications

- Radius –800 mm / 33.5 inch
- Payload – 5 kg / 11 lbs
- Footprint – ø 149 mm
- Weight 20.6 kg / 45.4 lbs

The latest offering in our collaboration robot series, UR5, extends the capabilities of agents ready for future change with collaborative innovation, Human Centric UX, and the ecosystem for each application. Transform ambition into results by changing the way you manufacture using the most flexible automation platform.

Universal Robots “UR10e”

Image 5. Universal Robots UR10e

Specifications

- Radius – 1300 mm / 51.2 inch
- Payload – 10 kg / 22 lbs
- Footprint – ø 190 mm
- Weight 33.5 kg / 73.9 lbs
-

Universal Robots “UR16e”

Image 6. Universal Robots UR16e

Specifications

- Radius – 900 mm / 35.4 inch
- Payload – 16 kg / 35.3 lbs
- Footprint – ø 190 mm
- Weight 33.1 kg / 73 lbs

Universal Robots “UR16e”, a recently released novelty that expanded the e-series family, one of the main differences from the “UR10e” is the reduced range from 1300 mm to 900 mm, but this is offset by an increase in carrying capacity by 6 kg, for example, “UR10e” - 10 kg vs “UR16e” - 16 kg, also “UR16e” became 400 grams lighter than its predecessor.

Consider an analogue of the Universal Robotics

HTF OFAXT

ROZUM Robotics model 90

Image 7. PULSE 90

Specifications

- Payload – 4 kg
- Radius – 900 mm
- Weight – 13.6 kg
- Footprint – 120 mm
- Non-Stop lifetime cycle – 20000+ hours

In this work, it will be rational to choose a collaborative robot “UR5e”, since the maximum weight of the bottles will reach 3.5 kg, it would also be better to use the kobot “UR10e” in the radius of use, but for the work area, “UR5e” is enough, in addition, a larger radius may be needed only in isolated cases, it will not be necessary to overpay for a more expensive modification if it does not work out at 100 percent.

One of the main differences and arguments for using cobots of the “Universal Robots” from their counterparts is the safety of working with people around, for example, if a person touches him while the robot is working, the cobot will stop and wait for further action or according to the algorithm it will work after a specified time further

Also, the presence of the robot itself is not sufficient to realize its full functionality - grips are additionally used (we will consider below different analogs of grips that have unified mounts for a universal platform of colorative robots).

Image 8. Grip WSG25-CR

Specifications

– Compliance with safety requirements for human-robot interactions
– Quick integration
– Built-in web interface with documentation for configuration and diagnostics
– Support for textual communication protocols over TCP / IP and UDP, as well as the industrial Modbus / TCP interface
– Grip control directly by the robot controller via the integrated Modbus / TCP interface

Grip integration without the need for programming. The built-in controller uses the latest capture algorithms, high-speed object detection and capture control.

External position sensors are no longer required since position measurement is carried out using internal sensors. This simplifies the process of integrating a robotic solution into your manufacturing process.

Image 9. OnRobot RG2 Gripper

Specifications

- Easy installation
- Integrated control board
- Flexible, easy to reconfigure
- Support for two grips simultaneously
- Adjustable force
- Wide working range, work with objects of different sizes
- Fast change of fingers of capture
- Plug & play
- Easy programming
- Retention of gripping force in case of power loss
- Analog Robot Feedback

Adjusting the grip force allows you to hold both light and heavy objects. Standard fingers can be used with many different objects. Installation on capture of third-party fingers is possible. Configure and control capture from Universal Robots software. Technical specifications are shown in the image 10.

Параметр	Мин.	Типичное	Макс.
Полный ход (регулируемый)	0	-	110 мм
Точность позиционирования захвата	-	0,1 мм	-
Повторяемость	-	0,1 мм	0,2 мм
Обратный люфт	0,2 мм	0,4 мм	0,6 мм
Сила захвата (регулируемая)	3 Н	-	40 Н
Точность силы захвата	±0,05 Н	±1 Н	±2 Н
Скорость захвата	55 мм/с	110 мм/с	184 мм/с
Время захвата	0,04 с	0,07 с	0,11 с
Рабочее напряжение	10 В	24 В	26 В
Потребляемая мощность	1,9 Вт	-	14,4 Вт
Максимальный ток	25 мА	-	600 мА
Рабочая температура окружающей среды	5 °C	-	50 °C
Температура хранения	0 °C	-	60 °C
Вес	-	0,65 кг	-

Image 10. Technical specifications

And the last of the three grip options

Image 11. GRIPKIT-E1

Specifications

- 20 million work cycles guaranteed
- Uptime 24/7
- Automatic detection and monitoring of captured objects
- Support for up to 8 captures connected to one robot

A fully integrated solution for Universal Robots. GRIPKIT contains everything you need to realize the task of capturing and moving within a few minutes. It is fully compatible with all Universal Robots models and integrates seamlessly into the Polyscope software environment with the easy-to-use URCaps plug-in.

GRIPKIT is available in various sizes with grip forces from 7.5 to 550 Newtons and is compatible with all robots from Universal Robots, making it the ideal solution for a wide range of applications.

Software was used to work as collaborative robots.

- URsim
- RoboDK
- Programming environment – Python

The software RoboDK is such a description:

Processing robots

Use your robot arm like a 5-axis milling machine (CNC) or a 3D printer. You can simulate and convert NC programs (G-code or APT-CLS files) in the program of the robot itself. RoboDK automatically optimizes the robot path, avoiding features, axis restrictions and collisions.

Offline programming software

Modeling and autonomous programming of industrial robots has never been easier. Create your own virtual environment to simulate your application in minutes.

Easily create robotic programs offline for any robot controller. You no longer need to learn vendor specific programming.

Also, robbik has a built-in online library or manually loaded with many different manipulators, robots that you will find on the market, there are also many objects with which these robots work, for example, a grab or drill, or even a welding machine.

One of the conveniences of this program is that the programming of collaborative robots allows you to download program code written in the python language and edit in the program itself each movement in each axis individually for any task.

It can also be noted that robots can be controlled not only by a software algorithm, but also use a real-time control display (shown in the image 12).

Image 12. Control display

Display features

- Real-time robot control
- Emergency stop
- Monitoring the work of each axis and their degrees of rotation
- Robot calibration

Also, one of the programs for work is yursim software, it allows you to start work in a virtual mode, it is convenient when your robots are busy with work and stopping them can cause the process to stop, therefore testing certain modes of work in virtual mode is a good solution.

Principle of operation

The initial position of the manipulator is a capture over the conveyor in anticipation of a defective bottle (image 12).

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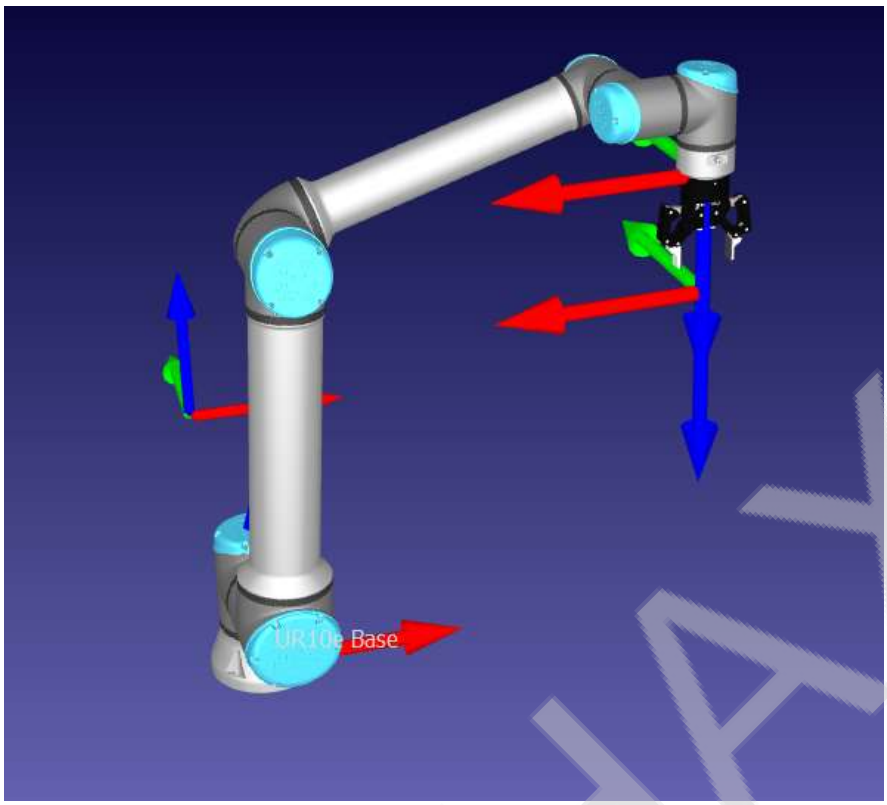

Image 13. Initial position

When a defective bottle is detected, according to the algorithm, the conveyor stops for a short period of time so that the dispenser fills and clogs the bottle, at the same time the marriage is monitored and the moment the conveyor pauses again, the manipulator will lower and capture the defect. (Shown in image 14)

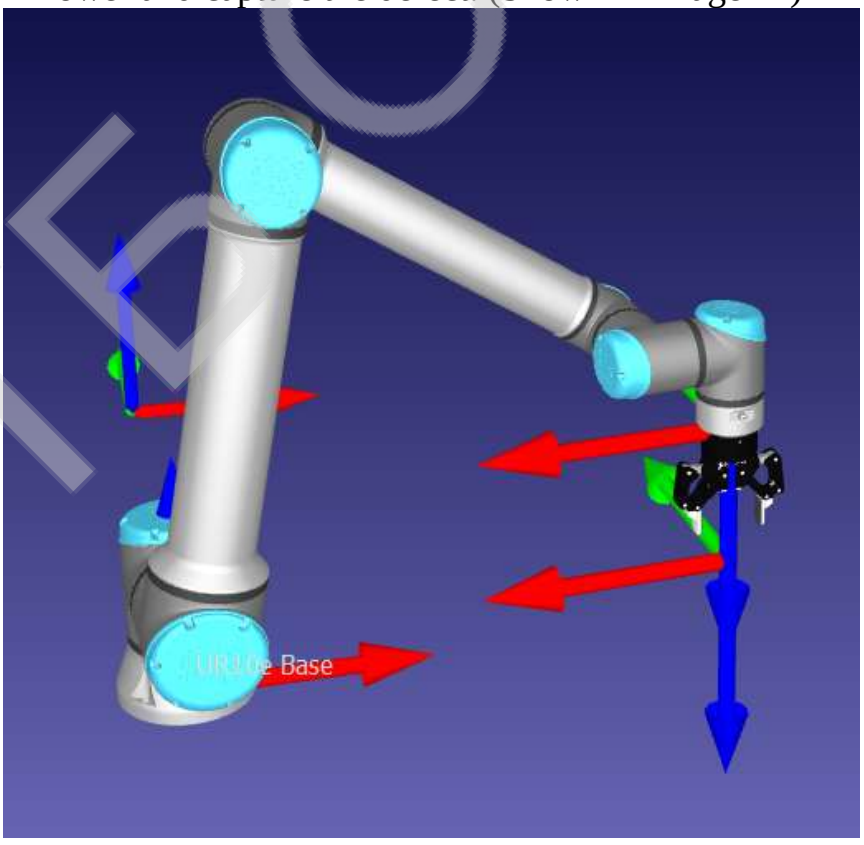

Image 14. Defective Bottle Capture

Then the bottle is lifted and moved to a box. (It is shown in figures 15 - 17)

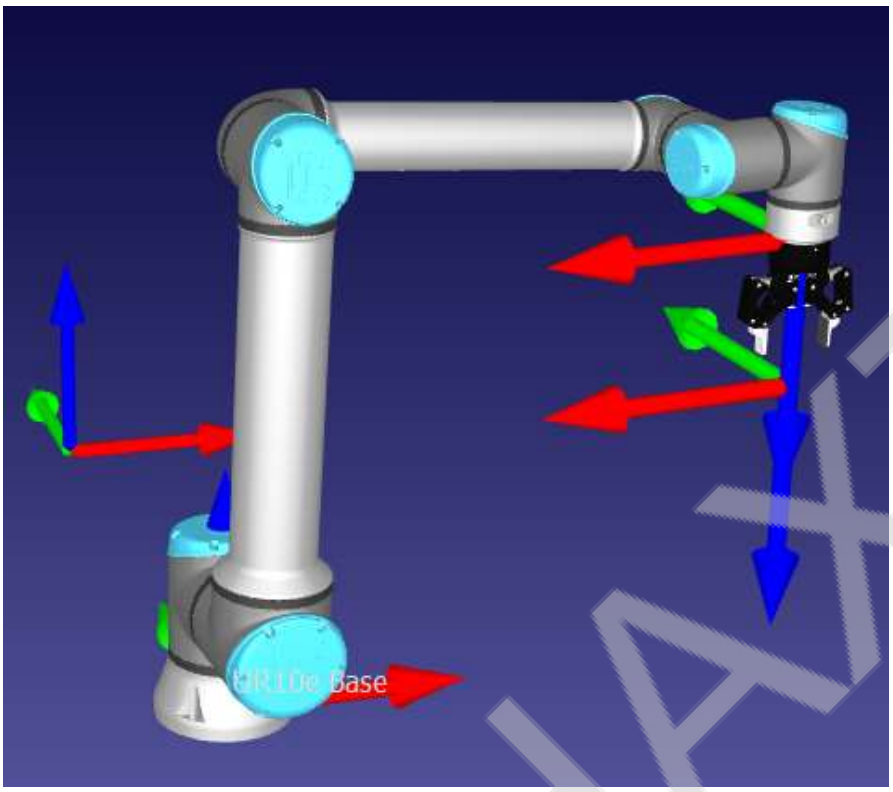

Image 15. Raising a defective bottle

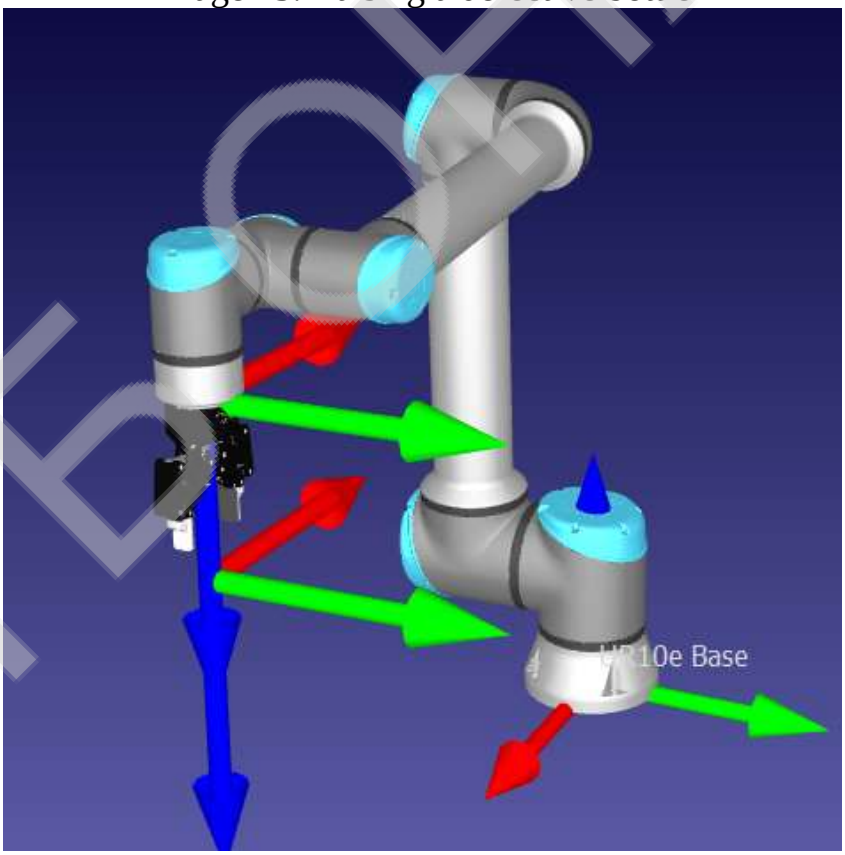

Image 16. Moving from a conveyor to a conditional box

НТБОНАХТ

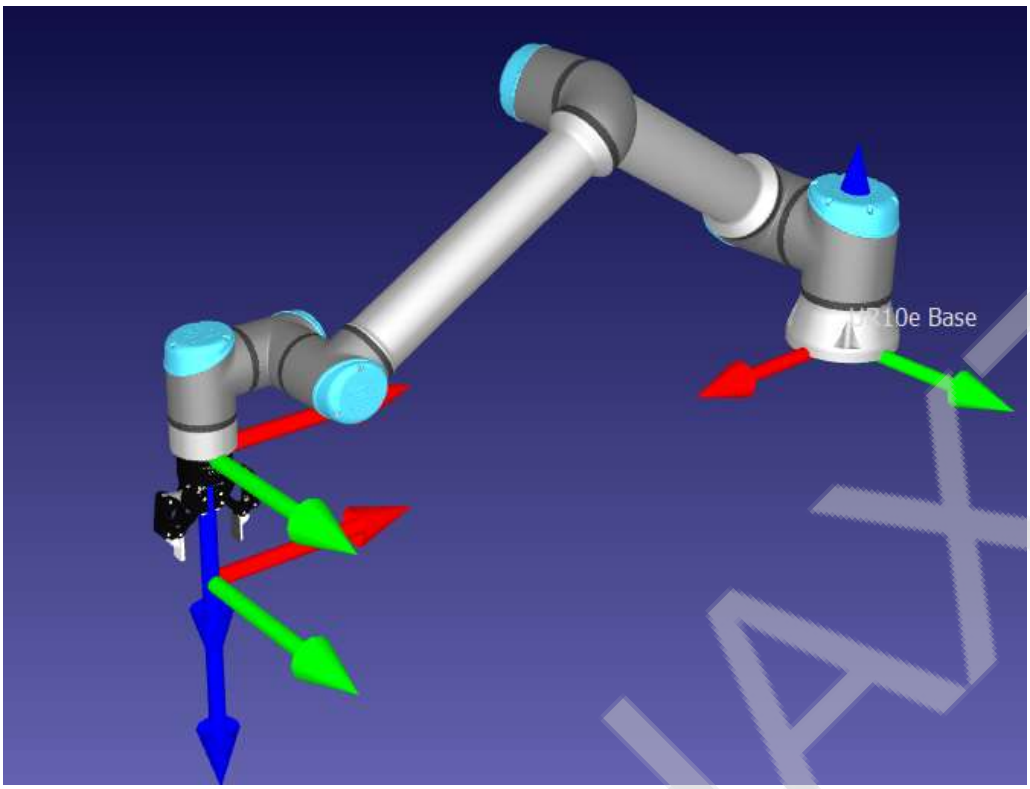

Image 17. Placement of defective products

Conclusions

The paper considers the task of production safety in the wine industry, namely, the safe contact of people with collaborative robots in the packaging section of the wine champagne technological process.

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USAGE OF MODERN INFORMATION TECHNOLOGIES OF SOLVING THE OPTIMAL ALLOCATION PROBLEM INVESTMENTS IN THE ENTERPRISE

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Abstract*. This work concerns the present-day problems of modern information technologies usage in solving the optimal allocation problem investments in economics.*

Key words: *method, solution, enterprise, technology, investments, efficiency.*

Introduction

The development of various enterprises, the accumulation and use of capital investments have been urgent problems of the economy of different countries of the world for the last, almost three centuries. Today these problems are solved with the use of modern information technologies. Over the past period, a considerable number of methods of solving economic problems have been introduced, so when creating the appropriate information technology, there is always a question, and accordingly a task, on the basis of which method to implement the relevant information technology.

One of these tasks this work is dedicated.

Literature Review: This work is based on three main types of literature: modeling in economics (Kartaev F.S. Econometrics, Baldin K.V. Mathematical Methods and Models in Economics, Markin Y.P. Economic Analysis, Karaseva R.B. Mathematical Enhancement student's competence in introducing research problems into the learning process), the use of MS excel in economic tasks (Internet tutorials in Excel, Microsoft Excel user manual, Guseva O.L. Mironova N.N. Excel for Windows), as well as programming of economic processes (Karaseva R. B. Tend of Modern, Mathematical Education, I.L. Akulich, Mathematical Programming in Examples and Problems, M.G. Zaitsev (Methods of Management Optimization for Managers).

Problem statement: based on the analysis of the results of the use of three known methods: search; search for a solution; dynamic programming to justify the choice of one of them to solve the problem of optimal distribution of investments in the development of the enterprise.

In this way, you can form the purpose, object, subject and methods of research of this work.

The purpose of the work. Based on the results of the analysis of the use of the three methods of solving the optimal problem, it is reasonable to use one of them to create the appropriate information technology.

Object of research. The process of optimizing the efficiency of investment in the development of each enterprise.

The subject of research. Results of efficiency of use of capital investments by the enterprise.

Research methods:

1. The search method

2. Solution Finder
3. Programming method.

This work was done based on MS Excel

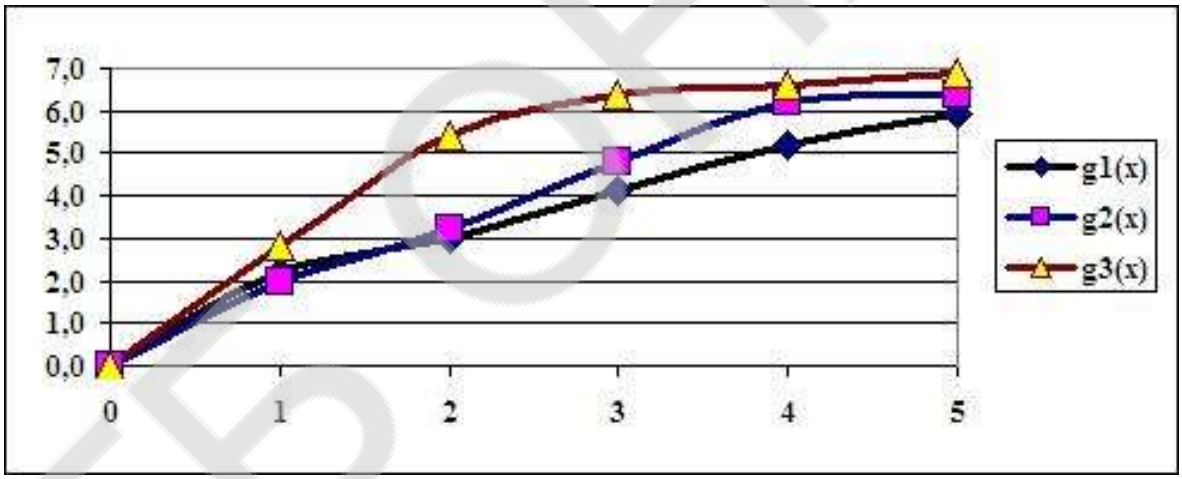
Task

• Exploring different methods of finding the most profitable investment
• Identify opportunities for using modern technologies
• Investigation of the most rational method for individual tasks

For the development of three enterprises allocated 5 million UAH. The known efficiency of investments in each enterprise, given by the values of nonlinear functions g1 (Xj) presented in the table below:

Xj	g1(x)	g2(x)	g3(x)
0	0,0	0,0	0,0
1	2,2	2,0	2,8
2	3,0	3,2	5,4
3	4,1	4,8	6,4
4	5,2	6,2	6,6
5	5,9	6,4	6,9

Figure 1. Graphical representations of performance features.



The calculations will be made on the assumption that the distribution of funds is made in integers Xj = {0,1,2,3,4,5} million UAH.

The search method.

The application of this method is justified by the fact that the problem is solved in integers with a small range of values of variables. In this case, the three variables x1, x2 and x3 take one of the six possible values of Xj. So there are 63 = 216 combinations of variables in total. However, only those with x1 + x2 + x3 = 5 should be considered for consideration

The output is recorded in the MS Excel worksheet as shown in Figure 2.

	B	C	D	E
2	Xi	g1	g2	g3
3	0	0,0	0,0	0,0
4	1	2,2	2,0	2,8
5	2	3,0	3,2	5,4
6	3	4,1	4,8	6,4
7	4	5,2	6,2	6,6
8	5	5,9	6,4	6,9

Figure 2. Organization of output data on a worksheet.

To systematically search all combinations, it is rational to translate decimal numbers in the range from 0 to 215 in a six-point system of calculus. Separate bits of the hex representation and will be the values of the variables sought.

A possible variant of translation of decimal numbers of combinations in the digits of hex code is presented in Fig. 3.

	A	B	C	D
12				
13	Дес экв	x1	x2	x3
14	0	0	0	0
15	1	=ЕСЛИ(И(C14=5;D14=5);ЕСЛИ(B14+1=6;0;B14+1);B14)	=ЕСЛИ(D14=5;ЕСЛИ(C14+1=6;0;C14+1);C14)	=ЕСЛИ(D14+1=6;0;D14+1)
16	2	=ЕСЛИ(И(C15=5;D15=5);ЕСЛИ(B15+1=6;0;B15+1);B15)	=ЕСЛИ(D15=5;ЕСЛИ(C15+1=6;0;C15+1);C15)	=ЕСЛИ(D15+1=6;0;D15+1)
17	3	=ЕСЛИ(И(C16=5;D16=5);ЕСЛИ(B16+1=6;0;B16+1);B16)	=ЕСЛИ(D16=5;ЕСЛИ(C16+1=6;0;C16+1);C16)	=ЕСЛИ(D16+1=6;0;D16+1)

Fig. 3. Formulas for translating decimal combinations numbers into hex codes.

The calculation of the investment performance is made in the column g1 + g2 + g3. To do this, enter the formula E14: = IF (B14 + C14 + D14 = 5; VIEW (B14; $ B $ 3: $ B $ 8; $ C $ 3: $ C $ 8) + VIEW (C14; $ B $ 3: $ B $ 8; $ D $ 3: $ D $ 8) + VIEW (D14; $ B $ 3: $ B $ 8; $ E $ 3: $ E $ 8); 0), which is then extended (extended) to the bottom of the table (Fig. 4).

	E
12	
13	g1+g2+g3
14	=ЕСЛИ(B14+C14+D14=5;ПРОСМОТР(B14;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР(C14;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР(D14;$B$3:$B$8;$E$3:$E$8);0)
15	=ЕСЛИ(B15+C15+D15=5;ПРОСМОТР(B15;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР(C15;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР(D15;$B$3:$B$8;$E$3:$E$8);0)
16	=ЕСЛИ(B16+C16+D16=5;ПРОСМОТР(B16;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР(C16;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР(D16;$B$3:$B$8;$E$3:$E$8);0)

Figure 4. Formulas for calculating overall performance with constraints on variables x1, x2 and x3.

To select the optimal solution in the cell F14, the formula for selecting the maximum value from the whole range of variants is introduced, and the cells G14, H14, and I14 enter formulas for choosing from the range of the combinations x1, x2, and x3 at which this maximum is reached (Fig. 5).

	F	G	H	I
12	Решение			
13	Max	x1	x2	x3
14	=МАКС(E14:E229)	=ИНДЕКС(B14:B229;ПОИСКПОЗ($F14;$E14:$E229;0);1)	=ИНДЕКС(C14:C229;ПОИСКПОЗ($F14;$E14:$E229;0);1)	=ИНДЕКС(D14:D229;ПО

Figure 5. Choosing the best solution formulas.

To facilitate the visual search for the best solution, a column with cumulative performance can be formally conditionally formatted to equal the maximum cumulative efficiency value. A fragment of the letter showing the final decision is presented in Fig. 6.

	A	B	C	D	E	F	G	H	I
12	Дес экв	x1	x2	x3	g1+g2+g3	Решение			
13						Max	x1	x2	x3
14	0	0	0	0	0	*10,8*	1	2	2
15	1	0	0	1	0				
16	2	0	0	2	0				
64	50	1	2	2	*10,8*				
65	51	1	2	3	0				
66	52	1	2	4	0				
67	53	1	2	5	0				
68	54	1	3	0	0				
69	55	1	3	1	9,8				

Figure 6. The final results of the decision by the search method.

"Finding a Solution".

Solution Finder allows you to limit the number of variables. Therefore, this problem can be solved with this tool.

Figure 7 shows the possible organization of the worksheet, and Figure 8 - setting options options "Search for a solution."

	B	C	D	E
2	Xi	g1	g2	g3
3	0	0	0	0
4	1	2,2	2	2,8
5	2	3	3,2	5,4
6	3	4,1	4,8	6,4
7	4	5,2	6,2	6,6
8	5	5,9	6,4	6,9
9				
10				
11	x1	x2	x3	x1+x2+x3
12				=B12+C12+D12
13				
14	Целевая функция			
15	=ПРОСМОТР(B12;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР(C12;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР(D12;$B$3:$B$8;$E$3:$E$8)			

Fig. 7. Organizing your worksheet when using the Solution Finder tool

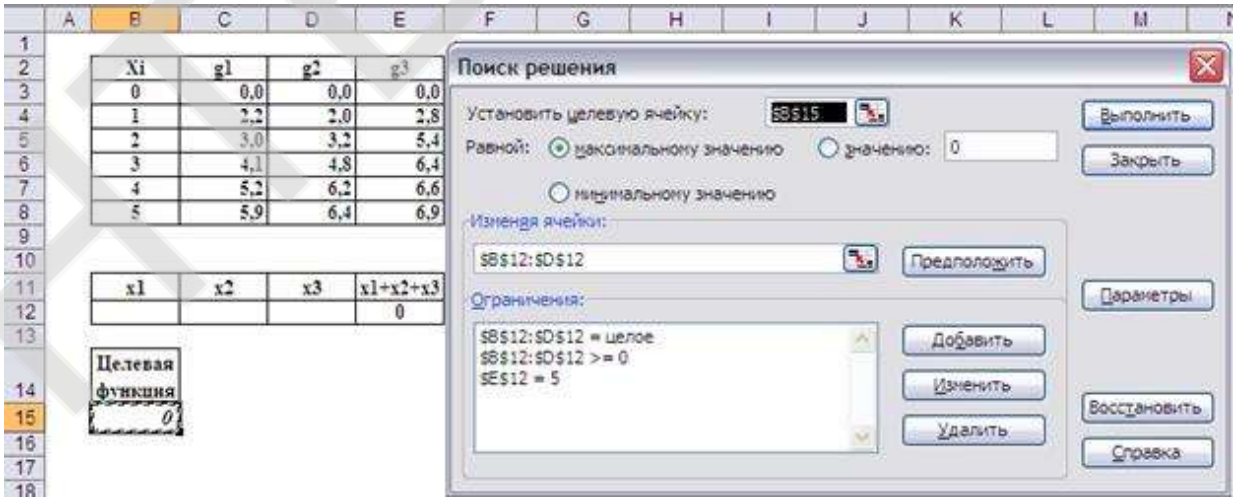


Fig. 8. Setting options for Solution Finder

The results of the decision (Fig. 9) coincide with the results obtained by the search method.

	A	B	C	D	E
1					
2		Xi	g1	g2	g3
3		0	0,0	0,0	0,0
4		1	2,2	2,0	2,8
5		2	3,0	3,2	5,4
6		3	4,1	4,8	6,4
7		4	5,2	6,2	6,6
8		5	5,9	6,4	6,9
9					
10					
11		x1	x2	x3	x1+x2+x3
12		1	2	2	5
13					
14		Целевая функция			
15		*10,8*			

Figure 9. The final results of the solution using the Find Solution

Dynamic programming method. The above methods of decision are rationally applied at small dimensions of the problem. In the case of a large number of enterprises and a large amount of investment, the dynamic programming method is used.

According to the idea of the method of the problem is solved in two stages.:

Stage 1 Conditional optimization (k = 3, 2, 1).

Step 1: k = 3. It is assumed that all funds in the amount of x3 = UAH 5 million. dedicated to a third company. In this case, the maximum revenue, as can be seen from the output table and the table for the Bellman function F3 (c3) = g3 (x3) will be g3 (x3) = UAH 6.9 million.

c3\x3	0	1	2	3	4	5	$F_3(c_3)$	x_3^*
0	0,0	-	-	-	-	-	0,0	0
1	-	2,8	-	-	-	-	2,8	1
2	-	-	5,4	-	-	-	5,4	2
3	-	-	-	6,4	-	-	6,4	3
4	-	-	-	-	6,6	-	6,6	4
5	-	-	-	-	-	6,9	6,9	5

Step 2: k = 2. Determine the optimal strategy for allocating funds between the second and third companies. In this case, the Bellman recurrence relation has the form: F2 (c2) = max {g2 (x2) + F3 (c2-x2)}

Based on the last relation, a table is constructed for the Bellman function F2 (c2)

c2\x2	0	1	2	3	4	5	$F_2(c_2)$	x_2^*
0	0+0	-	-	-	-	-	0,0	0
1	0+2,8	2,0+0	-	-	-	-	2,8	0
2	0+5,4	2,0+2,8	3,2+0	-	-	-	5,4	0
3	0+6,4	2,0+5,4	3,2+2,8	4,8+0	-	-	7,4	1
4	0+6,6	2,0+6,4	3,2+5,4	4,8+2,8	6,2+0	-	8,6	2
5	0+6,9	2,0+6,6	3,2+6,4	4,8+5,4	6,2+2,8	6,4+0	10,2	3

Stage II: k = 1. Determine the optimal strategy for allocating funds between the first and two other enterprises, using the formula for calculating total income: F1 (c1) = max {g1 (x1) + F2 (c1-x1)}, on the basis of which compiled table for Bellman function F1 (c1)

c1\x1	0	1	2	3	4	5	$F_1(c_1)$	x_1^*
0	0+0,0	-	-	-	-	-	0,0	0
1	0+2,8	2,2+0	-	-	-	-	2,8	0
2	0+5,4	2,2+2,8	3,0+0	-	-	-	5,4	0
3	0+7,4	2,2+5,4	3,0+2,8	4,1+0	-	-	7,6	1
4	0+8,6	2,2+7,4	3,0+5,4	4,1+2,8	5,2+0	-	9,6	1
5	0+10,2	2,2+8,6	3,0+7,4	4,1+5,4	5,2+2,8	5,9+0	10,8	1

Stage 2 Unconditional optimization (k = 1, 2, 3).

We determine the trajectory of the optimal strategy.

Step 1: k = 1. According to the table for the Bellman function F1 (c1), the optimal plan for the distribution of 5 million UAH. between the three enterprises is: c1 = 5 F1 (5) = 10.8. In this case, the first enterprise should be allocated x1 = 1 million UAH.

Step 2: k = 2. Determine the amount of cash remaining in the shares of the second and third companies: c2 = c1-x1 = 5-1 = UAH 4 million.

According to the table for the Bellman function F2 (c2) we find that the optimal variant of the distribution of funds in the amount of 4 million UAH. between the second and third enterprises is: F2 (4) = 8.6 when allocating the second enterprise x2 = 2 million UAH.

Step 3: k = 3. Determine the amount of cash remaining in the share of the third enterprise: c3 = c2-x2 = 4-2 = 2 million UAH.

According to the table for the Bellman function we find: F3 (2) = 5,4; x3 = UAH 2 million

The trajectory of the steps of the second stage is clearly illustrated in Fig. 10.

HTBOHAT

c3\x3	0	1	2	3	4	5	F3(c3)	X3m
0	0,0	-	-	-	-	-	0,0	0
1	-	2,8	-	-	-	-	2,8	1
2	-	-	*5,4*	-	-	-	5,4	*2*
3	-	-	-	6,4	-	-	6,4	3
4	-	-	-	-	6,6	-	6,6	4
5	-	-	-	-	-	6,9	6,9	5

c2\x2	0	1	2	3	4	5	F2(c2)	X2m
0	0,0	-	-	-	-	-	0,0	0
1	2,8	2,0	-	-	-	-	2,8	0
2	5,4	4,8	3,2	-	-	-	5,4	0
3	6,4	7,4	6,0	4,8	-	-	7,4	1
4	6,6	8,4	*8,6*	7,6	6,2	-	8,6	*2*
5	6,9	8,6	9,6	10,2	9,0	6,4	10,2	3

c1\x1	0	1	2	3	4	5	F1(c1)	X1m
0	0,0	-	-	-	-	-	0,0	0
1	2,8	2,2	-	-	-	-	2,8	0
2	5,4	5,0	3,0	-	-	-	5,4	0
3	7,4	7,6	5,8	4,1	-	-	7,6	1
4	8,6	9,6	8,4	6,9	5,2	-	9,6	1
5	10,2	*10,8*	10,4	9,5	8,0	5,9	*10,8*	1

Figure 10. The trajectory of the steps of the second stage of optimization by the method of dynamic programming

Thus, the optimal enterprise investment plan: x1 = 1, x2 = 2, x3 = 2, which provides a maximum return equal to F1 (5) = g1 (1) + g2 (2) + g3 (2) = 10.8 million UAH

Figure 11 shows a possible organization of tables on a sheet of MS Excel application.

Xi	g1	g2	g3
0	0,0	0,0	0,0
1	2,2	2,0	2,8
2	3,0	3,2	5,4
3	4,1	4,8	6,4
4	5,2	6,2	6,6
5	5,9	6,4	6,9

c3\x3	0	1	2	3	4	5	F3(c3)	X3m
0	0,0	-	-	-	-	-	0,0	0
1	-	2,8	-	-	-	-	2,8	1
2	-	-	5,4	-	-	-	5,4	2
3	-	-	-	6,4	-	-	6,4	3
4	-	-	-	-	6,6	-	6,6	4
5	-	-	-	-	-	6,9	6,9	5

c2\x2	0	1	2	3	4	5	F2(c2)	X2m
0	0,0	-	-	-	-	-	0,0	0
1	2,8	2,0	-	-	-	-	2,8	0
2	5,4	4,8	3,2	-	-	-	5,4	0
3	6,4	7,4	6,0	4,8	-	-	7,4	1
4	6,6	8,4	8,6	7,6	6,2	-	8,6	2
5	6,9	8,6	9,6	10,2	9,0	6,4	10,2	3

c1\x1	0	1	2	3	4	5	F1(c1)	X1m
0	0,0	-	-	-	-	-	0,0	0
1	2,8	2,2	-	-	-	-	2,8	0
2	5,4	5,0	3,0	-	-	-	5,4	0
3	7,4	7,6	5,8	4,1	-	-	7,6	1
4	8,6	9,6	8,4	6,9	5,2	-	9,6	1
5	10,2	10,8	10,4	9,5	8,0	5,9	10,8	1

Figure 11. Organize data on a worksheet.

Fig. 12 shows a fragment of the worksheet in the display of formulas. The cells H3, H13, and H23 correspond to the upper left corners of the Bellman function tables ,,, respectively. Addressing cells in formulas provides automatic filling of all tables when spreading formulas throughout the field of tables.

	G	H
1		
2	c3\x3	0
3	0	=ЕСЛИ(H$2=$G3;ПРОСМОТР($G3;$B$3:$B$8;$E$3:$E$8);"-")
4	1	=ЕСЛИ(H$2=$G4;ПРОСМОТР($G4;$B$3:$B$8;$E$3:$E$8);"-")
11		
12	c2\x2	0
13	0	=ЕСЛИ(H$12<=$G13;ПРОСМОТР(H$12;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР($G13-H$12;$G$3:$G$8;$N$3:$N$8);"-")
14	1	=ЕСЛИ(H$12<=$G14;ПРОСМОТР(H$12;$B$3:$B$8;$D$3:$D$8)+ПРОСМОТР($G14-H$12;$G$3:$G$8;$N$3:$N$8);"-")
21		
22	c1\x1	0
23	0	=ЕСЛИ(H$22<=$G23;ПРОСМОТР(H$22;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР($G23-H$22;$G$13:$G$18;$N$13:$N$18);"-")
24	1	=ЕСЛИ(H$22<=$G24;ПРОСМОТР(H$22;$B$3:$B$8;$C$3:$C$8)+ПРОСМОТР($G24-H$22;$G$13:$G$18;$N$13:$N$18);"-")

Fig. 12. Introducing formulas into the cells of a worksheet to populate the main fields of the Bellman function tables

Calculation of maximum values of functions and finding of corresponding values of arguments is carried out by means of functions MAX () and SEARCH () (Fig.13).

	N	O
1		
2	**F3(c3)**	**X3m**
3	**=МАКС(H3:M3)**	**=ПОИСКПОЗ(N3;H3:M3;0)-1**
4	**=МАКС(H4:M4)**	**=ПОИСКПОЗ(N4;H4:M4;0)-1**
11		
12	**F2(c2)**	**X2m**
13	**=МАКС(H13:M13)**	**=ПОИСКПОЗ(N13;H13:M13;0)-1**
14	**=МАКС(H14:M14)**	**=ПОИСКПОЗ(N14;H14:M14;0)-1**
21		
22	**F1(c1)**	**X1m**
23	**=МАКС(H23:M23)**	**=ПОИСКПОЗ(N23;H23:M23;0)-1**
24	**=МАКС(H24:M24)**	**=ПОИСКПОЗ(N24;H24:M24;0)-1**

Fig. 13. Entering formulas into cells of a worksheet finding maximum values of functions and finding appropriate arguments.

Conclusion

In this paper, we have explored the use of modern technology, as exemplified by the most optimal capital allocation.

We managed to solve the problem of optimal distribution of investments between the three enterprises. All of them gave the same result, which confirms their effectiveness and reliability.

Thus, we can draw the following conclusions: in small dimensions, it is easier to solve by the search method or by using the Solution Search tool. These methods are easy to understand and implement. However, for large dimensions, it is rational to use a dynamic programming algorithm. It is stable in solution and the most fast-acting.

Mastering the method requires some mental effort. The above solution is considered by this method "manually". To solve similar problems with other source data, it is rational to automate the process of compiling Bellman function tables.

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НТБ ОмГТУ

4. POWER ENGINEERING AND ENERGY EFFICIENCY

НТБ ОНАХТ

EXPERIMENTAL PERFORMANCE ANALYSIS OF AN EJECTOR REFRIGERATION CYCLE IN CASCADE REFRIGERATION CYCLE

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Abstract. *The exhaust heat from compressor is removed by a heat driven ejector refrigeration cycle (ERC) in the compression - ejector cascade refrigeration system, which can effectively improve system performance by reducing the condensation pressure and the electric power consumption. The working conditions of ERC extremely affect the performance of cascade system. In order to explore the best working conditions of the system, a test rig of ERC operating with refrigerant R245fa was design and built to investigate the performance carefully. Thermal coefficient of performance (COP_{th}), entrainment ratio and cooling capacity of ERC at various operating conditions were measured and analyzed. Some useful conclusions could be obtained from the experimental data. ERC with high evaporation temperature has significantly better performance and hold great application potential in different cascade/hybrid systems. With the evaporation temperature of ERC increasing from 15°C to 30°C, its COP_{th} increases from 0.19 to 0.45 by 137.1% and the critical condensation temperature also increases from 39°C to 44°C. Higher COP_{th} and cooling capacity occur at the lower generation temperature, however, the critical condensation temperature keeps relatively low which is not conducive to working at high ambient temperatures. Experimental results and analysis in this study are helpful to the application and working condition optimization of ERC in cascade/hybrid refrigeration systems.*

Keywords: *Ejector refrigeration cycle; Cascade refrigeration system; Experiment; Performance*

I. Introduction

Ejector refrigeration cycle (ERC) holds great potential in utilizing low-grade thermal energy such as solar, geothermal energy and industrial waste heat. The key component - ejector in ERC could act like a pump or compressor without any moving parts, which makes ERC systems structurally simpler and more compact than other heat-driven refrigeration systems. It still has the advantages of low initial investment and maintenance cost. Conventional vapor compression refrigeration cycle (VCRC) is widely used in a long time. However, when the refrigeration machine works in the hot summer, the problems of high power consumption and low performance of the system always exist. Compared with the conventional single VCRC, the cascade refrigeration cycle has the advantages of improving system performance or producing lower evaporation temperature. Megdouli [1] introduces that compression cascade system provide cryogenic refrigeration at the cost of consuming a large amount of electricity. Performance optimization due to ejector expansion was limited. A heat driven ejector refrigeration cycle (ERC) can be used to remove the exhaust heat from the compressor in VCRC system, which can effectively reduce the condensation pressure and the consumption of compressor almost without increasing more electric power

consumption. This constitutes an ejector - compression cascade refrigeration cycle, which is consisted of two sub-cycles (VCRC and ERC).

II. Literature overview

The ejector - compression cascade system has great advantages in system structure, performance, economy and application. Chen [2] analyzed the system performance improvement of CO2 cascade mechanical compression-ejector cooling cycle. The working fluid supplied to the vapor generator of the ejector cooling cycle was preheated by the exhaust heat at compressor outlet, which increases the energy and exergetic efficiency parameters relative to the conventional cycle. However, there was a lack of experimental data analysis, including the analysis of factors affecting the performance with the ejector refrigeration sub-cycle and the cascade system. Chen [3] proposed a hybrid carbon dioxide (CO2) transcritical mechanical compression - ejector cooling cycle. The results shown that, due to adding an ejector cooling cycle, efficiency growth of the transcritical CO2 cooling cycle is higher with lower evaporation temperatures. Wang [4] proposed a novel hybrid auto-cascade refrigeration system coupled with an ejector cycle. The ejector is applied to increase the suction pressure of compressor and the ejector cycle provides cooling capacity for removing exhaust heat of compressor and flash heat. The results indicate that energy consumption of the compressor in HACRS could be reduced by 50% as compared to that in the conventional auto-cascade refrigeration cycle. Most of the research of the compression - ejector cascade refrigeration system was theoretical research, while the experimental research is relatively scarce.

Similar to cascade refrigeration system, the ejector cycle could be added to achieve a cascade/hybrid system in extensive ways for improving system performance, such as ERC-absorption refrigeration system, ERC-ORC hybrid system, ERC-compression hybrid system, ERC-ERC and so on. In the absorption refrigeration system, the coefficient of performance (COP) increases from 0.61 to 0.76, when absorber temperature was 40°C and condensation temperature decreases from 42°C to 35°C by Sencan [5]. The condensation temperature is 45°C and the cooling water temperature in absorber is 35.3°C [6]. ERC has potential to provide cooling capacity for absorber and condenser in order to achieve the high *COP*. In the ORC cycle, reducing the condensation temperature can significantly improve system efficiency. In general, the condensation temperature is mostly limited by the environment with range about 30~39°C [7,8]. Besides, ERC and ORC cycles can be driven by waste heat. If ERC can provide the cooling capacity for condenser in single ERC, the efficiency of the whole system will be improved significantly. Chen [9] introduced *COP* of ERC with refrigerant R245fa decreased from 0.95 to 0.32, when the condensation temperature increased from 27°C to 43°C, while the evaporation temperature and the generator temperature were 10°C and 90°C, respectively. Reducing condensation temperature can make a great contribution to improving performance coefficient, which has been proved it by theoretical and experimental analysis by Shestopalov [10]. It can be seen that the combination of ERC and conventional cycle have a wide potential application. ERC has great potential to moving the condensation load for improving the overall system performance.

The performance of sub-cycle directly affects the cascade system performance. As a matter of fact, *COP* of ERC is relatively lower compared with conventional machines, which partly limits its further application and popularization [11]. Researchers have carried out a lot of work in order to improve the performance of ERC systems, including optimization of ejector inner structure, refrigerant screening, suitable working conditions searching and so on. Varga et al. [12] used CFD to study the influence of structural parameters such as area ratio on the performance of steam ERC. The results showed that when the operating conditions were certain, there was an optimal area ratio of the ejector which can make the system obtain the best operating performance. It also was consistent with the research results of Yan et al. [13]. Chou et al. [14] based on the existing experimental data of R113, R141b and water vapor, established an empirical model to predict the maximum mass flow rate of the ejector by using different ejector sizes and operating conditions. The accuracy of the model was higher than that of the existing ejector model. However, the experimental verification and analysis was lacking. Aphornratana [15] tested the pressure profile along the ejector under the condition of the evaporation temperature lower than 15°C. The ejector can be clearly understood and explained by the research, while, the fact is that the performance of ejector has potential to be improved. Performance of ERC system is known to be very sensitive to the pressures at the inlets and outlet of the ejector, for the choking status inside the ejector could sharply change at the critical point [16]. Both theoretical and experimental results confirmed that, at the lower evaporation temperature condition, the *COP* of ERC system could not reach an economical level [17]. The best working conditions of ERC and the influence of working conditions are worthy of experimental study, especially under the working condition of the cascade refrigeration cycle.

Alternatively, assembling cascade system of ERC with VCRC is a more realistic and attractive solution. High sub-cycle performance of ERC is contributed by improving the working conditions of ejector. Moreover, it is also practical significant to improve the overall system performance due to removing the exhaust heat of compressor effectively. On the other hand, low grade heat driven ERC system could improve the *COP* of these conventional systems without increasing more electric consumption and initial cost. In such removing or recovering the heat from condenser or absorber applications, the evaporation temperature of ERC system should be carefully optimized by a trade-off balance between the combined two systems. To do this, one should make sure that the working characters of ERC under relative high evaporation temperatures *(Tev* is greater than 16°C), which were still barely investigated and could be much different with available ERC experiments.

Considering the facts listed above, this paper takes an ejector - compression cascade system as an example to analyze the overall system performance improvement brought by the addition of ERC. The first step was to analysis the best design parameters and cascade system performance. Then a test rig of ERC was built to investigate the working characters under cascade working conditions. Refrigerant is optimized according to working conditions. The system performance variation and appearance of critical points were experimentally detected at different operating

conditions. The optimized working conditions were clearly shown. These results were believed to be helpful in the guidance to ERC application in cascade or hybrid systems.

III. Object, subject and methods of study

The object of study an ejector - compression cascade system combined with a vapor compression refrigeration cycle (VCRC) and an ejector refrigeration cycle (ERC).

The subject of study is the thermodynamic processes in analyzing the best design parameters and cascade system performance, and then a test rig of ERC was built to investigate its optimal working characters under cascade working conditions.

The research methods are thermodynamic and experimental analysis the system performance of ejector - compression cascade system and ERC. The comparison of the improvement with results was complement.

3.1 Cycle description

The diagram of an ejector-compression cascade refrigeration system is shown in Fig. 1. It's not hard to know the heat of condensation is token away by ERC, which contribute to reducing the energy consumption of compressor and improving the system performance. The *P-h* diagram of ejector-compression cascade refrigeration is presented in Fig. 1 and 2. ERC includes an ejector, a generator, an evaporator, a condenser, a receiver, an expansion valve and a feed pump. It is driven by heat energy. That is, in addition to a feed pump, the system does not add additional high-grade energy consumption unit. The arrangement of these components of ERC is presented in the simplified diagram Fig. 2. The working principle of the heat driven ERC is as follows: the primary fluid from generator enters ejector through a convergent-divergent nozzle, which creates a low-pressure region at the nozzle exit and accelerates the flow from subsonic to supersonic velocity. The secondary fluid from evaporator is entrained due to the pressure difference. These two vapors mix together in the mixing chamber, and then, the mixing fluid achieves the objective pressure in the ejector exit through the diffuser. The ejector accomplishes the function of increasing the fluid pressure almost without consuming electricity.

The performance of the cascade refrigeration system is determined by the performance of two sub-cycles (VCRC and ERC). Single VCRC is an in-depth research and stable system at present. The performance of ERC is deeply related to the efficiency of ejector which is the core equipment. Further, the performance of ejector is closely affected by its working conditions. With the increasing of ejector outlet pressure, the ejector worked in three different modes, the critical, sub-critical and back flow mode [16] on the condition of constant pressures of primary flow and the secondary flow as shown in Fig.2. The curve describes the relation between condensation pressure and entrainment ratio. Critical mode achieves high entrainment ratio and coefficient of performance. This mode is also known as “double-choked mode”, which means the primary and secondary flows are both choked and the entrainment ratio is constant until the back pressure reaches the critical point. In the sub-critical mode, the entrainment ratio decreases rapidly with increase of back pressure. In this mode, only the primary flow is choked, and the entrainment ratio changes with the back pressure. Further increasing the back pressure, the ejector will work in back-flow mode.

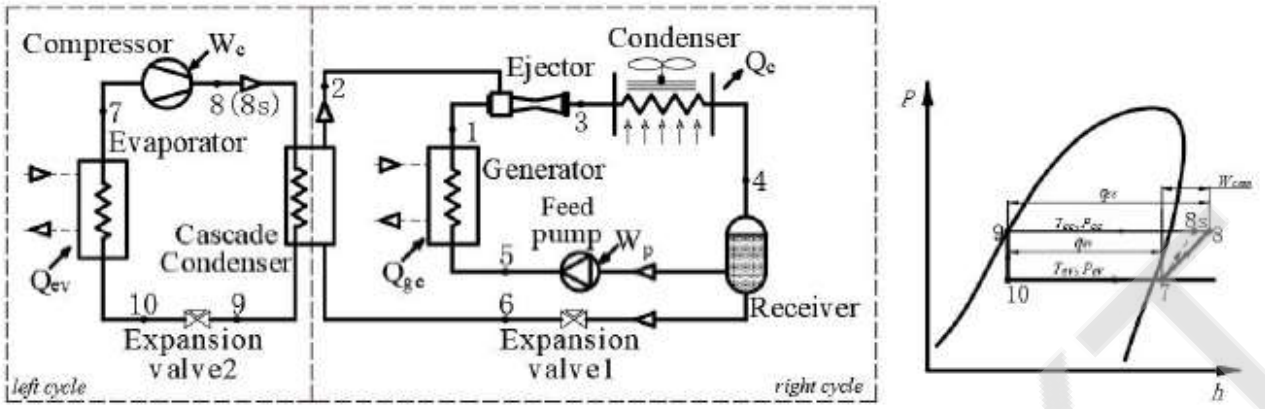

Fig. 1 System diagram of cascade refrigeration system and *P-h* diagram of left cycle

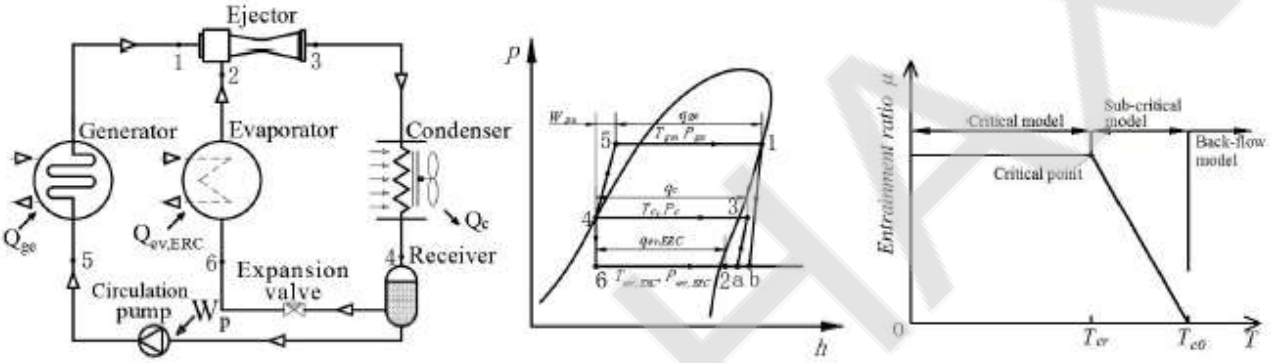

Fig. 2 System and *P-h* diagram of ERC and working mode of ejector

3.2 Mathematical model

Analysis of the cascade system is described as follows using the numbering in Fig. 1 and 2:

The ejector was designed according to one-dimensional homogeneous equilibrium model and constant-pressure mixing model which was introduced by Keenan [18] based on gas dynamics, and developed by Munday [19], Huang [20]. Moreover, to simulate the ejector, the following assumptions are made.

- The flow is 1D steady flow and the heat transfer between the flow and ejector walls are ignored.
- Velocities of streams at the inlet and outlet of the ejector could be negligible.
- The effects of frictional and mixing losses in the nozzle, mixing section and diffuser of ejector are involved by using the isentropic efficiency, as well as mixing loss coefficient.

The entrainment ratio of ejector is the ratio of the secondary fluid flow rate of the ejector to the primary fluid flow rate. According to the conservation of energy, mass, momentum, neglecting the inlet velocity of primary and secondary flow, as well as velocities of the mixed flow at the diffuser exit, the entrainment ratio can be deduced as [21]:

$$\mu' = \sqrt{\eta_n \eta_m \eta_d (h_p - h_{p,n,is})/(h_{mix,d,is} - h_{mix,m})} - 1 \quad (1)$$

Where μ' is entrainment calculated from mass flow rate, η_n is isentropic efficiency of the nozzle, η_n=0.85, η_m is isentropic efficiency of mix, η_m=0.95, η_d is

isentropic efficiency of diffusion, η_d=0.85 [21~23], h_p is the inlet enthalpy of primary flow, $h_{p,n,is}$ is the outlet enthalpy of primary flow under isentropic condition in the nozzle, $h_{mix,d,is}$ is the enthalpy of mixed flow under constant pressure mix in the chamber, $h_{mix,m}$ is the outlet enthalpy of mixed flow under isentropic process condition in the diffuser.

The entrainment ratio μ is expressed as

$$\mu = \frac{\dot{m}_s}{\dot{m}_p} = \frac{\dot{m}_2}{\dot{m}_1} \tag{2}$$

The cooling capacity of cascade system, the cooling capacity of ERC and the heating capacity of generator can be defined as follows

$$\dot{Q}_{ev}=\dot{m}_{ev}\times(h_7 - h_{10}) \tag{3}$$

$$\dot{Q}_{ev,ERC} = \dot{m}_s \times (h_2 - h_6) \tag{4}$$

$$\dot{Q}_{ge} = \dot{m}_p \times (h_1 - h_5) \tag{5}$$

The energy conservation of the cascade condenser heat exchanger is expressed as:

$$\dot{m}_8 \times (h_8 - h_9) = \dot{m}_2 \times (h_2 - h_6) \tag{6}$$

Considering non-adiabatic loss and friction loss, the power consumption of compressor is given by:

$$\dot{W_{com}} = \dot{m_{com}}(h_8 - h_7)/\eta_{com,is}\eta_{com,ele} \tag{7}$$

Where $\eta_{com,is}$ is isentropic efficiency of the compressor, and the isentropic efficiency is considered 0.85; $\eta_{com,ele}$ is electric efficiency of the compressor.

The power consumption of feed pump is given by:

$$\dot{W_{pu}} = \dot{m}_p(h_5 - h_4)/\eta_{pu} \tag{8}$$

Where η_p is the efficiency of circulation pump.

Considering that the system has two grades of energy input: thermal and electric energy, mechanical coefficient of performance *(COP_{me})* and thermal coefficient of performance *(COP_{th})* should be used to evaluate the performance of cascade system and ERC. COP_{me} can be defined as the ratio of the cooling capacity to the electric energy consumption of the compressor and pump. COP_{th} is dependent on the cooling capacity in the cascade condenser and heat input of the generator, which is to describe the performance of thermal drive system more accurately, shown as the following Eq. 10.

$$COP_{me}=\frac{\dot{Q}_{ev}}{\dot{W}_{com}+\dot{W}_{pu}} \tag{9}$$

$$COP_{th} = \frac{\dot{Q}_{ev,ERC}}{\dot{Q}_{ge}} = \frac{\dot{m}_s\times(h_2-h_6)}{\dot{m}_p\times(h_1-h_5)} \tag{10}$$

In order to compare the system performances under different operating conditions, the relative difference is defined and its calculation is shown in Eq. (11).

$$Dev = \frac{X_i - X_{ii}}{X_{ii}} * 100\% \tag{11}$$

3.3 The computation of system design parameters and performance

Proper refrigerant selection is also an important factor to ensure good performance of ERC. ERC with R245fa has better performance and a good application prospect, especially in air-conditioning operating conditions (the evaporation temperature higher than 5°C) [11,24]. R245fa is a kind of environmental-friendly working fluid. Its normal boiling point and the latent heat are 287.96 K and 196.23 kJ/kg, respectively. Meanwhile, it has low saturation pressure that improves the safety of ERC and reduces the initial cost of equipment. As a dry refrigerant which the saturation curve slope is positive, refrigerant R245fa also features cheap and none Ozone Depletion Potential (ODP). Therefore, R245fa was selected as the working fluid in this system.

The cascade system performance is deeply related to working conditions of two sub-cycles. Under the same ambient (Tc= 45°C) and evaporation temperature (Tev= 5°C), the optimization cascade condenser parameters are a core for the maximum efficiency of the cascade system.

The cascade system is designed for the working condition that the condenser outlet temperature Tc = 45°C, the evaporation temperature Tev = 5°C, the cooling capacity *Qev* =11.8 kW and the refrigerant is R410a. Fig. 3 shows the variation in *COPme* of VCRC with condensation temperature. The coefficient of performance increases from 4.0 to 7.3 with condensation temperature decreasing from 45°C to 30°C. It is quite effective to reduce the condensation temperature to improve the system performance of VCRC.

Fig. 4 shows the variation in *COP*me of cascade system with evaporation temperature at different generator temperature of ERC. The temperature difference between the condensation side and the evaporation side in the cascade condenser is 5°C. With the increase of the evaporation temperature of ERC, *COP*me increases first and then decreases. The maximum *COP*me of cascade system value occurs at the evaporation temperature of ERC about 25°C. High evaporation temperature of ERC is beneficial to the improvement of overall system performance. While the evaporation temperature exceeds 31°C, the power consumption of the feed pump will have a negative impact on *COP*me. The evaporation temperature of ERC should be limited.

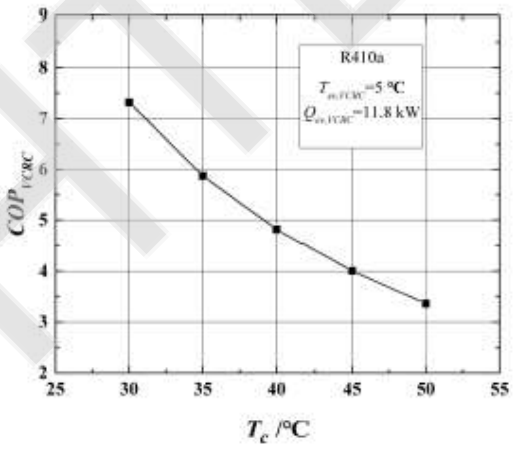

Fig. 3 The variation in COP_{VCRC} with condensation temperature

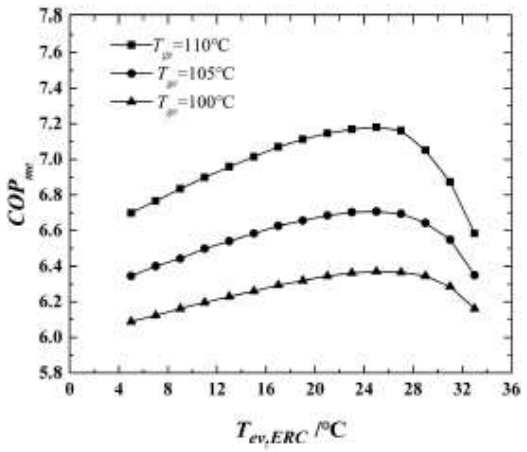

Fig. 4 The variation in COP_{me} of cascade refrigeration system with evaporation temperature of ERC

According to the theoretical analysis of the cascade refrigeration system performance advantage, it is worth carrying out the experimental research in order to promote its promotion and application.

3.4 Experimental setup

In order to realize the performance test and analysis of the ejector - compression refrigeration system under different working conditions, an ERC test rig with a cooling capacity of 15 kW was designed and built for analyzing the performance of the ERC operated under high evaporation temperatures. Based on the results presented in Fig. 4 and the ambient temperature of working, the ejector structure was designed for the working condition that the condenser outlet temperature T = 45°C, the generation temperature T_{ge} = 110°C, the evaporator inlet temperature T_{evERC} = 25°C and other relevant design conditions are listed in Table 1. The size design of the ejector is shown in Table 2 and Fig. 5.

Table 1 The preliminary design conditions of ERC

Generation temperature = 110.0°C_{sat}
Generation pressure = 1571.1 kPa
Evaporation temperature = 25.0°C_{sat}
Evaporation pressure = 148.6 kPa
Condensation temperature = 45°C_{sat}
Condensation pressure = 294.6 kPa
Critical condensation temperature = 45.0°C
Evaporator capacity = 15 kW

Table 2 The structural dimensions of the ejector

Throat diameter = 4.9 mm
Nozzle exit diameter = 8.8 mm
Diverging angle at nozzle exit = 6.0 °
Converging angle at nozzle enter =15.0 °
Constant area section diameter = 14.4 mm
Length of constant area mixing chamber = 97 mm
Length of diffuser = 183.05mm
Diverging angle of diffuser = 8 °
Exit diameter of diffuser= 40 mm

Table 3 Measuring instruments and their uncertainties.

Required Measurements	Instruments	Range	Uncertainty
Temperature	RTD sensor (Pt100)	-200 ~ 350°C	±0.2°C
Pressure of primary fluid	Druck PT[a], UNIK 5000	0~3.0MPa	±0.2% FS[b]
Pressure of secondary fluid	Druck PT, UNIK 5000	0~0.35MPa	±0.2% FS
Outlet pressure of ejector	Druck PT, UNIK 5000	0~1.6MPa	±0.2% FS
Outlet pressure of condenser	Druck PT, UNIK 5000	0~1.6MPa	±0.2% FS
Inlet pressure of evaporator	Druck PT, UNIK 5000	0~0.35MPa	±0.2% FS
Inlet pressure of pump	Druck PT, UNIK 5000	0~0.35MPa	±0.2% FS
Inlet mass flow rate of generator	EMERSON Coriolis flow meter CMF050	0~0.96kg/s	±0.1% (Liquid, FS)
Inlet mass flow rate of needle valve	EMERSON Coriolis flow meter CMF025	0~0.302kg/s	±0.1% (Liquid, FS)
Inlet mass flow rate of cooling water through condenser	EMERSON vortex flow meter 8600D	0~9.6kg/s	±0.8% (Liquid, FS)
Inlet mass flow rate of cooling water through evaporator	EMERSON vortex flow meter 8600D	0~6.0kg/s	±0.8% (Liquid, FS)

[a] PT, Pressure transmitter; [b] FS, full scale.

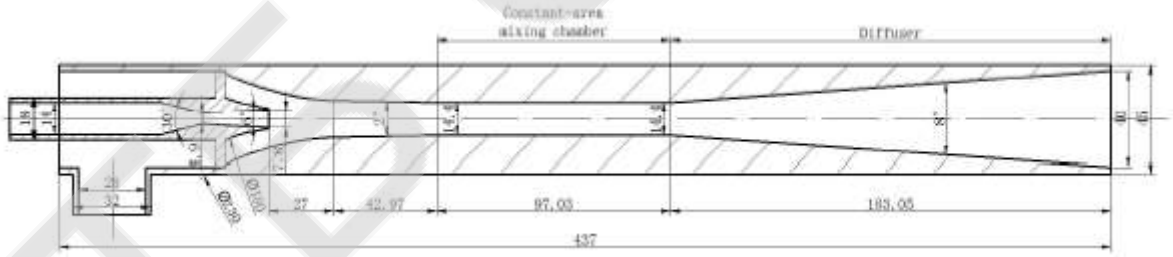

Fig. 5 Structure of the ejector

The schematic diagram of the ERC test rig was shown in Fig. 6. The test rig equipment consists of the following several major components: an ejector, a generator, an evaporator, a condenser, a chilling unit, a needle valve, a gear-type feed pump, a boiler, several regulating ball valves and a control panel equipped with different measurement instruments. The chilling unit provides cooling capacity for the condenser of ERC by regulating ball valves (RBV2^ RBV3). Meanwhile, the water flow rate through evaporator is regulated by RBVK RBV4 so as to regulate the cooling load of evaporator. The measuring instruments are listed in Table 3. RTD sensors were set up at inlets and outlets of the evaporator, condenser, generator and ejector, transmitting output signals to a PC through a data acquisition unit. The expanded

uncertainty of experimental results is calculated according to the **detail information of sensors.**

$$U_c = k * u_Y = k * \sqrt{\sum_i \left(\frac{\partial Y}{\partial x_i}\right)^2 u^2(x_i)} \quad (12)$$

$$Y = f(x_1, x_2, \ldots) \quad (13)$$

Where k is the coverage factor, Y represents the performance parameters (*COP*, entrainment ratio and critical back pressure). The measured variables x_i include temperatures, pressure and mass flow rates. All the estimated uncertainties were given in the experimental results section.

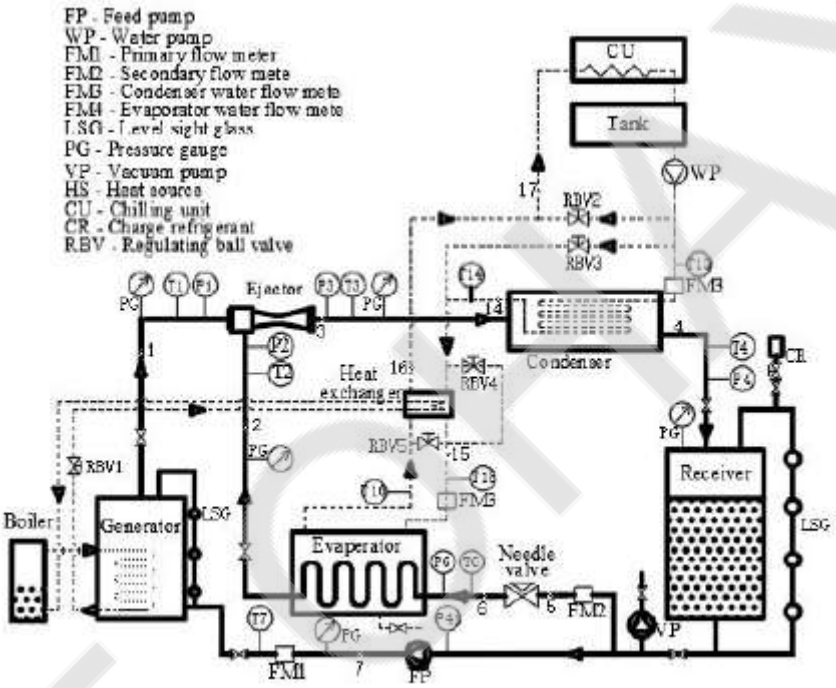

Fig.6 Schematic diagram of the experimental procedure

A plate heat exchanger was used as the condenser to obtain the best test condition of lower ejector backpressure. Shell and tube heat exchangers were employed as generator and evaporator, and the shell side is the refrigerant to ensure adequate heat transfer for superheating refrigerant. A gear pump is adopted in the experimental system as feed pump to achieve stable operation, especially in the lower condensation pressure. The flow rate of primary fluid was changed by the adjustable speed of the pump using a frequency converter which can work at maximum 1.1 kW and an output frequency ranging 0~60 Hz. Some details of the equipment are listed in Table 4.

Table 4 Details of the equipment.

Name	Category
Condenser	50 kW plate heat exchanger (R245fa/ water)
Generator	35 kW shell and tube heat exchanger (R245fa/ steam)
Evaporator	20 kW shell and tube heat exchanger (R245fa/ water)
Pump	Gear pump
Expansion valve	0.312″ (7.9mm) HOKE's needle valve 3912F8B
Receiver	45L Stainless steel tank

The experimental procedures were as follows:

1. Check the water tank and make sure it with plenty of water and circuit safety.
2. Turn on the measuring instruments and data collector for collecting the parameters including temperature, pressure and flow rate.
3. Confirm each valve is switched in a precise way, and make cooling water flow through the condenser and chilled water through the evaporator.
4. Turn on the chilling unit and boiler in turn.
5. Turn on the feed pump and use frequency converter to control the flow rate of the generator, in order to achieve the regulation of pressure and temperature of the primary fluid.
6. When the system is running stable, use the needle valve to control the evaporating temperature, and
   regulate the ball valves (RBV1 RBV4) to meet the cooling load.
7. Regulate the ball valves (RBV2^ RBV3) to achieve the target condensation temperature in need.
8. After stabilization for 15 minutes, record the system parameters for one set, and after that, acquire the average of every ten sets for the final result.
9. Change the experimental conditions and repeat the procedure 5~8.

IV. Results

The performance of ERC was experimentally tested under the following operation conditions, the condensation temperature (T_c) was in the range of 40°C~54°C, the generation temperature (T_{ge}) was in the range of 100°C~110°C and the evaporation temperature (T_{evmc}) was in the range of 15°C~30°C.

According to the expanded uncertainty calculation formula shown in Eq. (12) and the measuring instruments and their uncertainties in Table 3, an error analysis is carried out to show the accuracy of measurement. The value of the coverage factor *k* here is chosen to be 3 with a 99 % confidence interval [25]. The maximum typical expanded uncertainty of the COP_{th} of the ERC is about 0.6%. That is, the detailed value of expanded uncertainty indicates that the accuracy of measurements in this study is acceptable.

5.1Effects of Tc changing under different Tge

Fig. 7 is experimental results measured at $T_{ev,ERC}$ = 30°C and Tge =100°C, 105°C and 110°C, respectively. For an ejector with a constant structure, the condensation temperature and the generation temperature have a great influence on the working performance.

Fig. 7a shows the variations of *COPth* with *Tc* at different Tge. It can be seen that the trend of *COPth* keeps the constant first and then decreases with the increase of Tc. This is closely related to the ejector's operational modes in Fig.3. Moreover, *COPth* changes significantly with the variety of Tge. Lower pressure and temperature of the primary fluid can achieve greater performance of ERC, however, the critical points also appear in lower pressure. For an ejector with constant structure and size, the primary mass flow rate is lowered with speed decreasing when the primary fluid pressure decreases. Under critical model, *COPth* decreases from 0.489 to 0.346 when the generation temperature increases from 100°C to 110°C since the entrained duct are longer and larger for primary flow with smaller momentum [15]. That is to say, a higher coefficient of performance before the critical point can be obtained at lower generation temperature and pressure. A maximum *COPth* of 0.489 can be reached at $T_{ev,ERC}$=30°C, Tc = 40°C and Tge = 100°C.

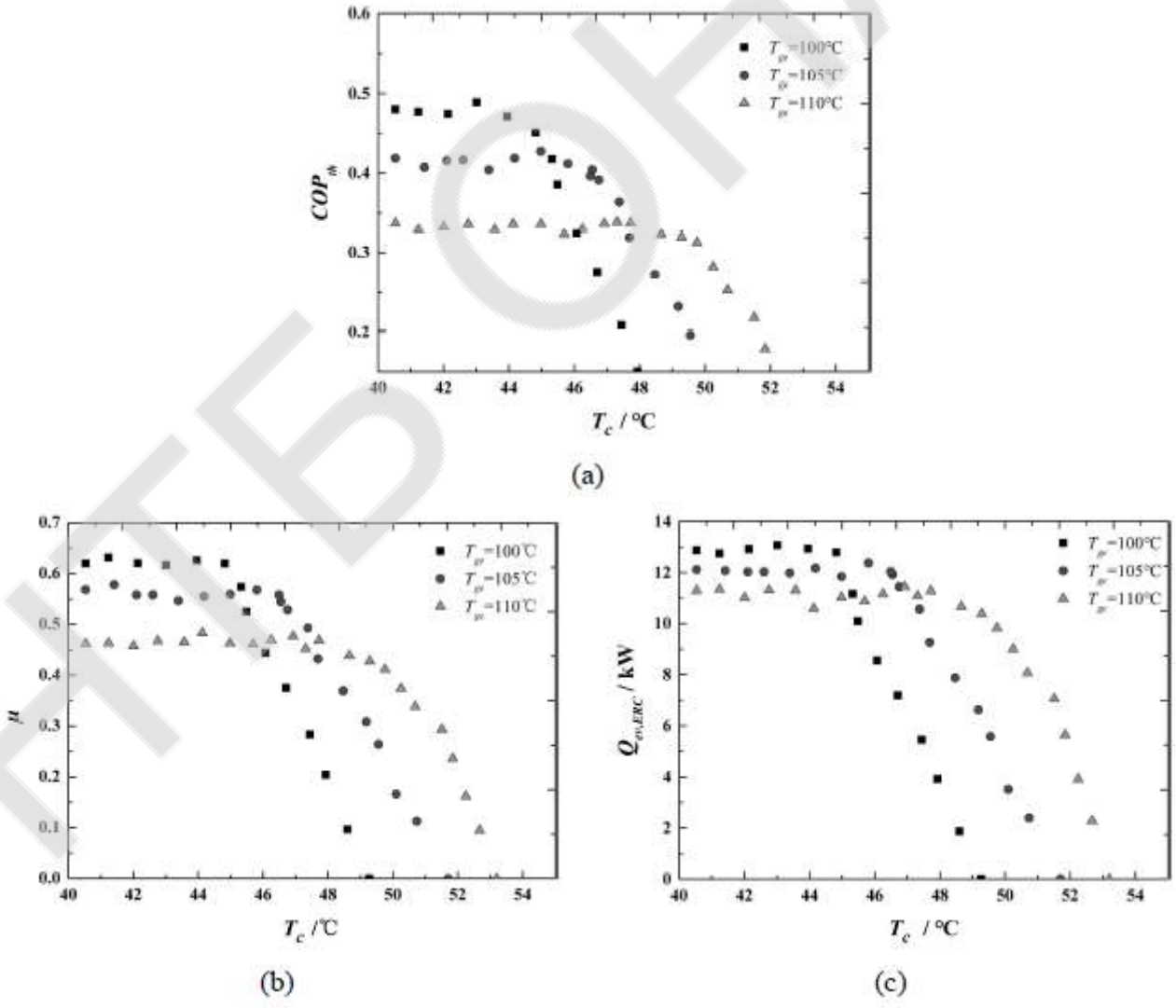

Fig. 7 Measured variations of COP_{th}(a), μ (b), $\dot{Q}_{ev,ERC}$ (c) with T_c at different T_{ge}

Fig. 7b shows the variations of *p* with *Tc* at different Tge. When the evaporation pressure and condensation pressure are constant, the primary fluid with lower temperature and pressure can achieve a smaller expansion angle and a larger entrained duct to obtain a larger effective area of the nozzle. That is, the entrainment ratio before the critical point under lower generation temperature and pressure is higher than at higher generation temperature. A maximum entrainment ratio of 0.62 can be reached at $T_{ev,ERC}$ =30°C, Tc = 40°C and Tge = 100°C.

The cooling capacity Q_{eVfERC} shown in Fig. 7c is mainly influenced by the secondary fluid flow rate when the $T_{ev,ERC}$ is constant. A maximum cooling capacity of 12.9 kW can be reached at $T_{ev,ERC}$ =30°C, Tc = 40°C and Tge= 100°C.

5.2 Effects of *T*c changing under different $T_{ev,ERC}$

Fig. 8 shows experimental results measured at Tge = 100 °C and $T_{ev,ERC}$ =15°C, 20°C, 25°C and 30°C, respectively. The state parameters of secondary fluid have great influences on the ejector operation.

Fig. 8a shows the variations of *COPth* with *Tc* at different $T_{ev,ERC}$. It can be seen that the trend of *COPth* increase exponentially with evaporation temperature of ERC increasing. For an ejector with a fixed structure, *COPth* shows a constant first and then decreases with the increase of condensation temperature under the constant evaporation temperature. High evaporation temperature helps to reduce the momentum difference between the primary fluid and the secondary fluid in the mixing chamber of ejector thereby reducing irreversible losses and improving the working efficiency. The maximum *COPth* of the ERC is 0.197, 0.265, 0.366 and 0.489 at evaporation temperatures of 15°C, 20°C, 25°C and 30°C, respectively. ERC has considerable performance improvements at higher evaporation temperatures. Moreover, the critical condensation pressure is higher when the evaporation temperature is higher in ERC, which can achieve better system performance at higher ambient temperatures.

Fig. 8b shows the variations of *p* with *Tc* at different $T_{ev,ERC}$. It can be seen that the trends of *p* are almost the same as that of the *COPth*. In fact, secondary fluid with higher temperature and pressure is easier to be entrained. The maximum *p* of the ERC is 0.276, 0.376, 0.50 and 0.631 at evaporation temperatures of 15°C, 20°C, 25°C and 30°C, respectively.

Fig. 8c shows the variations of $\dot{Q}_{ev,ERC}$ with *Tc* at different $T_{ev,ERC}$. The cooling capacity at high evaporation temperature of ERC is obviously larger than that at low evaporation temperature. The trend of $\dot{Q}_{ev,ERC}$ are closely related to that of entrainment ratio. The maximum $\dot{Q}_{ev,ERC}$ is 12.9kW at evaporation temperatures of 30°C. The trend of cooling capacity with condensation temperature and evaporation temperature are available for reference.

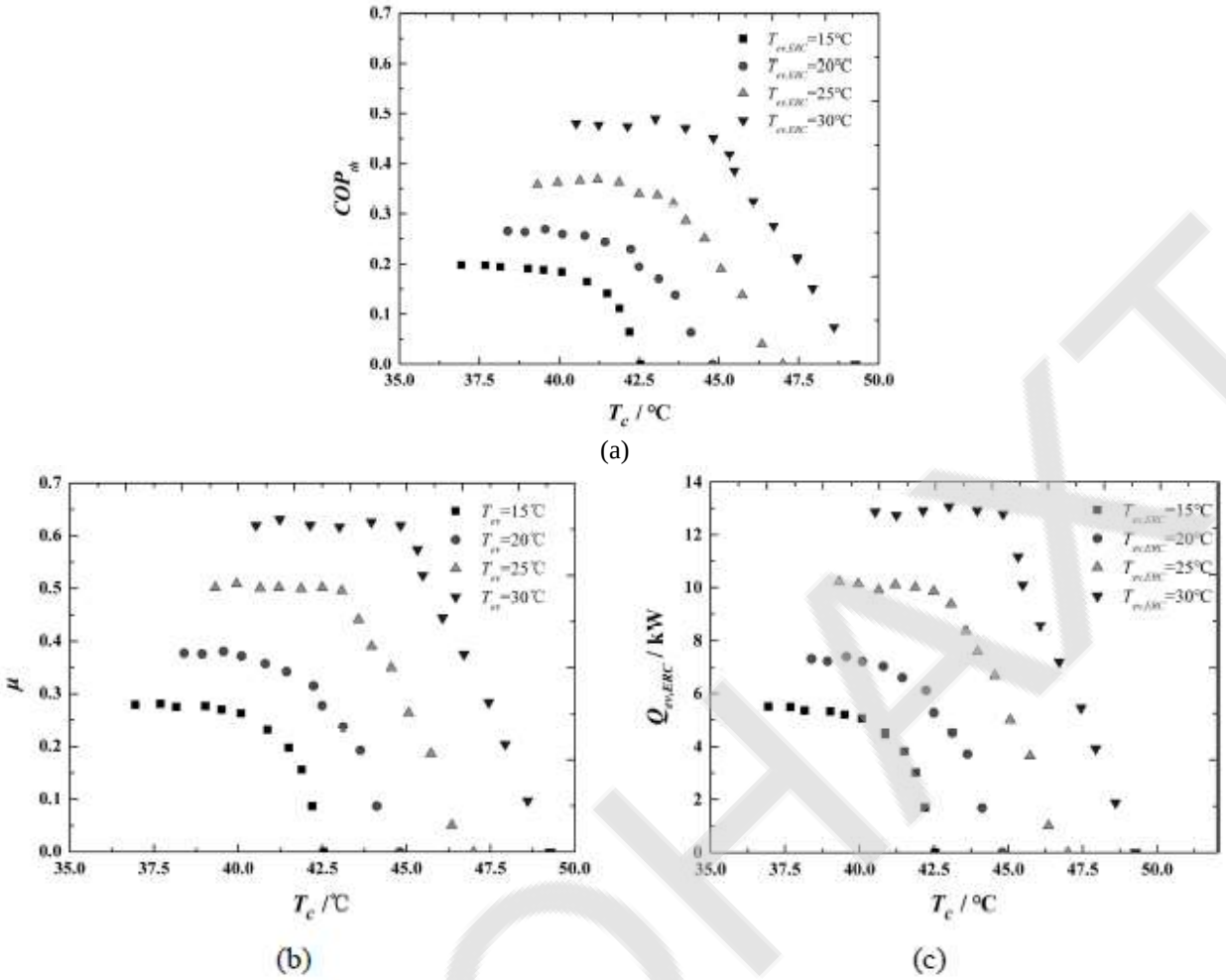

Fig. 8 Measured variations in COP_{th}(a), μ (b), $\dot{Q}_{ev,ERC}$ (c) with T_c at different $T_{ev,ERC}$

5.3 Effects of the working conditions on the critical points

Fig. 9 is experimental Tc of critical points measured at Tge =100 °C, 105 °C, 110 °C and $T_{ev,ERC}$ = 15°C, 20°C, 25°C, 30°C.

Fig. 9a shows the measured critical condensation temperature ($T_{c,cr}$) at different Tge and $T_{ev,ERC}$. The $T_{c,cr}$ increase with the increase of evaporation temperature. When the Tge is 110°C, and Tev changes from 15°C to 30°C, the critical condensation temperature could increase from 43.9°C to 47.7°C. For a fixed structure ejector, the second fluid with high temperature and pressure will help to achieve high back pressure of ejector. That is, ERC operated under high evaporation temperatures is appropriate to be utilized under high ambient temperature. Meanwhile, with the changing of Tge, the critical condensation temperature fluctuation in high $T_{ev,ERC}$ is less than in low. It also can be observed that the critical condensation temperature increase with the increase of generation temperature. When the $T_{ev,ERC}$ is 30°C and Tge changes from 100°C to 110°C, the critical condensation temperature increases from 44.8°C to 47.7°C. Under relative higher ambient temperatures, high generation temperature is conducive to better performance and cooling capacity.

Fig. 9b shows the measured data of *COPth* at critical points under different Tge and $T_{ev,ERC}$. When the Tge = 100°C and $T_{ev,ERC}$ = 20°C, the improvement of *COPth* (taking the evaporation temperature of 15°C as reference) is 36.2%. While, the improvement of *COPth* (taking the evaporation temperature of 15°C as reference) could

be as large as 137.1% at $T_{ev,ERC}$ = 30°C. The higher Tge has a greater impact on the *COPth* at the high $T_{ev,ERC}$. In order to improve the performance of the system, the $T_{ev,ERC}$ can be properly increased and the Tge can be lowered within a limited operating range.

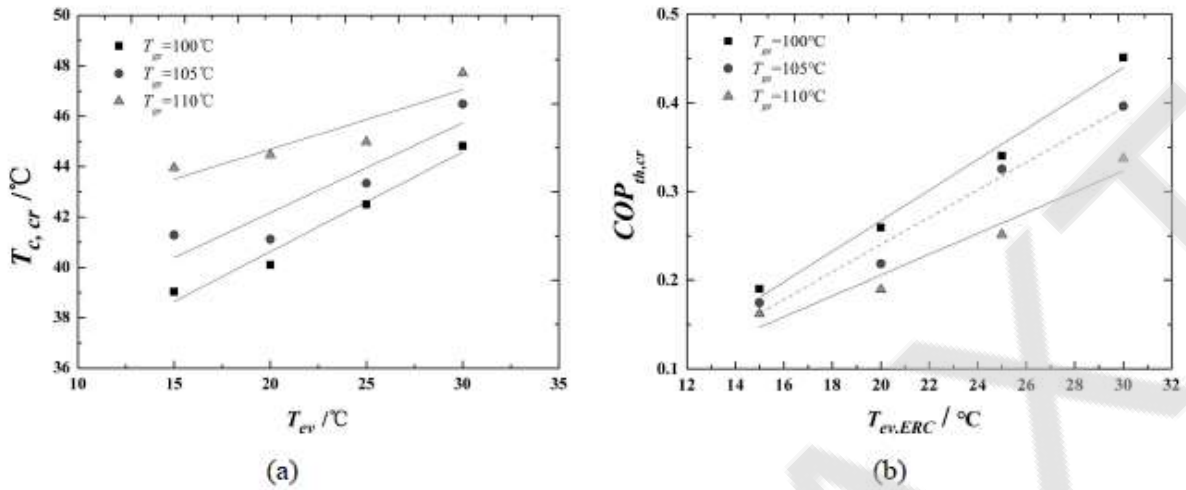

Fig. 9 Measured critical points in $T_{c,cr}$ (a) and COP_{th} (b) at different T_{ge} and $T_{ev,ERC}$

V. Conclusions

ERC, with advantages of simple structure and low cost, holds great application potential in cascade/hybrid cycles to improve the overall system performance by removing or recovering the heat from condenser or absorber applications. The compression - ejector cascade refrigeration system effectively reduces the power consumption and improving system performance owing to the addition of ERC. Its system performance is determined by the working conditions and the performances of these two sub-cycles. The theoretical calculation and experimental test were developed for the best system performance in this paper. A series of effect trends with different operating conditions on the system performance were analyzed. The main conclusions of this study are summarized as follows:

1 The theoretical calculation shows that sub-cycle of ERC with high evaporation temperature is more beneficial to improve the performance of overall cascade system. The maximum cascade system coefficient of performance value occurs at the evaporation temperature of ERC 25°C.

2 The ERC with high evaporation temperature not only improves the performance of ERC, but also improves the performance of cascade refrigeration system. The *COPth* relative improvement of ERC (taking the evaporation temperature of 15°C as reference) is 137.1% at the evaporation temperature of 30°C.

Performance improvement is very beneficial to the promotion and application of ERC.

3 For a constant structure ejector, the better *COPth* and higher cooling capacity occur in the condition of low generation temperature and high evaporation temperature operating in critical model. That is because the primary fluid with smaller momentum can achieve a longer and larger entrained duct which can increase the mass flow rate of secondary fluid.

4 Lower generation temperature can help improve system performance at double-choked mode, however, critical condensation temperature would also be lower

which limits ejectors working at high ambient temperatures.

These results could be helpful to the application of ERC in cascade/hybrid system, including correctly selection of heating and cooling sources under different ambient temperatures and optimization of working conditions. Also, the high quality experimental data which has not been reported before could be used to confirmed the extrapolation reliability of different available theoretical models for ERC.

Nomenclature			
ERC	Ejector refrigeration cycle	**Subscript**	
ORC	Organic Rankine cycle	c	Condenser
VCRC	Vapor compression refrigeration cycle	cr	Critical point
COP	Coefficient of performance	*com*	Compressor
Dev	Relative difference	*d*	Diffuser
h	Specific enthalpy [kJ kg^{-1}]	*p*	Primary fluid
k	Coverage factor	*ele*	Electric
$\dot{m}$	Mass flow rate [kg·s^{-1}]	ev	Evaporator
P	Pressure [MPa]	ge	Generator
$\dot{Q}$	Unit load [kW]	*m*	Mixing chamber
T	Temperature [°C]	*n*	Nozzle
U_c	Expanded uncertainty	*pu*	Pump
u_y	Standard uncertainties	*is*	Isentropic
$\dot{W}$	Unit power [kW]	st	Stagnation state of fluid
q	Specific load [kW kg^{-1}]	cc	Cascade condenser
Greek symbol		s	Secondary fluid
μ	Entrainment ratio	1,2,3…	State points

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НТБ ОНАХТ

THERMODYNAMIC ANALYSIS OF PERIODIC OPERATION AMMONIA-WATER ABSORPTION REFRIGERATION UNITS IN ATMOSPHERIC WATER GENERATION SYSTEMS

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Abstract*. The usage of heat absorption water-ammonia refrigeration units in atmospheric water generation systems is considered. A basic design of periodic operation AWRU is described. A method for thermodynamic calculations and analysis of AWRU PO cycles and modes of operation is presented. Specific refrigerating capacity depending on the composition of water-ammonia solution, the temperature of the heating source, the ambient temperature of the environment is calculated. It is shown that increasing the temperature of the heating source from 65°C to 95°C leads to minimum temperature in the cooling zone decreasing from 7°C to -17°C. Low-temperature ambient air at 25°C enables attaining the maximum value of refrigerating capacity of AWRU PO by increasing the proportion of ammonia in the initial composition from 0.3 to 0.5, and this enables lowering of the heating temperature from 95°C to 65°C.*

Key words: *ammonia-water absorption, periodic operation refrigerator, thermodynamic analysis, atmospheric water generation.*

NOMENCLATURE

t	temperature,	(°C),
P	pressure,	(Pa)
h	heating, heated,	
m	mass,	(kg)
w	cooling, cooled	
Δm	transferred mass,	(kg)
a	absorption	
X, x	fraction of NH_3,	(kg/kg)
r	heat of evaporation,	(kJ/kg)
Q	cooling capacity,	(kJ)
beg	at the beginning	
q	specific cooling capacity, (kJ/kg)	
A	ammonia (NH_3)	
WAS	water-ammonia solution	
B	water	
AWRU	absorption refrigeration unit	
(x)	in liquid	
PO	periodic operation	
(y)	in vapor	
G-A	generator-absorber	
A-E	absorber-evaporator	
0	useful capacity	

HTBOHAT

y	fraction of NH_3 in vapor, (kg/kg)
ob	an object

1. INTRODUCTION

It is a common knowledge that one of the most valuable resources in the future of our planet is going to be fresh water, and the demand for water resources is already one of the main factors in global logistics of contemporary world, and this trend will only grow in the foreseeable future. One of the developments in water production technology is mechanical air dehumidification — condensation of water vapor on the surfaces with a temperature below the dew point. In this case, there are great prospects for the methods associated with the work of independent generators of cold — chillers that are guaranteed to provide the temperature below the dew point temperature. A necessary condition for operation of compression refrigeration machine is the availability of electrical energy. At the same time, the majority of countries facing water scarcity are limited in energy resources, too. Often the readily available source of energy in there is the sun. [Alekseyev V.V., Chekarev K.V. 1996.]

In this regard there have been developed original schemes of absorption water-ammonia refrigeration units of periodic operation (AWRU PO) based on solar collectors, which differ with autonomy and independence from the sources of electrical energy, and unlike heat-analogues (steam jet and lithium-bromide absorption) can be operated with air cooling of their heat-dissipating elements. [Pearlstein B.H. 2008.]

2. A METHOD OF CALCULATION FOR AWRU PO CYCLE

A scheme of flows in AWRU PO during different phases of its work is shown in Figure 1. In the initial time, when AWRU PO zones are at the same temperatures equaling ambient temperature, the composition of the working fluid (WAS) is the same in both zones. In the charging period, the heat flux Q_h arrives to the AWRU PO generator (left part in Fig.1.a) at the temperature t_h. The absorber-evaporator (right part in Fig.1.a) is at ambient air temperature (t_w) and removes the absorption heat Q_a.

During the charging period (Figure 1.a), there occurs the movement of mostly lower boiling component (ammonia) from the generator-absorber (G-A) into the absorber-evaporator zone (A-E). Herewith a temperature in G-A is increased from ambient temperature toward the temperature of the heating medium (t_h), the rate of change is slightly influenced by the initial composition of WAS. At the end of the evaporation process, the temperature in the G-A is at its maximum, the pressure in the system is also at maximum, and the temperature in A-E can be assumed constant and equal to t_w. At the same time, the maximum proportion of ammonia in the WAS is in the A-E, and the minimum — in the G-A.

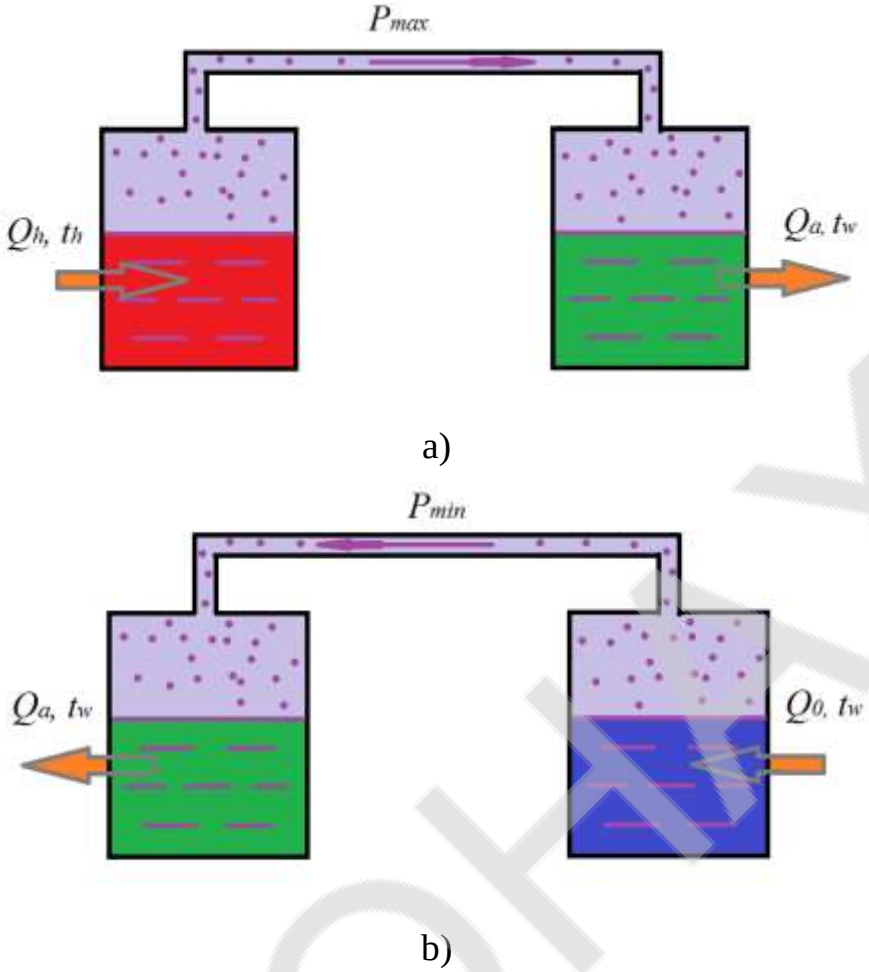

Figure 1. The diagram of the heat and mass flows inside the operating AWRU PO
a) — operation during the charging phase; b) — operation during the cooling phase

In the cooling phase (Figure 1.b), the heat flow from the heat source is blocked, and the outside air is supplied to the outer surface of the G-A, leading to its cooling to ambient environment temperatures. Due to the equilibrium shift in the WAS, when the temperature in the G-A is lowered, the system moves into a state of reduced pressures. In the internal volume of AWRU PO, the system pressure falls to the minimal (in the initial time) value $P_{\min}$. At this point, saturated with ammonia WAS in the A-E starts to boil with heat removal from the outside air flow. Upon cooling of WAS, a thermal flow Q_0 from the environment into the G-A appears due to the temperature difference, that flow is a refrigerating capacity of the AWRU PO. The generated vapor of ammonia is absorbed in the G-A zone with a heat of absorption Q_a transferring to the environment with the corresponding temperature t_w. In this process, there is a monotonic increase of pressure with a corresponding increase of temperature in the A-E zone. The air flow that washes over the outer surface of the A-E is cooled to temperatures below the dew point, and the water condensate devaporates out of it. The cooling process takes place until the establishment of thermal equilibrium in zones G-A and A-E.

For the practical implementation of such a device, it is necessary to estimate its specific cooling capacity q_o when operating under different climatic conditions, with the prospect of maximal utilization in the arid tropical zones of the planet. This

refrigerating capacity is determined by the amount of heat, removed from air while it cools below the dew point temperature, relatively to refrigerant's mass. In connection with this, the initial data must include temperature and humidity of atmospheric air and the potential maximum temperature of the heating source t_h.

At the initial stage of the calculation, there was specified an initial equilibrium composition of WAS, denoted as x_{beg} (in the liquid phase) and y_{beg} (vapor phase). When calculating, the volumes of WAS in G-A and A-E zones are assumed equal. Considering equal temperatures of all system elements $t_w^{G-A} = t_w^{A-E}$ before operation, the composition of the phases are defined as:

a) for the liquid phase:

$$x_{\mathrm{G-A}}{}^{beg} = \frac{m_{\mathrm{G-A(x)}}{}^{\mathrm{A}}}{m_{\mathrm{G-A(x)}}{}^{\mathrm{A}} + m_{\mathrm{G-A(x)}}{}^{B}} = x_{A-E}{}^{beg} = \frac{m_{A-E(\mathrm{x})}{}^{\mathrm{A}}}{m_{A-E(\mathrm{x})}{}^{\mathrm{A}} + m_{A-E(\mathrm{x})}{}^{B}} \quad (1)$$

b) for the vapor phase:

$$y_{G-A}{}^{beg} = \frac{m_{G-A(y)}{}^{\mathrm{A}}}{m_{G-A(y)}{}^{\mathrm{A}} + m_{G-A(y)}{}^{B}} = y_{A-E}{}^{beg} = \frac{m_{A-E(y)}{}^{\mathrm{A}}}{m_{A-E(y)}{}^{\mathrm{A}} + m_{A-E(y)}{}^{B}} \quad (2)$$

where *m* is the mass of solution components, kg; A — ammonia, B — water.

During the charging period (Figure 1.a), some mass of ammonia vapor and water vapor transfers from the zone G-A to the zone A-E. The maximum possible value of the proportion of ammonia in the liquid phase in the A-E is determined by the following relationship:

$$x_{\mathrm{A-E}}{}^{max} = \frac{m_{\mathrm{A-E(x)}}{}^{\mathrm{A}} + \Delta m_{(\mathrm{x})}^{\mathrm{A}}}{m_{\mathrm{A-E(x)}}{}^{\mathrm{A}} + \Delta m_{(\mathrm{x})}^{\mathrm{A}} + m_{\mathrm{A-E(x)}}{}^{B} + \Delta m_{(\mathrm{x})}^{B}} \quad (3)$$

Respectively, the mass in the G-A proceeds to decline:

$$x_{\mathrm{G-A}}{}^{min} = \frac{m_{\mathrm{G-A(x)}}{}^{\mathrm{A}} - \Delta m_{(\mathrm{x})}^{\mathrm{A}}}{m_{\mathrm{G-A(x)}}{}^{\mathrm{A}} - \Delta m_{(\mathrm{x})}^{\mathrm{A}} + m_{\mathrm{G-A(x)}}{}^{B} - \Delta m_{(\mathrm{x})}^{B}} \quad (4)$$

where $\Delta m_{(x)}^{A}$ and $\Delta m_{(x)}^{B}$ — respectively, the mass of ammonia and water in the liquid phase, transferred from G-A to A-E, kg.

The values of $x_{G-A}^{\min}$ and the values of $x_{G-A}^{\max}$ are linked by their thermodynamic parameters — pressure and temperature.

The aim of the thermodynamic calculation of AWRU PO is to define the operating range with the estimation of specific cooling capacity, which determines the performance of installation for the atmospheric water generation by mechanical dewatering (ensuring the temperature of wall and air contact area is below the dew point).

The calculation was carried out for a range of regime parameters:

a) the temperature of the heating source (generator wall) $t_h = 65…95$°C;

b) the temperature of the "cold source" (ambient air temperature) $t_w = 25…45$°C;

The water-ammonia solution (WAS) is used as the working fluid. The calculations assume the maximum operating temperature in the cooling area to be $t_{ob} = 10$°C.

3. THE RESULTS OF CALCULATION AND THEIR ANALYSIS

The analysis of received results shows that with the ambient air temperature rising, the minimum pressure in the system $P_{\min}$ (for a fixed WAS composition in the area of generation) increases, moreover the increase is higher for larger values of ammonia fraction in G-A ($X_{\min}$). This suggests that the increase in ambient air temperature and pressure rise in the system means the temperature in the cooling area increases too, i.e. the cooling capacity of AWRU PO decreases. This dependency is even more noticeable at higher numerical values of $X_{\min}$.

The analysis of the dependency in Figure 2 shows that with increasing temperature of the heating source, the temperature in the cooling zone is reduced. Thus, when t_h = 65°C, t_{ob} = 7°C, but when t_h = 95°C, t_{ob} = minus 17°C. The composition of WAS in the generation area has only a little effect on the minimum temperature in the cooling zone, as illustrated in Figure 3.

To assess the cooling capacity of AWRU PO there was conducted the calculation of current operating parameters of WAS in operating zones during the processes of charging and discharging. Using the formulas (3) and (4), and neglecting the amount of ammonia in the vapor phase, we obtain the dependencies of current parameters (primarily the temperature in A-E zone) during the discharge period.

To estimate the specific cooling capacity of AWRU PO in the range of real modes of operation (the cooling area temperature is not above 10°C), there was carried out a calculation of average integral values of the heat of vaporization of ammonia (r_{cp00}) for the operation period of "charge-discharge". The value of r_{cp00} is depending on the pressure and temperature.

During the operating period, the specific cooling capacity is calculated from the mass of evaporated ammonia $\Delta m^A_{(x)}$ with the equation:

$$q_0 = \Delta m^A_{(x)} \cdot r_{cp00} \tag{5}$$

The Figure 4 represents the obtained dependencies of the AWRU PO specific cooling capacity, calculated by formula (5). Analysis of the curves in Figure 4 shows that the cooling capacity increases with the temperature of the heating source, as expected. Thus, when t_w = 25°C and $X_{\min}$ = 0.3, at t_h growth from 65 to 95 °C, the value of q_0 changes from 650 to 2800 kJ. When t_w = 35°C, the value of q_0 is increased from 50 kJ to 1200 kJ. When ambient air temperature is t_w = 45°C, the operating mode of AWRU PO cannot be implemented at temperatures of the heating medium below 95°C.

At low ambient air temperatures, sufficiently high cooling capacity can be achieved by increasing the amount of ammonia in WAS in the generation-absorption area ($X_{\min}$). Thus, similar values of q_0 = 2650 kJ when t_w = 25°C can be obtained at t_h = 95°C and $X_{\min}$ = 0.3, as well as at t_h = 65°C and $X_{\min}$ = 0.5.

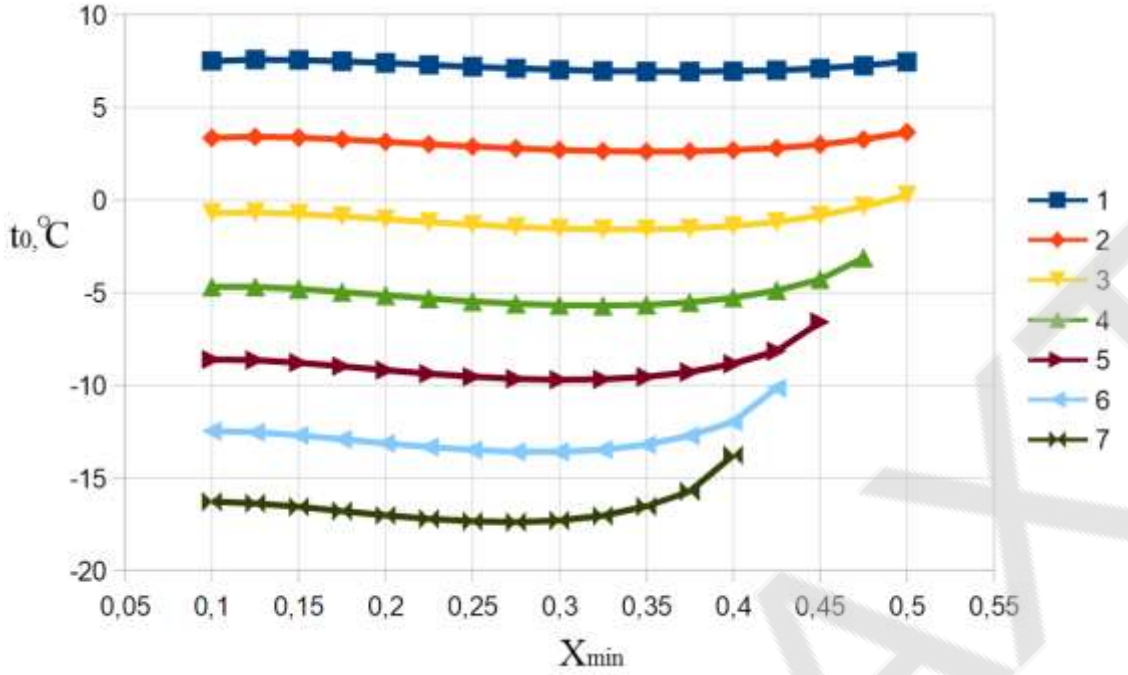

Figure 2.a

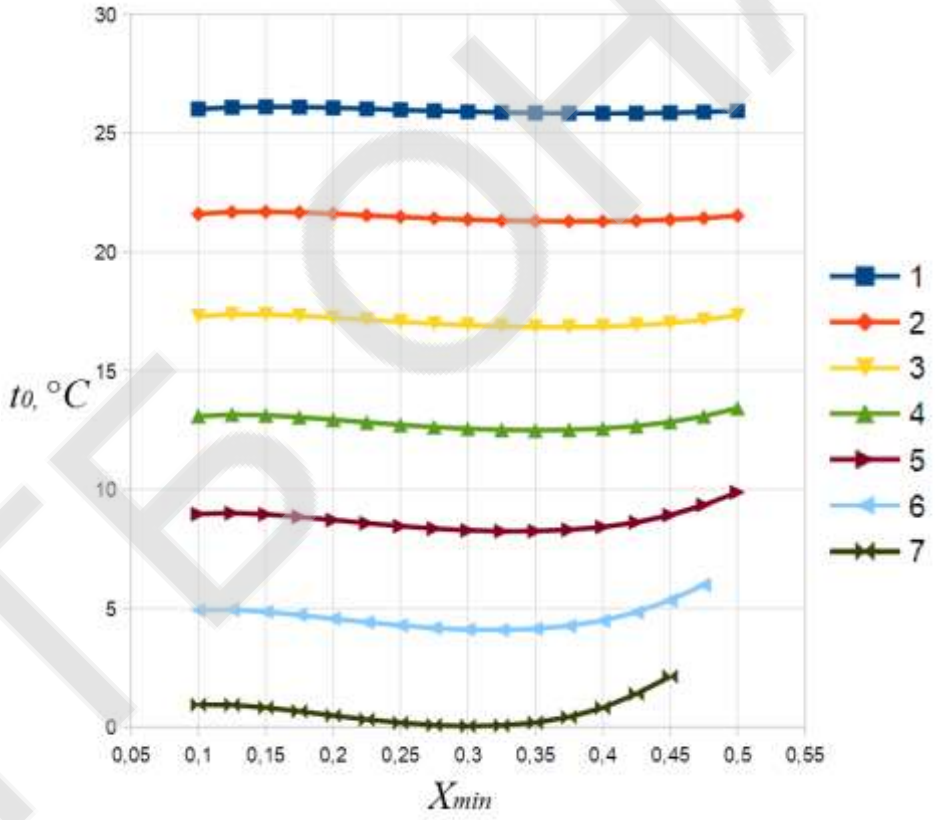

Figure 2.b

Figure 2. The minimal temperature in the cooling zone depending on the composition of WAS in the generation zone and the temperature of heating source at the fixed ambient temperature: a) t_w = 35°C; b) t_w = 45°C; 1, 2, 3, 4, 5, 6, 7 — the temperature of heating source, respectively 65, 70, 75, 80, 85, 90, 95 °C

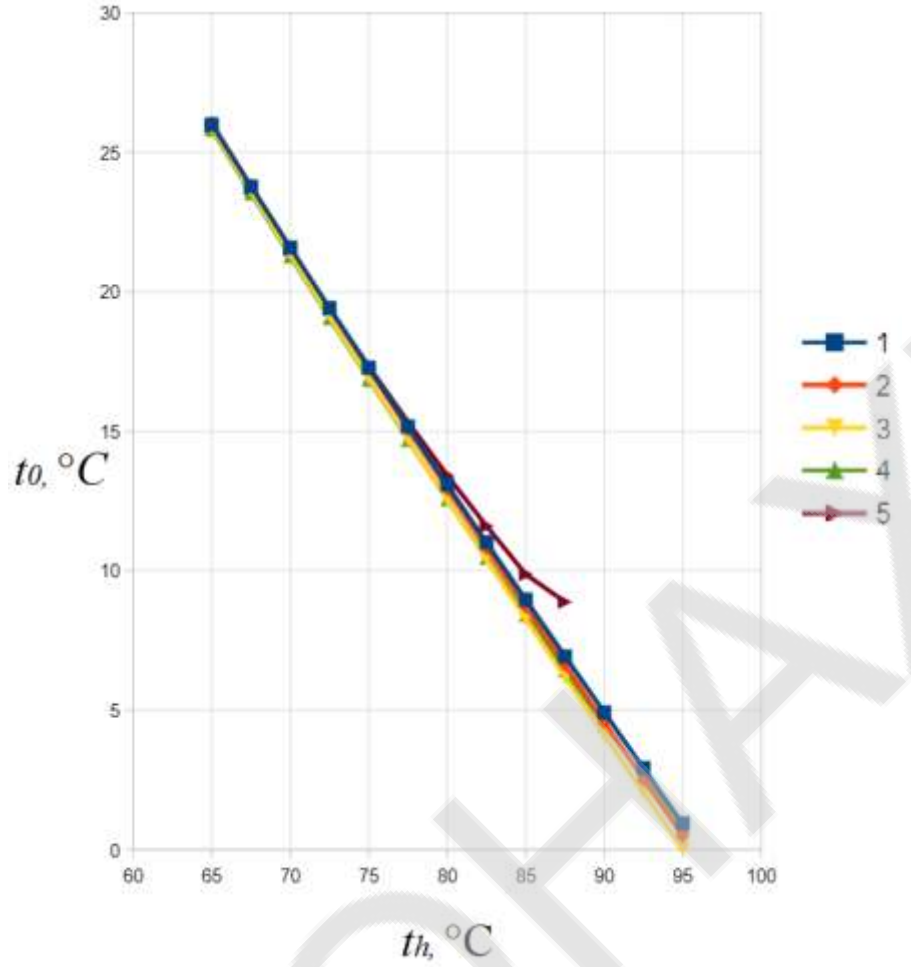

Figure 3. The minimal temperature in the cooling zone depending on the temperature of heating source and the composition of WAS in the generation zone at the fixed ambient temperature t_w = 35°C; 1, 2, 3, 4, 5 — the composition of WAS with minimal fraction of ammonia $X_{\min}$, respectively 0.1, 0.2, 0.3, 0.4, 0.5

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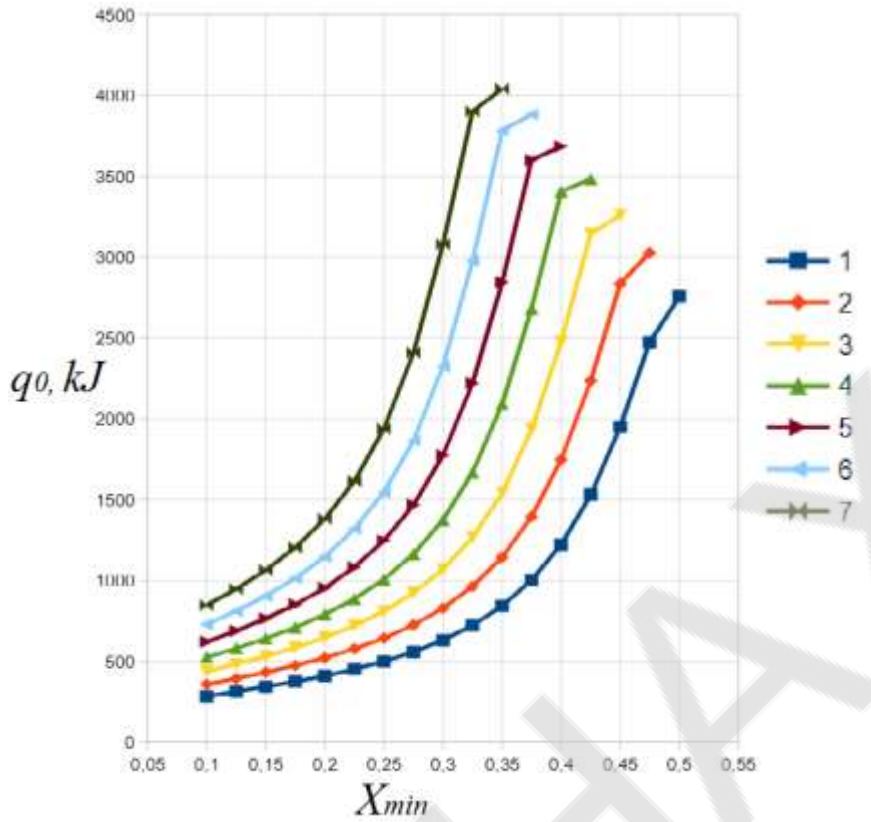

Figure 4.a

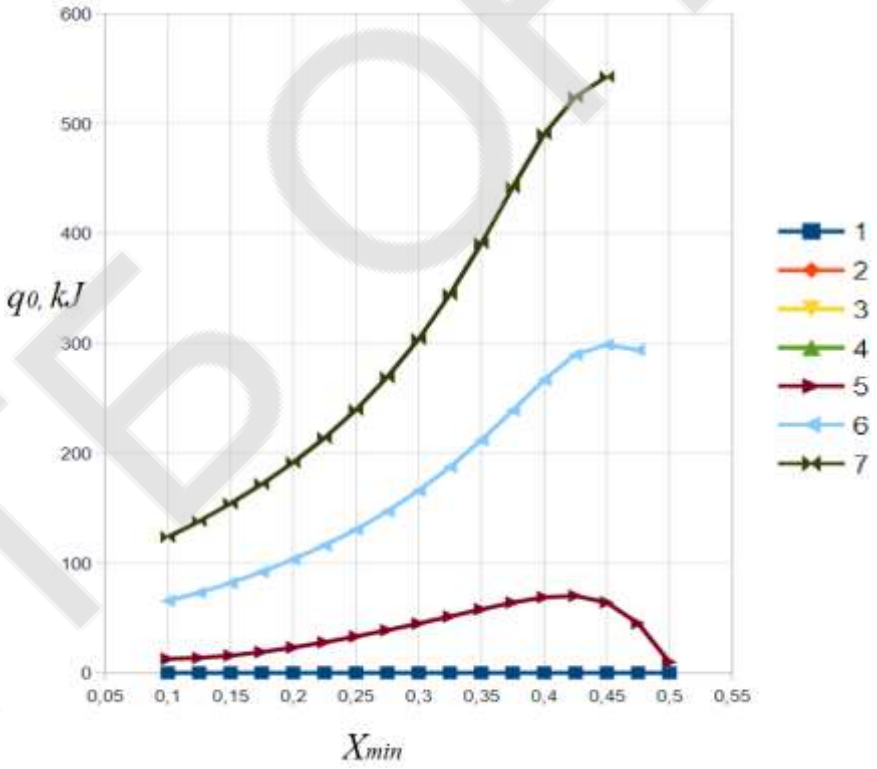

Figure 4.b

Figure 4. The specific cooling capacity of AWRU PO, depending on the mixture composition in the generation zone and the temperature of heating source, at the constant ambient temperature: a) t_w = 25°C; b) t_w = 45°C; 1, 2, 3, 4, 5, 6, 7 — the temperature of the heating source, respectively 65, 70, 75, 80, 85, 90, 95 °C

НТБ ОНАХТ

4. CONCLUSIONS

1. By increasing the temperature of heating source, the proportion of ammonia in the G-A zone is reduced, allowing to obtain higher potential capacity of absorption process during the cooling phase, i.e. to increase the specific cooling capacity of AWRU PO and the performance by water extraction from the air. Since the temperature rise of the heating source from 65°C to 95°C, minimal temperature in the cooling area decreases from 7°C to minus 17°C.

2. When the ambient air temperature increases, the specific cooling capacity of AWRU PO decreases, and this tendency is especially noticeable at higher ammonia fraction in the generation area.

3. The performed estimation of specific cooling capacity of the AWRU PO has shown that it increases along with the temperature of heating source, and at lower ambient air temperatures, this trend is more obvious.

4. At low ambient air temperature, the maximal values of specific cooling capacity of the AWRU PO can be obtained, by increasing the amount of ammonia in the generation area.

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НТБ ОНАХТ

DETERMINATION OF RATIONAL GEOMETRICAL RELATIONS OF SINGLE-PHASE ELECTROMAGNETIC SYSTEMS WITH RECTANGULAR CROSS SECTIONS OF RODS

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Abstract*. Determination and comparison of TLI variants of traditional ISD with a rod EMS having a rectangular section of the rods and different methods for making the magnetic circuit.*

The numerical comparison of the TLI variants of ST electromagnetic systems with twisted and charged magnetic circuits, on the basis of the principle of electromagnetic equivalence and the development of design mathematical models of transformers is carried out.

The analysis is carried out at different voltage classes K_f = 0.2 ... 0.3, ratios of specific active materials (coil copper and ETS) $\gamma_o/\gamma_c = 8{,}9/7{,}65$, as well as their values in the range C_o / C_c = 3,0 ... 5,5.

Key words*: single-phase transformer and reactor, twisted and charged magnet conductor, mass indexes, optimization, controlled variables.*

1. INTRODUCTION

For more than 100 years, the designs of inductive static devices (ISD) electromagnetic systems (EMS) of small and medium power have practically not changed. All single-phase transformers (ST) and single-phase reactors (SR) of the specified power have rectangular "traditional" forming contours (FK), which are manufactured in different ways. ISD magnetic leads are made of electrotechnical steel (ETS) by charging, winding or bending of strips [1-7].

In connection with the mass release of ST and SR of small and medium power, both with the charged and with the twisted magnet, the question arises of their rational choice based on the numerical comparative analysis of technical level indicators (TLI) results.

The goal of the work. Determination and comparison of TLI variants of traditional ISD with a rod EMS having a rectangular section of the rods and a different methods for making the magnetic circuit.

2. PREVIOUS STUDIES OF SINGLE-PHASE ROD TRANSFORMERS ANALYSIS

The introduction shows the need to develop an optimal benchmarking method for selecting ISD based on their own characteristics. According to the results of the survey, in [12, 13] the problem of comparative analysis of EMS was considered, but general recommendations for the relations of the geometric dimensions of the magnetic core and graphic dependences were determined.

In these papers [10-12], according to the optimization criterion, a minimum of one of the specific TLI was taken - the mass, volume or value of the EMS per unit of power of the ISD. The applied dimensionless geometric controlled variables (CV) *l, m, n* are the ratios, respectively, of the rectangular section of the rod *b*, the height *h* and the width *c* of the winding window to the section of the rod width *a*:

$$l = b/a;\ m = h/a;\ n = c/a. \quad (1)$$

On the basis of equations (1) we obtain practical, analytical, geometric dependences for choosing the optimal geometric relations for the above criteria for EMS structures.

According to [12, 13], the methods of calculating one-and three-phase transformers with rectangular cross sections of the cores of the magnetic circuits contain inaccuracies and errors, and there are no methods that allow the evaluation of the technical parameters of the ISD at the stage of the choice of the principal structure, that is, the methods of structural synthesis of these devices. It is shown the possibility of optimizing transformers with the use of common target functions (TF) and dimensionless (relative) CV (1) is proposed in [10]. It is determined that for all EMS structures with rectangular generating contours, the optimal ratio of the sides of the cross-section of the rod is close to two, and the ratio of the sides of the window is more than two. However, numerical results of the optimization comparison of single-phase electromagnetic loading (EML) of variants in [13], as in [11, 12], are absent.

The question of determining the optimal geometric ratios of traditional single-phase EMS is also considered in [8], where the TF and graphic dependences of the determination of optimal geometric relations of traditional EMS are presented. Similar analogous (1) relative geometric CV are used. For all traditional EMS structures, the ranges of optimal geometric ratios of main dimensions of the magnetic conductors.are obtained. However, there is no analytical comparison (the meaning and difference of the technical level indicators) of the EMS variants in [8], as in [10-13].

2.1 Method of electromagnetic systems comparative analysis

The determination and comparison of the TLI of the EMS variants is possible on the basis of the principle of electromagnetic equivalence, as well as in the design of the design mathematical models (MM) with the private and integral optimization criteria containing universal (identical for each construction) relative CV [2,3] . Such a position corresponds to the MM method with integral functions containing optimization components with universal geometric and electromagnetic variables [6].

$$F_{kii} = \mathrm{K}_{\mathrm{tii}} \left(\sqrt[4]{\mathrm{P}_{\mathrm{sd}}}\right)^3 \cdot \mathrm{P}^*_{kii}, \quad (2)$$

where P_{sd} – index of source data and EML; $\mathrm{K}_{\mathrm{tii}}$ – component of specific indicators of used materials K ≥ 3 of TF – private optimization criteria; P^*_{kii} – a dimensionless optimization component that characterizes each of the *i*-CV, the main of which are the functions of the mass P_{1ii}, the cost P_{2ii} and the loss of the active power P_{3ii} of the ii version of the EMS.

Extremes P*kii of dimensionless components of the TF (2) are TLI ISD. Each of the P_{kii}* depends on the form of filling form the winding window with the conductive material of windings coils (voltage class) K_f and two identical and acceptable for any of the available and possible versions of the EMS CV - the ratio a_m of the outer diameter D_{1ii} and the internal diameter D_{2ii} of the calculated circles of the magnetic circuit for each *ii* EMS variant, the ratios λ_0 of height h_{0ii} and the width b_{0ii} of the winding window and the main angle of the rod α_c [5, 6]:

$$P_{1(2)ii} = f\left(K_f, a_m, \lambda_0, \alpha_c\right); \quad (3)$$

$$a_m = D_{1ii} / D_{2ii}; \quad (4)$$

$$\lambda_0 = h_{0ii} / b_{0ii}, \quad (5)$$

where K_f – the filling the winding window coefficient, taking into account the voltage class is used in the part of EMS; a_m and λ_0 – geometric relative CV; α_c – the main angle of the rod;

The component of K_{tii} of the target function (2) includes, depending on the optimization criterion, the ratio of the specific densities of materials (coil copper and ETS) (kg / m3) and their values C_o/C_c = 3,0 ... 5,5, the coefficients of stacking K_c = 1 , 13 and an excitation K_e = 1.15 turns of coils at impregnation [2], contour coefficient, $K_k = 1$. The calculations are performed at different K_f = 0,2 ... 0,3 and the ratios of the specific values of the active materials in the range $C_c/C_o = 3{,}0\ldots5{,}5$.

In modern ST and SR used anisotropic ETS grades 3406-3409 with $K_{зс} = 0{,}96 - 0{,}97$ at the thickness of the tape (roll, plate) $\delta_c = 0{,}27 - 0{,}35$ mm. At f1 = 50 Hz, in ranges $S_н = 0{,}3\text{-}1\,кВ\cdot А$ and $S_н = 1\text{-}2{,}5\,кВ\cdot А$ respectively $J_0 = 2{,}4\text{-}1{,}7\,А/мм^2$ and $J_0 = 1{,}7\text{-}2{,}4\,А/мм^2$ [13].

In the comparative analysis of the considered variants in accordance with the principle of electromagnetic equivalence [5], respectively, the same materials used, the density of currents of windings, the mean values of the magnetic field induction amplitudes in the rods and yards, and also the execution and methods of cooling the ISD are taken.

3. DEVELOPMENT OF SINGLE-PHASE TRANSFORMERS MATHEMATICAL MODELS

3.1 Mathematical models development of mass and cost of a basic electromagnetic system with a twisted magnetic circuit

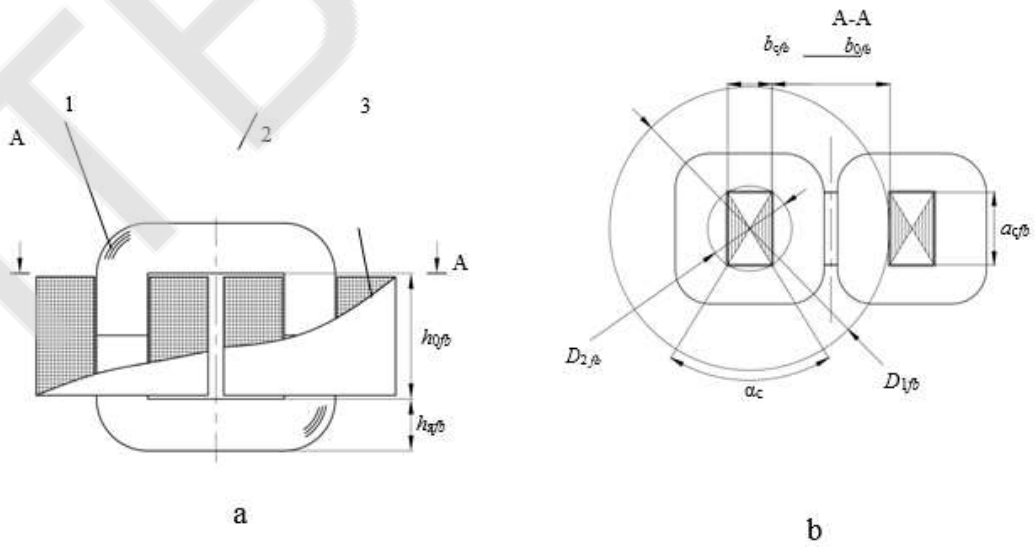

Fig. 1 - Constructive scheme (a) and design diameters (b) of planar EMS with a rectangular winding window and sections of the rods of the twisted magnet circuit:
1 – rod; 2 – yoke; 3 – winding.

The first controlled change of the TF of basic rod EMS with rectangular FC MM (Fig. 1)

$$a_m = D_{1fb} / D_{2fb}, \quad (6)$$

where D_{1fb}, D_{2fb},, – outer diameter and internal diameter of calculated circles of the magnetic circuit, respectively.

Second controlled change in the MM EMS (Fig. 1)

$$\lambda_0 = h_{0fb} / b_{0fb}, \quad (7)$$

where h_{0fb} and b_{0fb} – winding window height and width of the base magnetic EMS.

The values of the sides of the a_{cfb} and b_{cfb} of the rod section (Fig. 1) are determined by D_{2fb}, and the center angle of the rod α_c:

$$a_{cfb} = D_{2fb} \sin(\alpha_c / 2); \quad (8)$$

$$b_{cfb} = D_{2fb} \cos(\alpha_c / 2). \quad (9)$$

The area of the ETS of the magnetic circuit rods of the EMs (Fig. 1), is determined taking into account (8) and (9)

$$S_{cfb} = K_{зс} a_{cfb} b_{cfb} = K_{зс} D_{2fb}^2 \sin(\alpha_c) / 2. \quad (10)$$

The width of winding windows b_{0fb} (Fig. 1) depends on D_{2fb}, a_m and (9)

$$b_{0fb} = D_{2fb} / 2 - b_{cfb} / 2 = D_{2fb} / 2 (a_m - \sin(\alpha_c / 2)). \quad (11)$$

The ETS mass of the EMs magnetic circuit is determined using (7), (8) and (9)

$$m_{mfb} = K_{зс} \gamma_c \left(2 h_{0fb} S_{cfb} + 2 b_{0fb} S_{cfb} + \pi S_{cfb} b_{cfb}\right) =$$

$$= 0{,}5 K_{зс} \gamma_c D_{2fb}^3 \sin\alpha_c \left((a_м - \sin(\alpha_c / 2))(\lambda_0 + 1) + \pi \sin(\alpha_c / 2)\right). \quad (12)$$

On the basis of (10) and (11) we obtain the basic equations of the EMS variants (Fig. 1) and the connections S_{cfb} and b_{0fb}

$$S_{cfb} = P_{sd} / \left(S_{0fb} K_f\right) = P_{sd} / \left(b_{0fb}^2 \lambda_{0fb} K_f\right) = 4 P_{sd} / \left(D_{2fb}^2 \lambda_{0fb} (\sin(\alpha_c / 2))^2 K_f\right), \quad (13)$$

where S_{0fb} – area of the winding window EMS (Fig.1),

$$S_{0fb} = h_{0fb} b_{0fb} K_f = b_{0fb}^2 \lambda_{0fb} K_f, \quad (14)$$

From equation (10) and (13) follows:

$$K_{зс} D_{2fb}^2 \sin(\alpha_c) / 2 = 4 P_{sd} / D_{2fb}^2 \lambda_{0fb} (a_m - \sin(\alpha_c / 2))^2 K_f;$$

$$D_{2fb} = \sqrt[4]{8 P_{sd} / \left(K_f K_{зс} \lambda_0 \sin(\alpha_c)(a_m - \sin(\alpha_c / 2))^2\right)}. \quad (15)$$

After substituting equations (15) into (12), the expression for finding the mass of the ETS of the magnetic circuit EMC (Fig. 1):

$$m_{mfb} = 0{,}5 K_{зс} \gamma_c \sin\alpha_c \left(\sqrt[4]{8 P_{sd} / \left(K_f K_{зс} \lambda_0 \sin(\alpha_c)(a_m - \sin(\alpha_c / 2))^2\right)}\right)^3 \times$$

$$\times \left((a_m - \sin(\alpha_c / 2))(\lambda_0 + 1) + \pi \sin(\alpha_c / 2)\right) = \gamma_c \left(\sqrt[4]{P_{sd}}\right)^3 P^*_{mfb}. \quad (16)$$

where P^*_{mfb} – relative mass index of the magnetic circuit (Fig. 1),

$$P^{*}_{mfb} = 0{,}5K_{зс}\sin\alpha_c\left(\sqrt[4]{8P_{sd}/\left(K_f K_{зс}\lambda_0 \sin(\alpha_c)(a_m - \sin(\alpha_c/2))^2\right)}\right)^3 \times$$
$$\times\left((a_m - \sin(\alpha_c/2))(\lambda_0 + 1) + \pi\sin(\alpha_c/2)\right). \quad (17)$$

The average length of the coil rope for the rod EMS (Fig. 1) is determined on the basis of (8), (9) and (11):

$$l_{wfb} = 2\left(a_{cfb} + b_{cfb}\right) + \pi b_{0\,fb}/2 = D_{2\,fb}\left(\sin(\alpha_c/2) + \cos(\alpha_c/2) + \frac{\pi}{8}(a_m - \sin(\alpha_c/2))\right). \quad (18)$$

Substituting (11) in (18) we obtain the mass equation of copper winding for EMS:

$$m_{ofb} = \gamma_o K_в K_y K_f D^3_{2\,fb}\lambda_0 0{,}5(a_m - \sin(\alpha_c/2))^2\left((\sin(\alpha_c/2) + \cos(\alpha_c/2))\right) +$$
$$+ \pi(a_m - \sin(\alpha_c/2))/8 \quad (19)$$

Substitution of equation (15) transforms (19):

$$m_{ofb} = \gamma_o K_в K_y K_f\left(\sqrt[4]{8P_{sd}/\left(K_f K_{зс}\lambda_0 \sin(\alpha_c)(a_m - \sin(\alpha_c/2))^2\right)}\right)^3 0{,}5\lambda_0(a_m - \sin(\alpha_c/2))^2 \times$$
$$\times\left((\sin(\alpha_c/2) + \cos(\alpha_c/2))\right) + \pi(a_m - \sin(\alpha_c/2))/8 = \gamma_o\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{ofb}, \quad (20)$$

where P^{*}_{ofb} - relative mass index of active materials of the EMS winding (Fig. 1).

$$P^{*}_{ofb} = \gamma_o K_в K_y K_f\left(\sqrt[4]{8/\left(K_f K_{зс}\lambda_0 \sin(\alpha_c)(a_m - \sin(\alpha_c/2))^2\right)}\right)^3 0{,}5\lambda_0(a_m - \sin(\alpha_c/2))^2 \times$$
$$\times\left((\sin(\alpha_c/2) + \cos(\alpha_c/2))\right) + \frac{\pi}{8}(a_m - \sin(\alpha_c/2)). \quad (21)$$

The weight m_{afb} and cost C_{afb} of EMS active materials (Fig. 1) are determined on the basis of (16) and (20):

$$m_{afb} = m_{mfb} + m_{ofb} = \gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{mfb} + \gamma_o\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{ofb} = \gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{1\,fb}; \quad (22)$$

$$C_{afb} = C_{mfb} + C_{ofb} = \gamma_c C_c\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{mfb} + \gamma_o C_o\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{ofb} = \gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^{*}_{2\,fb} \quad (23)$$

where $P^{*}_{1\,fb}$ and $P^{*}_{2\,fb}$ relative indicators of mass and cost of planar (Fig. 1), with rectangular rods of twisted magnetic circuits:

$$P^{*}_{1\,fb} = \left(\sqrt[4]{8/\left(K_f K_{зс}\lambda_0 \sin(\alpha_c)((a_m - \sin(\alpha_c/2)))^2\right)}\right)^3 \times$$
$$\times\left(K_{зс}0{,}5\sin\alpha(a_m - \sin(\alpha_c/2))(\lambda_0 + 1) + \pi\sin(\alpha_c/2) + (\gamma_o/\gamma_c)K_в K_y K_f \times\right.$$
$$\left.\times 0{,}5\lambda_0(a_m - \sin(\alpha_c/2))^2(\sin(\alpha_c/2) + \cos(\alpha_c/2)) + \pi(a_m - \sin(\alpha_c/2))/8\right); \quad (24)$$

Extremes (minima) $P^{*}_{1\,fb}$ of indicators (24) obtained for three values K_f in Annex 1 (Table 1).

$$P^{*}_{2\,fb} = \left(\sqrt[4]{8/\left(K_f K_{зс} \lambda_0 \sin(\alpha_c)((a_m - \sin(\alpha_c/2)))^2\right)} \right)^3 \times$$

$$\times \left(K_{зс} 0{,}5 \sin\alpha_c (a_m - \sin(\alpha_c/2))(\lambda_0 + 1) + \pi \sin(\alpha_c/2) + (C_o \gamma_o / C_c \gamma_c) K_в K_y K_f \times \right.$$

$$\left. \times 0{,}5 (a_m - \sin(\alpha_c/2))^2 (\sin(\alpha_c/2) + \cos(\alpha_c/2)) + \pi (a_m - \sin(\alpha_c/2))/8 \right); \quad (25)$$

Extremes (minima) $P^{*}_{2\,fb}$ of indicators (25) obtained for three values K_f in Annex 1 (Table 2).

3.2 Mathematical models development of mass and cost of a rod electromagnetic system with a charged magnet wire

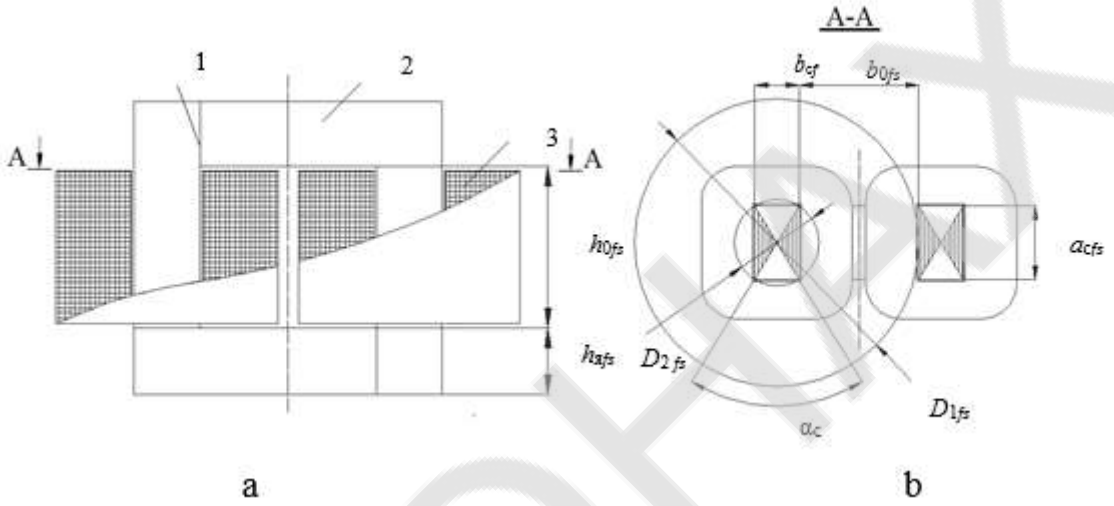

Fig. 2 - Constructive scheme (a) and design diameters (b) planar EMS with a rectangular winding window and sections of the magnetic core: 1 – rod; 2 – yoke; 3 – winding

First CV TF MM of base rod EMS with rectangular CK, are determined accordingly (4)

$$a_m = D_{1sf} / D_{2sf}\,, \quad (49)$$

where D_{1sf}, D_{2sf} – outer diameter and internal diameter of calculated circles of the magnetic circuit, respectively;

Second CV TF EMS determined by the (5)

$$\lambda_0 = h_{0sf} / b_{0sf}\,, \quad (50)$$

where h_{0sf}, and b_{0sf} – winding window height and width of the base magnetic EMS..

The values of the sides of the a_{csf} and b_{csf} of the rod section (Fig. 1) are determined by D_{2sf}, and the center angle of the rod α_c:

$$a_{c\,sf} = D_{2sf} \cos(\alpha_c/2); \quad (51)$$

$$b_{c\,sf} = D_{2sf} \sin(\alpha_c/2). \quad (52)$$

The area of the ETS magnetic circuit rods EMS, determined by taking into account the size of the sides a_{csf} and b_{csf} the cross-section of the rod

$$S_{c\,sf} = K_{зс} a_{csf} b_{c\,sf} = K_{зс} D_{2sf}{}^2 \sin(\alpha_c)/2\,. \quad (53)$$

The width of each of the winding windows b_{0sf}, depends on D_{2sf}, a_m and the side of the rod section b_{csf}

$$b_{0sf} = D_{2sf}/2 - b_{csf}/2 = D_{2sf}/2\left(a_m - \sin(\alpha_c/2)\right). \quad (54)$$

The mass of the ETS of the magnetic circuit of the EMS is determined using the second CV MM EMS, and the values of the sides a_{csf} and b_{csf} are the cross-section of the rod

$$m_{msf} = K_{зс}\gamma_c D_{2sf}^3 \sin\alpha\left[\left(a_m - \sin(\alpha_c/2)\right)\lambda_o \cdot 0{,}5 + \left(a_m - \sin(\alpha_c/2)\right)\cdot 0{,}5 + 2\sin(\alpha_c/2)\right]. \quad (55)$$

Based on ETS area of the magnetic circuit rods S_{csf} and the widths of each winding window b_{0sf} we obtain the basic equations of the EMS variants and the connections S_{csf} and b_{0sf}

$$S_{csf} = P_{sd}/\left(S_{0sf} K_f\right) = P_{sd}/\left(b_{0sf}^2 \lambda_o K_f\right) = 4P_{sd}/\left(D_{2sf}^2 \lambda_0 \left(\sin(\alpha_c/2)\right)^2 K_f\right), \quad (56)$$

where S_{0sf} – area of the winding window EMS

$$S_{0sf} = h_{0sf} b_{0sf} K_f = b_{0sf}^2 \lambda_0 K_f, \quad (57)$$

From the equality of equations (53) and (58) follows:

$$K_{зс} D_{2sf}^2 \sin\alpha_c/2 = 4P_{sd}/D_{2fb}^2 \lambda_0 \left(a_m - \sin(\alpha_c/2)\right)^2 K_f;$$

$$D_{2sf} = \sqrt[4]{8P_{sd}/\left(K_f K_{зс} \lambda_0 \sin(\alpha_c)\left(a_m - \sin(\alpha_c/2)\right)^2\right)} \quad (58)$$

After substituting equations (58) into (55), the expression of finding the mass of the ETS magnetic circuit EMS will have the form

$$m_{msf} = K_{зс}\gamma_c \left(\sqrt[4]{8 \cdot P_{sd}/\left(K_f K_{зс} \lambda_o \sin(\alpha_c)\left(a_m - \sin(\alpha_c/2)\right)^2\right)}\right)^3 \times$$

$$\times \sin\alpha\left[\left(a_m - \sin(\alpha_c/2)\right)\lambda_o \cdot 0{,}5 + \left(a_m - \sin(\alpha_c/2)\right)\cdot 0{,}5 + 2\sin(\alpha_c/2)\right] = \gamma_c \left(\sqrt[4]{P_{sd}}\right)^3 \cdot P_{msf}^*, \quad (59)$$

where P_{msf}^* – relative mass index of the magnetic circuit

$$P_{msf}^* = K_{зс} \sin\alpha_c \left(\sqrt[4]{8P_{sd}/\left(K_f K_{зс} \lambda_0 \sin(\alpha_c)\left(a_m - \sin\alpha_c/2\right)^2\right)}\right)^3 \times$$

$$\times \sin\alpha\left[\left(a_m - \sin(\alpha_c/2)\right)\lambda_o \cdot 0{,}5 + \left(a_m - \sin(\alpha_c/2)\right)\cdot 0{,}5 + 2\sin(\alpha_c/2)\right]. \quad (60)$$

The average length of the coil rope for the rod EMS is determined on the basis of (51), (52) and (54):

$$l_{sf} = D_{2sf}\left(2\cos(\alpha_c/2) + 2\sin(\alpha_c/2) + (\pi/8)\left(a_m - \sin(\alpha_c/2)\right)\right). \quad (61)$$

Substituting (54) into (61) we obtain the mass equation of copper winding for EMS:

$$m_{osf} = \gamma_o K_в K_y K_f \lambda_o D_{2sf}^3 \left[0{,}25\left(a_m - \sin(\alpha_c/2)\right)^2 \times \right.$$

$$\left.\left[2\cos(\alpha_c/2) + 2\sin(\alpha_c/2) + \pi/8\left(a_m - \sin(\alpha_c/2)\right)\right]\right] \quad (62)$$

Substitution (58) transforms (62)

$$m_{osf} = \gamma_o K_в K_y K_f \lambda_o \left(\sqrt[4]{8P_{sd}/\left(K_f K_{зс} \lambda_o \sin\alpha_c \left(a_m - \sin(\alpha_c/2)\right)^2\right)}\right)^3 \cdot \left[0{,}25\left(a_m - \sin(\alpha_c/2)\right)^2 \times\right.$$

$$\times\left[2\cos(\alpha_c/2)+2\sin(\alpha_c/2)+(\pi/8)\left(a_m-\sin(\alpha_c/2)\right)\right]=\gamma_o\left(\sqrt[4]{P_{sd}}\right)^3\cdot P^*_{osf}, \quad (63)$$

where P^*_{osf} – relative mass index of active materials of the EMC winding:

$$P^*_{osf}=\gamma_o K_в K_y K_f \lambda_o\left(\sqrt[4]{8P_{sd}/\left(K_f K_{зс}\lambda_o \sin\alpha_c\left(a_m-\sin(\alpha_c/2)\right)^2\right)}\right)^3\times$$

$$\times\left[0{,}25\left(a_m-\sin(\alpha_c/2)\right)^2\left[2\cos(\alpha_c/2)+2\sin(\alpha_c/2)+\pi/8\left(a_m-\sin(\alpha_c/2)\right)\right]\right]. \quad (64)$$

Mass m_{asf} and cost C_{asf} of active EMS materials are determined on the basis of (59) and (63) equations:

$$m_{asf}=m_{msf}+m_{osf}=\gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{msf}+\gamma_o\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{osf}=\gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{1\,sf}, \quad (65)$$

$$C_{asf}=C_{msf}+C_{osf}=\gamma_c C_{csf}\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{msf}+\gamma_o C_{osf}\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{osf}=\gamma_c\left(\sqrt[4]{P_{sd}}\right)^3 P^*_{2sf}, \quad (66)$$

where $P^*_{1\,sf}$ and $P^*_{2\,sf}$ relative indicators of mass and cost of planar, with rectangular cores of charged magnetic conduits:

$$P^*_{1\,sf}=\sqrt[4]{\frac{8}{\sin\alpha\cdot K_{зс}K_f\lambda_o\cdot\left(a_m-\sin(\alpha_c/2)\right)^2}}\cdot\left[K_{зс}\sin\alpha_c\left(\left(a_m-\sin(\alpha_c/2)\right)\cdot\lambda_o 0{,}5+\right.\right.$$

$$+\left(a_m-\sin(\alpha_c/2)\right)\cdot 0{,}5+2\sin(\alpha_c/2)\Big)+\left(\gamma_o/\gamma_c\right)K_f K_y K_в\lambda_o\cdot\left[0{,}25\left(a_m-\sin(\alpha_c/2)\right)^2\times\right.$$

$$\left.\left.\times\left[2\cos(\alpha_c/2)+2\sin(\alpha_c/2)+\pi/8\left(a_m-\sin(\alpha_c/2)\right)\right]\right]\right]; \quad (67)$$

Extremes (minima) Π^*_{1sf} of indicators (67) obtained for three values K_f in Annex 2 (Table 3).

$$P^*_{2sf}=\sqrt[4]{\frac{8}{\sin\alpha\cdot K_{зс}K_f\lambda_o\cdot\left(a_m-\sin(\alpha_c/2)\right)^2}}\cdot\left[K_{зс}\sin\alpha_c\left(\left(a_m-\sin(\alpha_c/2)\right)\cdot\lambda_o 0{,}5+\right.\right.$$

$$+\left(a_m-\sin(\alpha_c/2)\right)\cdot 0{,}5+2\sin(\alpha_c/2)\Big)+\left(C_{osf}\gamma_o/C_{osf}\gamma_c\right)K_f K_y K_в\lambda_o\cdot 0{,}25\left(a_m-\sin(\alpha_c/2)\right)^2\times$$

$$\left.\left.\times\left[2\cos(\alpha_c/2)+2\sin(\alpha_c/2)+\pi/8\left(a_m-\sin(\alpha_c/2)\right)\right]\right]\right]. \quad (68)$$

Extremes (minima) Π^*_{2sf} of indicators (68) obtained for three values K_f in Annex 2 (Table 4).

4. TECHNICAL LEVEL COMPARISON OF ELECTROMAGNETIC SYSTEMS VARIANTS OF SINGLE-PHASE TRANSFORMERS WITH TWISTED AND CHARGED MAGNET CIRCUIT

The results of electromagnetic systems comparative analysis are characterized by PTR comparison of transformers with twisted and charged magnetic circuits according to separate criteria of minimum masses and values. According to [16], a basic transformer with a rod EMC, which has a charged magnetic circuit, was selected in the baseline for comparing the TLI. The results of changes in these indicators are shown in Table. 5

Table 5 - Numerical values of the advantages of technical level indicators of single-phase electromagnetic systems with wired and charged magnetic circuits

Ratio of indicators P^*_{fb} / P^*_{fs}	The range of changes in relation values,%					
	Mass index	Cost Indicator				
		3,5	4	4,5	5	5,5
$K_f = 0,2$	-2,656 %	-3,569 %	-3,663 %	-3,742 %	-3,815 %	-3,877 %
$K_f = 0,25$	-2,822 %	-3,723 %	-3,813 %	-3,891 %	-3,959 %	-4,021 %
$K_f = 0,3$	-2,957 %	-3,846 %	-3,934 %	-4,008 %	-4,076 %	-4,134 %

Note * "-" Improvement of the TLI.

The results of calculations (Table 5) are graphically explained (Figures 3-6), which are given in Annex 3, and show a numerical comparison of the mass values in the EMS with wired and charged magnetic circuits. From Fig. 3-6 it follows that when the coefficient of filling the magnetic system with steel $K_{зс} = 0,97$ and the voltage class $K_{зо} = (0,2;0,25;0,3)$, respectively, there is a linear dependence of the change in the mass index, and the advantage is practically the same (2-3%) of the twisted EMS.

The comparison of the extremes of value TF of the specified transformers in the correlations ranges of ETS values and the wrapping material (copper), has a linear dependence of the improvement of the TLI of the twisted magnetic circuits, which is (3.6-4.1%).

5. CONCLUSION

1. An analysis of the features of manufacturing EMC with a rectangular section of the rods, having different methods of manufacturing is done.

2. The analysis of calculation-optimization methods of single-phase static EMS designing is carried out. It is determined that the method of MM with TF that has universal geometric and electromagnetic controlled variables is the best in terms of universality for the determination of the TLI, and in work adopted as a basic method.

3. Using the base method, the following comparison results are obtained:

– the mass index of the single-phase twisted EMS is improved relative to the core EMS with the charged magnetic core at (2.6 ... 2.96%);

– the value index of a single-phase twisted EMS is improved relative to the core EMC with the charged magnetic core at (3.6 ... 4.1%).

4. For the first time, ranges of numerical values of the comparison of the main PTR (mass and cost) of the proposed variants of the EMF were obtained.

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7. ANNEXES

Annex 1.

Results of calculations of values of controlled variables and indicators of mass and cost of a twisted shaft electromagnetic system with a rectangular section of the rods

Table 1

Mass index, r.u.	Coefficient of filling of the winding-up window, r.u.	Extreme values of controlled variables			The value of the mass index of EMS, r.u.
		a_m, r.u.	λ_0, r.u.	α_c, deg.	
$P^*_{1\,fb}$	0,2	2,232	2,087	0,876	21,986
	0,25	2,046	2,094	0,879	20,591
	0,3	1,909	2,099	0,880	19,561

Table 2

Cost index, r.u.	Coefficient of filling of the winding-up window, r.u.	ratio of winding copper and electrotechnical steel value, r.u.				
		3,5	4	4,5	5	5,5
$P^*_{2\,fb}$	0,2	40,521	43,499	46,349	49,091	51,741
	0,25	38,613	41,526	44,317	47,005	49,604
	0,3	37,204	40,069	43,817	45,464	48,026

Annex 2.

Results of calculations of controlled variables and mass and cost parameters values of planar rod electromagnetic system with a rectangular section of the cores of the charged magnetic circuit

Table 3

Mass index, r.u.	Coefficient of filling of the winding-up window, r.u.	Extreme values of controlled variables			The value of the mass index of EMS, r.u.
		a_m, r.u.	λ_0, r.u.	α_c, deg.	
P^*_{1sf}	0,2	2,204	2,205	0,819	22,586
	0,25	2,024	2,220	0,824	21,189
	0,3	1,891	2,233	0,829	20,157

Table 4

Cost index, r.u.	Coefficient of filling of the winding-up window, r.u.	ratio of winding copper and electrotechnical steel value, r.u.				
		3,5	4	4,5	5	5,5
P^*_{2sf}	0,2	42,021	45,153	48,151	51,038	53,828
	0,25	40,106	43,172	46,111	48,943	51,682
	0,3	38,692	41,710	44,605	47,396	50,097

Annex 3.

Graphical explanation of the technical level indicators of a rod electromagnetic system with a twisted and charged magnetic core numerical comparative analysis

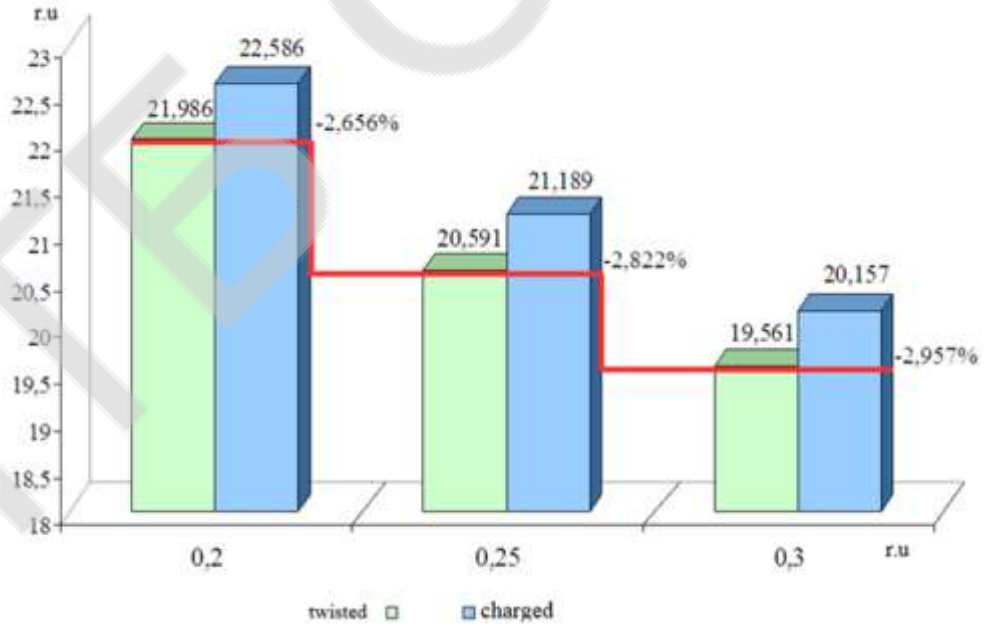

Fig. 3 Diagrams of comparison of technical level (masses) of single-phase electromagnetic systems with wired and charged magnetic circuits

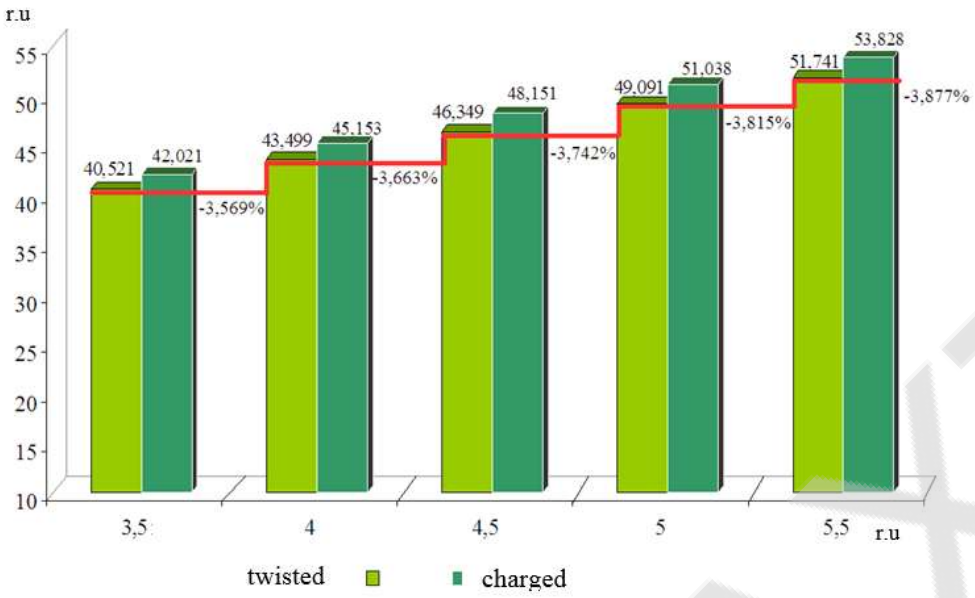

Fig. 4 Diagram of comparison of the technical level (cost) of single-phase electromagnetic systems at K_f = 0,2 r.u.

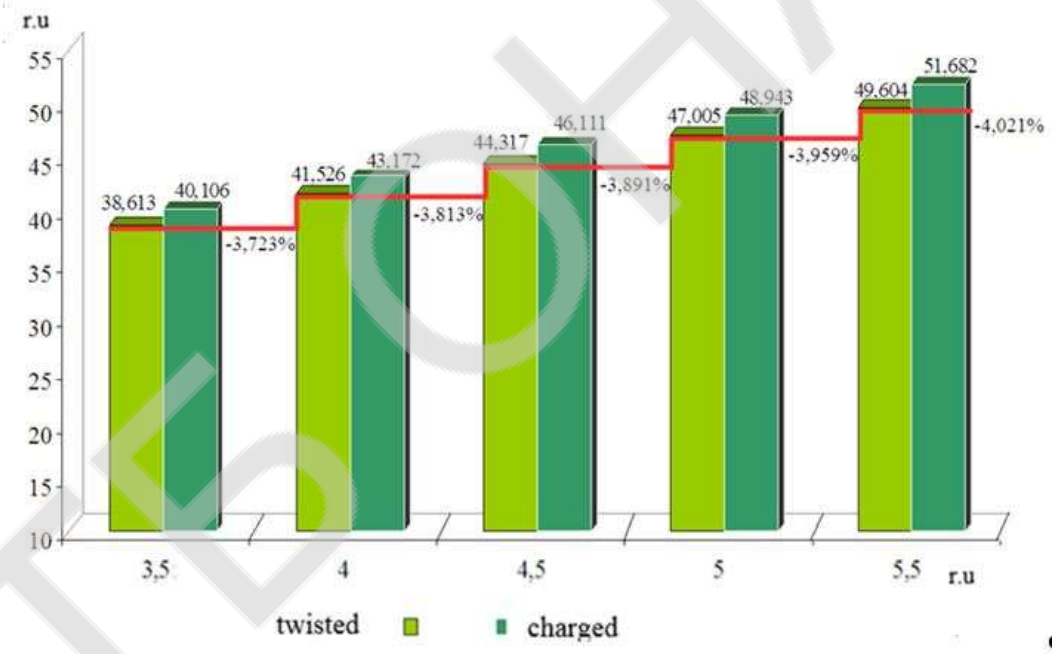

Fig. 5 Diagram of comparison of the technical level (cost) of single-phase electromagnetic systems at K_f = 0,25 r.u.

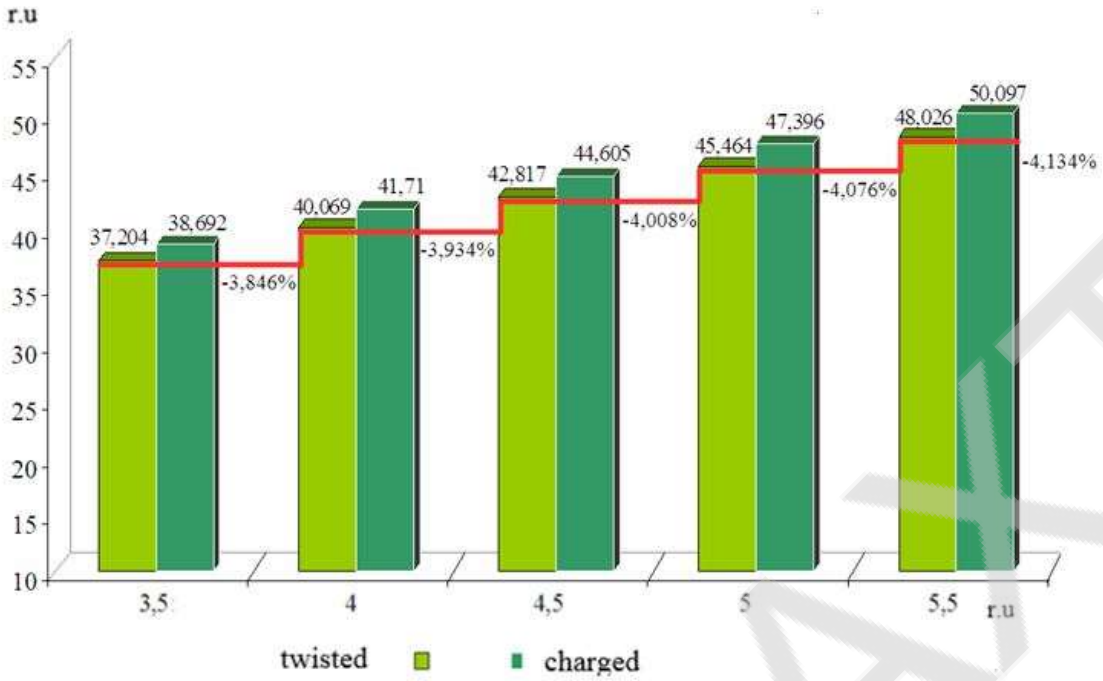

Fig. 6 Diagram of comparison of the technical level (cost) of single-phase electromagnetic systems at K_f = 0,3 r.u.

НТБ ОНАХТ

INVESTIGATION OF LED LIGHT SOURCES AND THEIR INFLUENCE ON THE POWER SUPPLY NETWORK

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Abstract*. This article presents the results of research of the operation of led strips and spotlights, they are a nonlinear load with harmonic components. High harmonics that occur when using led light sources lead to a significant increase in energy transfer losses, a decrease in the power factor, and can cause failures in the operation of start-protective equipment. When selecting start-protective devices for power lines, it is necessary to enter correction coefficients that take into account the non-linear nature of led technology.*

Keywords: *LED light sources, strip, spotlight, voltage, current, power factors.*

Introduction

The share of electricity consumption for electric lighting in total electricity consumption varies from country to country and ranges from 5 to 15% for the developed countries and up to 80% or more for the developing countries. In 2018 electricity consumption in the Republic of Belarus amounted to 38.8 billion kWh, with electric lighting accounting for about 19% of this amount [1]. In recent years many developed countries have begun to replace incandescent lamps and gas-discharge light sources to more modern energy-saving light sources. In Russia the rejection of incandescent lamps with a capacity of more than 100 W allowed to save 6030 MW, which is the capacity of the Sayano-Shushenskaya HES [2].

The most interesting and promising of the existing sources of optical radiation, are led light sources created on semiconductor devices with a p-n junction that emits incoherent light when an electric current is passed through it in the forward direction. They are a real alternative to incandescent and gas-discharge lamps that are widely used in Belarus at the present time.

The parameters of LEDs depend significantly on the amount of voltage applied to them and the current flowing through them. The most widely used models of LEDs are designed for a current of 10 to 20 mA. With an increase in the voltage applied to the led and the current flowing through it, the light output of the radiating p-n junction increases. Thus, by changing the applied voltage, you can adjust the amount of light flux of the source.

A number of factors contribute to the widespread use of led light sources, including:

- low power consumption, which is several times lower than that of fluorescent lamps, and almost by an order less than that of incandescent lamps;

- high luminous efficiency, which is up to 200 LM / W, which is higher than the luminous efficiency of incandescent lamps 6 ... 12 times, fluorescent lamps 1.5...2 times;

- long service life, which can reach some LEDs up to 30,000 hours;
- high resistance to mechanical damage;
- the absence of high electrical voltages and temperatures of all elements of the lamp;
- sufficiently high environmental safety and the absence of particularly dangerous compounds, such as mercury.

At the same time led sources have a fairly high cost, incompatibility with the existing supply voltage and special requirements for power sources, a gradual decrease in lighting characteristics with an increase in service life, a limited angle of light flux, features associated with the colour spectrum and light pulsation.

One of the most important features of led sources is that they are non-linear elements of the electrical network. The consequence of this is the appearance of harmonic components in the spectrum of electrical quantities of the supply network. Increasing the use of led sources in consideration of the above advantages, leads to a noticeable increase in the distortion of the harmonic signal of the supply network and the deterioration of the quality of electrical energy, and this affects the operation of electric motors, transformers and thermal electrical equipment.

The number and magnitude of the higher harmonics of led sources will largely be determined by the fact that many manufacturers, seeking to reduce the cost of their products, reducing its quality.

As a result, led light sources can be a source of higher harmonics, which will lead to exceeding the permissible standard values of current and voltage. As previously conducted studies have shown, led and gas-discharge light sources can have quite significant values of higher harmonics of the third order, as well as in some cases of the 9th and 15th order [3].

The return of mains harmonic components of voltage and current led light sources leads to a number of negative consequences they are measurement error of electricity, additional power losses in networks and transformers, excessive strain on wire and insulation of the mains, the problems of compensation of the reactive component of electrical power, interference for the transmission of electromagnetic signals.

Non-linear characteristics of led devices are not taken into account in the existing methods of calculations of electric networks and the choice of start protective devices, although the value of such current deviations can be up to 63%, and additional power losses can be up to 30% [1, 4-8]. This is confirmed by the authors experience during the study of the use of led light sources on various objects.

Today automatic switches with an electromagnetic release are used, in order as a rule, to protect lighting networks from short-circuit currents. They are selected according to the rated voltage, the rated current, the maximum cut-off current, the current of the setpoint operation (cut-off). When selecting the setpoint (cut-off) current, the following conditions must be met:

$$I_{cut-off} \geq k_{m.d.} I_{c.c.max}; \quad (1)$$

$$I_{cut-off} \geq k_{a.m.} I_{r.m.r.}, \quad (2)$$

$k_{m.d.}$- reliability coefficient of maximum disconnectors with reverse current-dependent characteristic;

$k_{a.m.}$- multiplicity of the actuation current of the maximum instantaneous release in relation to the rated current of the release;

$I_{c.c.max}$- maximum short-circuit current at the location of the switch, A;

$I_{r.m.r.}$- rated current of the maximum release, A.

Taking into account the fact that the share of electricity for lighting in the total consumption of electricity for many consumers is about 20-30 %, it is important to understand the consequences of switching to led light sources and the associated negative impact of harmonic components on the power supply system.

Research methods

The active power of led light sources can differ significantly from the product of the actual values of voltage, current and power factor, since the curves of instantaneous values of these values are significantly different from sinusoids, and, therefore, to calculate the true value of the discharge power in the interelectrode gap, it is necessary to decompose the current and voltage curves into harmonic components. To characterize this process, except for the power factor determined by the formula:

$$\cos \varphi = \frac{P}{UI}, \quad (3)$$

the term harmonic signal distortion coefficient is used:

$$k_d = \frac{\sqrt{U_2^2+U_3^2+U_4^2+\ldots+U_n^2}}{U_1}, \quad (4)$$

P -active power, W;

U- current voltage value, V;

I- current value, A;

U_n-voltage of higher harmonics, V;

U_1- voltage of the first harmonic, V.

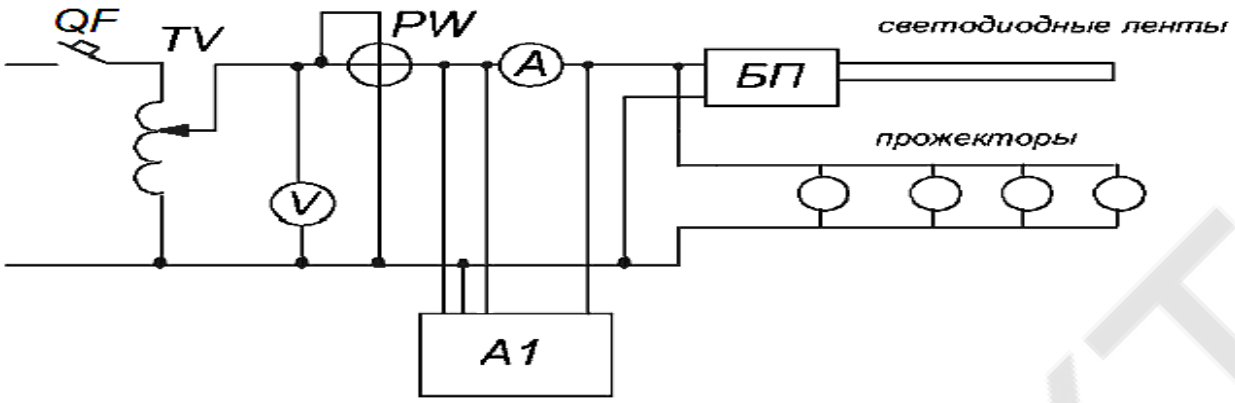
The distortion coefficient of the harmonic signal depends on the quality of the mains voltage and is not constant for these optical radiation sources. GOST 32144-2013 [9] allows a deviation of the voltage at the consumer ± 10% of the nominal for 100% of the time interval of one week, i.e., a change in the network phase voltage is allowed in the range from 198 V to 242 V, which entails changes in the current and power of the led light source.

For each led, there are valid supply voltage values U_{min} and U_{max}. When the voltage is applied above the U_{max} values, an electrical breakdown occurs, as a result of which the led fails. At a voltage below U_{min}, the led does not generate visible radiation. The range of supply voltages between both U_{min} and U_{max} x is called the "working" zone (the allowable range of voltage variation).

For a more detailed study of these phenomena at the Department of energy-efficient technologies of the ISEI state University named by A.D. Sakharov BSU developed and manufactured a test table (picture 1), which allows you to record not only the integral characteristics of the measured values, but also to observe them in dynamics.

The research was carried out in the range of "working" voltage from 100 to 260 V, i.e. from the moment of ignition to the permissible overvoltage. The voltage and current waveforms were examined with a two-beam Hantek DSO 5062B oscilloscope.

ИПФОАТ



Picture 1. Schematic diagram of the test stand: QF-circuit breaker; TV-voltage regulator; PW-wattmeter; A-ammeter; V-voltmeter; BP-led strip power supply AC input 180-264 V; A1-Hantek DSO5062B oscilloscope.

Research result

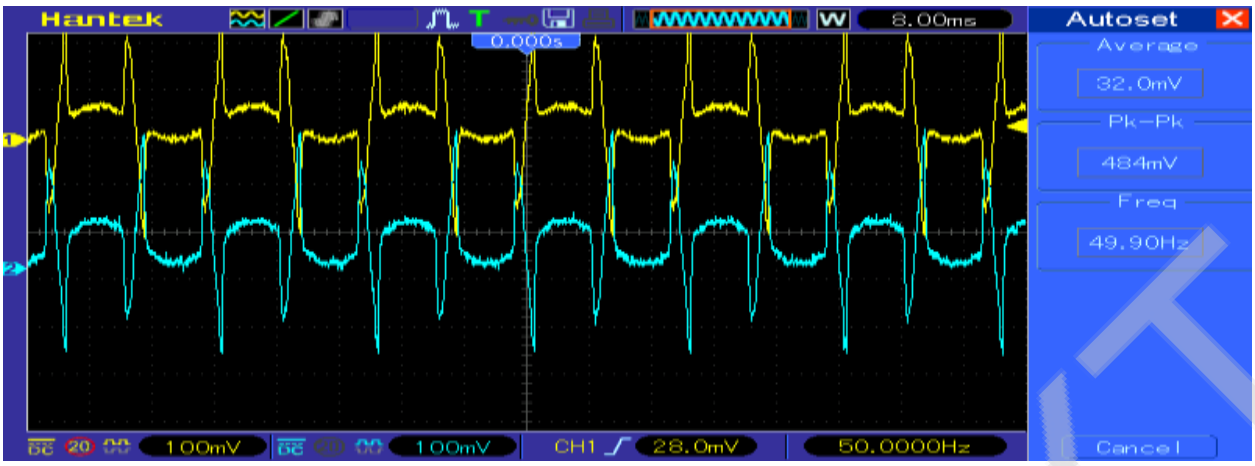
The received waveforms of the voltages at the sources with led tape and projectors are represented respectively in Pic. 2 and 3. The oscillograms showed the presence of harmonics in the voltage passing through the led source, which significantly distort the shape of the sinusoidal signal of these values. However, lamp power is not equal to the product of effective values of voltage and current as curves the instantaneous values of these quantities differ substantially from sinusoids, and consequently to calculate the true value of the discharge power in a p–n junction of the led must be expanded curves of current and voltage harmonic components. Therefore, the term "distortion coefficient" is used».

$$k_a = \frac{P}{UI} \quad . \tag{5}$$

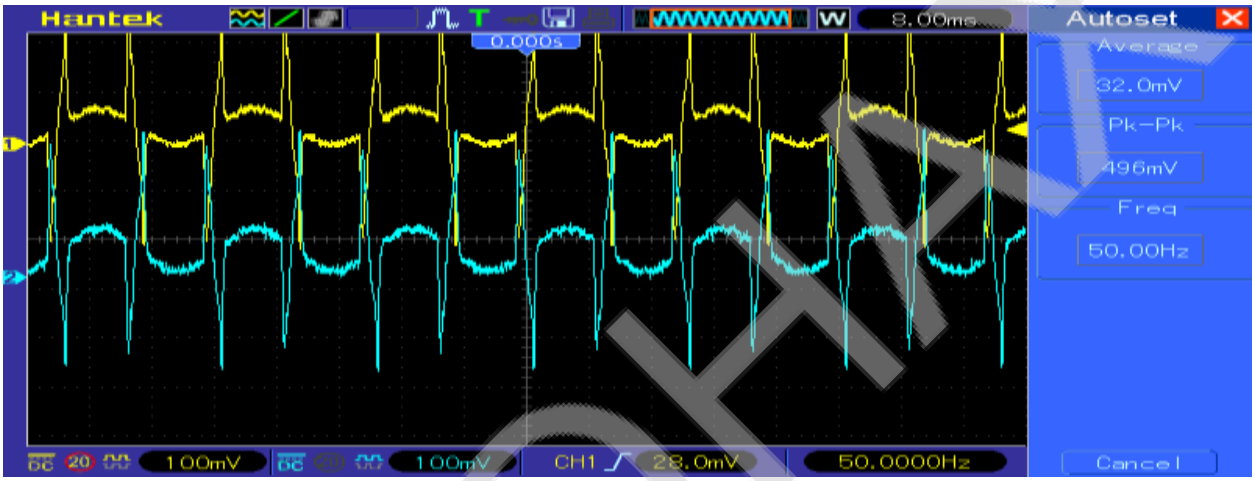
The operation of led light sources in the AC network is somewhat different from the operation in the DC network and makes its own additional requirements for optimizing the circuits of their power sources. During operation in the AC network the processes of occurrence and termination of electric discharge in the source are resumed each half-period of a sinusoidal change in the voltage of the supply network, while the source parameters (voltage, current and radiation flow) are constantly changing.

The volt-ampere characteristic of the led is nonlinear, and each voltage value corresponds to its own value of the current flowing through the led. The increase of voltage, the results in increase of the current value and the increase of the radiated light flux (luminosity), since the light flux changes, therefore, and is regulated when the voltage changes.

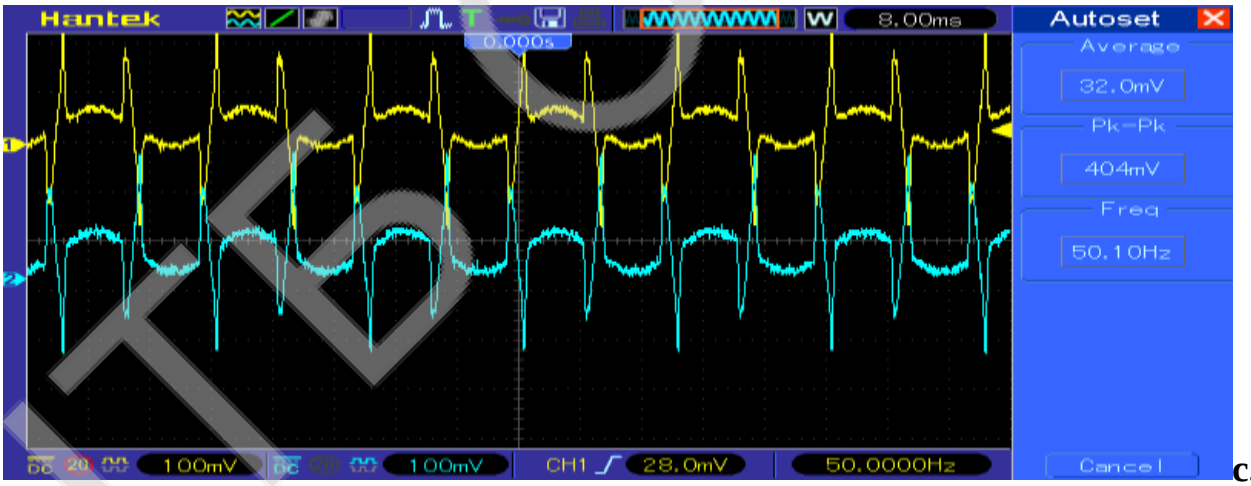
The current and active power values were obtained using the stand's measuring instruments, and the total power, power factor were calculated on the studied led light sources at different values of the input voltage in the accepted "working" range. The results of the research are presented in table 1 and 2.



a.



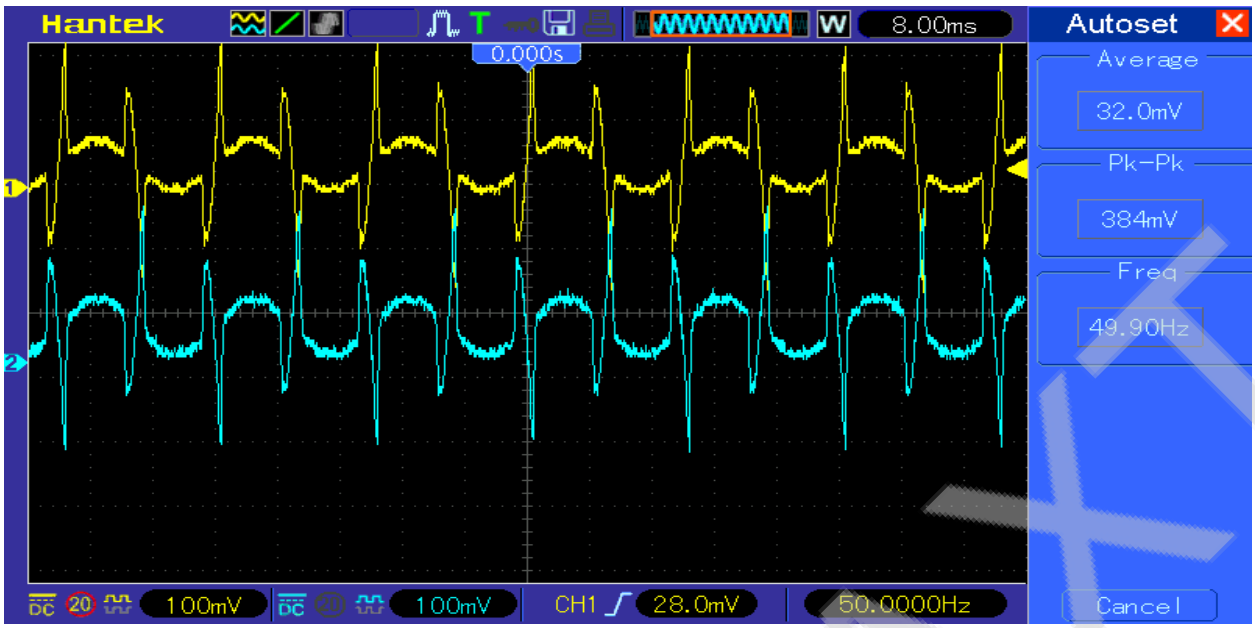
b.



c.

Picture 2. Oscillogram of voltage (1) and current (2) during operation of LED strips at voltage: a - 200 V; b - 225 V; in - 250 V

НТБОКНТ



Picture 3. Oscillogram of voltage (1) and current (2) during operation of SDO06 led spotlights

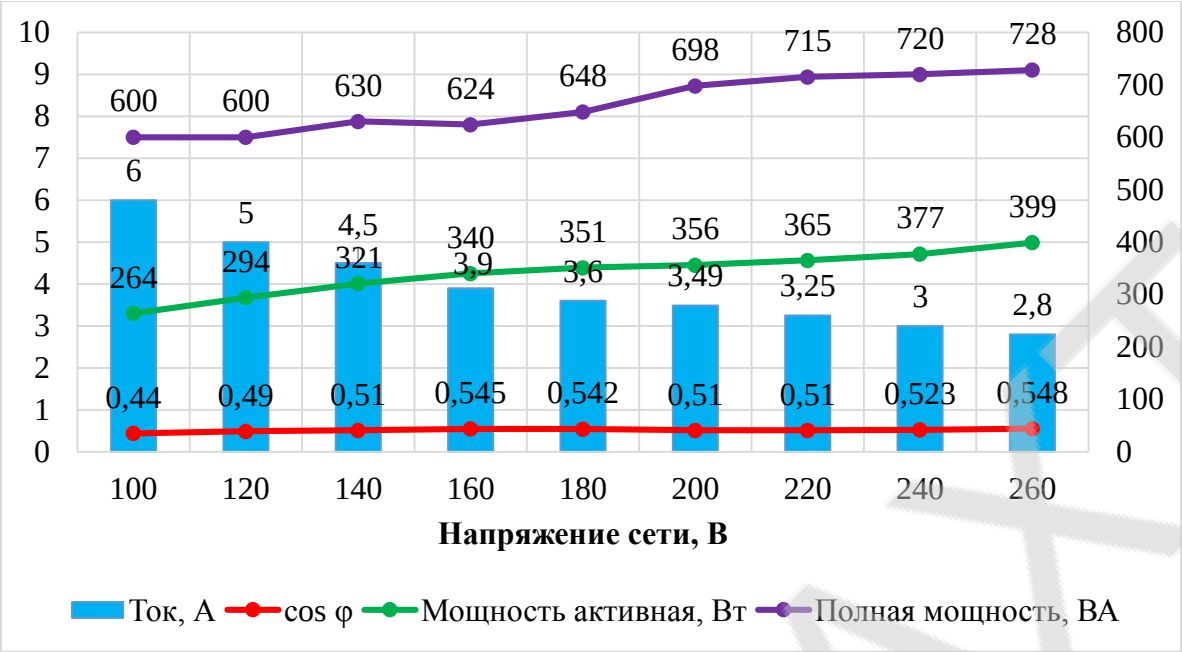
Table 1 – Research results of LED strips LED Strip 5050SND l = 5 m, 6 pcs., 2 blocks x 300 W

Network voltage, V	Current, A	Active power, W	Full power, VA	cos φ
100	6,0	264	600	0,440
120	5,0	294	600	0,490
140	4,5	321	630	0,510
160	3,9	340	624	0,545
180	3,6	351	648	0,542
200	3,5	356	698	0,510
220	3,25	365	715	0,510
240	3,0	377	720	0,523
260	2,8	399	728	0,548

Table 2 – The research results of LED spotlights SDO - 06

Network voltage, V	Current, A	Active power, W	Full power, VA	cos φ
100	3,10	266	310	0,850
120	2,93	295	352	0,839
140	2,74	321	384	0,837
160	2,56	340	410	0,830
180	2,40	352	432	0,772
200	2,28	356	456	0,781
220	2,20	365	484	0,754
240	2,11	377	506	0,740
260	2,03	399	528	0,750

Based on the results obtained, graphs of the dependence of current, active, full power and power factor for the studied voltage values were constructed, which are shown in picture 4 for a source with led strip and in picture 5 for led spotlights.



Picture 4. Dependence of current, active and apparent power, power factor of LED Strip 5050SND LED strip on supply voltage.

The analysis of the obtained results shows that the change in the mains voltage in the range allowed by the current standard from 198 V to 242 V on led light sources leads to a decrease in current by 17% and an increase in active power by 8 %, and the total power on average by 12 %. In this case, the power factor will have sufficiently low values and be in the specified voltage range for the investigated source on the led strip 0.51-0.55, and for led spotlights-0.74-0.78.

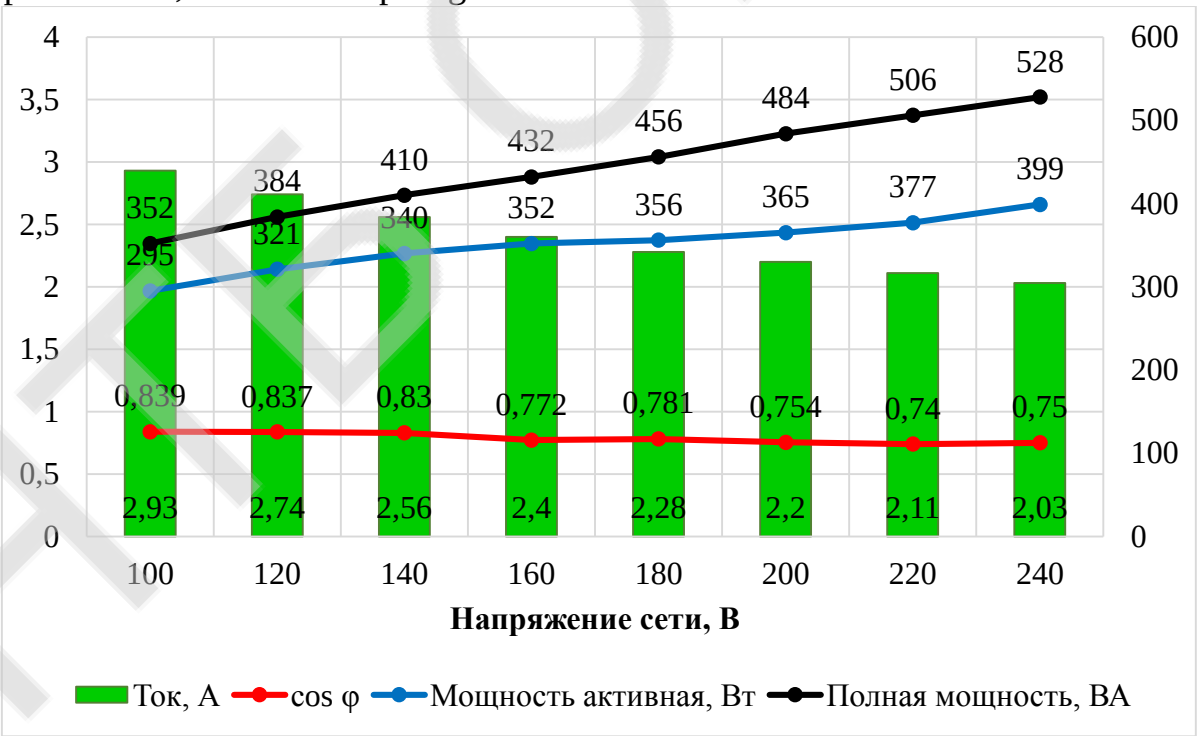


Figure 5. Dependence of current, active and apparent power, power factor of LED spotlights SDO-06 on supply voltage.

To increase the power factor of the supply network with a static lighting load, it is possible to use passive filter-compensating devices.

The use of reactive power compensation devices allows:

- maintain the required power factor of electrical installations;
- improve the quality of electricity directly in the power supply networks;
- reduce power consumption for lighting up to 45-49% for led strips and 22-26% for led spotlights;
- reduce energy and power losses in the power supply system (overhead lines, transformers);
- reduce the load of the elements of the supply or distribution network, increase their service life.

Reactive power compensation in the lighting system it can be individual when compensating capacitors are installed at each lamp or power supply unit of the led strip, and group when they are installed on group lines, in the power supply network or on the buses of a substation. The choice of a method of compensation for reactive power is determined by the feasibility study.

The power of the compensating unit Q, kVAr, required to increase the power factor of the network, is defined as:

$$Q = P_{calc}(tg\varphi_1 - tg\varphi_2), \quad (6)$$

P_{calc}- total rated power of the lighting system taking into account the demand and loss factors in the power supply, kW;

$tg\varphi_1,\ tg\varphi_2$- phase shift angles before and after compensation, respectively.

Conclusion

Led light sources are non-linear loads with a capacitive nature.

The widespread introduction of led lamps may be accompanied by problems associated with maintaining the standard values of electricity quality indicators, because their operation leads to the appearance of higher current and voltage harmonics in the power supply networks. Real instantaneous and active currents differ significantly from those of the first harmonic.

High harmonics that occur when using led light sources lead to an increase in losses during transmission and consumption of energy by other consumers up to 30 % and can cause failures in the operation of start-up protection equipment.

The results of the research can be the following recommendations:

– when selecting start-up protection devices and supply lines, it is necessary to introduce corrective coefficients that take into account the nonlinear nature of the load and the associated increase in instantaneous current values. The specification of the coefficients requires further research.

– to reduce the current harmonics and increase the power factor, it is advisable to use active correction in circuits with led light sources using special power factor correctors.

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НТБ ОНАХТ

5. ECOLOGY AND ENVIRONMENTAL PROTECTION

НТБ ОНАХТ

ORGANIC WASTE DISPOSAL WITH USING OF IMPROVEMENT METHOD OF VERMICULTIFICATION BY CALIFORNIAN WORMS (EISENIA FETIDA)

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Abstract*. As part of this research work, an efficient and environmentally friendly technology for the disposal of organic wastes based on vermiculture of the California worm (Eisenia fetida) has been substantiated and developed. The developed technology allows not only to fully utilize vegetable raw materials, but also to obtain a valuable fertilizer for increasing yields (biohumus) and a source of animal protein for food (worm biomass).*

The studies have made it possible to determine the most rational parameters of the substrate for cultivation of the California red worm (Eisenia fetida), which will significantly increase the yield of free humic acids, and therefore - to improve the quality of biohumus (pH = 6.5 -7.0, temperature - 18 -25 ° C, humidity -70-80%).

It is experimentally found that the best variant of solid organic substrate on which the red worm (Eisenia fetida) is cultivated, as well as undergoing the most efficient disposal of waste is potato peel, cabbage, apple peel, tea in a ratio of 2:1:1:1:1.

It is found that the best variant of the substrate based on wastewater MPP and activated sludge is the option with a weight ratio.Studies have shown that the cultivation of the California worm (Eisenia fetida) on plant substrates processes of destruction of dietary fibers.

Technology for the disposal of organic food waste and WFP waste and activated sludge using the cultivation of the red California worm (Eisenia fetida) has been developed, and each step of the technological process has been described, indicating the optimal technological parameters obtained through experimental studies

Keywords: *recycling, waste, biotechnology, biohumus, vermiculture, earthworm, vermicompost, recycling.*

I. Introduction

Actuality of theme: As a result of human activity, a large amount of various (solid, liquid and gaseous) wastes are present at all stages of production and in life, which contaminate the biosphere and pose a threat to public health. Nowadays, man-made waste has reached a geological scale. The occurrence of local environmental problems related to air and soil pollution, contamination and pollution of natural waters, transboundary pollutants, leads to the accumulation of harmful substances in the environment.

Awareness of the effects of environmental pollution and the depletion of natural resources has contributed to the development of approaches to the disposal and reuse of waste as secondary material resources. Recycling of waste generated by society is one of the indicators of its sustainability. Therefore, in most developed countries, recycling and disposal of waste have become a priority in the economic sectors. Waste

recycling reaches 80%, and their disposal is in compliance with all environmental requirements.

However, in Ukraine, the gap between the progressive accumulation of waste and the measures for its disposal and disposal at the present stage has not been overcome. There is a deepening ecological crisis.

Today, in most developed countries, there is a shift from landfilling and incineration to alternative solutions to waste management that minimize the negative impact of waste on the environment. The practical experience of waste management in different countries shows that there is no one-size-fits-all method that meets the current requirements of ecology, economy and resource conservation. The implementation of biotechnological disposal methods is the most consistent with these requirements and trends in world practice.

There are many technologies known to successfully solve the problem of the efficient disposal of vegetable waste. The combustion of vegetable raw materials in boilers generates emissions of pollutants into the atmosphere, which contributes to the deterioration of the environment. It is also worth noting that using traditional recycling technologies reduces the utilization rate of natural resources, since organic waste is a valuable raw material for further biofertilization. Therefore, the development of an efficient and environmentally friendly technology for the disposal of organic waste is urgent.

The purpose of this qualification is to substantiate and develop a technology for the disposal of organic waste by cultivating the red California worm (Eisenia fetida);.

To achieve this goal, the following tasks were defined: to analyze the current problem of waste disposal;to consider biotechnological methods of waste disposal and determine their benefits;to identify the main features of the substrates on which the red California worm (Eisenia fetida) is cultivated;to determine the basic parameters of the process of cultivation of red California worm (Eisenia fetida), which may affect its biological efficiency;to determine the rational ambient temperature for the cultivation of the red California worm (Eisenia fetida);to determine the rational moisture level of the substrate for cultivation of the red California worm (Eisenia fetida);to determine the rational pH of the substrate for cultivation of the red California worm (Eisenia fetida);to determine the best version of the solid organic substrate on which the red worm (Eisenia fetida) is cultivated.

Subject: Investigation of organic waste utilization by vermiculture of the California rain worm (Eisenia fetida).

Object of study: household and industrial organic waste.

Purpose: The justification and development of technology for the disposal of organic waste by vermiculture California rain worm (Eisenia fetida).

Practical importance of the topic: The technology of organic waste utilization, which has no negative impact on the environment, is substantiated and developed. This technology allows not only to dispose of waste, but also to obtain biofertilizers and additional feed for livestock.

Conclusion. Development of technology for recycling of organic waste. Based on the results of research, the technology of organic waste utilization has been developed and substantiated.

II. Analytical review of literature

At this time of active development, the technology of vermicomposting exists. Vermicomposting is based on the ability of the Red Hybrid Californian's (ECG) (Eisenia fetida Andrei) to absorb a large amount of organic matter, plant residues, and with them the bacteria, fungi, algae, protozoa [1].Worms are known to contribute to the conversion of nutrients into readily available form and to activate microbiological activity [2].Spanish scientists have described vermicomposting as "biological oxidation and stabilization of organic matter, that associated with the action of earthworms and [mesophilic] microorganisms" [3].Thus, with the participation of microorganisms in the process of composting in the beds, the decomposition of easily digestible compounds - sugars, polysaccharides, proteins, hemicelluloses, and at last the lowest speed of decomposition have lignin, tannins, etc. at first .The decomposition is accompanied by the synthesis of a complex of humic compounds. As a result, the mass of organic matter decreases, the substrate is enriched with nitrogen, humus, its ash content increases [4].

It is interesting that vermiculture has a sterilizing effect on pathogenic microorganisms.Thus, the study of the sanitary status of composts showed that vermicompost does not contain representatives of dangerous groups of microorganisms [13].The worm's gut is a kind of "filter" and simultaneously an enzymatic system for microorganisms. Part of the microorganisms that enter the gut of the worm is eliminated, others multiply and enrich the substrate [5].The results of studies of American and Russian scientists show that the worm's coprolites are dominated by gram-negative aerobic bacteria of the genus Pseudomonas, in slightly smaller numbers - representatives of the genera Flavobacterium, Streptomyces, Bacillus [6], as well as Cellumonas, Acostobacterium, [7].In works [4-8], the dominant bacterial species in vermicompost (biohumus) are presented.Thus, the bacterium Pseudomonas putida has a high intestinal survival and reproduction in the biohumus, and species such as Azospirillum brasilense and Pseudomonas stutzeri do not develop under these conditions at all.The survival of bacteria from the genus Pseudomonas has been confirmed by other researchers. At the Institute of Agricultural Microbiology and Agroindustrial Production of NAAS, it is established that the grouping of vermicompost microorganisms is represented by bacteria of the genus Pseudomonas, Bacillus, Enterobacter, Alcaligenes, Flavobacterium and others.In the course of research, the active growth of the stimulating and phosphate-mobilizing strain of Pseudomonas putida 17 was isolated [6].Despite the aforementioned advantages and the prospect of vermicomposting, technology has some disadvantages.These include the considerable duration of composting (4-6 months), the unmanageable microbiological processes, and the production of compost as a general-purpose organic fertilizer, which does not allow solving individual problems in growing crops.

One of the ways to solve the last drawback is to create biohumus based fertilizers and microbial preparations with specified properties (fungicidal, growth-stimulating, phosphate-mobilizing, etc.) by inoculation of the compost with agronomically valuable microorganisms.To a greater extent, today it is hypothetical. However, such attempts have been described in the literature. Thus, a method of producing biofertilizers, which is to obtain biohumus by composting a substrate from an organic waste of agriculture

and industry with the participation of "Obolensky hybrid", that obtained as a result of crossing the red hybrid Californian with the Russian population of rainworms (*Eisenia fetida*).Vermicomposting is carried out at + 16-24 ° C for 4-6 months. In the resulting biohumus, the microorganisms with fungicidal properties are introduced.Microorganisms are introduced after the removal of worms and maturing of biohumus.As a producer of fungicides used strain of bacteria*Bacillus subtilis* IPM-215in the amount of from $10^9$to 10^{12}spores per1 kgof biohumus, or culture*Trichoderma viride* 16 at concentrations from $10^4$to 10^8colony forming units (CFU) per 1 kg of biohumus [8].

III. Object, subject and methods of research

*Object of research:*bioconversion of organic waste of composting.

Subject of study: change of indicators of bioconversion process of organic waste by vermicomposting method.

The studies were conducted within three months. Worms cultivation was in cultivators (plastic containers).The width of the container is 0.15 meters, the length is 0.25 meters, the height is 0.1 meters.The container was put a pre-fermented substrate (in our case - potato peel, cabbage, apple peel + tea / coffee), which was pre-prepared by grinding, moistening (crushed substrate with water in a ratio of 1: 1.5) and naturally was fermented with microorganisms, a layer of 2 cm, and introduced worms.Conditions of the environment were monitored during the bioconversion period. New portions of the substrate were added after 7-10 days with a layer of 1 cm. The number of worms was calculated 1/30 (once a day) [9]. After the bioconversion process, worms and biohumus are separated. Excess worms are used in feed production [10].

*In laboratory studies, standard and adapted methods of analysis were used.:*determining the optimal temperature, humidity and pH of the medium for worms to calculate their population [11]; determination of the chemical composition of the substrate according to the calculations of the biological efficiency coefficient [12]; determination of the amount of humic acids by extraction method [12].

IV. Results of the work

To determine the speed and efficiency of organic waste processing by vermiculture we use the biological efficiency indicator. The essence of the calculation is to determine the relationship between the increase in biological mass and the time during which this gain.

$$\frac{\Delta}{\tau}, \text{h/d} \qquad (1)$$

де Δ – biomass growth, г;τ – time, days (we are take like 10 days).

At a temperature of 30-32 ° C, especially at excess moisture of the substrate, in response to the temperature stimulus, the activity and body weight of the earthworms is reduced by increasing the secretion of the mucous secretion. At 37 ° C, the worms die. The effect of temperature on the number of individuals has been investigated. It is shown that the most favorable temperature at which Eiseniafetida increases with maximum speed and retains high activity is 18-28 ° C (Fig. 1). The studies were performed for 25 days.

The effect of temperature on the weight gain of worms has been investigated. It

is shown that the most favorable temperature at which Eisenia fetida gains mass with maximum speed and retains high activity is 18-25 ° C (table 1).

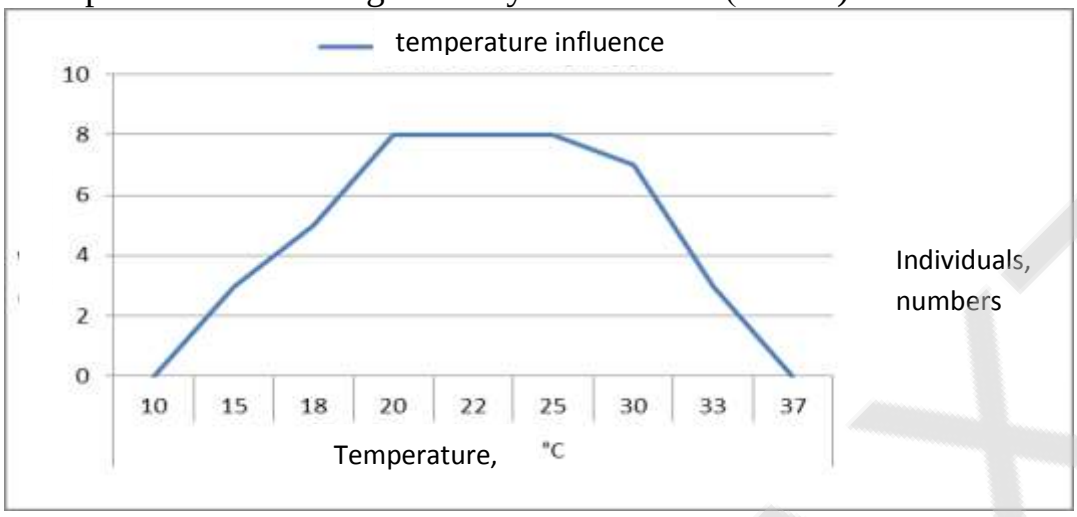

Fig.1 - Effect of temperature on the number of individuals Eisenia fetid.

Table 1 - Effect of pH of substrates on BA of red California earthworm Eisenia fetida.

Substrates variation	pH,unit.	BA, t/days
№1	5,0	0,63
№2	5,3	0,69
№3	6,5	0,72

Studies have shown a relationship between the BE of the red California worm (Eisenia fetida) and the pH of the substrate on which it is cultivated (Fig. 2).

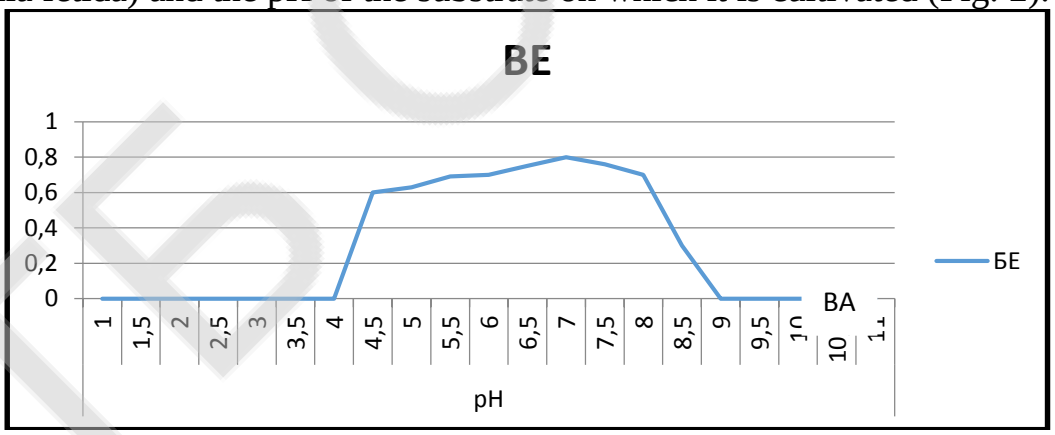

Fig. 2 - Substrate pH dependence on the BE of the California worm.

An increase in humidity of up to 90% impeded the access of oxygen to the substrate, which led to the development of anaerobic processes of substrate decomposition, which slowed the growth and development of worms. The studies were performed for 25 days.

The dynamics of growth of the number of individuals is shown in Fig. 3.

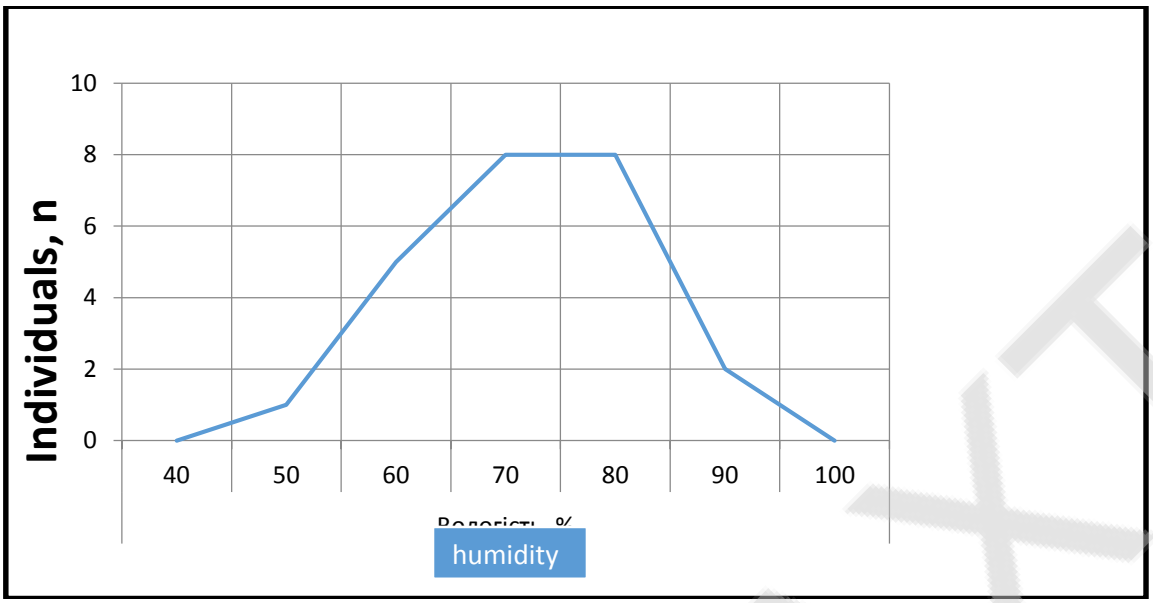

Fig. 3 - Effect of humidity on the number of individuals Eisenia fetid.

When growing earthworms in the laboratory, the maximum mass and production of biohumus are achieved with a humidity of the substrate, which varies in the range of 70 ... 80%, that is, is close to the water content in the body of the worm.

Research into the efficiency of food waste treatment. The studies have been conducted since September 2016 for three months. The cultivation of worms occurred in cultivators (plastic containers). The width of the container is 0.15 meters, the length is 0.25 meters, the height is 0.1 meters. In the container was placed the substrate, which was prepared in advance by grinding, moistening and natural fermentation using microorganisms, a layer of 2 cm, and introduced worms.

Preparing the substrate (feed) for feeding worms. Worm feed is a variety of high cellulose organic wastes that have undergone fermentation [1]. Raw vegetables, especially potatoes, should be cleaned thoroughly (through a meat grinder), otherwise they will not be processed. Under conditions of access of water and oxygen and under the influence of microorganisms-aerobes that are on the substrate (fungi, actinomycetes, bacteria), organic waste decomposes. Hydrolytic cleavage of high molecular weight compounds (proteins, fats, carbohydrates) produces intermediate and final low molecular weight products consumed by worms. Large organic waste particles need to be ground (up to 1 mm, not more) because they are not eaten by the worms[14].

Important is the condition that such a feed is free from harmful and toxic impurities.

There are the following requirements for the source organic substrate (waste) to produce quality feed for worms [1]: humidity 70–80%, pH 6.8–7.2, sufficient cellulose (20–25%), iron oxide content not more than 10%, no solid parts - metal, wooden, stones, glass, etc. Feed for worms should not contain pesticides, petroleum products, large amount of protein (not more than 25-30%), ammonia, methane, pathogenic microflora , eggs and helminth larvae. Worms are killed when 40% of the protein is in the feed.

At the beginning of studies to determine the increase in biomass for 2.5 months of substrate processing, the average weight of one adult adult worm was 0.15 g (Table

2). The largest increase in the average weight of the worm at the end of the experiment was found in option № 3 (0.36 g) and option 2 (0.31 g). The average earthworm biomass increase in version № 1 was 0.17 g. This substrate does not contain sufficient nutrients, so the biomass growth rate is negligible. It can be concluded that it is desirable to add coffee and tea to the main substrate.

Table 2 - Effect of substrate type on biomass production*Eiseniafoetida*

Substrates variation	Duration of cultivation, days	Average biomass of an adult indiviual, g		Avarage biomass groeth, g
		On the beginning	On the end of exploration	
№ 1	75	0,14±0,01	0,31±0,01	0,17
№ 2	75	0,15±0,01	0,47±0,01	0,32
№ 3	75	0,16±0,01	0,52±0,01	0,38

Thus, the data obtained indicate that the optimal substrate for vermicult propagation is substrate No. 3. The dynamics of change in the total weight of vermiculture, which was studied for 75 days is presented in Fig. 4, 5, 6.

The dynamics of change in the increase of total biomass of vermiculture are presented in Fig. 7. 8, 9.

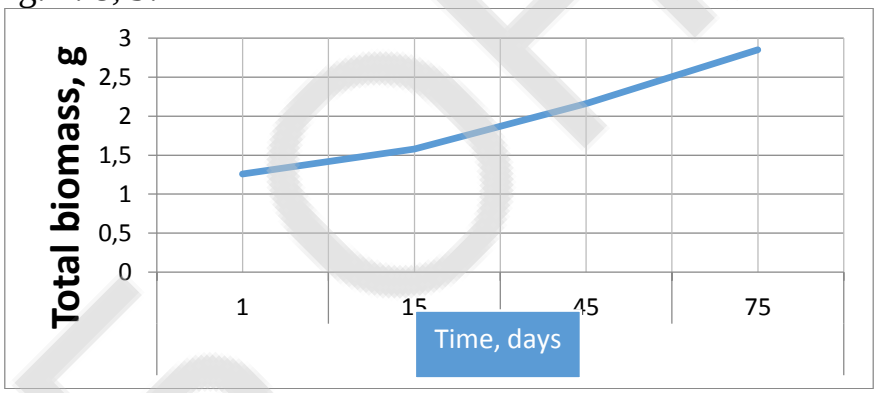

Fig. 4 – Integral dependence of change in total weight of Eisenia fetida for substrate №1 - potato peel, cabbage, apple peelin a weight ratio of 2: 1: 1

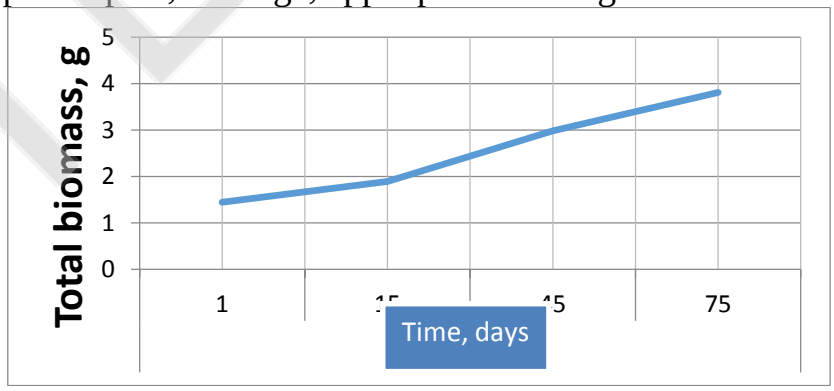

Fig. 5 – Integral dependence of change in total weight of Eisenia fetida for substrate №2 - potato peel, cabbage, apple peel, kava in a weight ratio of 2: 1: 1: 1

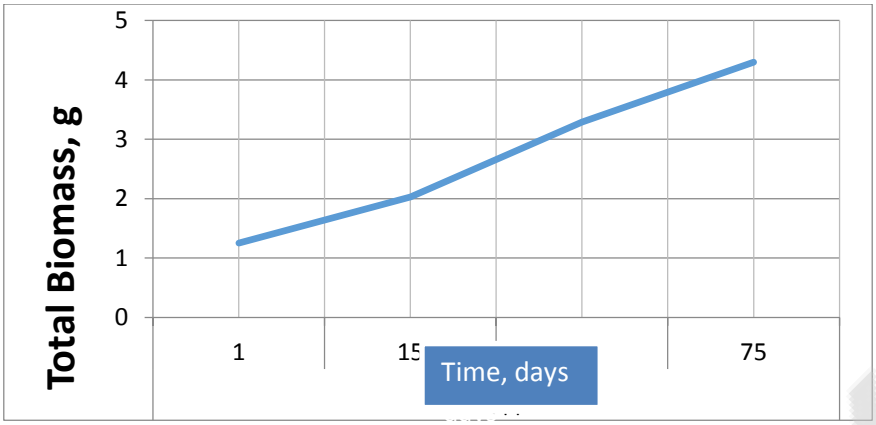

Fig. 6 – Integral dependence of change in total weight of Eisenia fetida for substrate №3 - potato peel, cabbage, apple peel, tea in a weight ratio of 2: 1: 1: 1

From the obtained data of the differential dependence, it can be concluded that the increase in biomass increases in direct proportion to time.

This graph shows the maximum increase after 45 days of cultivation, then the total increase is smaller, in connection with the physiological features of vermiculture.

In this graph, similarly, we observe the maximum increase after 45 days of cultivation, then the total increase decreases, due to the physiological features of vermiculture.

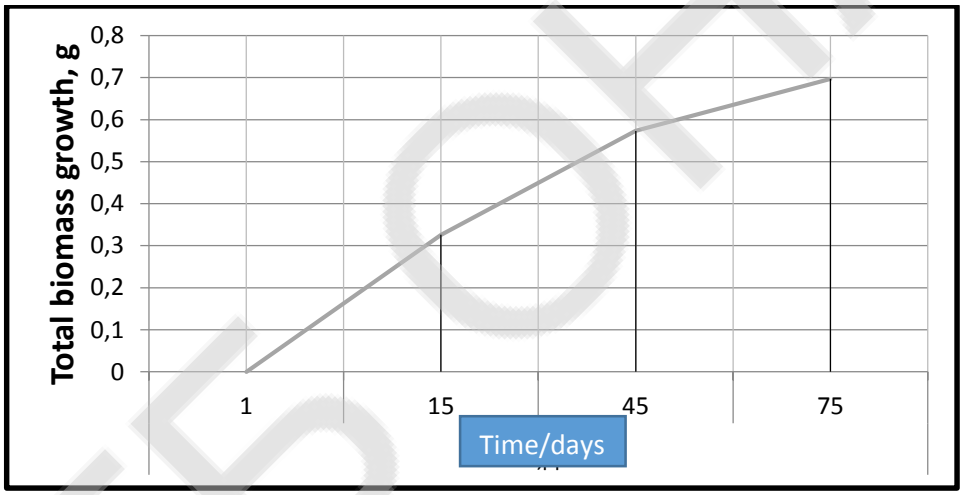

Fig. 7 – Dynamics of change of total biomass Eisenia fetida for substrate №1– potato peel, cabbage, apple peel in a 2: 1: 1 ratio

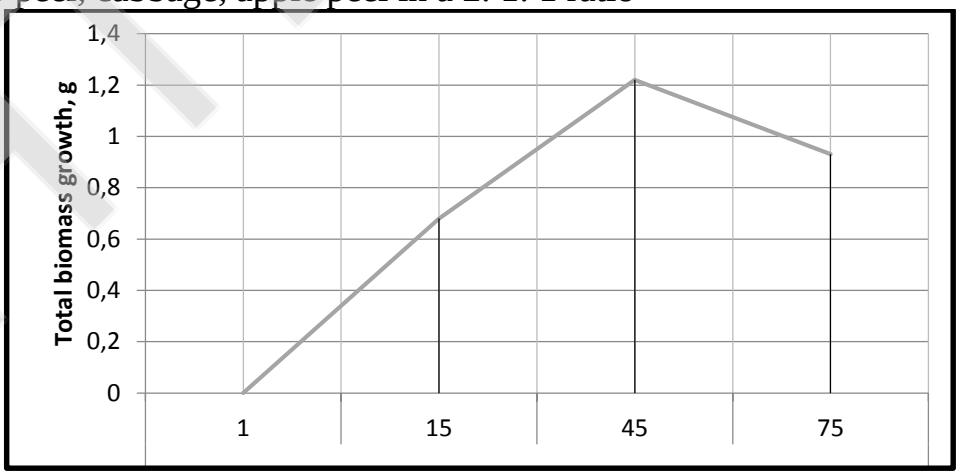

Fig. 8 – Dynamics of change of total biomass Eisenia fetida for substrate №2– potato peel, cabbage, apple peel, coffee by weight 2: 1: 1: 1

The formation of large quantities of highly concentrated sewage plants (MPPs) and the lack of efficiency of the methods used for their treatment pose a significant threat to the environment. The decisive role in the prevention of the pollution of reservoirs by sewage MSP belongs to and will certainly belong to the methods of biological sewage treatment, which is due to the technological, economic and environmental advantages of these methods over others.

The processing of this concentrated poly-mineral substrate and lignin wood with the help of earthworms into biohumus will allow to turn the production of biogas into a closed waste-free cycle, thus closing the natural cycle of substances[15]. Therefore, it is the process of vermicomposting of this substrate and will lead to the creation of valuable humic organic fertilizer. There is nothing left in the process of producing biogas that cannot be used and recycled. The obtained biohumus is a valuable natural highly efficient, environmentally safe, biologically active complex balanced humic organic fertilizer for all types of plants.

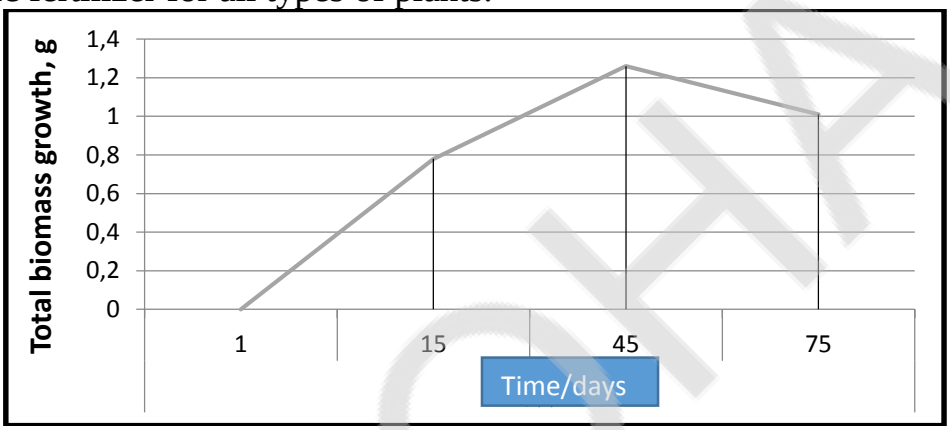

Fig. 9 – Dynamics of change in the growth of total biomass Eisenia fetida for substrate №3 - potato peel, cabbage, apple peel, tea in a weight ratio of 2: 1: 1: 1

The task is to create a method of treatment of fatty sewage sludge by aeration of a mixture of raw sludge and activated sludge with cellulose-containing filler and vermicult population to ensure the intensification of the process of biodegradation of sedimentary enrichment of the obtained organic fertilizer with biologically active substances. This problem is solved by the fact that in the method of processing fatty sludgeprovides the mixing of the sludge from the primary sedimentation tanks with activated sludge and aeration of air into the crude sludge and activated sludge enter cellulose-containing filler in different volumetric ratios, the resulting mixing and mixing is obtained humidity of 50 - 80%, after which they populate vermiculture and sustain for 30 - 60 days, maintaining humidity of 60 - 80% [9,16].

Raw fatty sludge is formed at the enterprises of meat and dairy, oil and fat processing industry of mechanical and physico-chemical methods of sewage treatment (in sedimentation tanks, grease traps, flotators, etc.). Sludge is a mass of paste-like consistency with an unpleasant odor and high fat content - 50 - 90% of dry matter.

Active sludge is a complex of colloidal type microorganisms with adsorbed and partially oxidized contaminants that are extracted from sewage by biological purification methods (in aeration tanks, etc.)[17].

This method of treatment of sewage sludge involves their aeration and processing vermiculture. Aeration is necessary for the decomposition of organic matter

sludge up to 4 simpler compounds consumed vermiculture.

A mixture of crude fatty sludge and activated sludge is prepared. Active sludge enriches a mixture of microorganisms that oxidize the organic matter of sediment in the presence of oxygen. However, the paste-like consistency of the mixture complicates the passage of air, so to give a structure that provides aeration, enter cellulose-containing filler. As cellulosic fillers can be used wood sawdust, crushed waste of wooden containers andtrains of packaging materials, residues of plant materials (leaves, straw, waste of vegetables and fruits, etc.).

The prepared mixture is placed in containers and aerated. In the process of aeration there is intensive development and reproduction of microorganisms, with the temperature rising to 50-55 ° C. As the temperature accelerates the processes of oxidation and decomposition of organic matter precipitation, as well as the disinfection of the mass of the mixture.

Significant effect on the passage of oxidation processes has a moisture content of the mixture, because the nutrients dissolve in water, before they become available for consumption by microorganisms.

The influence of humidity on the processes of oxidation of organic matter during aeration was investigated. The data obtained presented in table 3.

Research data show that the rational humidity during aeration is 50-80%. An increase in humidity of more than 80% leads to inhibition of the oxidation processesin the mixture.

In the process of decomposition of the protein matter of wastewater, ammonia is formed, which adversely affects the vital activity of vermiculture.

The effect of aeration duration on the quality of the mixture was investigated. The obtained data are presented in table 4.

Table 3 – Influence of humidity on the processes of oxidation of organic matter during aeration

№	humidity, %	Sabstrates quality
1	30	Humidity does not contribute to the passage of biothermal processes, slows the development of microorganisms. The substrate is not suitable for oxidation.
2	50	Humidity provides the penetration of air into the voids in the substrate structure, sufficient for the passage of biothermal processes. The substrate is suitable for oxidation processes
3	65	Humidity provides access to oxygen to microorganisms. The substrate is suitable for oxidation processes.
4	75	Humidity provides access to oxygen to microorganisms. The substrate is suitable for oxidation processes.
5	85	The voids in the structure are filled with water. Which restricts the access of oxygen to microorganisms. The substrate is not suitable for oxidation.

Table4 – Influence of aeration duration on substrate quality.

№	Duration of aeration, days	Substrate quality
1	10	A significant amount of ammonia. The quality of the substrate for processing is poor.
2	15	Ammonia is minimal. The substrate is suitable for processing.
3	22	Ammonia is minimal. The substrate is suitable for processing.
4	30	No ammonia. The substrate is suitable for processing.
5	35	The substrate is suitable for processing, but extending the aeration term is not economically advantageous.

Studies show that the optimal aeration period is 15 - 30 days.After aeration, the substrate is inhabited by vermiculture.In the process of processing is swallowing pieces of organic matter worms and the formation in the intestinal cavity of humic substances. They markedly and for the better differ in chemical composition from the humus, which is formed with the participation of only microorganisms, because the intestines of the worms are the processes of polymerization of decomposition products of organics and formed molecules of humic acids, due to the intensive enzymatic and fermentative enzymatic enzymatic activity. etc.), which acceleategermination of seeds, have a positive effect on the growth and development of plants, increase their resistance to disease.It is also important that microorganisms found in biohumus contribute to the conversion of toxic forms of metals to non-toxic, as well as block the inflow of plants and plant production of radionuclides [9].

The following were studies of the effect of humidity on the quality of processing of the mixture vermiculture. These studies are presented in table 5.

Table5 – Influence of humidity on the process of vermiculture.

Humidity, %	Sabstrates quality	Δ during10 days, h
50	Humidity is insufficient. Vermiculture is motile. The substrate is not recyclable.	0
60	Humidity is sufficient. The substrate is suitable for processing.	0,1
70	Humidity is sufficient. Vermiculture is quite mobile. The substrate is suitable for processing.	0,15
80	Humidity provides comfortable cultivation. The substrate is suitable for processing.	0,15
85	Humidity is too high. Molds are developing.	0

These studies have shown that the rational humidity of the mixture in the processing of vermiculture is a humidity of 60 - 80% (table 6).

Table 6 - Effect of weight ratio of substrate components on biological efficiency

Sabstrates variation	Biological efficiency. h/t
1:2:2	0,07
1:1:2	0,075
1:2:1	0,05
1:1:1	0,06

The data obtained indicate that an increase in the amount of wastewater contributes to a decrease in the BA, as shown by the comparison of substrates 1: 2: 1 and 1: 1: 1. An increase in the amount of activated sludge contributes to an increase in BE, as shown by the comparison of substrates 1: 1: 2 and 1: 1: 1.

From the data obtained, we can conclude that the biological efficiency is greater in the variant of the substrate, where the content of activated sludge prevails.

The main indicator of the quality of the obtained biohumus is the release of free humic acids.

The results of the study of the influence of the weight ratio of components on the quality of biohumus are presented in table 7.

Table7 –Influence of weight ratio of substrate components on biohumus quality

Sabstrates variation	**The yield of free humic acids,%**
1:2:2	9,4
1:1:2	9,3
1:2:1	8,6
1:1:1	9,2

The data obtained indicate that an increase in the amount of wastewater contributes to a decrease in the yield of free humic acids, as indicated by the comparison of substrates 1: 2: 1 and 1: 1: 1. Increasing the amount of activated sludge contributes to an increase in the yield of free humic acids, according to a comparison of substrates 1: 1: 2 and 1: 1: 1.

Therefore, it can be concluded that the best variant of the substrate for the cultivation of Eisenia fetida and the processing of liquid organic waste is option number 2, in which the content of MSW wastewater is lower and the content of activated sludge is more prevalent.

The technological scheme of cultivation of red California worm (Eisenia fetida) on solid organic substrates is as follows, shown in Figure 10.

Using vermiculture different substrates, the technological scheme of processing may vary, but the main provisions are similar. Conducting an experiment with the different constituent composition of the substrate, we obtained different qualities of biohumus.The results are presented in table. 8.

Table8 – The influence of the ratio of substrate components on the quality of biohumus

Sabstrates variation	The yield of humic acids,%
Potato peel, cabbage, apple peelin a 2: 1: 1 ratio **(control)**	8,48
Potato peel, cabbage, apple peel, **coffee** in a 2: 1: 1: 1 ratio	8,76
Potato peel, cabbage, apple peel**, tea** in a 2: 1: 1: 1 ratio	8,98

Therefore, it is advisable to use 2 variant of the substrate, because the yield of free humic acids is the highest, which is the main indicator of the quality of biohumus.Functional technological scheme for the disposal of WFP waste and activated sludge by vermiculture method of red California worm (Eisenia fetida) includes the steps (Figure 11).

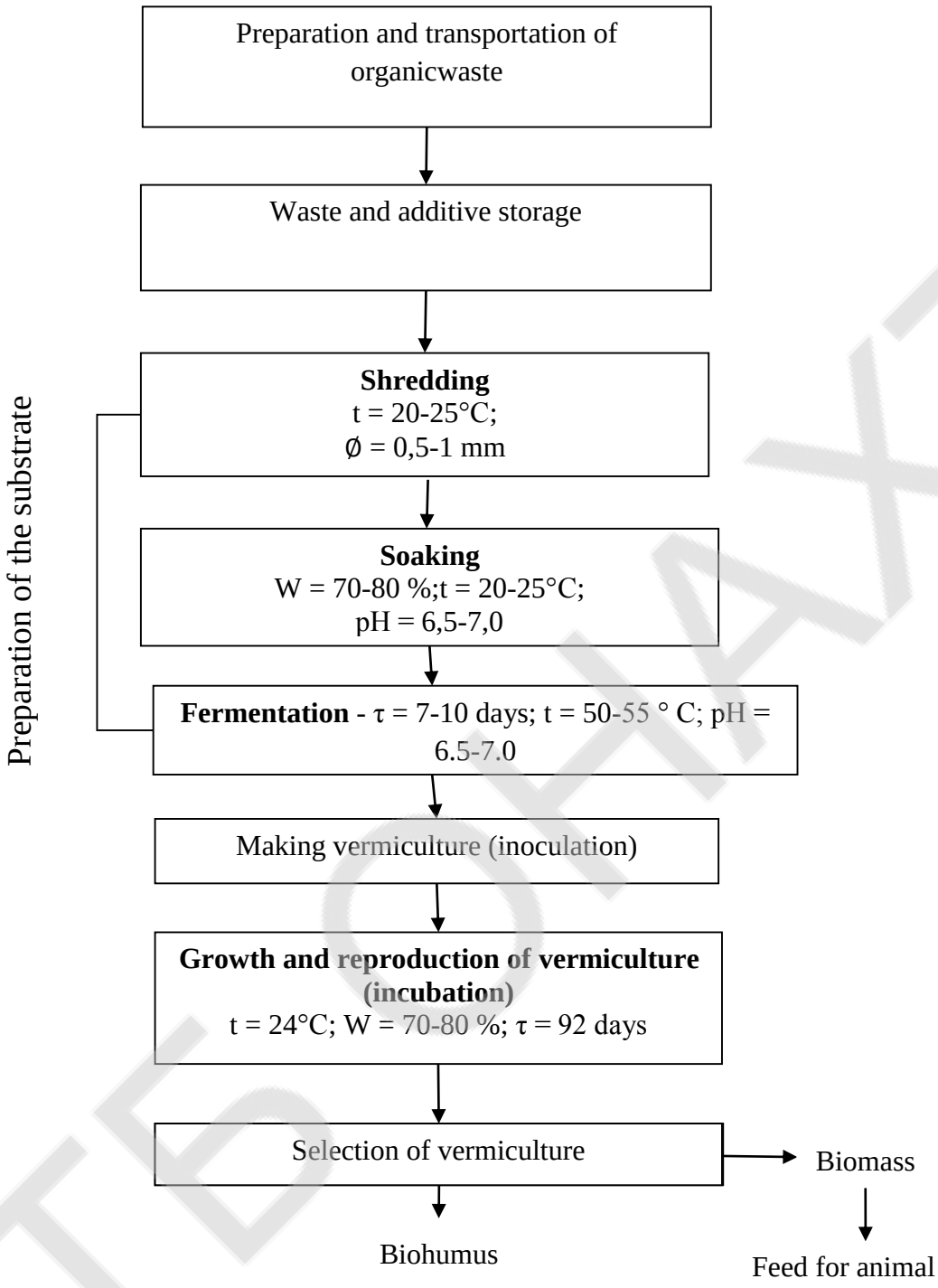

Fig. 10 – Technological scheme of organic waste disposal

The data obtained indicate that an increase in the amount of wastewater contributes to a decrease in the yield of free humic acids, as shown by the comparison of substrates 1: 2: 1 and 1: 1: 1 (table 9).

Increasing the amount of sludge in the biogas plant increases the yield of free humic acids, as shown by the comparison of substrates 1: 1: 2 and 1: 1: 1.Therefore, it can be concluded that the best variant of the substrate for the cultivation ofEisenia fetida and processing of liquid organic waste is option number 2, in which the content of wastewater MPP is less and the activated sludge is greater.

Table 9 – The influence of the ratio of substrate components on the quality of biohumus

Sabstrates variation	The yield of free humic acids,%
1:2:2	9,3
1:1:2	9,4
1:2:1	8,6
1:1:1	9,2

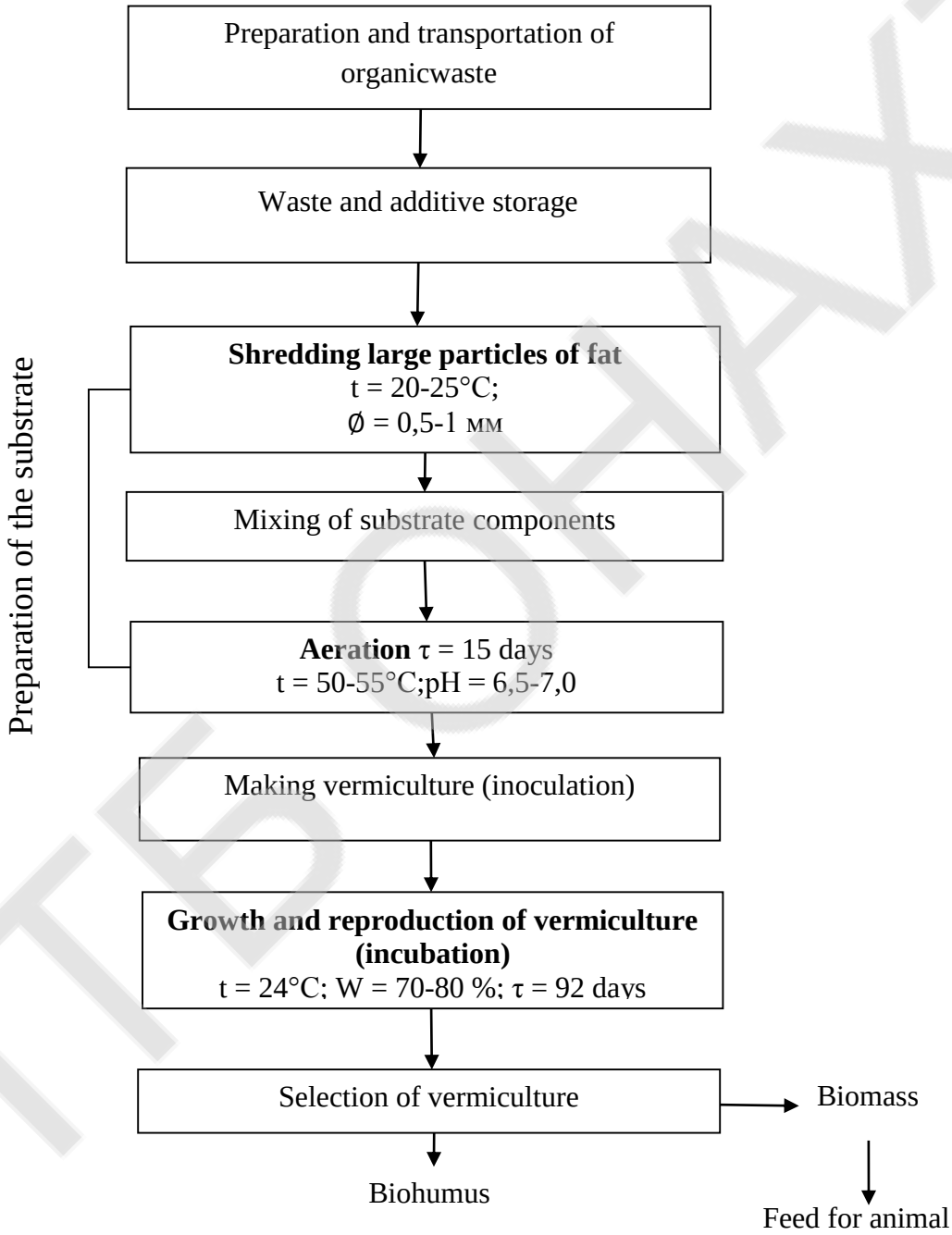

Fig. 11 -Technological scheme for waste management of MPP and activated sludge

V. Conclusions

1. Studies have shown that the process of artificial cultivation (Eisenia fetida) can be improved by determining the most rational parameters of the substrate on which the red California worm is cultivated.

2. It is found that the optimal temperature for the cultivation of the red California worm (Eisenia fetida) is 18-28 ° C.

3. Studies of the effect of substrate pH on the red California worm (Eisenia fetida) have shown that substrate acidification lowers worm's Biological efficiency, so vermicultivating is recommended on the substrates with a neutral pH.

4. When cultivating a red California worm (Eisenia fetida) on the basis of an organic substrate, the highest values of BE are recorded at a substrate humidity of 70-80%, so this moisture is considered rational for vermiculture.

5. It is established that the best version of the solid organic substrate on which the red California worm (Eisenia fetida) is cultivated, and also the most effective organic waste disposal is carried out, is option No. 3 (potato peel, cabbage, apple peel, tea in a weight ratio of 2: 1: 1: 1).

6. It is established that the best variant of the liquid organic substrate, in which the most effective utilization of waste is held, is the variant No. 2 - sawdust, sewage, activated sludge in a weight ratio of 1: 1: 2.

It has been proven that organic waste is degraded by the cultivation of the red California worm (Eisenia fetida).

VI. References

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НТБ ОНАХТ

INVESTIGATION OF THE DESTRUCTION OF THE WINEMAKING SOLID WASTE THROUGH BIOCONVERSION PROCESSES

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Abstract*. The work is devoted to the research of the enzymatic destruction process of solid waste of the primary winemaking enterprises the introduction of advanced technology of their utilization and creation of optimally balanced feed additive. The processing of grapes produces waste, the storage and accumulation of which in environmental components leads to the loss of valuable resource in the composition of waste and leads to the creation of increased levels of environmental hazards.*

Enzymatic degradation of cellulose in the composition of waste by the cellulase enzyme through the microorganisms' action is the basis of the biotechnological process. To implement this process, it is necessary to determine the main parameters and modes of the bioconversion process, investigation of which the study is devoted.

The basic characteristics of the enzymatic degradation process were determined and data were obtained for the technology improvement of solid waste utilization of the wine industry enterprises. Comparative analysis of bioconversion of different types of waste proves that the cellulose enzymatic degradation is the most effective for the grape pomace in the waste, allows us to obtain valuable feed additive and reduce the environmental danger level.

Keywords: *winemaking waste, grape pomace, enzymatic degradation, bioconversion, cellulose, cellulase, environmental safety*

I. Introduction

The waste accumulation and management is the first among the environmental problems in Ukraine. The organic waste management technologies of the national economy objects, in particular, food enterprises, have been received a great deal of attention both nationally and internationally, due to their specificity and extent of formation and relative homogeneity.

Thus, as a result of the activity of the primary winemaking enterprises, together with discharges of concentrated sewage into the hydrosphere and emissions into the atmosphere, is the annual formation of over 80 thousand tons of solid wastes. Such solid wastes have a wide nomenclature and specific composition and contribute to the formation of environmental dangers in the case of their placement in environmental components.

When processing grapes for grape must, wine fermentation, processing and distilling wine materials, waste is formed, which includes such valuable components as sugar, alcohol and tartaric compounds. The waste such as grape pomace, stalks, yeast deposits, distillery cognac dregs and tartar are recyclable to obtain useful

components. That allows obtaining food and feed products for a number of the economy sectors, as well as reducing the environmental burden.

Bioconversion of renewable plant materials into fuels, feed and food, intermediates for the chemical and microbiological industries is now considered as one of the key biotechnology industries.

Grapes by content of useful components are one of the richest representatives of perennial cultivated plants. A significant part of the grape components after its industrial processing remains in the secondary products - winemaking waste, the main types of which are the grape pomace, stalks, yeast deposits and wine stone. However, in terms of the formation volumes the grape pomace prevails over all other types of the winery solid waste, so one of the most urgent solutions to the problem of winemaking waste recycling is the processing of the grape pomace to feed additive.

The grape pomace includes the grape stalks, husks and seeds, which are both separate wastes of winemaking and a component of the pomace mix. The results of the chemical composition analysis of the grape pomace (Table 1) indicate the value of raw materials for the production of feed additives for cattle by the content of lipids, proteins, carbohydrates, nitrogenous and other compounds.

Table 1. The grape pomace chemical composition

№	Group of substances	% in terms of dry matter
1	Lipids	9,0
2	Hydrocarbons, including	20,1
3	- Monosaccharides	28,0
4	- Cellulose	36,1
5	Lignin	19,0
6	Protein (total)	15,0
7	Ash	1,5
8	Phenolic compounds	6,0

Among the nutrients of the grape pomace a protein has a great importance; its content is 15.0%. The biological value of a protein depends on its amino acid composition [1], so the next stage of the study was to study the amino acid composition of the grape pomace, which revealed that the grape pomace is rich in critical amino acids such as tryptophan (7.2%) and lysine (7.5%), the presence of which contributes to weight gain and optimal metabolism in animals [2, 3].

As mentioned above, the grape pomace contains fragments of the grape husks and seeds in a ratio of 2:1, so one of the most important steps in the research was the detailed study of the chemical composition of both grape husks and grape seeds included into the grape pomace.

Lipids, being isolated from grape seeds, contain 87.0-93.0% of physiologically valuable unsaturated fatty acids, including linoleic (1.3%), linolenic (1.1%), oleic (3.4%), arachidonic acids (19.0%), which are the main source of energy reserve material and perform extremely important physiological functions in cell metabolism and in enzymatic processes [4].

According to the results of experimental studies, the grape husks are rich in carbohydrates, cellulose (39.0%), but poor in lipids (0.4%) and protein (5.8%).

II. Analytical review of literature

As a result of the grapes' industrial processing, a significant amount of waste is generated, which accounts for 10 to 20% of the amount of raw material being processed. The scientific works of researchers [5, 6] in the field of recycling of secondary wine raw materials are based on the data of many years of experimental and analytical works [6, 7]. The total potential of food and feed by-products can be estimated from the data given in Fig. 1.

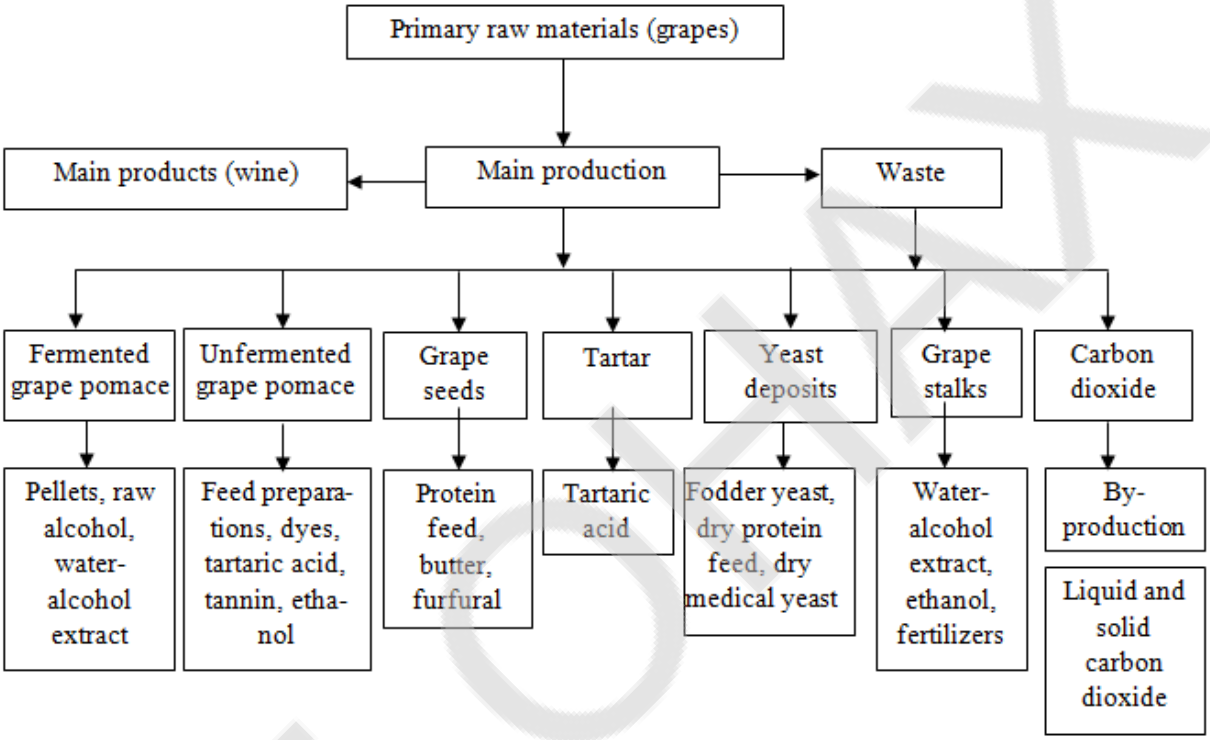

Fig. 1. Scheme of the utilization methods of the wineries production wastes

The grape pomace is the most significant by volume of winemaking waste. It consists of husks, seeds, and liquids (juices and worts). The composition and yield of pomace depends on the method of processing grapes, its varietal features and the spinning degree. The grape pomace (as a percentage of total weight): husks - 37-39; pulps (with a particle size up to 2.5-3.0 mm) - 30-32; seeds - 28-29; grape stalks - 1-1,2; vine residues (sticks) - 0.2-0.25. Given that grape pomace contains valuable components and is the most significant waste, there are many options for processing it.

In one embodiment, the pressed grape pomace is laid in beads. For 5-6 months it is fermented and stored due to the separated CO_2 and ethanol, after which it is subjected to distillation and rectification. The solid residue is squeezed, washed, followed by the separation of wine limestone (WLS) and seeds [8].

In another embodiment, the grape pomace is treated with hot acidified water on continuous extractors. Diffusion juice is neutralized with $CaCO_3$ with the addition of $CaCl_2$. Separated sludge of WLS is dehydrated, distilled and rectified. The grape pomace after extraction and pressing is also dried. The ground grape husk is sent to the feed, and the separated seeds is sent to obtain technical grape oil, tannin and extraction

cake by the press or extraction method. A technology using 0.2-0.4% $NaHSO_3$ solution has been developed for the production of red dye from the red varieties' pomace [9, 10].

Steam and hot air have been proposed as technologies for extraction of winemaking waste instead of sulfuric acid [11], and later the use of complex cellulolytic enzyme preparations has been proposed [12].

The grape stalks are the next ones in volume of the wineries waste; their output ranges from 1.8 to 8.5%. After the grinding process, the grape stalks are separated with little wort content. The wort is separated from the grape stalks by pressing or washing with water. The wort, which is obtained from the high-sugar grape stalks, is used for blending wines; but the wort from the low-sugar grape stalks is fermented and distilled for alcohol. After pressing, the grape stalks are used to obtain fertilizers. The extracts obtained from the grape stalks are used for the production of the colorants and raw alcohol.

A promising way of separating WLS from distillery stillage by clarifying and adding adsorbents has been developed. A biological method of processing cognac distillery dregs with the use of basidiomycetes, which is accompanied by the production of feed product and reduction of environmental pollution [13, 14].

According to literature data [15-17], a complex technology of seed processing was developed to produce grape oil, enotanine, phytin, protein concentrate and refined food oil [18-19].

The processing of the yeast sludge for alcohol, WLS and feed components is carried out on the same equipment as the grape pomace processing. Obtained after wine distillation the cognac distillery dregs are treated with sulfuric acid, filtered or settled, and then WLS is precipitated, a dense precipitate is dried on protein feed. Calcium tartrate is separated from the tartaric solution.

III. Object, subject and methods of research

The predominant substance of the grape pomace chemical composition is carbohydrates, namely, cellulose (36.1%), which must be degraded in the solid waste compound. Cellulose refers to polymers that are poorly soluble, it is determined by the crystalline structure and the cellulose chains packing into microfibrils.

The chemical properties of cellulose are determined by the presence of a β-glycosidic linkage and by three hydroxyl groups in each glucose residue. Amorphous areas of cellulose react faster than crystalline ones. Dense packing of cellulose fiber generally prevents the attack with reagents, resulting in cellulose is characterized by largely toponymic (surface) reactions. That is why enzymatic hydrolysis is essential for the destruction of cellulose, which is the basis of grape pomace, however the cellulose is subjected to chemical action or grinding before the process.

The aim of the research is to study the parameters and the course of the processes of enzymatic degradation of winemaking wastes, in particular the grape pomace, for improving their utilization process and creating an optimally balanced feed additive.

Enzymatic transformation of cellulose is promising not only from point of view of separate low-waste technologies creation, but also from point of view of the ecological danger reduction of various productions, which process vegetable raw materials and are accompanied by the formation of a considerable amount of waste.

The cellulase enzyme catalyzes the breakdown of cellulose to glucose, cellobiose and oligosaccharides production. It is synthesized by microorganisms (bacteria, microscopic fungi and actinomycetes), which mainly hydrolyze cellulose and do not use other components of the nutrient medium as energy sources.

Cellulases are obtained by deep or more often surface cultivation of microorganisms on media with different cellulose-containing substrates (bran, exhausted cossettes, sawdust, straw, woody pulp, paper and viscose mass), purified cellulose, molasses and simple sugars. The enzyme complex formation is influenced by the composition and ratio of the components, the acidity and aeration of the medium. Of the currently known cellulase producers, the most active enzymes producers that are capable of saccharifying natural cellulose-containing substrates are various strains of fungi of the genus *Trichoderma*. The advantage of *Trichoderma* fungi, as a cellulase source, is that they produce a sufficiently complete complex of high yield cellulases. *Trichoderma* fungi were found to exhibit three types of cellulasolytic activity: exo-β-1,4-glucanase (KF.3.2.1), endo-β-1,4-glucanase (KF.3.2.1.4) and β-glucosidase (KF.3.2.1.21).

To determine the features of enzymatic degradation and to determine the optimal regimes of the process, it is necessary to study the physicochemical properties of cellulase. The pH optimum of cellulolytic enzymes was found to be in the range of 4 to 6 pH units. Cellulolytic enzymes are characterized by relatively high thermal stability, the temperature optimum of many of them is 60°C. The qualitative and quantitative composition of the cellulose complex depends on the type of producer and the conditions of its cultivation.

IV. The work results

In the first study stage, the exoglucanase, endoglucanase and glucosidase activities of the *Trichoderma* cellulolytic complex were determined to be 880, 109.1, and 112.9 u/mg cellulase, respectively. The results of the pH- and thermo-optimum and enzyme stability studies are presented in Figures 2-4.

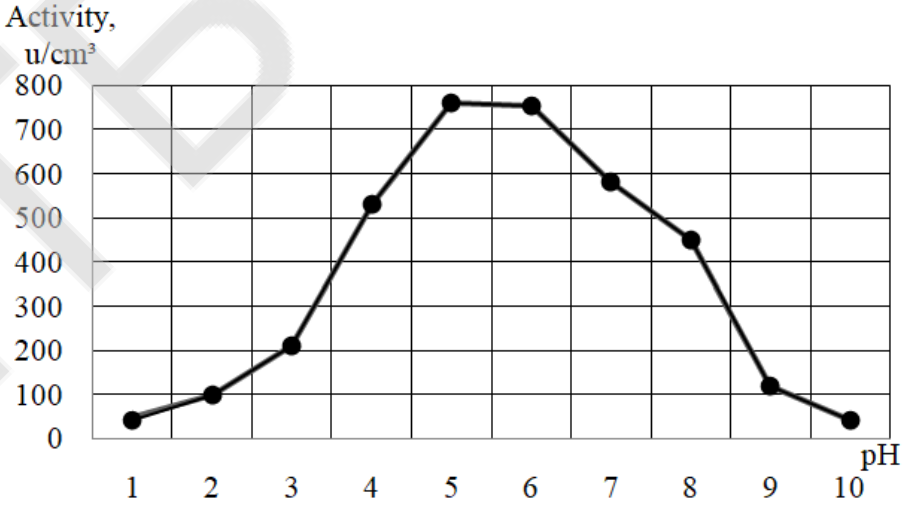

Fig. 2. pH-optimum of the cellulose enzyme

From the presented in Fig. 2 experimental data we can conclude that the pH-optimum of cellulase is observed in the region of 5.0, which indicates that the enzyme belongs to the group of acidic cellulases, which is further indicate a sharp decrease in

the enzyme activity with increasing pH (6.0) and complete lack of activity when pH = 10.0.

When carrying out an enzymatic reaction, there are two different factors, that deal simultaneously, determining the temperature effect: on the one hand - an increase in the initial rate, on the other - denaturation of the enzyme under the action of temperature, which causes a continuous decrease in the concentration of the active enzyme. The optimal temperature depends on the relationship between the temperature effect on the rate of the enzymatic reaction and its effect on the rate of the enzyme denaturation.

The thermo-optimum of the cellulase enzyme was determined at the optimum pH value (5.0) and the temperature change in the range from 20 to 80°C. The maximum activity of the enzyme (Fig. 3) is observed in the temperature range of 40-45°C, with its rapid decrease with further increase in temperature, which is caused by thermal denaturation of the native protein molecule.

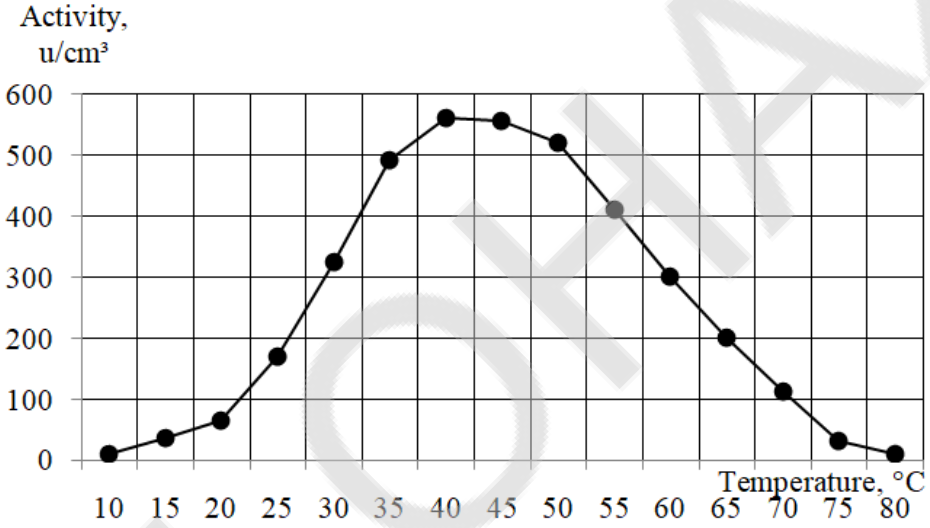

Fig. 3. Thermo-optimum of the cellulase enzyme

pH stability (Fig. 4) was investigated at the optimum pH value (5.0 pH units), in acidic medium at pH<6.0 and in alkaline medium at pH> 8.0 at 40°C for 6 hours. In acidic environments, the activity decreased sharply during the first 20 minutes. At alkaline pH values, a slower inactivation of the enzyme was observed. Complete loss of activity was observed after 3 hours of the enzyme incubation. Under optimal conditions of enzyme functioning the activity is stable for 50 minutes, and then it decreases and is completely lost after 4 hours due to protein denaturation.

The temperature effect on the rate of enzymatic reactions may be due to the action of various factors. Temperature affects the enzyme stability, the decay rate of the enzyme substrate complex, the affinity of the enzyme with the substrate. The cellulase thermal stability was determined at pH=5.0 and at temperature values of 20, 40, 60 and 80°C (Fig. 5).

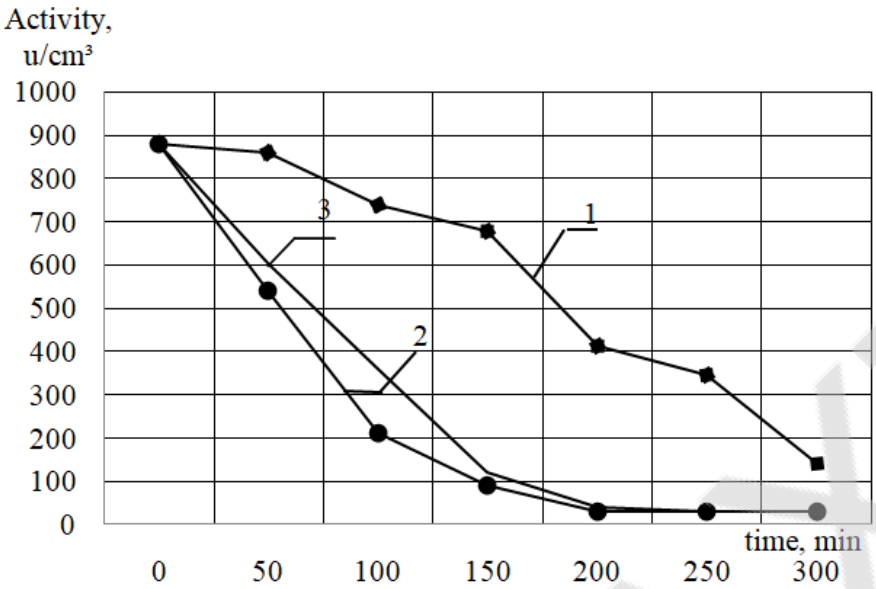

Fig. 4. pH stability of the cellulase enzyme at 40^0C, where 1– pH=5; 2 – pH=2.5; 3 – pH=8

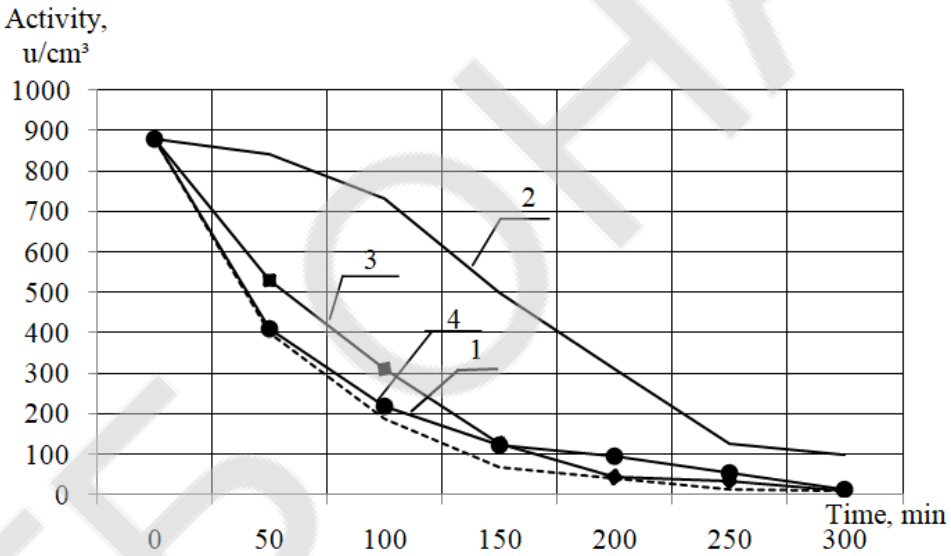

Fig. 5. Thermostability of the cellulase enzyme at pH=5.0, where 1– 20°C, 2 – 40°C, 3 – 60°C, 4 – 80°C.

The obtained results (Fig. 5) allow us to find out that the maximum activity of the enzyme was observed at a temperature of 40°C, complete loss of activity occurred after 200 minutes. At a temperature of 60°C and above there was a sharp decrease in the rate of hydrolysis reaction due to thermal denaturation of the protein.

The purpose of this work stage is to determine the most optimal modes of enzymatic hydrolysis of the grape pomace, for which the role of such parameters as the temperature influence (T, °C), water duty (WD), the duration of the enzymatic hydrolysis process, (τ, min), the pH of the reaction medium, the grinding degree and the enzyme solution concentration on the process of fermentolysis were investigated [20].

From the literature analysis it is known that one of the important parameters of the cellulose hydrolysis process is the water duty, so the next step was to study the

effect of WD, shown in Fig. 6. The obtained results of the study, presented in Fig. 6, allow us to determine that the maximum degree of hydrolysis for cellulose for the grape pomace is the highest at WD 9 and it is 67.1%. The WD increasing does not lead to a significant increase in the hydrolysis level, so it is not advisable to increase the WD.

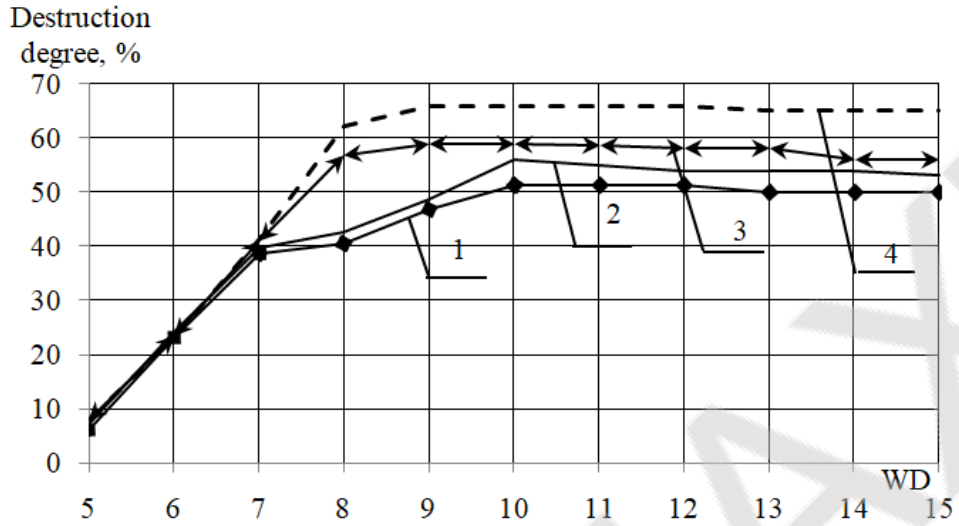

Fig. 6. Dependence of the cellulose hydrolysis degree (%) on WD, where 1 – the grape seeds, 2 - the grape stalks, 3 – the grape husks, 4 – the grape pomace

There are various methods of pre-treatment of cellulose-containing raw materials in order to increase the hydrolysis degree. The mechanical pre-treatment method involves the grinding of raw materials. The influence of the substrate grinding degree on the hydrolysis degree is shown in Fig. 7.

The change in the hydrolysis degree from the particle size, shown in Fig. 7, allows us to conclude that the maximum degree of cellulose hydrolysis is achieved with a particle size of 500 μm. This is because the grinding increases the contact surface area of the biopolymers of the raw material with the enzyme complex and leads to an increase in the rate of enzymatic transformations.

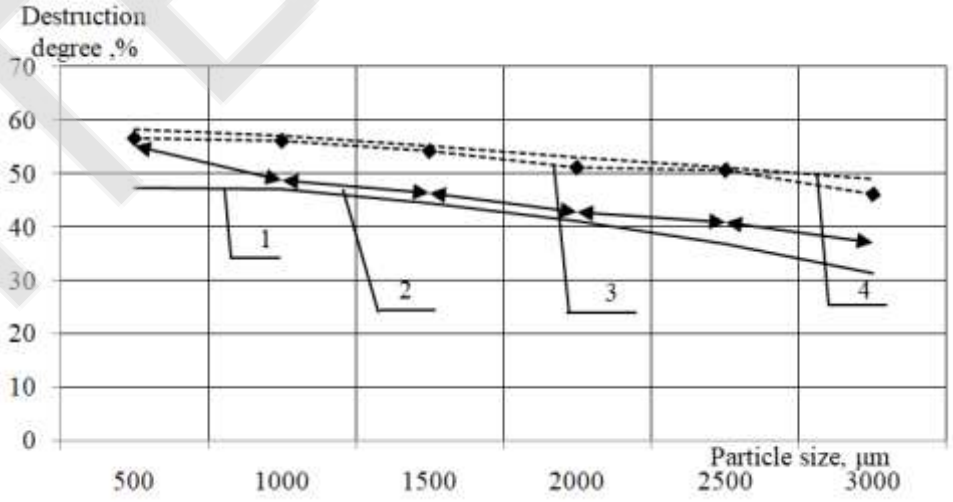

Fig. 7. Dependence of the cellulose hydrolysis degree (%) on the substrate grinding degree, where 1 – the grape seeds, 2 – the grape husks, 3 – the grape stalks, 4 – the grape pomace

One of the most important factors that influence the fermentation process is the temperature regime. The temperature effect on the cellulose hydrolysis process is shown in Fig. 8.

Thus, the data of Fig. 8 determine that the maximum of the cellulose hydrolysis degree is observed at a temperature of 40°C for the grape pomace and it is 70.1%. With increasing temperature, the degree of hydrolysis decreases due to the thermal denaturation of the enzyme protein part.

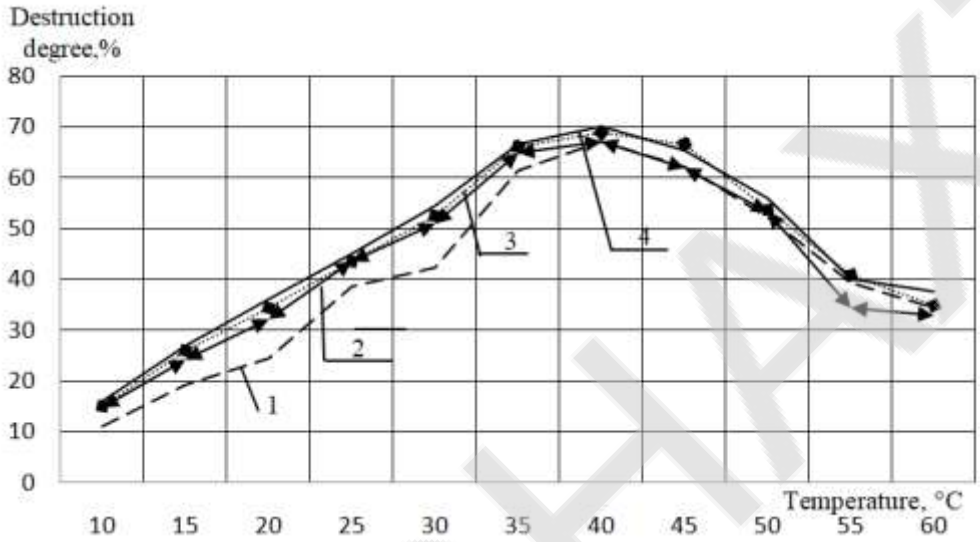

Fig. 8. Dependence of the cellulose hydrolysis degree (%) on temperature, where 1 – the grape seeds, 2 – the grape stalks, 3 –the grape husks, 4 – the grape pomace

The next stage of research was to determine the optimal pH value for the enzymatic hydrolysis process of cellulose (Fig. 9), since the enzymes activity depends on the pH of the solution in which the enzymatic reaction takes place.

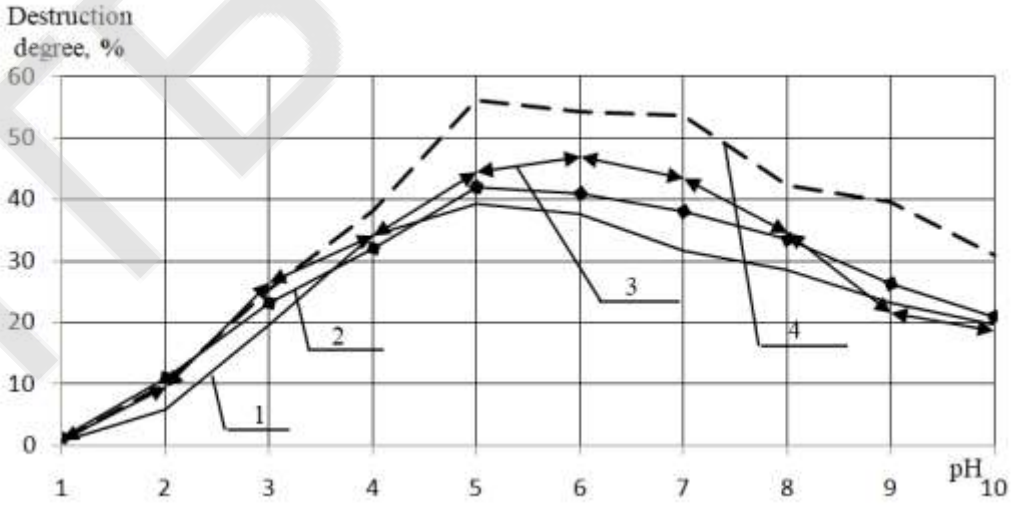

Fig. 9. Dependence of the cellulose hydrolysis degree (%) on the pH value of the medium, where 1 –the grape seeds, 2 – the grape husks, 3 – the grape stalks, 4 – the grape pomace

The data, presented in Fig. 9, allow us to determine that the maximum degree of cellulose hydrolysis in the substrate is observed at pH =5.0 exactly for the grape pomace and it is 56.2%.

The process duration of enzymatic hydrolysis is essential for improving the technology of waste processing into the feed resource, so the effect of the process duration on the degree of cellulose destruction was determined separately (Fig. 10).

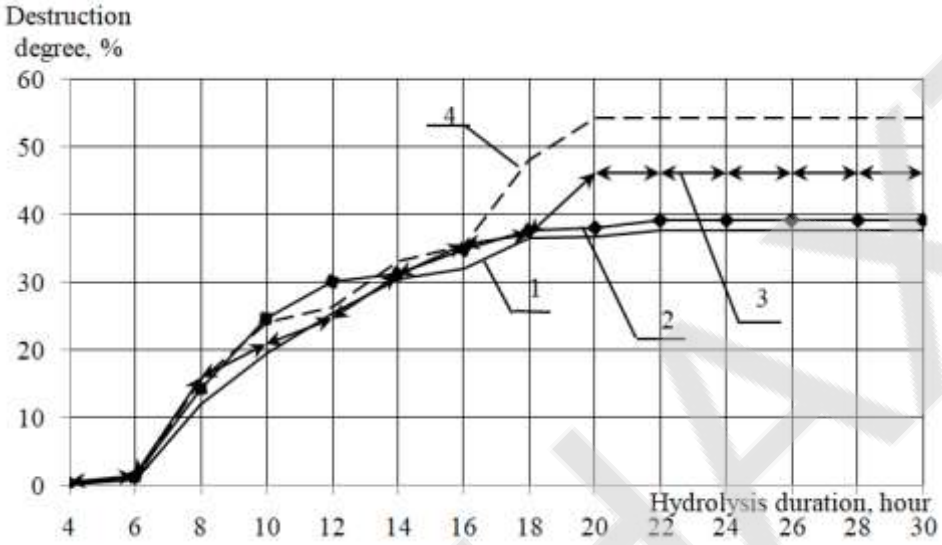

Fig. 10. Dependence of the cellulose hydrolysis degree (%) on the fermentation process duration, where 1 – the grape seeds, 2 – the grape husks, 3 – the grape stalks, 4 – the grape pomace

The study of dependencies in Fig. 10 lead to the conclusion that the destruction of the grape pomace lasts the least time compared to other types of waste, taken separately, and it takes 20 hours with a degradation rate of 54.3% versus 22 hours and destruction of the grape seeds and husks up to 40%. Further retention of the substrate is impractical.

The enzyme concentration significantly influences the speed of enzymatic reaction and cellulose destruction [3, 20] so determining the optimal concentration of cellulase is an important stage of research and it is presented in Fig. 11.

Data of Fig. 11 allow us to conclude that the highest degree of cellulose destruction for the grape pomace in fermentation by cellulose is observed at an enzyme concentration of 0.3% and it is the maximum value (52.6%). Increasing the enzyme concentration does not lead to a significant increase in the destruction degree, and a decrease in the concentration leads to its decrease [20].

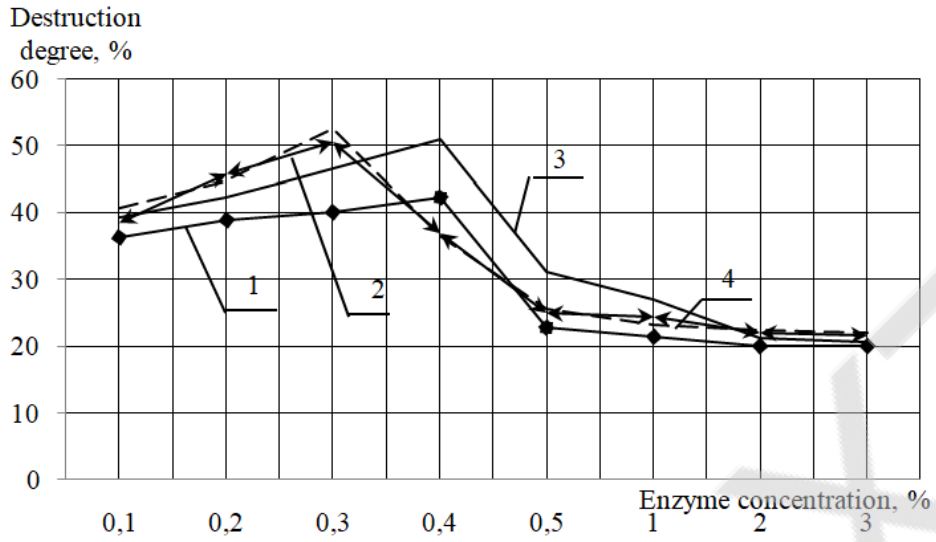

Fig. 11. Dependence of the cellulose hydrolysis degree (%) on the concentration of the enzymatic solution, where 1 – the grape seeds, 2 – the grape husks, 3 – the grape stalks, 4 – the grape pomace

V. Conclusions

Investigations into the enzymatic degradation processes of winemaking waste have made it possible to determine the basic physicochemical properties of the cellulose enzyme that affect the destruction process, and hence the waste processing, and the optimal regimes of the fermentation process.

Thus, it is found that the pH optimum of cellulase is in the region of 5 pH units, and the pH stability is observed for 50 minutes. The maximum activity of the enzyme was observed at a temperature of 40°C, and its complete loss occurred after 200 min.

The most optimal parameters of the enzymatic hydrolysis process of the grape pomace were obtained in comparison with the destruction of certain types of waste, such as the grape seeds, husks and stalks of grapes. Comparative analysis leads to the conclusion that enzymatic degradation is of paramount importance for the grape pomace, since its degree is maximum for the complex substrate, as studies have shown.

Thus, the maximum degree of hydrolysis for cellulose for the grape pomace is greatest at WD 9 (67.1%), at a temperature value of 40°C (70.1%) and at a pH value of 5.0 units (56.2%). Also, the destruction of the grape pomace lasts the least time compared to other types of waste and takes 20 hours at a degradation rate of 54.3%, and the highest degree of cellulose destruction for the grape pomace by the cellulose fermentation is observed at an enzyme concentration of 0.3% and it is the maximum value - 52.6 %.

That’s why the enzymatic degradation of the grape pomace, as a common waste of the food industry, in particular, the wine industry, is a relevant and effective biotechnological processing method to produce a useful product (feed additive), to increase the role of resource conservation and to reduce the environmental safety level by reducing solid waste.

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НТБ ОНАХТ

ECOLOGICAL ASPECTS OF NO-TILL TECHNOLOGY IN THE CONDITIONS OF SOUTHERN STEPPE OF UKRAINE

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Abstract. *It was studied the effect of No-till technology on soil density, soil moisture reserves, soil microbiological activity, and crop yields. It was found that the soil density under winter wheat according to No-till technology did not exceed the optimal index of 1.30 g/cm^3 and it was 1.14-1.25 g/cm^3 for the sowing period and it was 1.18-1.29 g/cm^3 for the harvesting period. The moisture content in the soil was significantly higher according to No-till technology and it was amounted to up to 21.3-27.6 mm during the winter wheat sowing period and it was 22.4-27.4 mm during the harvest period, where as with traditional technology this indicator was 16.8-20.2 mm and 17.3-23.9 mm, respectively. The average yield of winter wheat using No-till technology for two years was 4.54 t / ha, yield of soybean was 2.24 t / ha, yield of sunflower was 2.71 t / ha. The increase in crop yield up to 14.3-22.9 % by No-till technology allowed us to draw a conclusion about optimizing soil fertility indicators in the climatic conditions of the southern Steppe zone of Ukraine in comparison with traditional intensive technologies.*

It was shown that the introduction of No-till technology would improve environmental processes in the soil, reduce the anthropogenic load on agroecosystems and the manifestation of erosion processes, increase crop yields and reduce energy costs for their cultivation.

Keywords: *soil, No-till technology, soil density, soil moisture, fertility, yield.*

I. INTRODUCTION

The Earth's soil cover plays a key role in maintaining the complex functioning of the biosphere, ensuring ecological balance and preserving biodiversity, and it is the main natural resource for growing crops and food production.

In the modern world, soil degradation processes are rapidly developing due to excessive ploughing of the soils, non-compliance with science-based farming systems and agronomic and environmental land use standards, and the lack of an appropriate system for managing soil fertility processes. According to [1, 2], 33 % of global soil resources are degraded due to erosion, pollution, compaction, salinization, acidification, dehumidification, and other adverse processes associated with poor soil use.

At the same time, in the 21st century, the food shortage on the planet is rapidly increasing. The reasons for this are partly due to the rapid rate of population growth on Earth, according to scientists, by 2050 the world's population will exceed 9.2 billion [1]. The International Research Institute for food policy showed that in 2010, more than 1.0 billion people suffered from hunger, while more than 20,000 people died every day, most of them children under 3 years of age. The highest level of hunger is recorded in sub-Saharan Africa and South Asia [3]. Scientists predict that by 2030, more than

2.5 billion of the world's population will suffer from hunger, which is at least a third of the world. Therefore, in order for humanity to survive for the next 30 years, it is necessary to increase food production by about 70% [1]. According to the FAO definition, only a few countries in the world can accelerate food production and stop the rapid development of the global food crisis, including Ukraine [4].

Ukraine is one of the largest countries in Europe with a strong land and resource potential. About 42 million hectares of the state's 60.3 million hectares of land, are agricultural land (70%), 32.5 million (77.3%) of which are arable land. Ukraine is home to about a third of the world's and 70% of Europe's chernozem reserves, as well as favorable climatic conditions for growing the most important food crops [1]. However, now, the fertility of chernozems is reduced due to irrational use, and natural processes, in particular, climate changes.

In this regard, it is particularly important to research and develop energy-saving and resource-saving farming systems, in particular, the promising No-till technology for Ukraine. The No-till system is a modern farming system that provides for the abandonment of tillage, sowing on stubble, the use of cover crops and the use of crop rotation. No-till is based on soil protection: sowing is performed without mechanical impact on the soil. Crop residues form a mulching layer. It preserves moisture, protects the soil from water, wind erosion and dust storms, which is especially important in the arid conditions of the southern Steppe of Ukraine. The spread of No-till technology in countries with an intensive agricultural sector (the United States, Canada, Brazil, and other Latin American countries) indicates that it meets modern economic, environmental, and social conditions [5].

The goal of this work is to study the effect of No-till technology on the physical and biological properties of soil and crop yields in the southern Steppe of Ukraine.

To achieve this goal it was necessary to solve the following tasks:

1) to identify the effect of No-till technology on soil density in a layer of 0-30 cm;
2) to determine soil moisture using No-till technology;
3) to investigate the microbiological activity of the soil;
4) to determine the effect of No-till technology on soil fertility and crop yields.

II. ANALYTICAL REVIEW OF THE LITERATURE

Ecological and economic functions of soils. Soil cover, as the main component of land resources and as a macroecosystem, plays a very important role in the biosphere. In general, it acts as a regulatory mechanism for interaction between geospheres on the verge of interaction between biota, the lithosphere and the atmosphere. In the geosphere system, the soil is one of the earth's shells of the pedosphere and it performs important functions that are of direct ecological significance for plants, bacteria and other organisms, including humans [6]. Among the main functions of the soil cover, there are biospheric and ecological functions in relation to living organisms.

The most important biosphere function of the soil cover is to provide life on Earth. It consists in the concentration of biophilic elements necessary for organisms in the soil in the forms of chemical compounds available to them. The soil is also able to accumulate the necessary water supply for the primary producers of terrestrial ecosystems in the forms available to them [8].

The soil provides a constant interaction of large (geological) and small (biological) cycles of substance rotations. All biogeochemical cycles of elements, including such important biophiles as carbon, nitrogen, and oxygen, as well as flow-forming cycles of water occur only with the participation of soil [6].

The soil cover performs regulation of the composition of the atmosphere and hydrosphere, it does this due to its high borehole (40-60 % of the volume) and dense population of organisms (plant roots, animals, microorganisms and worms). At the same time, there is a constant gas exchange between the soil and the surface atmosphere [7, 8].

The soil regulates the intensity of biosphere processes by regulating the density and productivity of organisms on the earth's surface. The limiting factors of the soil include: high acidity or alkalinity, low water capacity, the presence of toxic substances, strong compaction, and the like [6].

In the biological cycles of synthesis and destruction of organic matter that constantly occur on the earth's surface, the soil acts as an accumulator of the residual products of these cycles. Organic matter, especially its specific part – humus, thanks to the fertility function provides stability of the process of production – destruction of biomass [6-8]. Another important ecological function of soil is that it is the main source of nutrition elements for plants and microorganisms [7].

Among the material conditions which are necessary for human life, a special place is occupied by the soil cover of the Earth. It is the first prerequisite and natural basis in many sectors of the national economy. In different industries which use land, different soil properties are taken into account.

Agriculture is a branch of the national economy that is completely based on the use of soils, their main property of fertility. In this area, the soil is the economic basis, the main means of production. In addition, the soil in agriculture performs two more functions: at the same time it is both an object of labor and a product of labor [9, 10].

No-till system in the world. According to the latest data the volumes of using No-till technology in the world are in the range of 105 million hectares including, in US the squares, with embedded new technologies, are of approximately 87 million hectares, in Australia they are 12 million hectares, in other countries they are 6 million hectares. Sum of the total area of six countries: such as Brazil, Argentina, USA, Canada, Australia and Paraguay have 95% of America area. The European continent, including the Eastern part of it, accounts for 2.5-3%. Each year, the area under No-till grows by about 1 million hectares [6].

Zero-tillage technology is now a fundamental and somewhat revolutionary approach to agricultural technology that can stop soil degradation and create the prerequisites for sustainable land use. After 10-15 years, the soil under permanent vegetation cover switches to the natural non-degradable mode of functioning of energy and substances and at the same time it does not lose its productive function [11].

In the world, this technology is considered primarily as a soil protection measure. Followers of zero-tillage claim that no-till technology is effective in all soil-climatic and economic conditions. There are positive examples from Equatorial countries (Kenya, Uganda), from countries which are located at 40º South latitude (Argentina, Chile) or 60º North latitude (Finland). Zero-tillage is effective at an altitude of 3000 m,

as noted in Bolivia and Colombia, if the soil contains 90 % of the sand fraction (Australia, Paraguay) or 85% of the clay (Brazil), if the precipitation level is 200 mm (Western Australia), 2000 mm (Brazil) and even 3000 mm (Chile) [12]. At the same time, permanent and necessarily significant vegetation cover (mulch) on the soil surface is considered as a new strategy for weed control. Tools for cutting annual weeds without breaking the mulch have been widely used [13].

The analysis of literature sources confirms that the main advantages of zero-tillage are in energy saving and soil protection. However, even these advantages do not contribute to the spread of zero-tillage in European countries, in particular progressive ones in the agricultural sector such as Great Britain, Germany, and France. At the same time, the experience of South American countries is very effective as in a short time, archaic backward agriculture was transferred to the level of modern high-tech and productive agriculture [13, 14].

The global trend towards the minimization of tillage is now determined not only by the attempt to reduce costs of material resources and labor of tillage, and how much control of soil-creating cultural processes and the expanded reproduction of soil fertility, which is unrealistic at a constant shelf processing [15].

Due to the growing problem of contamination and the development of diseases, even where the minimum-tillage and zero-tillage has already been successfully tested, farmers from different countries perform plow processing every 4-5 years to clean the fields [16]. On the other hand, a permanent and necessarily significant thickness of vegetation (mulch) on the soil surface is at the same time considered as a new strategy for weed control. Tools for cutting annual weeds without breaking the mulch have been widely used [13]. In some farms, at first, problems with sprouting the seeds of the forerunner crops can lead to certain crop losses due to little experience, inadequate mechanization, or unfavorable weather conditions [17].

In the US, the rationale for implementing No-till is to increase productivity and the soil protection value of zero-tillage. For Canada, where grain production is concentrated in the steppe regions, the main factor is the accumulation and preservation of moisture. The same factor applies to agriculture in the Western provinces of Australia. For the tropics of Brazil, the No-till technology is a government program that aims to preserve soil fertility and protect it from water erosion. Regarding the European continent, where the undisputed leader is the UK, the main argument for introducing zero-tillage is to increase productivity at the stages of preparing the soil and sowing grain crops [18].

This technology is also becoming widespread in other countries of the world, as every year the area under No-till technology in the world is growing by more than 1 million hectares [19]. Among the countries of Western Europe, Spain and France have the largest areas under No-till technology, although in Europe as a whole, the share of land under such technology does not exceed 3% in the structure of cultivated areas [20].

No-till system in Ukraine. The development of the agricultural sector of Ukraine in recent years has a stable and positive direction of growth, there is an increase in the rate of agricultural production [21].

Therefore, in Ukraine, which is an agricultural country and it has 33 million hectares of agricultural land (70 % of the total territory, 80 % of which is arable land), issues and measures on soil quality and fertility should be in the first place both at the state level and among agricultural producers and agricultural scientists [22].

Zero-tillage is a highly effective agromeliorative method of retaining and preserving soil moisture from precipitation. In summer, it has a typical effect of 30-50 mm, that's why it stabilizes agriculture, especially during severe droughts. Therefore, the most promising area for the introduction of minimum-tillage and "zero-tillage" is the steppe zone, a significant part of the Right-Bank Forest-Steppe. [15]

According to N. K. Shikula and G. V. Nazarenko, permanent minimum-tillage of the soil ensures the accumulation of organic substances, nutrients and accumulated energy in the upper part of the soil profile, which creates the basis for expanded reproduction of chernozem fertility [23]. It is established that as longer the systematic zero tillage is applied, as higher the yield of field crops is [24].

According to experts from the European continent, Ukrainian chernozem soils are ideal objects for the introduction of zero-tillage [25], which makes it possible to manage the cultural soil-making process and access to expanded reproduction of soil fertility, which is unrealistic due to constant cultivation [26].

The advantages of zero tillage are demonstrated by the experience of a number of Ukrainian agricultural enterprises which have successfully introduced the No-till system. Among them, we should highlight the company "Agromir", "Agrosoyuz", the agronomic experimental station NUBiPu of the Vasilkovsky district of the Kiev region [5]. According to the researchers of Uman NUS during the first years of its development water supply conditions of crops did not worsen [27], and the density of a 30-centimeter layer of podzol chernozem though somewhat increased, but it remained within the optimal parameters [28]. Progressive is the experience of using the No-till system in the FH "Arcadia" of the Mykolaiv region, where corn, winter wheat and legumes (peas, chickpeas, soy) are grown using this technology [29].

Summarizing the scientific data obtained both in foreign countries and in Ukraine, we can conclude that it is promising to conduct research on the environmental aspects of the No-till technology and its impact on soil fertility in the southern Steppe zone of Ukraine.

III. OBJECT, SUBJECT AND RESEARCH METHODS

The object of research is the southern Chernozem soil with winter wheat agrocenosis using the No-till technology.

The subject of research is the density, humidity and microbiological activity of the soil, the yield of winter wheat, soy, and sunflower.

The research was conducted in 2017-2019 yrs on the basis of the FH "Arcadia" of the Bratsk district of the Mykolaiv region, located in the southern Steppe zone of Ukraine. The average annual precipitation is 350 mm, the absolute maximum air temperature in July-August is 32-38^{0}C. The area of cultivated land is 1600 ha. The structure of the farm's sown areas are: soy as 25-30%; winter wheat as 10-15 %; winter barley as 10-15 %; corn as 10-15 %; sunflower as 20-25 %; rapeseed as 7-10 %; peas as 5-7 %; mustard as 2%; chickpeas as 2%.

The soil of the experimental field is southern low-humus medium-loam chernozem. The humus content in the layer 0-30 cm was 2.4 %, the content of light-hydrolyzed nitrogen by Tyurin is 6.3 mg/100 g soil (low), mobile phosphorus by Machygin is 6.0 mg/100 g soil (medium), exchangeable potassium by Maslova is 24,0 mg/100 g of soil (high).

The research was carried out in the seventh and ninth years of the introduction of No-till technology. To determine the agrophysical and biological indicators of soil fertility, experimental plots of winter wheat, whose predecessor was soy, were used as a model system. For sowing of winter wheat using the No-till technology, it was used the JD 7000 stubble grain seeder, which allowed to apply mineral fertilizers simultaneously with sowing. As a control, wheat plots were grown using the traditional technology adopted for the southern Steppe zone with intensive soil cultivation, including plowing to a depth of 20 cm up to 22 cm. We also determined the yield of winter wheat, soy and sunflower, which were grown using No-till technology compared to the control.

We used the following research methods: empirical (field, laboratory-field, laboratory); theoretical (comparison, analysis, commensuration, synthesis); statistical (descriptive statistics); computational and comparative (justification of research results and dependencies of influence of factors). The soil density was determined using the Kaczynski method, and the moisture content was determined using the thermostatic-weight method [30]. Determination of the total microbiological activity of the soil was carried out according to the generally accepted method based on the intensity of decomposition of linen [31].

The area of experimental plots is 0.05 ha, their placement is randomized. Their repeatability is four times.

IV. RESULTS OF RESEARCH

The main principle of the No-till system is to use natural processes that occur in the soil. According to a number of researchers [5, 23, 24], an untilled field to a depth of 1 m - 2 m is permeated with billions of capillaries left after the roots of annual plants or these capillaries formed as a result of the life of earthworms and other organisms. Through these thin, but deep passages, the earth is saturated with moisture, and in winter it freezes and breaks the channels. This is how natural loosening occurs. Sowing is carried out with a special seeder which cuts off crop residues, it distributes them on the soil surface, it makes a furrow in the soil surface of the desired depth, it sows the seeds and it closes the seedbed. The No-till technology has a set of positive environmental consequences. Crop residues remain in the field, serve as mulch for the soil, they retain moisture, reduce soil temperature, protect the soil from erosion, they make it possible to manage soil carbon, which is the basis of humus, it improves the soil structure, and it is a substrate for energy production by microorganisms. Also, the No-till technology significantly reduces the cost of fuel for soil treatment, respectively, it reduces emissions of carbon dioxide into the atmosphere, and organic matter created by removing carbon dioxide from the atmosphere is fixed in plant residues.

The No-till technology is particularly relevant in the arid conditions of the southern Steppe zone of Ukraine, where the limiting factor for growing high yields of

strategic crops is moisture, the soils are subject to wind erosion, and there are dry winds in the spring.

Among the agrophysical indicators of soil fertility, the soil density and soil moisture reserves have the greatest impact on crop yields.

Soil density. Density is an important indicator of fertility. The optimal density for most crops is in the range of 1.0 up to 1.3 g / cm^3. With these density values, the most favorable water, heat, air, and nutrient regimes are created in the fertile soil layer, as well as the most optimal conditions for the development of the root system. Under the influence of intensive load of agricultural machinery, the soil density can increase to the level of 1.4 up to 1.6 g / cm^3 or more, at the same time, not only the arable layer, but also the subsurface layer is re-compacted [12].

As a result of the conducted research, it was found that the density increased with the depth of the soil layer and the time from sowing to harvesting of winter wheat using both traditional technology and No-till (Table. 3.1).

Table 3.1

Soil density under winter wheat according to No-till technology, g / cm^3

Technology	Soil layer, cm	Period of sowing		Period of harvesting Harvest period	
		2017 yr	2018 yr	2018 yr	2019 yr
Traditional (control)	0-10	1,09	1,10	1,14	1,18
	10-20	1,12	1,12	1,20	1,24
	20-30	1,16	1,18	1,26	1,25
No-till	0-10	1,16	1,14	1,22	1,18
	10-20	1,20	1,17	1,27	1,22
	20-30	1,25	1,22	1,29	1,26

In the control, the soil density fluctuated between 1.09-1.18 g / cm^3 for the sowing period and it increased from 1.14 up to 1.25 g / cm^3 for the harvest period. In the absence of mechanical treatment of the soil, the density was significantly higher, it was 1.14 up to 1.25 g / cm^3 for the sowing period and it grew from 1.18 up to 1.29 g / cm^3 for the harvesting period. However, over the years of research, the soil density of the No-till technology in different periods was within the optimal limits and it did not exceed the equilibrium index, which was 1.30 g/cm^3.

Increasing the density of the soil layer 0-10 cm in the no-till variant from 1.14 up to 1.16 g / cm^3 compared to 1.09 up to 1.10 g/cm^3 in the control did not have a negative impact on the emergence of winter wheat seedlings and their further development and overwintering (Fig. 3.1). This indicates that this density of the seedbed soil does not create a mechanical barrier to wheat seedlings and it provides a sufficient level of aeration.

Figure 3.1-Winter wheat in the tillering phase using No-till technology, December 10, 2018

Soil moisture. In the southern Steppe zone of Ukraine, the limiting factor for obtaining stable crop yields is moisture. Especially important factors are the reserves of available moisture in the soil for obtaining seedlings. Often in the fall or spring, there is not enough moisture in the soil, so technologies aimed at accumulating and preserving moisture in the soil are relevant.

The moisture content in the soil under winter wheat was determined during the sowing period and before harvesting (Table. 3.2).

Table 3.2

Moisture content in the soil under winter wheat according to No-till technology, mm

Technology	Soil layer, cm	Period of sowing		Period of harvesting	
		2017 p.	2018 p.	2018 p.	2019 p.
Traditional (control)	0-10	18,4	20,2	23,9	22,0
	10-20	17,4	19,5	20,1	19,2
	20-30	16,8	17,6	17,3	18,0
No-till	0-10	25,2	27,6	27,4	26,3
	10-20	23,7	24,8	25,3	25,3
	20-30	21,3	23,0	22,5	24,0

Analysis of the results shows that with the No-till technology, soil humidity was higher compared to the control in all layers, both during the sowing period and during the harvesting period of winter wheat. It is especially important that during the sowing period, the humidity in the experimental version in the upper layer significantly exceeded this indicator in the control, which was an important condition for the emergence of seedlings.

Thus, the moisture content in the soil was significantly higher according to No-till technology and it was amounted from 21.3 up to 27.6 mm during the winter wheat sowing period and it was from 22.4 up to 27.4 mm during the harvest period, whereas

with traditional technology this indicator was from 16.8 up to 20.2 mm and from 17.3 up to 23.9 mm, respectively.

Microbiological activity of the soil. Soil is an organo-mineral substrate with a characteristic zoning and individual composition of microorganisms of different levels of organization which completely populate it. Soil microorganisms play a key role in the formation of fertility, transforming organic residues and ensuring the synthesis of humus substances in the soil. Cellulose is the main component of plant matter, which accounts for 40-70 % of the annual organic matter produced on the planet. The decomposition of cellulose is the largest natural destructive process on the scale, soil microorganisms play the main role in which [31].

In our research, we determined the overall microbiological activity of the soil based on the decomposition of cellulose (linen fabric), depending on the technology of soil treatment. The experiment was laid in two terms – during the sowing period (October) and the harvest period (end of June - beginning of July), in the soil layer 10-20 cm, the exposure of samples in the soil for 20 days.

Analysis of the results of the study on the intensity of linen fabric decomposition showed that the overall microbiological activity of the soil depended on both the technology and the duration of the research (Table. 3.3, Fig. 3.2). When comparing the effect of soil treatment technology on the activity of soil microorganisms, it was found that in both periods of research, the highest percentage of decomposition was observed when using the No-till technology.

Table 3.3

The intensity of decomposition of linen fabric in the soil under winter wheat by No-till technology, %

Technology	Period of sowing		Period of harvesting	
	2017 yr	2018 yr	2018 yr	2019 yr
Traditional (control)	14,2±1,2	11,9±2,1	20,7±2,5	24,0±2,3
No-till	22,0±2,4	19,7±2,7	35,1±2,9	40,7±3,7

a **b**

Figure 3.2- The rate of decomposition of linen fabric in the soil under winter wheat, depending on the application of the technology: a - traditional (control), b - No-till

In June-July, the loss of linen fabric weight was by 7.8% higher compared to the control, and in October it was by 14.4-16.7 %. Obviously, the revealed pattern is

associated with a large amount of substrate for microorganisms using the No-till technology and higher soil moisture compared to traditional technology, which contributes to the reproduction of microorganisms.

The greatest loss of fabric mass occurred during the harvest period (June-July), when the environmental conditions for cellulose-destroying microorganisms are more favorable. It is known that for cellulose-destroying bacteria, the optimal temperature of life is 20-25 C and the soil humidity is 60-70% of the total saturation of the soil with water. In October, the soil temperature decreased, which caused a decrease in microbiological activity. In the control, the rate of decomposition of linen fabric during the harvesting period was 20.7-24.0 %, which was by 6.5-12.1% more than during the harvest period. According to No-till technology, the loss of fabric mass during the harvest period was 35.1-40.7 %, which was by 13.1-21.0% more than during the sowing period.

Thus, the use of No-till technology in the cultivation of winter wheat contributed to an increase in the overall microbiological activity of the soil. When using this technology, the highest rate of decomposition of flax tissue in the soil was observed during the harvest period of 35.1up to 40.7 %, which was by 14.4-16.7% more than in the control period.

Crop yield. Yield is the amount of crop production obtained from one hectare as a result of the vital activity of a certain set of plants, which consists in the absorption of nutrients and water from the ground and the synthesis of organic substances under the influence of solar energy. That is, yield is an integral indicator of soil fertility.

In our studies, we determined the yield of agricultural crops in the crop rotation with such an alternation of crops: soy, winter wheat, soy, and sunflower. The yield was determined separately using the Ag Leader Technology device (Fig. 3.3) and the weight method.

a **b**

Figure 3.3 - Determination of soybean yield:
a - using the Ag Leader Technology device; b - test area before harvesting

Analysis of the data table. 3.4 shows that growing of all the crops included in the research program using No-till technology provided a significant increase in yield compared to the control.

Table 3.4

Crop yield using No-till technology, t / ha

Culture	Technology	Crop yield, t/ha			
		2018 yr	2019 yr	average for 2018-2019 yrs.	± to control
Winter wheat	Traditional (control)	3,21	4,12	3,67	-
	No-till	3,86	5,21	4,54	0,87
HIP_{05}	-	0,42	0,48	-	-
Soya beans	Traditional (control)	2,03	1,89	1,96	-
	No-till	2,50	2,18	2,24	0,28
HIP_{05}	-	0,42	0,27	-	-
Sunflower	Traditional (control)	1,98	2,19	2,09	-
	No-till	2,56	2,85	2,71	0,62
HIP_{05}	-	0,32	0,45	-	-

The average yield of winter wheat for two years using No-till technology was 4.54 t/ha, which was by 0.87 t/ha (23.7 %) more than the control. The yield of soybeans was 2.24 t / ha, and the addition to the control was 0.28 t / ha (14.3 %). Sunflower formed a yield in the experimental version of 2.71 t/ha, which was by 0.62 t/ha (22.9 %) more than the control.

The increase in crop yield of 14.3-22.9 % by No-till technology allows us to draw a conclusion about optimizing soil fertility indicators in the climatic conditions of the southern Steppe zone of Ukraine in comparison with traditional intensive technologies.

Environmental aspects of No-till technology. The analysis of modern literature sources and scientific publications and the results of our own experimental studies allow us to make the following generalizations about the environmental advantages of the No-till technology:

1. The soil density in different periods of winter wheat cultivation did not exceed the equilibrium index, which was 1.30 g/cm^3.

2. Soil moisture was higher compared to the control in all layers both during the sowing period and during the harvest period of winter wheat.

3. It was revealed an increase in the overall microbiological activity of the soil.

4. Increase of productivity of agricultural crops amounted from 14.3 up to 22.9%.

5. Thanks to the plant residues, a mulching layer is formed on the field surface, which helps to reduce the soil temperature, moisture losses and to make the manifestation of wind and water erosion.

6. Organic carbon losses are reduced due to a decrease in mineralization intensity and increased humification.

7. Fuel costs are reduced by about 50 % compared to traditional technology, which helps reduce greenhouse gas emissions.

The results of the research were implemented in the FH "Olena" of the Bratsk district of the Mykolaiv region and they were tested at the all-Ukrainian scientific and practical conference "Actual problems of the agricultural industry and ways to solve them" (Mykolaiv, 4-6 December 2019 yr) [32].

V. CONCLUSIONS

On the basis of the conducted scientific research, the ecological justification for the use of No-till technology in the southern Steppe zone of Ukraine is given. Based on the results obtained, the following conclusions are formulated:

1. The soil density under winter wheat according to No-till technology did not exceed the optimal index of 1.30 g/cm3 and was 1.14-1.25 g/cm3 for the sowing period and 1.18-1.29 g/cm3 for the harvesting period.

2. The moisture content in the soil was significantly higher according to No-till technology and amounted to 21.3-27.6 mm during the winter wheat sowing period and 22.4-27.4 mm during the harvest period, whereas with traditional technology this indicator was 16.8-20.2 mm and 17.3-23.9 mm, respectively.

3. The use of No-till technology helped to increase the overall microbiological activity of the soil – the intensity of decomposition of flax tissue in the soil during the harvest period was 35.1-40.7 %, which is 14.4-16.7% more than in the control.

4. The average yield of winter wheat using No-till technology for two years was 4.54 t / ha, soybean-2.24 t / ha, sunflower-2.71 t / ha. the Increase in crop yield of 14.3-22.9 % using No-till technology allows us to conclude that soil fertility indicators are optimized in the climatic conditions of the southern Steppe zone of Ukraine in comparison with traditional intensive technologies.

5. The positive environmental effects of No-till technology was noted, such as a reduction in moisture loss, organic carbon and water and wind erosion, as well as a reduction of about 50% compared to traditional technology, which contributes to a reduction in greenhouse gas emissions.

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НТБ ОНАХТ

THE ROLE OF SOIL MICROBIOCENOSIS IN THE COMPOSTING OF THE ORGANIC COMPONENT OF THE MUNICIPAL SOLID WASTE

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Annotation. *In order to increase the efficiency of composting the organic component of solid municipal waste as a highly effective biotechnological method, and to compare the characteristics of the processes, it is suggested to use soil as an inoculum, as a microbiological additive - an extract from the soil.*

The article presents the results of the study of the soil microbiocenosis qualitative and quantitative composition in order to use it as an inoculum in the process of composting the organic part of solid municipal waste. The influence of microbiological additive on the process of the organic waste composting for acceleration in mesophilic and thermophilic temperature regimes with controlled parameters was studied.

The results of the conducted studies allow us to conclude that the organic waste composting with the microbiological additive is appropriate, both in the case of thermophilic and in the case of mesophilic regimes. The period of the compost maturation with the use of a microbiological additive is 6 weeks. It was shown that the microbiological complex accelerates the process of composting the organic component of solid municipal waste by 3.3 times for the thermophilic regime and by 2.1 times for the mesophilic conditions of composting process, which testifies to the efficiency of its use in the operation of the solid municipal waste processing in order to improve the general level of environmental safety.

Keywords: *soil; microbiocenosis; composting; waste; microbiological additive; mesophilic and thermophilic composting regimes*

I. Introduction

The management of solid municipal waste (SMW) is the subject of an annual regional report on the state of the environment [1], statistical surveys [2], special studies [3], environmental programs. Description of the problem is mainly limited to data on the number and area of landfills, volumes placed in specially designated waste sites (mostly industrial). But such an array of information on waste disposal in specially designated areas does not allow to fully characterize the environmental consequences of the existing waste situation in the Odessa region and determine the resource potential of such waste.

In recent years, the countries of the European Union (EU) have gained considerable experience in utilizing SMW and, in the course of time, have improved their methods of handling, taking into account the features of the territory and ecological and economic feasibility [4,5]. In the EU, over 90 directives in the field of environmental protection have been adopted, the main principles in the field of waste management are defined in [6], which form the general EU strategy for management of SMW flows. Recycling, in particular, composting and receiving biogas as an energy source, is the main methods used by the EU government to dispose of SMW [7].

The most environmentally appropriate solutions for management of SMW reprocessing are recognized as minimization and prevention of environmental pollution. The international recycling system is aimed at minimizing waste by sorting and recycling feedstocks, the rest goes to recycling and composting, combustion and stockpiling of residues. Since up to 40% of the SMW relates to easily degradable organic wastes (food waste, market waste, urban greenhouses, municipal power supply, sewage systems, household waste [8]), the removal of this part of waste from waste land due to composting and waste conversion on the secondary material resource will significantly reduce the environmental burden on actually deployed and potentially planned landfills.

Aerobic composting is one of the best available technologies for an integrated waste management system by minimizing anthropogenic environmental impact, complying with the latest domestic and foreign developments, economic and practical acceptance of technology.

But composting is characterized by relatively low popularity in comparison with other methods of waste utilization due to a number of its disadvantages, such as a long production cycle and sometimes the obtaining of a product of unstable quality. Because of this, many studies on SMW processing are devoted to methods of accelerating the process of composting, which can be achieved in various ways, such as the development of high-efficiency composting machines and the change of biotic (vermicomposting, use of specialized cultures and communities of microorganisms) or abiotic (temperature, pH, etc.). parameters of the process.

II. Analytical review of the literature

Attention to the technologies of rationalization of methods for the preparation of manure and other organic waste was drawn in the early twentieth century. On the basis of the formed stratified composting method in piles in the 30s, a composting technique with stratified formation of semi-buried piles was proposed (Indore method) [9,10]. Some exploration work was aimed at developing various ways to speed up the composting process with a change in the abiotic parameters of the process [11,12].

Among modern researchers of the composting process as a rational method of waste management, there are innovative works of M. V. Gatsenko [13], M. K. Linnik [14], A. A. Lyashenko [15], V. V. Shatsky [16], in which a lot of attention is paid to the issues of composting technology, mechanization of the preparation of the substrate, optimization of the controlled parameters of the process, design of piles, composition of the substrate and the ratio of the main nutrients in it.

The feedstock for composting– the organic fraction of the SMW– typically has a low density of anaerobic microorganisms that spontaneously colonize waste during collection, transportation, and storage. This amount of microorganisms is not enough for the composting process. To start and speed up the fermentation process, it is necessary to inoculate the raw material with an active anaerobic microbial community from other sources. Fermented sludge from wastewater treatment plants, ground extracts, sludge from industrial wastewater treatment systems, manure, etc. are used as inoculum [17]. According to the literature, fermented sewage sludge contains all the necessary groups of microorganisms and is a versatile inoculum to start the process of fermentation of various organic wastes to produce biogas [18]. Other experiments with composting organic SMW and food waste at ambient temperature (20 ± 2 ° C) and in

a moderately thermophilic mode (50 ° C) showed that the soil of the SMW landfill is the best inoculum compared to fermented sewage sludge, since provides a higher rate of methanogenesis [19]. The soil of the SMW landfills is widely available, however, for use as an inoculum, its previous activation is needed by dilution, incubation with an organic substrate at the desired temperature, as well as the separation of solid particles of sand and clay.

According to the results of studies [20], the structure of microbial complexes is an integral component of the detailed characteristics of soils. Soil as a habitat and a waste product of microorganisms is a complex system, including physiological and taxonomic species that provide biological circulation of substances, soil formation processes and their resistance to natural and anthropogenic factors. Heterotrophic organisms that inhabit the soil (in particular, organic and organogenic horizons), provide a complex transformation of detritus, participate in the processes of decomposition and re-synthesis of organic substances in it.

The microbial biomass of the soil is represented by the biomass of soil microorganisms (bacteria, fungi, protozoa) in the soil. Its content substantially depends on the type of ecosystem, as well as the complex of hydrothermal conditions and ranges from 1 to 5% of the total content of soil organic matter [21]. These data are confirmed by studies [22], according to which microbial biomass contains from 0.27 to 4.8% of the total carbon content and 0.5 to 15.3% of nitrogen.

One of the important factors on which the temperature sensitivity of organic matter to mineralization depends is the physiological activity of the soil microbiota and it determines the effectiveness of the utilization of the substrate. Therefore, it is advisable to use microbial soil complexes containing cellulolytic microorganisms and bacterial colonies as a microbiological additive for composting in natural conditions. Bacteria and micromycetes are among the most active pulp decomposing microorganisms, however, bacteria play a major role in the decomposition of cellulose wastes during the composting process [23].

In the work it is envisaged to establish the technological features of the inclusion of a microbiological additive to compost mixtures with the food component of SMW, which makes it possible to determine the operating parameters of the technological operations of waste management. It is also proposed to establish the patterns of influence of microbiological additives on the biogenic and abiogenic parameters of composting processes, which allows regulating the process of utilization of the food component of SMW, which has not been done before and reflects the scientific novelty of the work. It is provided that the bacterial consortium isolated from the soil exhibits high cellulose activity, which allows accelerating the composting processes and improving the quality characteristics of the finished compost.

The purpose of this study was to study the role of soil microbiocenosis in the process of composting the organic part of SMW and the possibility of accelerating the process of composting plant waste by introducing microbiological additives. It was assumed that their addition to the composition of the feedstock will lead to the activation of microbial activity in the initial stages of the composting process.

In the course of this study, it was necessary to perform the following tasks:

1) to investigate the composition of soil microbiocenosis for use as an inoculum and feedstock for the preparation of a microbiological additive;

2) to investigate the effect of microbiological additives on the processes occurring during composting of the organic part of SMW in mesophilic regimes;

3) to investigate the conditions of the processes of composting with the addition of a microbiological additive by the main abiotic and biotic indicators and by the indicators of maturity.

III. Object, subject and research methods

Soil samples were collected in the background relative to the soil of the SMW dump site (MSW-1 «Dalnitsky quarries», taking into account typical signs (typical for the region black southern earth less humus), uniformity of vegetation and meteorological conditions. So, in total, three soil samples from the fields of the Ovidiopolsky district were used, which were taken in an envelope (zig-zag) pattern from a depth of 5-10 cm. After transportation in a plastic container, the samples were subjected to laboratory analysis using standardized methods. Soil samples were freed from inclusions, sifted through a sterile sieve, and the sample of 50 g, which was subject to tenfold dilution (1: 1000, 1: 10,000, 1: 100,000), was selected by the quartering method.

All indicators of a complete bacteriological analysis of the soil were determined by the generally accepted methods of quantitative introduction of the prepared average soil sample into the corresponding media [24], temperature control of the samples, visual inspection and quantitative count of cultures. The total number of bacteria was determined by the deep culturing method on the plain agar medium. The presence of Escherichia coli (coliform bacteria analysis) was determined by culturing in modified medium Kessler. To determine the titre of *Clostridium perfringens*, iron sulfite agar (Wilson-Blair medium) was used. Identification of proteus was carried out according to the method of Shukevich.

A mixture of food, agricultural and landscape gardening wastes was used as a raw material for composting in a weight ratio of 1: 1: 1. Deciduous waste was used as a filler. The feedstock was crushed to a size of 10-15 mm, dried in air for two hours and loaded into the reactor for composting. To increase the efficiency of the composting process and compare the features of the processes, an extract from the soil was used as a microbiological additive.

The experiment was carried out in three stationary reactors with a volume of 3 dm^3 with forced aeration for 6 weeks. A mixture was introduced into each reactor, composted, in the amount of 1.2 (2/3 of the reactor volume) with a moisture content of 72%, which was mixed with 100 g of soil as an inoculum. 100 ml of distilled water was added to reactor 1 (control), and 100 ml of a microbiological additive was added to reactors 2 and 3, which is an aqueous extract of the soil obtained by incubating the soil with water from the water module 10 for 20 minutes while stirring. An extract from the soil was used as a microbiological additive to increase the efficiency of the composting process.

Reactors 1 and 2 were isolated from exposure to ambient temperature. The reactor 3 was placed in a thermostat with a set temperature of 55 ° C for the purpose of thermophilic composting. Composting was continued for 6 weeks, while the mixture was composted, stirred daily and moistened to maintain a moisture level of about 70-75%. Each week, we conducted a selection of samples weighing about 10 g for research.

The parameters of the composting process were controlled with a change in temperature, pH and the number of microorganisms in the mixture composted, as well as CO2 emissions from the reactor [25]. The maturity of the compost, which was obtained, was determined by the germination index [26] and the ratio of the total carbon and nitrogen in the mixture, composted [27].

The temperature inside the mixture, composted, measured using an alcohol thermometer, which was fixed in the lid of the reactor, the lower end of which was in the mixture, composted. Once a week, the gas fraction was collected from the reactors using disposable plastic syringes per 50 cm^3. The amount of carbon dioxide in the sample was determined using a gas chromatograph «Hromatek Crystal 5000.2». The determination of total organic carbon was carried out by the Tyurin method, and total nitrogen by the Kjeldahl method [27]. The pH of the aqueous extract was determined using a laboratory pH meter Hanna 221X. The number of microorganisms was determined by culturing on solid nutrient medium in Petri dishes by the method of Koch. The coefficient of germination was determined by the number of seeds of radish seed that germinated, with ten and the length of seedlings in water extracts from composts compared to control (distilled water). The quality control of the finished product was determined by the C / N ratio and the total nitrogen content in the dry matter.

IV. Results of research

The results of the study of the soil microbiocenosis for use as an inoculum and raw material for the further preparation of a microbiological additive in the composting process showed a relatively high quality of soil samples and proved the presence of common microbiological properties of the same type of soil from different sampling sites. Thus, the microbial grouping of typical low-humus black earth is 24.5-30.8 million CFU / g of soil, which is a high indicator of the total number of microorganisms in the soil. Such soils are the most biogenic and are characterized by a high content of bacteria, which are able to assimilate the nitrogen of organo-mineral compounds (6.4-7.9 million CFU / g of soil). Using the averaged data on the total number of microorganisms in the samples studied, we can estimate the soil according to the degree of its enrichment with microorganisms [28] and assign it to group I with a “very rich” rating with average values of 27,700,000 CFU / g of soil containing the total number of microorganisms in the soil.

As for the qualitative composition of the soil samples, it is worth noting that the soil is a multicomponent system, the decomposition and transformation of which depends on the functioning of a whole complex of microorganisms capable of producing such exoenzymes as cellulase, phosphatase, chitinase, dehydrogenase, etc. The main groups of such organisms are fungal and bacterial microflora, therefore, for a more detailed understanding and explanation of the composting process, the total number of bacteria and fungi was taken into account.

Since the main component of the organic fraction is cellulose, it is advisable, along with determining the total number of bacterial and fungal components of the microflora, to determine the number of cellulose microorganisms. An assessment of the change in the microbial population of compost mixtures has been carried out, which suggests that bacteria in the studied samples dominate the fungi (Fig. 1).

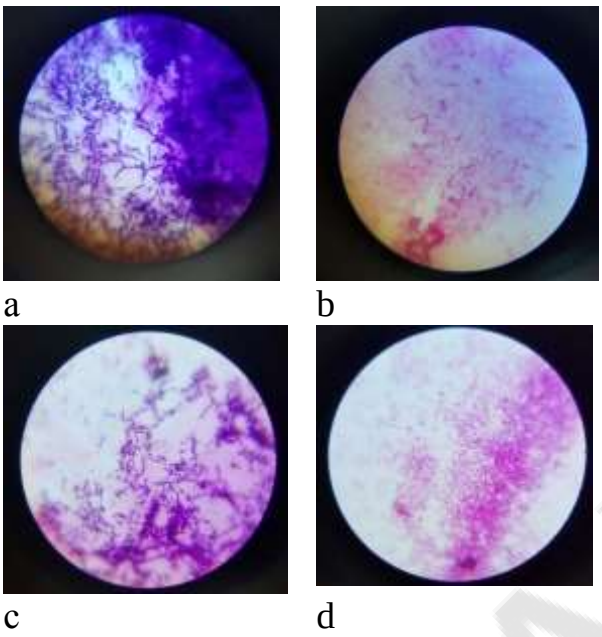

Fig. 1 - Representatives of microbial complexes (a – Myxobacteriales, b – Bacillus mycoides, c –B. subtilis, d– B. pasteurii), 1000-fold increase

Based on various morphological and biochemical characteristics, it was determined that most microorganisms isolated in pure culture belonged to the genus Bacillus. The entire bacterial community is divided into three main groups: gram-positive cocci, gram-positive bacilli and gram-negative bacilli. The first group is represented by bacteria of the genus Micrococcus, Planococcus and Staphylococcus. All gram-positive bacteria belong to the genus Bacillus. Gram-negative bacteria, found in specimens, were representatives of the genus Enterobacter and Flavobacterium.

Among the representatives of mushroom flora, mainly euroocomycetes and Ficomyces were found. In samples of two soil extracts anaerobic cellulose-decomposing bacteria of the genus Clostridium perfringens, insignificant number of bacteria of the genus Proteus were found; in all three samples of the series of experiments, no BGKP was detected, which in general indicates a high sanitary-hygienic index of the soils examined and proves the possibility of their use as an inoculum in the compostingprocess.

Thus, enrichment of the microbial consortium of compost mixtures in the initial stage of cellulose-decomposing organisms can help reduce the time of waste composting: mesophilic bacteria are the dominant organic waste debris at the initial stages of composting. During the thermophilic phase, they are replaced by thermotolerant bacteria. The domination of bacteria is due to their ability to grow rapidly, using proteins and other available substrates, as well as tolerance to high temperatures.

Destruction of cellulose is carried out by bacteria, fungi and actinomycetes under various aeration conditions, at different temperatures and at various pH values of the medium. The development of microorganisms on cellulose involves biosynthesis and the removal of cellulases. The regulation of the process of biosynthesis and excretion of enzymes is controlled by the mechanisms of induction and catabolistic repression. Cellulase synthesis inducers can be cellulose, cellobiose, lactose, etc. The reagent of biosynthesis of cellulases is glucose most often. Some organisms synthesize

cellulolytic enzymes when they grow on any substrate, others, for example, bacteria belonging to the genus Achromobacter, Pseudomonas, Vibrio, Cellulomonas, use cellulose only when there are no other sources of carbon.

The process of destruction of fiber begins with hydrolysis. Bacteria are able to break down cellulose under anaerobic and aerobic conditions. Most of the anaerobic cellulose bacteria identified in the soil extracts belong to the genus Clostridium.

Other anaerobic bacteria can also decompose cellulose: Acetovibriocelhdolyticus, Bacteroidessuccinogenes, Anaerocellumthermophillum, Thermotoganeapolitana, Halocellacellulolytica. All of these bacteria form the extracellular complex of cellulases, and the products of cellulose fermentation are ethanol, acetic, formic and lactic acids, molecular hydrogen and carbon dioxide, and extracellular cellulose is decomposed into celobiose. Cellulose is decomposed to actinomycetes, representatives of the genera Streptosporangium, Microbiospora, and also the species Streptomycescellulosae, Micromonosporachalcea, Thermoactynomycescellulosae, Thermomonosporacurvata.

Therefore, in the future, it was necessary to evaluate whether inoculation of compost mixtures with biological additives affects the composting process of solid waste. The conditions of the experiment are presented in the flowchart in Figure 2.

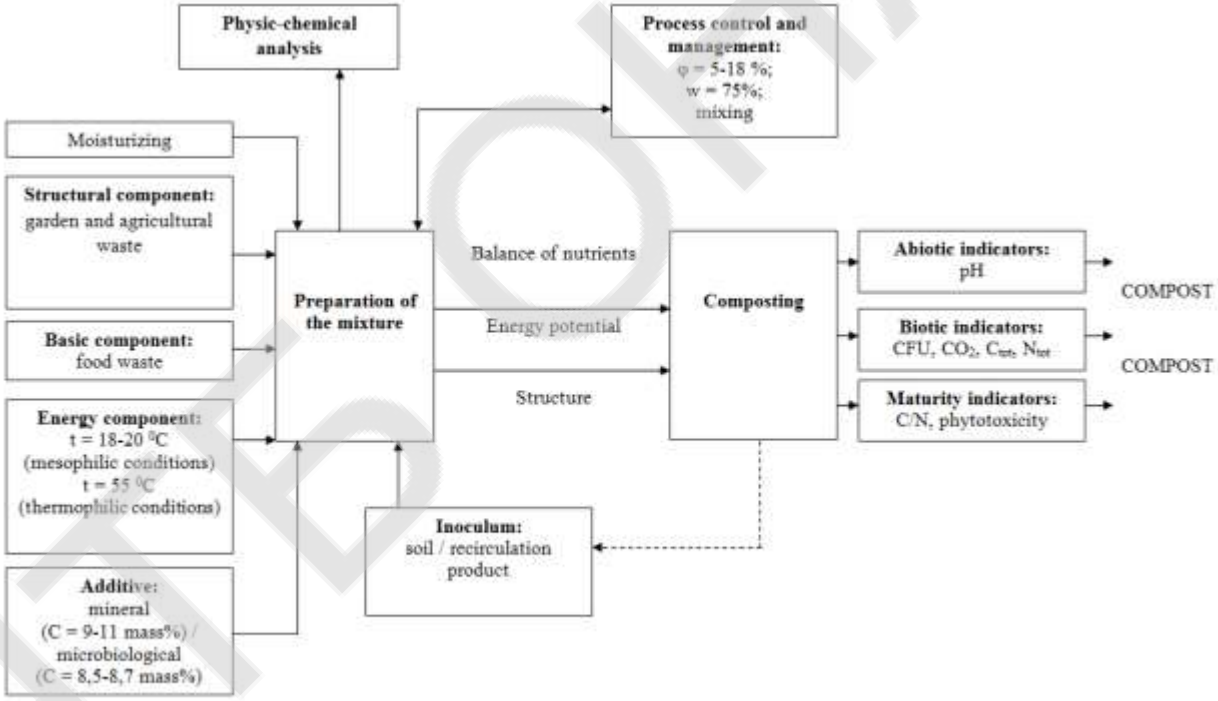

Fig. 2 - Block diagram of preparation of compost mixture and control of composting process

In general, the completeness of the composting process is characterized by two concepts –«stability» and «maturity» of compost, which, despite their conceptual differences, are simultaneously used to determine the degree of decomposition of organic substances in the composting process. Were selected parameters that allow to evaluate both the intensity of decomposition of organic substances (temperature, organic matter content, soluble organic carbon and ammonium nitrogen) and its

stability (respiratory activity and cellulolytic activity, number of bacteria and micromycetes) and maturity (pH, phytotoxicity).

The results of studies of changes in the pH of the mixture, composted with a microbiological additive, are presented in Fig. 3

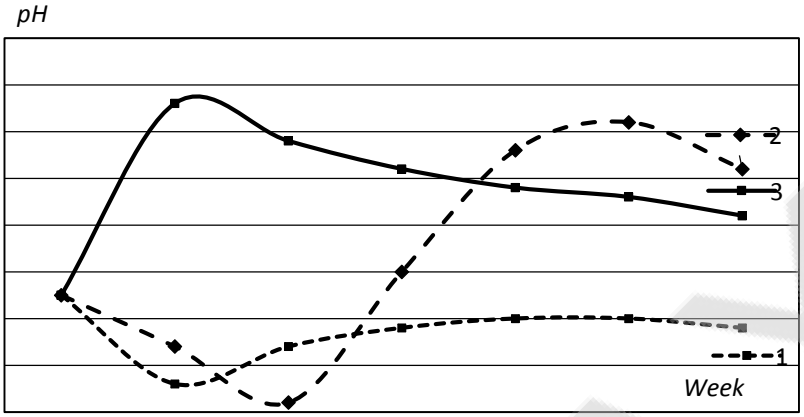

Fig. 3 - Change of the pH of the composted mixture in microbiological reactors in the mesophilic (2) and thermophilic modes (3) in comparison with the control sample (1)

Initial pH value of raw materials was subacidic, close to neutral (6.3). After the composting started, the pH value in the mesophilic regime in the reactor 2 decreased to 5.1 before the second week, at the fifth week it rose to 8.1, then decreased to 7.6. This can be explained by the formation of organic acids in the process of fermentation, and then their neutralization. Under the thermophilic conditions in the reactor 3 after the first week, the composting of the pH of the medium became alkalescent (8.3), which can be explained by the release of quaternary ammonium bases and salts, and then gradually decreased, stabilized at the value of 7.1. Thus, in reactors with a microbiological additive when mesophilic composting at the initial stage of composting, the pH was deviated to the side of the subacidic parameters, with the thermophilic - in the direction of alkalescent ones. The pH values observed in reactors 2 and 3 at the end of the composting process are optimal for growing plants and meet the requirements of mature compost. Stabilization and even a slight decrease in the pH level observed at the last week is likely to result from the formation of humus-like substances, as indicated indirectly by the stabilization of organic matter and soluble organic carbon during this period.

The rate of destruction of organic matter is directly dependent on the number of microorganisms and the composition of the microbial colonies of the mixture, which is composted. In reactor 2, accelerated growth of mesophilic microflora was observed, since the temperature in them was 23-25 ° C. In reactor 3, thermophiles reached a significantly larger number, since temperature conditions were more suitable for their growth (55 ° C). Thus, the addition of bio-additives based on soil extract increases the number of microflora in the compost samples by 2-3 times compared with the control. Since bacterial colonies correspond to composting for the decomposing of the organic part of the mixture, their increase in various modes of composting is expected to activate the formation of compost.

By the end of the composting process, there is a significant increase in the number of bacteria, in particular, cellulose-decomposing. So, if at the beginning of composting their number was 1.2-2.3*10^6 CFU g^{-1}, then at the end of the process it was 2-4 times higher. The number of cellulose fungi, on the contrary, sharply decreased from 0.7-1.9*10^4 CFU g^{-1} at the initial stage of composting to their complete elimination at the end. The likely reason for this dominance of bacteria is an increase in temperature, which creates unfavorable living conditions for most fungi.

The activity of microorganisms can be judged by the intensity of their respiration (oxygen consumption or release of carbon dioxide). Presented in Fig. 4 the time dependence of the change in CO_2 concentration in the reactor space is indicative of changes in the activity of the microbial community during the composting process.

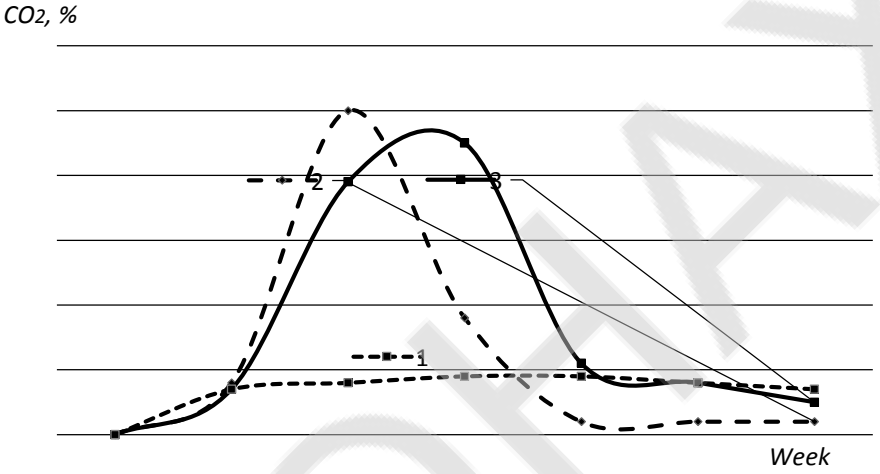

Fig. 4 - Change of CO_2 emissions from reactors during composting process of the composted mixture in reactors with microbiological additive in mesophilic (2) and thermophilic modes (3) in comparison with control sample (1),% CO2

The activity of microorganisms is much higher in a reactor that is in thermophilic conditions (reactor 3). In reactors 2 and 3, the peak activity is for the period from the second to the third week. Peaks of respiratory activity coincide with an increase in the rate of destruction of organic matter. In the first weeks of composting microorganisms actively decompose easily accessible compounds, which leads to an increase in CO_2 production. It is during this period that high rate of mineralization of organic matter and the maximum decrease in the content of soluble organic carbon is observed (Fig. 7). Since the peaks of activity in mesophilic and thermophilic conditions do not coincide, we can assume that in thermophilic conditions in the third week, bacterial colonies begin to more actively decompose complex organic compounds. At the final stage, the reduction and stabilization of the level of activity indicates that all available substances in the composted mixture are mineralized by microorganisms. Thus, the introduction of the microbiological additive stimulates the increase in the activity of the community of microorganisms in the initial stages of composting - within three weeks, which indicates that it is during these terms that the destruction of the organic part of the composted mixture is actively taking place.

The nature of the change in the number of total Carbon from the time of composting, shown in Fig. 5 is approximately the same for all three reactors: in the

first 4 weeks mineralization of a large amount of organic matter (about 7%), then Carbon is consumed insignificantly (3-4%). Maximum rates of consumption of organic substances in all reactors were observed after the second week, and the introduction of a microbiological additive doubles the rate of Carbon expansion, which confirms the role of the soil microflora in destroying the organic part of the composted mixture in both temperature regimes.

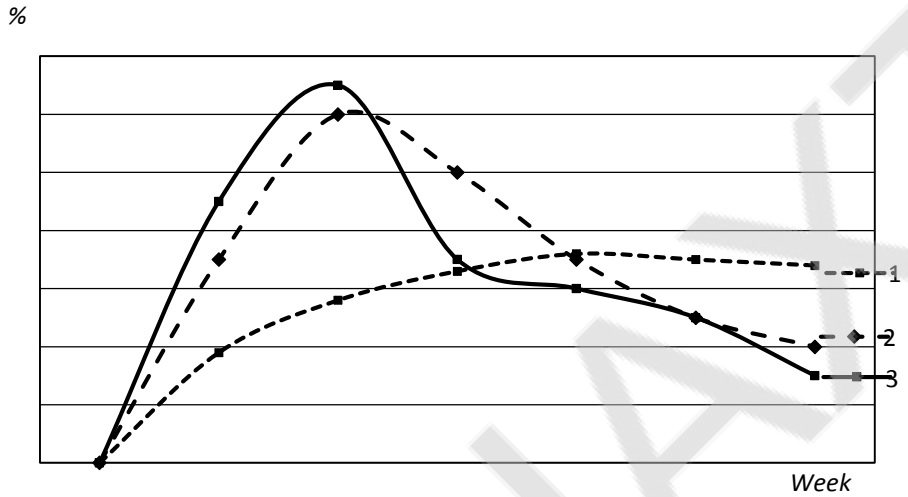

Fig. 5 - Change in the rate of loss of the total Carbon in a composted mixture in reactors with a microbiological additive in the mesophilic (2) and thermophilic modes (3) as compared to the control sample (1),% / week

The total losses of the total Carbon (Fig. 6) were somewhat higher in reactors 2 and 3 (21-22%) than in reactor 1 (about 12%). Thus, the overall losses and the rate of loss of the total Carbon are more pronounced when using a microbiological additive in both the thermophilic and mesophilic regimes, which suggests a greater efficiency of the composting process, which is obviously influenced by bacterial colonies of bio Additives - respectively thermophilic and mesophilic.

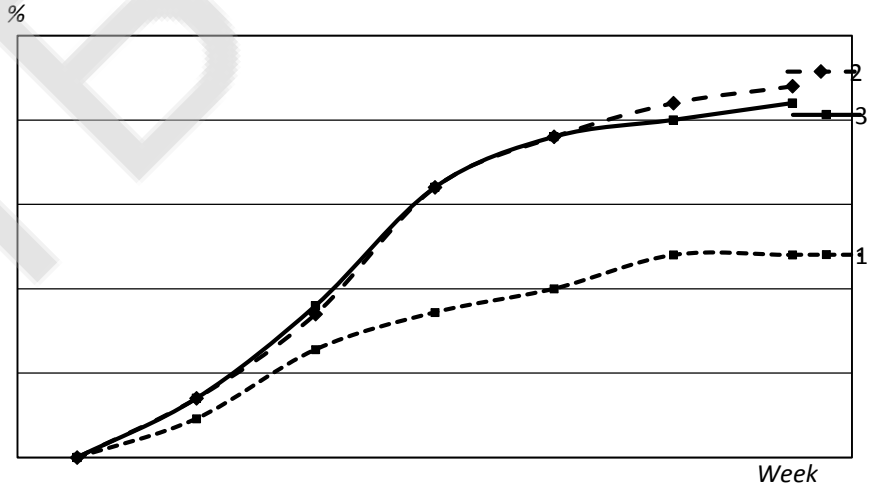

Fig. 6 - Changes in the rate of loss of the total Carbon in the composite mixture in the reactors with mineral additive in the mesophilic (2) and thermophilic modes (3) as compared to the control sample (1),% / week

The change in the content of the total nitrogene characterizes the dynamics of mineralization of nitrogen-containing substances. As can be seen from Fig. 7, the initial content of nitrogen in reactors is different: the largest amount is observed in reactors 3 and 2 (2 and 1.5 g / kg), which can be explained by the presence of bacterial colonies (possibly tuber bacteria), against 0.5 g / kg Nitrogen in a control reactor without the addition of a microbiological additive. The nature of the change in the content of the total Nitrogen in the composted mixture is virtually identical for all reactors (Fig. 7). The maximum nitrogen loss rates in all reactors were observed after the second week, and in reactors 2 and 3 they were greater (3.5 g / kg per week) than in reactor 1. Similar changes in the content of total nitrogene at the beginning of composting were associated with active the decomposition of nitrogen-containing compounds and evidence of the presence of unstable substances. Subsequently, in all experimental variants, there was a decrease in the total Nitrogen level, which by the end of the sixth week amounted to 0.2-0.5 g / kg. In general, at the end of composting, all samples tested showed a total nitrogen content below the level that is advanced to mature compost. However, it should be noted that the level of Nitrogene in mature compost varies in a sufficiently wide range and depends on the time of composting and composition of the source components. In our variant, the composting mixture did not contain substances that are characterized by high levels of Nitrogen (manure, sewage sludge, legume crops, etc.), which explains the reduced amount of nitrogene in the finished compost.

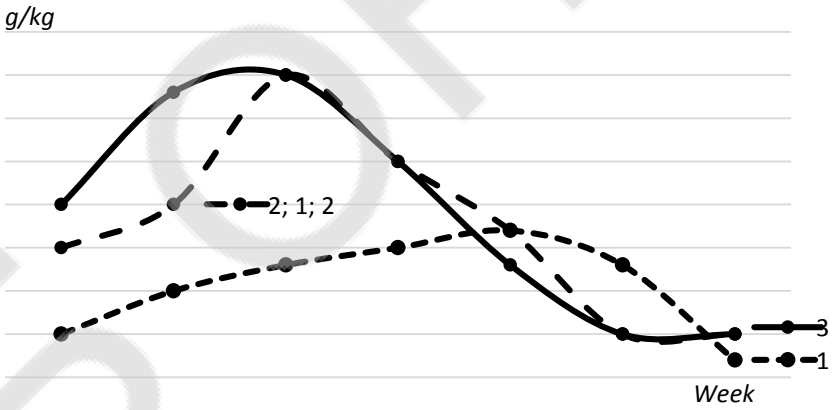

Fig. 7 - Changes in the rate of loss of the total nitrogen in a composted mixture in reactors with a microbiological additive in the mesophilic (2) and thermophilic regimes (3) as compared to the control sample (1), g / kg per week

Total losses of nitrogen in reactors 2 and 3 were the largest (about 13 g / kg of dry mass, which is compacted). In the control reactor, the losses of Nitrogen were lower (8 g / kg of dry mass, which is compacted). Thus, the losses of Nitrogen are slightly increased with thermophilic composting, however, both in the thermophilic and mesophilic modes, in the case of the introduction of a microbiological additive, the destruction of organic matter is almost 2 times greater than in the control sample.

Maturity of compost is estimated by the mass ratio in it of total Carbon and total nitrogen (C / N). According to international standards, quality compost should have C / N below 25. In Fig. 9 shows the dependence of the change of C / N on the duration of composting. The ratio of C / N reaches the minimum values after the second week

of composting and then does not change significantly. The final ratio of C / N in all obtained compost is less than 25, which indicates a reduction in maturation of the compost when the microbiological additive is applied, approximately twice, taking into account the rate of its change.

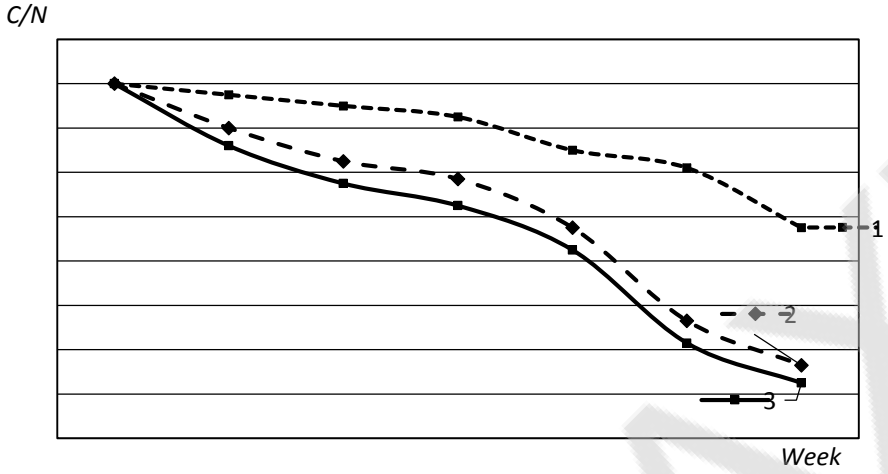

Fig. 9 - Changes in the ratio of total Carbon to total Nitrogen in a composted mixture in microbiological reactors in the mesophilic (2) and thermophilic regimes (3) as compared to the control sample, g / kg per week

An analysis of the experimental study suggests that the intensity of destruction of the organic part of the mixture of municipal waste that is composted depends on the bacterial colonies derived from the soil extract and doubles both in the mesophilic and in the thermophilic conditions. The activity of thermophilic microorganisms is somewhat higher, however, taking into account the energy costs of heating the composted mixture, it is possible to recommend composting in mesophilic mode with the addition of dietary supplements as a resource-saving means of composting organic waste.

The results of the study indicate that the index of seed germination of radish is gradually reduced with an increase in the length of composting (Fig. 10). Compost with germination index less than 80% is considered phytotoxic, more than 80% - mature.

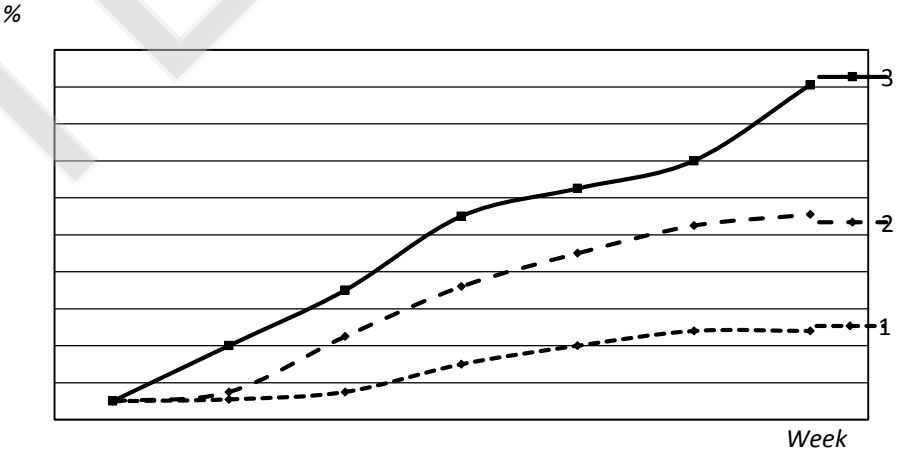

Fig. 10 - Changes in the germination index in the composting process in a composted mixture in reactors with a microbiological additive in the mesophilic (2) and thermophilic regimes (3) as compared to the control sample (1),%

After 6 weeks compost composting in reactors 2 and 3 is characterized by a germination index of more than 100%, indicating that the compost is not only free from phytotoxins, but also has a stimulating effect on germination. Experimental data of the research allow us to conclude that maturation of the compost in thermophilic conditions is completed faster than in the mesophilic, and the duration of maturation of the compost when the microbiological additive is accelerated by 3.3 times under the thermophilic conditions and 2.1 times by the mesophilic ones. Thus, the temperature regime affects the maturity of the compost in the stage of germination and the evaluation of the phytotoxicity of the compost, but not the intensity of destruction of the organic matter, since in the mesophilic regime, the mesophilic microflora takes on the destructive role in approximately the same degree as in the thermophilic - thermophilic microflora.

V. Conclusions

The results of the conducted research allow to draw the following conclusions.

1. Aerobic composting is a highly effective ecologically-manageable biotechnological method for treating the organic part of the TMB.

2. Microbiological characteristic of soil complexes proves the expediency of using the soil as an inoculum during composting, for launching and accelerating the process of biofermentation.

3. The microbiological additive from the soil extract can be used for composting both in the thermophilic and mesophilic modes.

4. The bacterial complex accelerates the composting process of the organic component of the TMV by 3.3 times in the thermophilic regime and 2.1 times in the mesophilic conditions of composting process, which testifies to the efficiency of its use in the processes of TMB processing in order to increase the overall level of environmental safety.

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НТБ ОНАХТ

ENVIRONMENTAL MONITORING AND RECOMMENDATIONS ON DECREASING THE LEVELS OF PESTICIDE POLLUTION IN ZHYTOMYR REGION OF UKRAINE

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Abstract. *Environmental monitoring was conducted of facilities for storage and disposal of banned and unsuitable pesticides. Pesticide content in soil, water and products of agriculture in Zhytomyr region of Ukraine was examined, and accumulation of organochlorine pesticides by freshwater bivalve mollusks was assessed. Storage facilities of Zhytomyr region contain nearly 392.18 t of pesticides in 137 warehouses, of which 11 meet the requirements, 36 are tolerable, and 90 are in poor condition. 39.07 t of pesticides are kept in containers of good quality, 22.43 t are kept in tolerable containers, and storage containers of other pesticides are of poor quality. In 2018−2019, pesticide content (dichlorodiphenyltrichloroethane (DDT), heptachlor, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyldichloroethane (DDD), hexachlorocyclohexane (HCH)) was studied in soil and sediments in Zhytomyr region. The content ranged from 0.0007 to 0.07 mg/kg, which is lower than MPC (0.1 mg/kg). The content of HCH, DDT, DDE, DDD and heptachlor was at 0.0007−0.01 mg/dm^3 levels in water bodies of Zhytomyr region in 2018-2019, also lower than MPC. In a number of samples of soil, water and vegetables, the recorded levels of DDT and organophosphate pesticides Dragon, Dorpan, and Dursban exceeded MPC in 1.5–3.0 times. Traces of organochlorine pesticide Aldrin were found in soft tissues of bivalve mollusks and in the sediments of water bodies they inhabit. Recommendations are proposed to lower the pesticide content in the environment.*

Key words: pesticides, Zhytomyr region, warehouses, *soil****, water,*** *products of agriculture****, mollusks.***

I. Introduction

Relevance of the topic. Ukraine has ratified the Stockholm Convention (23 May 2001) with the Law of Ukraine N 949-V (949-16) of April 18, 2007. According to the Convention, persistent organic pollutants (POP) are recognized as toxic, resistant to decomposition, bioaccumulative, and are subject to transboundary movements by air, water and with migrating species. POP are also deposited at a great distance from the source of their emission, accumulating in terrestrial and aquatic ecosystems [13]. By this convention DDT, aldrin, dieldrin, endrin, chlordane, mirex, toxaphene, heptachlor are included to the list of most dangerous substances.

Long-term application of pesticides has led to large-scale environmental pollution over huge territories. The migration of toxic compounds in ecosystems causes the accumulation of residual amounts of pesticides in natural objects.

Today it is important to monitor both the storage conditions of pesticides, a lot of which are still kept in Zhytomyr Region of Ukraine [7], and the pesticide content in soil, water bodies, products of agriculture, and in aquatic organisms.

Aim and tasks of the study. ***Study aim:*** to conduct ecological monitoring of pesticides in Zhytomyr region and to prepare recommendations on decreasing the pesticide levels in environment.

The following ***tasks*** were chosen to fulfill the study aim:

1. Analysis of storage and utilization of the banned and unsuitable pesticides in warehouses of Zhytomyr region.
2. Determination of pesticide content in soil, water and products of agriculture in Zhytomyr region.
3. Assessment of bioaccumulation of organochlorine pesticides by freshwater bivalve mollusks.
4. Development of recommendations for decreasing the pesticide levels in environment.

Scientific novelty of obtained results. For the first time in Zhytomyr region, monitoring studies were conducted on the problem of pesticide storage and pollution of soils, water bodies, products of agriculture and local aquatic biota.

Theoretical and practical significance of obtained results. Our results contribute to the further development of ecotoxicology. The obtained data is of interest for the regional environmental monitoring. The main results and conclusions of the work can be used in teaching a number of disciplines in higher education institutions.

Author's contribution. The author personally conducted an information search, independently processed own samples, analyzed and summarized the results. Determination of pesticide content was carried out on the basis of the State Institution "Zhytomyr Regional Laboratory Center of the Ministry of Health of Ukraine" together with the laboratory staff and scientific supervisor. Data of the Department of the Department of Ecology and Natural Resources of the Zhytomyr Regional State Administration were processed.

Approbation of results of research. Study materials were presented at the Department of Ecology of the Zhytomyr State Polytechnic University, as well as at the All-Ukrainian scientific and practical conference of graduate students and young scientists "Sustainable development of Ukraine in the framework of European integration" (November 7, 2019, Zhytomyr State Polytechnic University).

Publications. Conference thesis is published on the results of research.

Structure and contents of work. The study consists of the introduction, the main four chapters, conclusions, references (22 sources: 13 in Cyrillic, 7 in English, and 2 Internet sources), 6 figures and 3 Tables.

II. Analytical survey of publications

Organochlorine pesticides (OCP) have been widely used, and some of them still are used in Ukraine [2, 5, 8, 11, 12, 14 and other countries [13, 15−20, 22] to control insect pests of agriculture and protect crops. Such OCP as DDD (dichlorodiphenyldichloroethane), DDT (dichlorodiphenyltrichloroethane), DDE (dichlorodiphenyldichloroethylene), and HCH (hexachlorocyclohexane) are highly persistent, accumulate for a long time in plants, animals, soils, and are poorly soluble

in water. Therefore they usually accumulate in considerable concentration in river sediments and silt.

In Ukraine, OCP have been used most extensively in 1950-1960s. At the beginning of 1970s, OCP were shown to be highly toxic to animal organisms. They are also very persistent. DDT does not decompose in the environment for 10 years [12]. When from the environment (soil, water, sediments) OCP enter the living organisms, the compounds circulate in trophic chains of local ecosystems, climbing the trophic levels. Thus, all these components of ecosystems, from producers to consumers of highest levels, contain pesticides in their bodies. DDT and HCH can accumulate in various organs and tissues (in case of DDT, mostly in fat tissue). OCP are polytropic compounds, thus they are significantly dangerous to human and animal organisms even in small doses. They negatively affect the functional state of the liver, glands, kidneys and other organs. They have also cytotoxic, carcinogenic, mutagenic effects. All this led to the restriction or ban of their use in early 1970s. But even today, OCP belong to the category of widespread pollutants both in Ukraine and abroad.

Content of DDD, DDT, DDE, HCH, DDVP (dichlorvos), 2,4-D (2,4-dichlorophenoxyacetic acid) has been analyzed in rivers of Luhynsky district of Zhytomyr region in 1988-2008. The results of analysis indicated the significant decrease of pesticide content in the two decades [8]. That is linked to the discontinuation of large agricultural enterprises that had used public funds to purchase pesticides. At present, only small farms and private homesteads operate in the district.

The long-term, often uncontrolled and unjustified, use of pesticides in agriculture has led to the contamination of inland water bodies with these dangerous toxicants and the disturbance of natural ecological balance. Pesticides of different chemical origin have a detrimental effect on all representatives of freshwater biota. Due to the cumulative properties, pesticides circulate and accumulate in the organisms of all aquatic organisms, including shellfish. In the early XXI century, a number of scientists [12] have registered persistent OCP (DDT and HCH) in various organs of six freshwater mollusk species of the family Unionidae in rivers of Zhytomyr and Khmelnitsky regions.

In the summer of 2008, several pesticides (DDT, DDE, DDD, HCH, aldrin, dieldrin and hexachlorobenzene) have been found in bivalve mollusks *Colletopterum ponderosum sedakovi* (Siemaschko, 1848) in Lake Baikal [15].

I. A. Fodchenko [14] has found pesticides (DDT, aldrin, HCH, heptachlor) in mussels, produced in Ukraine (the Black Sea coast of Odessa region) and abroad (Chile, China). Pesticides have been found in marine mollusks from other countries: Korea [16], Croatia [18], Italy [19], Asian countries [22] and others.

Today, organophosphate pesticides such as chlorophos, paraoxane, metaphos, carbofos, oxamethyl are used more and more frequently [5]. They are less toxic than OCP, and do not withstand water, i.e. they are subject to rapid decomposition, which eliminates their prolonged impact on the biota of reservoirs.

III. Object, subject and methods of study

Study object is pesticide storage warehouses; samples of water, soil and products of agriculture from Zhytomyr region; freshwater bivalve mollusks of the species *Unio crassus* (Retzius, 1783) from Perga river (Radovel' village, Olevsky district of

Zhytomyr region) (Fig. 1) and *Anodonta anatina* (Linnaeus, 1758) from Irsha river (Khoroshiv village, Zhytomyr region) (Fig. 2).

Fig. 1. The shell of *Unio crassus* (Retzius, 1783) from the Perha river (Radovel' village of Olevsky district, Zhytomyr region).

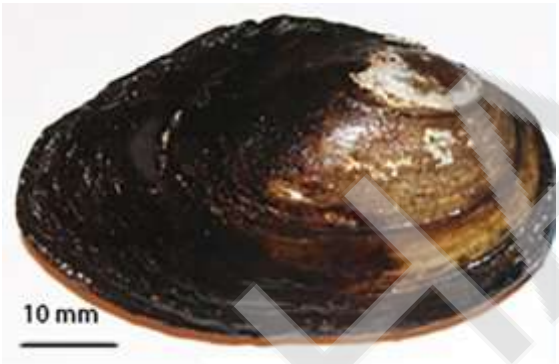

Fig. 2. The shell of *Anodonta anatina* (Linnaeus, 1758) from the Irsha river (Khoroshiv village, Zhytomyr region).

Study subject is ecological monitoring of pesticides in Zhytomyr region.

Methods of study. The content of pesticides in water, soil, agricultural products and tissues of mollusks was determined on the basis of the State Institution "Zhytomyr Regional Laboratory Center of the Ministry of Health of Ukraine" using standard methods of OCP research, gas-liquid chromatography and thin-layer chromatography: DSTU EN 1528-1-2002; EN 1528-2:1996; EN 1528-3:1996; EN 1528-4:1996; DSTU EN 12393-(1;2;3):2003; DSTU 4514:2006 [3, 4, 10].

Information about pesticide storage was given by the Department of Ecology and Natural Resources of Zhytomyr Region State Administration.

Bivalve mollusks were sampled manually at maximum depth 0.5–0.7 m [9]. Most mollusks live on sediments (silt, sandy silt), rarely on sands. Species identification of mollusks was performed on the basis of their conchological features [21].

The results of the study were processed using methods of variation statistics [1].

IV. Results

IV.I. The problem of pesticide storage facilities in Zhytomyr region

Numerous warehouses were built in almost all regions of then-Soviet Ukraine to store various types of pesticides (herbicides, fungicides, insecticides, acaricides, zoocides, etc.). Usually, such pesticides are stored in significantly damaged packages, contaminate the soil and seep into the groundwater. Hence, warehouses that contain pesticides are extremely dangerous. They also have no warning signs and are largely unsecured.

One of the acute environmental problems in the Zhytomyr region is the practice of dealing with unsuitable pesticides and agrochemicals. According to the Department of Ecology and Natural Resources of Zhytomyr Region State Administration, 137 warehouses with unsuitable pesticides and agrochemicals are in the Zhytomyr region, as of 01.01.2018 (Fig. 3). Eleven warehouses meet the requirements, 36 are tolerable, and 90 are in poor condition (Fig. 4, 5). The largest warehouses are located in Yahodynka village (Pulynsky district), with 23.00 tons of pesticides; N. Velidnyky village (Ovrutsky district), with 19.49 tons of pesticides at OJSC "Ovrutsky rajagrokhim"; Koshelivka village (Pulynsky district), with 17.0 tons of pesticides; Veselivka village (Ovrutsky district), with 12.07 tons of pesticides at LLC "Nehodivske" (Table 1).

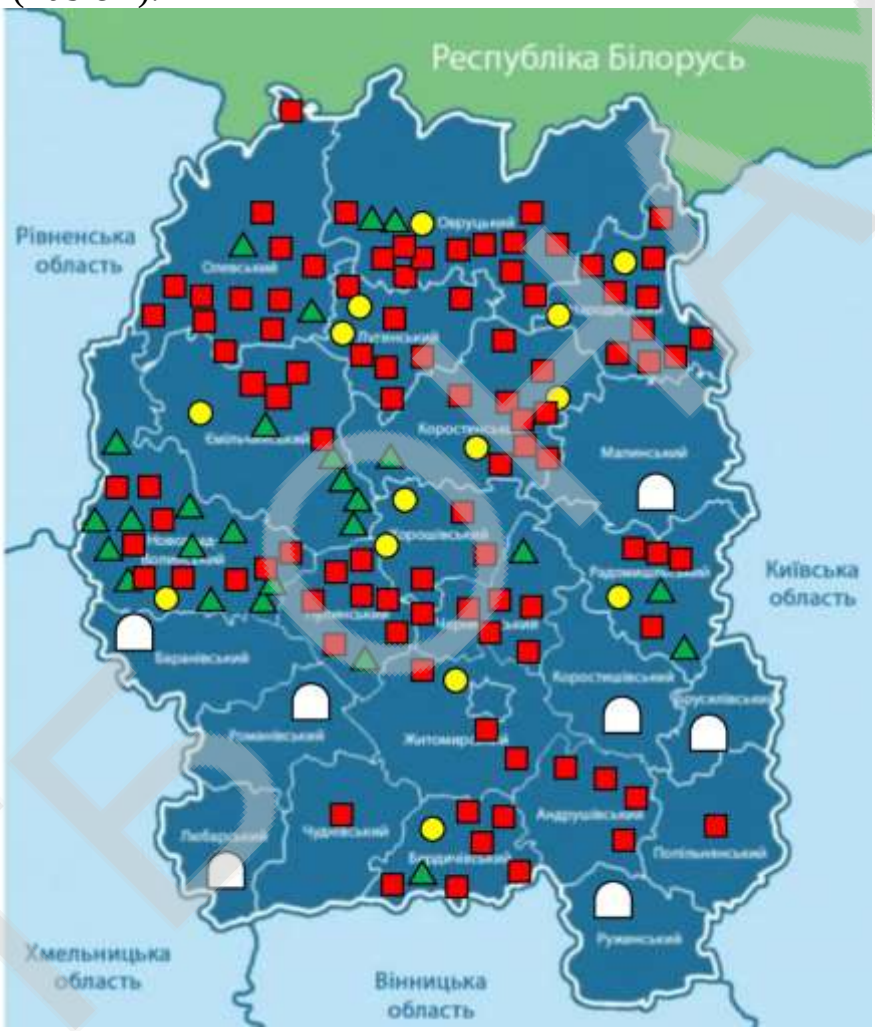

Fig 3. Map of warehouses storing unsuitable pesticides and agrochemicals in Zhytomyr region, as of 01.01.2018 (according to the Department of Ecology and Natural Resources of Zhytomyr Regional State Administration): triangle — under 0.5 t of pesticides; circle — 0.5–1.0 t of pesticides; square — more than 1.0 t of pesticides; horseshoe — pesticides were utilized in 2012.

Fig. 4. Pesticide storage in Toporische village of Khoroshiv district, Zhytomyr region (October, 2019).

Fig. 5. Pesticide storage in Znamianka village of Khoroshiv district, Zhytomyr region (October, 2019).

Table 1

Warehouses of unsuitable pesticides and agrochemicals of Zhytomyr region as of 01.01.2018 (according to the Department of Ecology and Natural Resources of Zhytomyr Regional State Administration)

Settlement	Number of warehouses	Tons in total	Settlement	Number of warehouses	Tons in total
Zhytomyrsky district					
Berezivska village council of Dubovets village	1	4.3	Vertokyivska village council of Vertokyivka village	1	6.8
Sinkhurivska village council of Sinkhuri village	1	3.854	Sadkivska village council of Sadky village	1	0.546
Andrushivsky district					
Yaropovichi village	1	7.0	Zarubyntsi village	1	4.0
Ivankiv village	1	3.0	Volosiv village	1	3.0
Berdychivsky district					
Raykhorodok village	1	3.2	Markushi village	1	2.5
Gordyshivka village	1	0.751	LLC “Shakur”, area of OSCJ “Roduchist”	1	2.2
Buriaky village	1	6.228	Andriyashivka village	1	0.2
Krasivka village	1	2.4	Ivanivtsi village, area of LLC “Fact”	1	4.5

Continuation of Table 1.

Settlement	Number of warehouses	Tons in total	Settlement	Number of warehouses	Tons in total
Pulynsky district					
Ivanovychi village, private enterprise “Ivonovytske”	1	8.0	Yahodynka village	1	23.0
Ten’kivka village	1	9.0	Kolodiyivka village	1	0.3
Huta-Yustynivka village, farm “Poliska nyva”	1	3.0	Khodorivka village, agricultural LLC “Tetirske”	1	4.0
Zelena Poliana village	1	3.0	Koshelivka village	1	17.0
Korostensky district					
Vas’kovychi village, agricultural LLC “Poliska nyva”	1	4.062	Kalenske village, agricultural LLC “Svitanok”	1	8.219
Kapysche village, private rent agricultural enterprise “Hrunty Polissia”	1	3.502	Medynivka village, agricultural LLC “Medynivske”	1	1.696
Sushky village, agricultural LLC “Nove zhyttia”	1	5.655	Khotynivka village, agricultural LLC “Khotynivske”	1	3.393
Khodaky village, private rent agricultural enterprise “Nyva”	1	0.768	Berestovetske village, private rent agricultural enterprise “Nyva”	0	4.124
Meleni village, private rent agricultural enterprise “Meleni”	1	1.256	Novyna village, agricultural LLC “Iskra”	1	0.411
Stremyhorod village, private rent agricultural enterprise “Zoria”	1	0.645	Schorsivka village, Petrovsky agricultural LLC	1	2.0
Luhyncky district					
Chervona voloka village	1	4.0	Private enterprise “Kremnianske”	1	4.1
Velyky Dyvlyn village	1	0.9	Stantsiyne village	1	3.9
LLC “Lypnyky”	1	2.7	Private enterprise “Kalynivske”	1	2.8
Litky village	1	1.7	Zherevtsi village	1	0.8
Topilnia village	1	10.6			
Narodytsky district					
Narodychi village, private enterprise “Berehynia”	1	1.8	Narodychi village, agricultural LLC “Zorya”	1	1.2
Zherev village, private enterprise “Smyka”	1	2.0	Lasky village	1	1.0
Selets’ village	1	1.1	Bolotnytsia village	1	0.7
Sukharivka village, agricultural LLC “Sukharivske”	1	1.2	Zalissia village, Vatutin agricultural LLC	1	3.6
Motiyky village	1	4.97	Lyplianschina village	1	4.7
Novy Dorohyn’ village	1	0.8	Noryntsi village	1	2.2
Novohrad-Volynsky district					
Private rent agricultural enterprise “Kolos”, Pykypovychi village	1	3.0	LLC “Schedry dar”, Kolodianka village	1	0.8
Khmelytsky agricultural LLC, Povchyne village	1	0.6	Private enterprise “Khliborob”, Pyschiv village	0	0.3
Private agricultural enterprise “Granit”, Tokariv village	1	2.0	Private agricultural enterprise “Yavir”, Yavorovka village	1	0.275
private enterprise “Poliana”, Polianivka village	1	1.5	Farm “Adelayida”, Tupaltsi village	1	1.5
LLC “Agrosoyuz”, Orepy village	1	2.9	Agricultural LLC “Rostok”, Kurchytsia village	1	2.1
Procurement and manufacturing plant “N-Volynsky”, Ivashkivka village	1	0.216	Agricultural LLC “Lisove”, Luchytsia village	1	1.7
Korolyov private enterprise, Taraschanka village	1	0.7	private agricultural enterprise “Tserem”, Krasylivka village	1	1.0

Continuation of Table 1.

Settlement	Number of warehouses	Tons in total	Settlement	Number of warehouses	Tons in total
Bronykivska village council	1	0.27	Maystrivska village council	1	0.2
Private agricultural enterprise “Khmil’”, Klenova village	1	0.45	Private agricultural enterprise “Promin’”, Uzhachyn village	1	0.3
Regional Sanitary-epidemiological station	1	0.488	Shevchenko Private agricultural enterprise, Mala Tsvilia village	1	0.3
Agricultural LLC “Oberih”, Bronyky village	1	2.5			
Ovrutsky district					
Pischanytsia village, agricultural LLC “Polissia”	1	4.2	Private agricultural enterprise “Ukrayina”, Pokaliv village	1	1.474
Khlupliany village, agricultural LLC “Khlupliany”	1	0.8	Levkovychi village, agricultural LLC “Mozharivske”	1	1.8
Mozhary village, agricultural LLC “Mozharivske”	1	3.94	Bihun’ village, private enterprise “Khotynivske”	1	1.9
Cherevky village, agricultural LLC “Cherevky”	1	0.5	Cherevky village, agricultural LLC “Cherevky”	1	0.2
N. Velidnyky village, OJSC “Ovrutsky rayagrokhim”	1	19.49	V. Khaycha village, LLC “Velykokhaychanske”	1	1.5
Sholomky village, agricultural LLC “Nove zhyttia”	1	3.3	Veselivka village, LLC “Nehodivske”	1	12.07
Rakivschyna village, agricultural LLC “Rakivschynske”	1	5.5	Hladkovychi village, farm “Dobrobut-Radychi”	1	1.6
Zaricchia village, agricultural farm “Zorya”	1	5.0			
Olevsky district					
Lopatychi village, private rent aricultural enterprise “Iskra”	1	1.65	Bilokorovychi village, private rent aricultural enterprise “Bilokorovytske”	1	6.35
Kamianka village, aricultural LLC “Svitanok”	1	2.87	Kyshyn village, private rent aricultural enterprise “Kyshynske”	1	1.4
Kopysche village	1	0.5	Majdan village	1	0.48
Zolnia village	1	1.9	Zubkovychi village	1	3.1
Zhubrovychi village	1	2.37	Komsomolsk village	1	1.1
Zamyslovychi village	1	1.3	Suschany village	1	1.907
Tepenytsia village	1	1.5	Olevsk city	1	5.8
Popylniansky sistrict					
Popilnia village	1	5.5			
Radomyshl’cky district					
Kachkyrivska village council	1	0.6	Kocherivska village council	1	0.2
Mirchans’ka village council	1	0.2	Krasnobirs’ka village council	1	2.0
Borschivska village council	1	5.0	Menkivs’ka village council	1	0.3
Vyshevetska village council	1	1.6			
Khoroshivsky district					
Znamianka village	1	0.25	Krayivschyna village	1	8.05
Skolobiv village	1	3.0	Sukhovolia village	1	0.6
Toporysche village	1	2.2			
Cherniakhivsky district					
Okilok village, private rent agricultural enterprise “Okilok”	1	2.59	Styrtynska village council	1	3.0
Zarolivska village council	1	3.3	Andriivska village council	1	3.5
Vysokivska village council, Gorodysche village	1	1.7	Seletska village council, Selets’ village	1	0.5
Смт. Черняхів ДП “Україна”	1	3,0			

Continuation of Table 1.

Settlement	Number of warehouses	Tons in total	Settlement	Number of warehouses	Tons in total
Chudnivsky district					
c. Vil'shanka village, OSCJ "Rayagrokhim"	1	1.2			
Yemilchynsky district					
Gannopilska village council	1	0.5	Maloglumchanska village council	1	1
Mokliakivska village council	1	0.7	Pidlubivska village council	1	0.5
Serhiivska village council	0	0.5	Serednivska village council	1	1.6
Stepanivska village council	1	1	Riasnenska village council	1	0.5
Velykojablunevska village council	1	1	Zelenytska village council	1	0.5

There are a total of 392.18 t of stored pesticides. Of these, 32.450 t are liquid, 24.975 t are solid, and 334.755 t is unknown mixtures. The condition of the storing containers is as follows: 39.07 t of pesticides are kept in good condition, 22.43 t in satisfactory condition, the rest in poor condition. Due to poor storage conditions, toxic pesticides enter the environment including water and air, presenting the risk of poisoning to humans, flora, and fauna.

Only warehouses storing unsuitable chemical plant protection products (CPPP) in Berdychiv and Pulyn districts are protected, the rest of the warehouses are not guarded. In Zhytomyr region, efforts were made of replacing CPPP containers. For example, 33.731 t of unsuitable agrochemicals of the former collective agricultural enterprises were weighed and reloaded in 11 village councils in Korosten district, in October 2014. 37 t of toxic waste were reloaded in sealed containers at the territories of Novovelidnytska, Nevhodivska, Mozharivska and Pokalivska village councils of Ovrutsky district in 2014. Popilnanska united territorial community (UTC) organized reloading at its own expense of 5.5 t of CPPP to sea containers in 13.05.2017.

In 2011–2012, 968.535 t of unsuitable CPPP were reloaded and exported from Ukraine. At present, the territory of Baranivsky, Brusyliv, Lubarsky, Malynsky, Romanovsky, and Ruzhyn districts of Zhytomyr region has been cleared of CPPP.

Expired pesticides are unusable and must be disposed of. Together with storage packaging, they are hazardous waste that must be correctly deactivated by licensed agencies. Currently, in Ukraine, there are no entities licensed to conduct hazardous waste management (collection, transportation, storage, treatment, disposal), including unsuitable pesticides.

The problem also lies in the lack of a scientifically sound concept of pesticide processing and deactivation, imperfect technological processes and the incomplete technological cycles of processing, the lack of safe methods of disposal. The whole range of issues related to the elimination or control of the negative effects of toxic waste on the environment and human health will only be effectively resolved with a national program for waste management.

IV.II. Pesticide pollution of soil, water bodies and products of agriculture in Zhytomyr region

According to State Institution "Zhytomyr Regional Laboratory Center of the Ministry of Health of Ukraine", pesticide (HCH, DDT, DDE, DDD, heptachlor) content was in the range of 0.0007−0.07 mg/kg in soils and sediments of Zhytomyr region in 2018−2019, within the MPC values (0.1 mg/kg) (Table 2).

In February 2015, an excess of **DDT** (0.3 mg/kg, MPC = 0.1 mg/kg) was observed in soil sampled at Romaniv village (Makarenko Street) (report № 1–10 of February 27, 2015). In September 2017, the content of **Dragon** pesticide (0.29 mg/kg) exceeded MPC of 0.2 mg/kg in soil sampled at the boundary of residential development in the Romanivka village of Brusylivsky district (Centralna str., 1.25 m from the corn field) (report № 148−154 of 28.09.2017). The active substance of Dragon is chlorpyrifos. It belongs to organophosphate compounds. It is a modern, broad-spectrum contact insecticide against sucking and biting insects. It has high initial toxicity, blocking primarily acetylcholine esterase enzymes, which play an important role in the transmission of nerve impulses in insects.

Content of HCH, DDT, DDE, DDD and heptachlor was measured in water bodies of Zhytomyr region in 2018−2019. It fluctuated in the range of 0.0007−0.01 mg/dm^3, which is within MPC values (Table 3).

In September, 2017, the content of **Dragon** (0.003−0.004 mg/dm^3) and **Dorpan** (0.003 mg/dm^3) pesticides exceeded MPC values (0.002 mg/dm^3) in waters of private dug out wells on the Centralna and Shevchenko streets of Romanivka village, Brusylivsky district (report № 297−301 of 28.09.2017). The active substance of Dorpan is chlorpyrifos, one of the organophosphate compounds. It is a broad-spectrum insecticide.

In August, 2016, content of **Dursban** pesticide (0.1 mg/kg) exceeded MPC of 0.05 mg/kg in vegetables (zucchini) produced in Yastrubna village of Brusylivsky district (report № 44 of 4.08.2016). The active substance of Dursban is also chlorpyrifos.

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Table 2

Levels of pollution of soil and sediments with residual amounts of pesticides (mg/kg, MPC = 0.1 mg/kg) in Zhytomyr region (2018–2019)

Water body	District	HCH MPC = 0.1		DDT MPC = 0.1		DDE MPC = 0.1		DDD MPC = 0.1		Heptachlor MPC = 0.1	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
«Stas'ka hreblia" UT MR	Andruchivka city	0.008	0.008	0.005	0.005						
Unorganized recreational area in Kvitneve village	Andrushivsky	0.01	0.009			0.005	0.004				
Pond of Vchorayshe village	Ruzhyncky							0.01	0.008		
Lake №1	Korostyshivsky	0.004	0.004								
Lake of Glybochok village	Korostyshivsky		0.02								
Quarry (near Zaricchia)	Korostyshiv city		0.07								
Tykhi Verby pond	Brusyliv village	0.0008	0.0007								
Irsha river (unofficial swimming area), Bondaryk str.	Malyn city	0.008	0.007	0.005	0.005						
Confluence of Sluch and Khomora rivers, Baranivka village	Baranivsky	0.07	0.07						0.06		
Pond of Chudniv city	Chudnivsky									0.01	0.01
Floodplain of Kodnianka river	Ozerne village								0.01		

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Table 3

Levels of pollution of water bodies with residual amounts of pesticides (mg/dm^3) in Zhytomyr region (2018–2019)

Water body	District	HCH MPC 0.02		DDT MPC 0.002		DDE MPC 0.002		DDD MPC 0.002		Heptachlor MPC 0.001	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
“Stas’ka hreblia”	Andrushivka city	0.009	0.008	0.001	0.0009						
Unava river, Kvitneve village	Andruchivsky	0.009	0.009					0.001	0.0009		
Pond of Popilnia village	Popilniansky	0.01	0.01	0.001	0.001						
Water body of Khodorkiv village	Popilniansky									0.0008	
Pond in Vchorayshe village	Ruzhynsky							0.001	0.0008		
Lake “Skirobjednannia”	Berdychivsky		0.007		0.001						
Irsha river	Khoroshiv city	0.006									
Vodoyma of Guta village	Khoroshivsky	0.001									
Lake № 1	Korostyshivsky	0.008									
Pond of Bezhiv village	Cherniakhivsky	0.002									
Tykhi Verby pond	Brusyliv village	0.0008	0.0007								
Irsha river (unofficial swimming area), Bondaryk str.	Malyn city	0.01	0.01	0.007	0.006						
“Kaliuzha” (unofficial swimming area), Gorodyschanska str.	Malyn city				0.0005	0.0008					
Pond of Malynivka village (unofficial swimming area)	Malynsky						0.0009				
Viznia river, in Rudnia-Gorodyschenska village	Malynsky					0.0008					
Myka river (unofficial swimming area)	Radomyshl’sky	0.008								0.0009	

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Teteriv river (250 m downstream of waste-water discharges)	Radomyshl'sky							0.0009			
Sluch river (200 m upstream of waste-water discharges of communal enterprise "Novohrad-Volynsky VUVKH")	Novohrad-Volynsky	0.009									
Sluch river (200 m downstream of waste-water discharges of communal enterprise "Novohrad-Volynsky VUVKH")	Novohrad-Volynsky	0.01									
Sluch river (recreational area near Zaricchia)	Baranivka city	0.005	0.001								0.001
Confluence of Sluch and Khomora rivers, Markivka village	Barankivsky	0.007									0.0008
Pond of brick factory	Pulyny village	0.008	0.009								
Teteriv river (100 m upstream of bridge)	Chudniv city	0.006			0.0009						
Pond of Chudniv city	Chudniv city									0.0007	

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IV.III. Accumulation of organochlorine pesticides by freshwater bivalve mollusks

We studied the organochlorine pesticide content in soft tissues of bivalve mollusks of the species *Unio crassus* from Perha river (Radovel' village, Olevsky district) and *Anodonta anatina* from Irsha river (Khoroshiv village, Zhytomyr region), and also in water and sediments of rivers inhabited by the mollusks. OCP enter the mollusk organisms same as other pesticides, either through skin, adsorption with food, or with metabolism. OCP are accumulated most intensively in the body parts of mollusks that are most exposed to the polluted environment (shell, mantle, foot and branchia).

HCH, DDT, DDD, DDE, heptachlor were not detected in water, sediments and tissues of bivalve mollusks by gas-liquid chromatography. Thin-layer chromatography revealed traces of **Aldrin** pesticide in sediments and soft mollusks (Fig. 6).

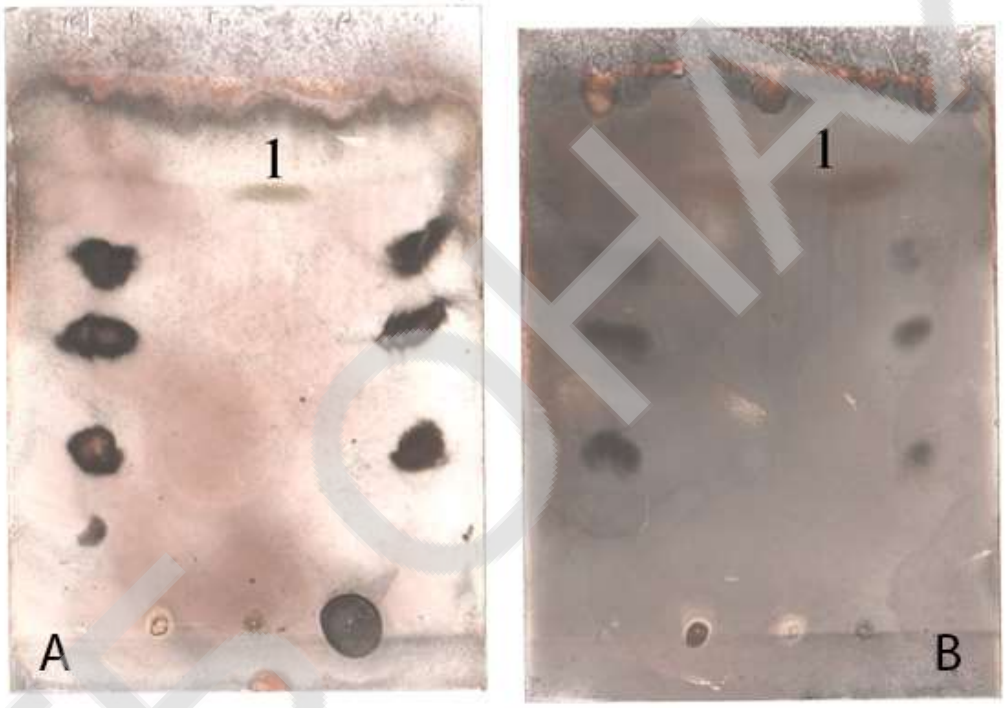

Fig. 6. Chromatogram of distribution of organochlorine pesticides on chromatogramic plate «Silufol», thin-layer chromatography (solvent system hexane, developer silver ammonia, September, 2019): A – foot tissues of *Unio crassus* mollusks from Perha river (Radovel' village, Olevsky district of Zhytomyr region); B – foot tissues of *Anodonta anatina* mollusks from Irsha river (Khoroshiv village, Zhytomyr region), 1 – trace amounts of Aldrin.

Aldrin ($C_{12}H_8Cl_6$) is a pesticide, used in pest control in plant cultures and against termites. Due to its toxic effect, it is banned not only for use but also for production in Ukraine and many other countries of the world. At the same time, it is possible that Aldrin reserves are kept in numerous pesticide storages in Ukraine.

IV.IV. Recommendations for decreasing pesticide content in environment

Development of scientific technologies and legislative framework is important in controlling and lessening the negative effects of pesticides on the environment [2, 6, 11]. Hence, the following recommendations are topical:

- the implementation of the Stockholm Convention on Persistent Organic Pollutants in Ukraine should become a matter of national priority;
- there should be scientific studies and development concerned with determination and monitoring of pesticides;
- system of state monitoring of environment and citizen health under the effect of pesticides should be implemented;
- the infiltration of pesticides into environment should be limited and/or prevented;
- control should be established over economic entities that produce and sell (or otherwise realize) pesticides, and over citizens or other legal entities engaged in activities related to such pesticides;
- people of Ukraine should be informed of the dangers of pesticides;
- training programs should be developed and implemented on pesticide hazards and their implications for the life and health of humans, the environment, and of alternatives to pesticides;
- illegal circulation of pesticides in Ukraine, circulation of banned and overdue pesticides should be prevented, and areas contaminated with pesticides that are unsuitable or banned to use should be detected and cleared.

V. Conclusions

1. In Zhytomyr region, nearly 392.18 t of pesticides are stored in 137 warehouses. Eleven warehouses meet the requirements, 36 are tolerable, and 90 are in poor condition. The quality of storage containers is as follows: 39.07 t are kept in good conditions; 22.43 t are kept in tolerable conditions; other pesticides are stored in containers of poor quality.

2. In 2018−2019, pesticide (HCH, DDT, DDE, DDD, heptachlor) content in soils and sediments of Zhytomyr region was in the range of 0.0007−0.07 mg/kg, i.e. within MPC values (0.1 mg/kg). Content of HCH, DDT, DDE, DDD, heptachlor in water bodies of Zhytomyr was in the range of 0.0007−0.01 mg/dm^3, at the same time, also within MPC.

3. In 2015, DDT content in soil (0.3 mg/kg) exceeded MPC (0.1 mg/kg) in Romaniv village; in 2017, Dragon pesticide content in soil (0.29 mg/kg) exceeded MPC (0.2 mg/kg) in Romanivka village. Also in 2017, Dragon pesticide content (0.003−0.004 mg/dm^3) and Dorpan pesticide content (0.003 mg/dm^3) exceeded MPC (0.002 mg/dm^3 and 0.002 mg/dm^3, respectively) in water samples from wells of Romanivka village. In August, 2016, Dursban pesticide content (0.1 mg/kg) exceeded MPC (0.05 mg/kg) in sampled zucchini produced in Yastrubna village of Brusylivsky district, Zhytomyr region.

4. In soft tissues of bivalve mollusks and sediments of the water bodies which they inhabit, residual traces of the organochlorine pesticide Aldrin were found.

5. Recommendations are developed to decrease the pesticide content in environment.

Prospects for further research. Experimental studies on biological test objects are planned to investigate the likely toxicity of residual OCP.

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ANALYSIS OF PHARMACEUTICAL WASTE MANAGEMENT METHODS BASED ON THE EXAMPLE OF THE QUALITY CONTROL DEPARTMENT OF A PHARMACEUTICAL COMPANY

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Abstract*. The methods of waste management in the pharmaceutical company. Shown classification of waste generated as a result of the quality control department, in their type, a way of recycling and registration. Established line of action designed for waste management enterprises investigated, legislation of Ukraine. The process of waste management in the pharmaceutical company PDCA cycle occurs. Statistical data obtained from the relevant documentation allow us to investigate, analyze and, if necessary, to make corrective actions in the process of waste management.*

Keywords*: ecology, environment, pharmaceutical company, waste management, waste water, plastics, chemicals.*

I. Introduction.

Pharmaceutical products are one of the most in demand on the market of Ukraine. By T. Shabelnik indicates: "that the average Ukrainian spend 10% of their income on medical products (drugs)" [2]. But it is important to note the government's activities in the area of drugs in Ukraine. For example, using the special program "Available drugs" drugs increased turnover because people could get drugs of certain groups for free.

S. Kulytskyi in his work "The pharmaceutical industry and pharmaceutical market in Ukraine: Status and Problems of Development" reports that the: "results of 2018 the volume of sales made in Ukraine of basic pharmaceutical products and pharmaceutical preparations by about 6% higher than the figure in 2013 (in comparable prices) and reached UAH 34.2 billion" [3].

This substantiates the joint influence of socio-cultural and demographic factors which include: alcohol, not active healthy lifestyle, improper use of drugs, , migration of diseases from abroad. resistance.

In this regard, to ensure that the basic function of drugs – to improve human health pharmaceutical companies are increasing their capacity. However, the increasing amount of waste pharmaceuticals that affect the environment.

II. Analytical review of the literature

Nowadays, manufacturers of medicinal products governed by the rules and principles set out in the guidelines of good manufacturing practices. This instruction is used to build a pharmaceutical quality system and proper organization of production of finished drugs and active ingredients; for the design, construction, reconstruction and technical re-equipment of enterprises producing finished products and active ingredients, which usually improves the quality of products produced. But, unfortunately, the principles and rules laid down in the GMP, do not apply to issues of environmental security [4].

According to the book by A.M. Kasimov, V.T. Semenova, N.G. Shcherban, V.V.

Myasoedov "Modern problems and solutions in the system of hazardous waste management": "it is impossible to make production waste-free". The accumulation of some types of waste can worsen the environmental situation, which is the pattern we can see today. Therefore, reducing their impact is a priority for pharmaceutical companies [1]. Performing this task will increase not only the level of social security, but also the degree of consumer confidence in the manufacturer.

The main document on which all participants pay attention production companies, including pharmaceutical, in the field of environmental safety is ISO 14001, the essence of which is that it contains the requirements for environmental management. Doing it organization can increase their efficiency and increase loyalty to their environmental stakeholders.

For example one of the requirements of this standard are: "the organization should evaluate those activities associated with its identified significant environmental aspects and ensure that these activities are conducted in a manner that allows you to control or reduce the associated adverse effects to meet the requirements of its environmental policy and achieve their goals and objectives. This should include all activities, including support and maintenance". [5]

The aim of the competition is:

– research aimed at determining the environmental safety of the pharmaceutical company an example of quality control.

– Analysis of waste disposal methods that can be used in work of department quality control of medicines.

III. The object, subject and research methods.

Object research – the process of disposal of waste generated as a result of laboratory quality control of medicines in the pharmaceutical company.

Subject research – pharmaceutical waste disposal methods on the example of the quality control department.

Methods research. In the course of analysis used causation to identify potential waste by building causal chain to determine the possible consequences and methods of their utilization.

IV. The results

Any analysis process begins with the definition of relevant terms. So relying on legislative acts of Ukraine:

"Waste– is any substances, materials and objects resulting from human activity and can't be used in place further education or identification and must be taken or destroyed". [6]

The process of waste management is their detection, identification, collection in special containers depending on their type (preventing mixing of different types of waste) registration.

The road of utilization is determined according to internal documents, internal instructions Company obtained a passport and map register waste.

Step identify waste includes not only identifying them at work, but predicting their formation using documented information, such as chemicals used in chemical laboratories.

At the stage of identification can be concluded that overall waste produced in the

laboratory as a result of analytical work can be divided into the following main categories: chemical nature, domestic nature, biological nature and packaging materials, which in turn are divided into different types, presented in Figure 1.

Waste generated as a result of the laboratory shall be:

1. Collection.
2. Placing in designated areas.
3. Recoded.
4. Timely removal.
5. Transfer on destruction.

Therefore, the most important step is the correct identification of waste, because it affects the correct action in management.

Correct waste identification requires to collect waste and placed according to their types.

The first step in identifying waste in the company is to establish classes of danger to the environment. The requirement to establish classes of waste hazard to the environment and human health legislated the Law of Ukraine "About Waste".

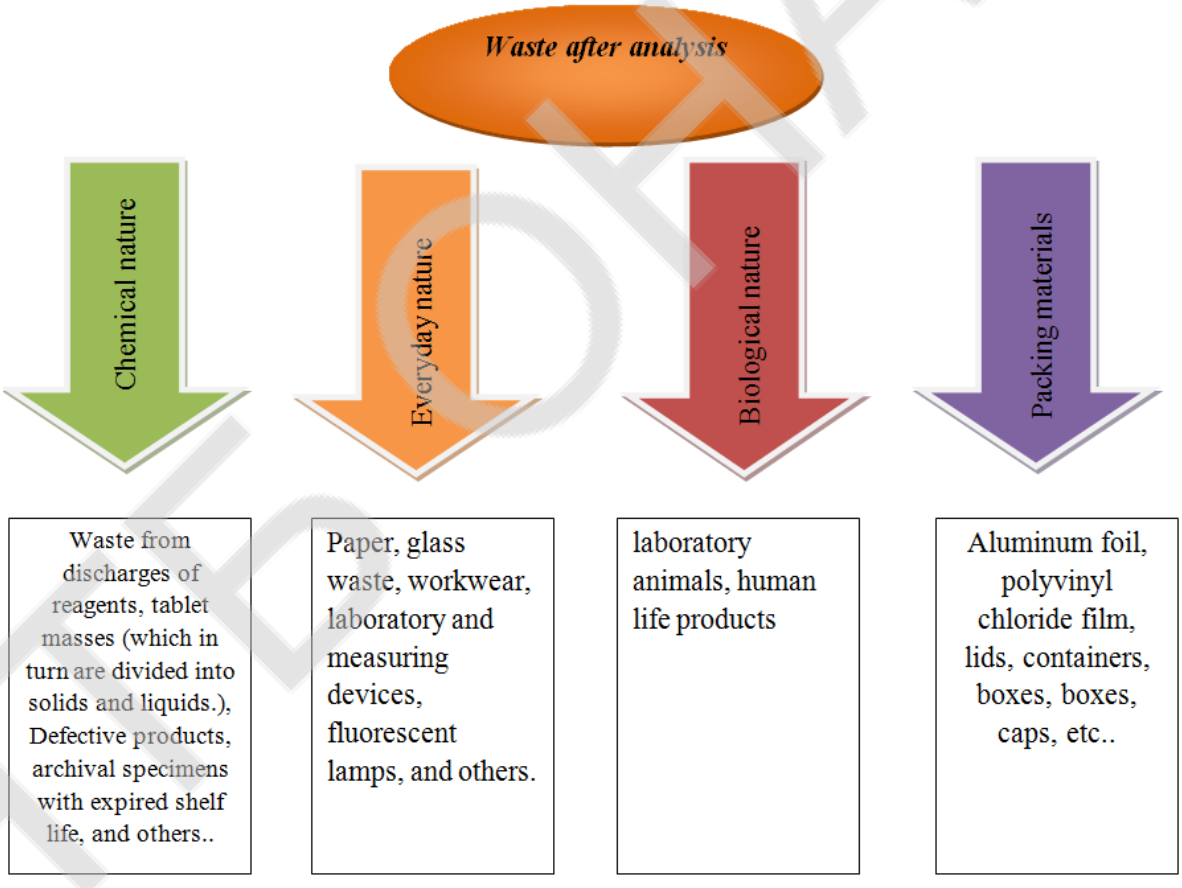

Fig. 1. Types of waste produced in the laboratory activities.

Under the criteria to hazardous waste hazard class are four classes of danger for the environment:

- extremely dangerous (1)
- high-risk (2)
- moderately hazardous (3)
- low-hazard (4).

Waste hazard class set depending on the degree of harmful effects on the environment by direct or indirect impact of hazardous waste on it.

The problem of plastic waste is a big problem, not only pharmaceutical companies, but also the whole country. Plastic, thanks to its pluses (ease, efficiency, satisfaction of consumer properties, less energy-intensive production, so for manufacturing the first plastic bottle costs of energy in the manufacture of up to 21% than for the manufacture of glass) [7] were quick substitute different materials used in human life. However, the rapid growth in popularity of plastic led not only to environmental pollution, due to its improper disposal, but also to a shortage of raw materials from which it is produced, what make it more expensive. Therefore, waste polymers are raw materials and energy resources. [7].

By the plastic used for the work of enterprise include: tape, lids, containers, bottles, caps, trays, buckets, bottles of drinking water, the film t / a.

Using in its work products from polymeric raw materials, the pharmaceutical company selected for analysis cooperates with special organizations on recycling of plastic waste.

But before passing the waste received their need to find, identify and collect. According to the requirements of enterprise waste plastic collected in a separate container that prevents their connection with other types of waste.

Choosing such a plastic waste management policy, the company investigates not only does not harm the environment (because it does not use the method of waste disposal with PET methods of disposal in the ground, burning), but on the contrary promotes the processing of plastic waste into polymeric raw materials, providing not only environmental safety, but also making it economical for businesses that use polymeric raw materials to create polyethylene items, as this is not only more cost effective but with recycling creating a large number of useful products for the national economy [7].

Table 1 shows the different types of waste generated during the quality control department and transferred to a specialized company for destruction and disposal.

Table 1.

Types of waste delivered to specialized organizations

Types of waste	Operations
Fluorescent lamps and waste containing rut (mercury thermometer)	Transferred to specialized organizations for recycling
Packing materials (aluminum foil fused PVC)	
Plastic packaging materials (film, lids, containers, bottles, caps, trays, buckets, bottles of drinking water, the film t / a).	
Paper for recycling paper and cardboard (waste paper and cardboard printed products made of twisted hoforokartonu and others.)	
Tools and instruments for general-mechanical nature, thermomechanical physico-chemical, biological (worked office, laboratory and measuring equipment, alcohol thermometers)	
Protective clothing (gloves)	
Waste utilities incl garbage from bins (rubbish from territories household waste polyethylene)	

Not all waste produced during laboratory quality of medicines are subject to disposal outside organizations.

This type of waste include waste chemical type, semi drugs domestic production (archival samples with expired) to be destroyed at the institution.

The life cycle of chemicals in a laboratory begins with the delivery necessary materials from supplier firms. The substances are used in the synthesis or analysis. In a work process can formed contaminated raw materials, products, contaminated solvents and reagents should be collect or recycle if their selection for reuse impossible. Unlike industrial wastes, chemical wastes in the laboratory are usually formed in small quantities and are very complex mixtures. Laboratory waste that are in different locations can differ in composition, acceptable way, need to know the types of experiments and used materials. But some types of hazardous waste produced in laboratories, can not be spread in their original form, they must first be prove to the required condition. Using the appropriate processes, the waste can be subjected to detoxification in place of their education. The advantage of detoxification is to reduce the probability of impact on untrained staff who can deal with these wastes and accidents that reduce the risk of environmental pollution.

Depending on the physical state of chemical waste used different methods of disposal. The method for encapsulation of solid waste, and a method for breeding liquid. The method of breeding is to create a solution of 1: 200, and the drain of the solution concentration in the pipeline.

It is important to understand that after this procedure the life cycle of chemicals does not stop as they enter the waste water.

Wastewater are any liquid that is poured into the sink. Ideally, they contain only water. But in practice they usually are aqueous solutions previously neutralized to a pH of 6 to 9, and do not contain heavy metals

The problem of waste water treatment in Ukraine remains today. The most influential reasons for this are:

1. Very limited funding construction of new treatment plants and to maintain the technical level of existing facilities sanitation.
2. Motivated by rising prices on energy reduce energy consumption for wastewater treatment.
3. High (compared with those of developed countries) labor to operate the facilities for wastewater treatment.
4. The lag in dewatering and disposal of sewage sludge [8].

In the process of recycling waste water must comply with concentration limits adopted for domestic wastewater. Can merge only those substances relating to dangerous substances. Substances which merge into the sewer must be environmentally friendly and does not create technological barriers when operating water purification stations. [9].

Wastewater under Ukrainian law shall:

1. Contain flammable gaseous impurities and dissolved substances that can form explosive mixtures.
2. Contain substances that are able to block up the pipes, wells, lattice or deposited on their surfaces (litter, soil, abrasive powders and other coarse suspension, gypsum, lime, sand, metal and plastic shavings, fats, resins, oil, brewer's grain, bread yeast etc).

3. Contain only inorganic substances or substances that are not amenable to biological degradation.

4. Contain substances that are not set maximum permissible concentration (MPC) for water reservoirs or toxic substances that prevent the biological wastewater treatment, as well as substances for which no definition developed analytical methods of control.

5. Contain dangerous bacterial, viral, toxic and radioactive pollution.

6. Have a temperature above 40 ° C.

7. Mother pH below 6.5 or above 9.0, [9].

Based on the requirements of environmental legislation with established periodicity is controlled as waste water, emissions control, research soil. Quality control of wastewater that enter the city sewer carried out according to schedule, developed annually, according to the rules of admission wastewater into the sewer network. To control the quality of wastewater analyzes the content of these elements:

– chlorides;
– phosphates;
– iron;
– sulfates;
– zinc.

In the work of the enterprises of pharmaceutical and chemical orientation emissions into the atmosphere are also formed: sulfur compounds, oxides of nitrogen, ammonia and carbon monoxide - in the use of sulfuric and nitric acids, chlorine and hydrochloric acid - in the use of chlorine compounds.

Control of emissions of air pollutants emissions makes, outside-organizations o that have a license for this activity. Using guidance on methods for determining pollutants in the air determine the content of the following elements: ammonia, hydrogen sulfide, phenol dioxide and nitrogen oxide, mercury, cyclohexane, formaldehyde, chlorine, carbon monoxide.

Sampling was performed by aspiration certain amount of air via the absorbing device filled with a liquid or solid sorbent material to absorb or through aerosol filter that retains part contained in the air. The study admixture is concentrated in a small volume of sorbent or filter. Type absorbing device or filter is determined depending on the substance to be tested.

In addition to safe waste activities in the laboratory can be formed dangerous, which include: inorganic acids, mixtures of acids, alkali, alkaline compounds, solvents and waste containing silver and caustic substances.

These substances prohibited disposed through the collection of household waste or sewage. Types of waste that include dangerous should be collected separately and transmit licensed companies that recycle hazardous waste. Manufacturer of waste should also be able to provide data on the type of hazardous waste. Each type of waste meet certain thresholds set for the departure of the components and their properties.

Since the legislation Ukraine does not fully regulate the sphere of hazardous waste, the most viable option would be to avoid the formation of such waste on the start.

To this end, it is important to try to reduce or completely eliminate the use of substances whose disposal costly, or replace them suitable analogues that can be disposed of at a lower price and more acceptable environmental manner.

For example, in the target company in the quality control department abandoned the use of chromium compounds, because it has carcinogenic properties. Therefore laundering persistent contaminants encouraged to use other means (alcoholic solution of alkali).

Hazardous waste is collected in special containers separately from other waste and sent to a place of storage of hazardous waste containers that store hazardous waste must be signed and marked.

The world is spreading practice of returning excess amounts of chemicals and solvents manufacturer. For example, a company Merck offers a service called Retrologistics®. The type and condition chemicals supplied and the number documented. After analysis and quality control of these substances are used in the production and synthesis. If re-use is not possible, these chemicals are disposed of according to regulations.

Any management is impossible without the use of statistics generated in the control process of waste management, as the company recorded every type of care in designated magazines, illustrated in Table 2.

Information on emissions control, wastewater quality, recycling and transfer to third parties, documented in the relevant documentation, allows for an annual waste generation and disposal limit, which can in turn be directly investigated and adjusted. This is how the PDCA cycle is performed in the waste control and management process.

Analyzing the activity of the studied company in waste management, we can conclude that the waste management in company is accordance with the requirements of the regulations presented in the legislation of Ukraine.

As noted above, the process of waste minimization is constantly updated and must meet modern requirements and trends. Especially now, when Ukraine became a step closer to European integration, is important not only quality products, but also protect the environment.

Among the theoretical constructs designed to address environmental and economic issues and at the same time acceptable to the scientific substantiation of activities related to waste management should be highlighted: the concept of technological determinism; the concept of "zero waste"; concept of assimilative capacity of the environment; concept of externalities. Each of these concepts can serve as a theoretical arguments of certain items of environmental waste management program. The problem is that the development of such programs usually involved officials of relevant government authorities, primarily using their practical experience, logic administrative actions and legislative rules that may come into conflict with each other and proposed the scientific community conceptual views. It is therefore important to develop an algorithm using scientific provisions allowing justify the measures planned environmental programs [10].

Table 2.

Actions performed by the waste generated in the department of quality control

Type of waste	Operations	Supporting documents
Rubbish bins of (municipal solid waste)	To collect solid waste in labeled containers with a plastic bag tucked in the space, weigh. Remove waste in solid waste containers, which are located on the premises	Journal of waste.
Waste paper and cardboard paper	Pick, crushed, transmit specialized enterprise	Journal of waste, waste deed to the warehouse
Waste chemical reagents, solvents showers	Daily collected in labeled glass container, weighed, placed in a specially designated place for recycling rent	Journal of waste, the act of transferring the warehouse
Archived samples from bypassing the shelf life and storage	Collected and placed in the space	The act of cancellation, the act of transferring waste to the warehouse
battle of glass	Battle of glass: -empty ampoules after analysis, collect, and place a special place in the presence of Commission crushed, crushed ampoule collected in a plastic bag, weigh, label, later the same battle transferred to the glass composition. -on excluding ampoules, collect, weigh, label, transfer enterprise specialized	The act of destruction logbook waste, waste deed to the warehouse
Plastics	Packing materials, plastics spoiled or contaminated waste is collected in containers marked separately (depending on the type of plastic), transmit specialized enterprise	Journal of waste, waste deed to the warehouse
The bodies of laboratory animals	Pick a special place, of the destruction carried out under the contract	The act of euthanasia
Aluminum foil	Pick aluminum foil containers labeled in a plastic bag tucked in the space, weigh label, transfer enterprise specialized	Journal of waste, waste deed to the warehouse
Protective clothing spoiled	Pick a plastic bag, weigh, label transfer to the container for solid waste	Journal of waste

In addition to ensuring that waste is reduced at the legislative level, it is also important to make changes at the level of the pharmaceutical enterprise itself. These may include more frequent filter replacement and inspection, moving from more dangerous solvents to safer ones that may not be used for analysis alone.

V. Conclusions

1. According to different authors demand for pharmaceutical products in Ukraine is high. In this regard, to ensure range of drugs pharmaceutical companies are increasing their capacity, leading to increased pollution.

2. Since GMP principles do not apply to the issue of environmental safety, the main document that recommends methods of environmental activities in environmental security companies are ISO 14001 and legislative acts of Ukraine in the field of

environmental protection.

3. The pharmaceutical company quality control department is used as an example for research.

4. The work analyzes the main stages of waste management produced during pharmaceutical organization. These include: detection, identification, collection, filling in the necessary documentation, further recycling, disposal or transfer to specialized enterprises.

5. It is established that the actions performed in the management of waste in the target company complies with legislation of Ukraine, which are used in environmental protection and waste management recommendations presented in ISO 14001.

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THE QUALITY OF DRINKING SPRING WATER AS A FACTOR INFLUENCING THE HUMAN HEALTH

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Abstract. *Determination of the quality of drinking spring water of the Kharkiv city to establish the level of safety for human consumption.* ***Research.*** *In the laboratory, the main characteristics of water quality from four urban drinking water sources were determined, and the dynamics were determined in connection with the changes of the seasons. The* ***results*** *were obtained. It is established that with change of season the chemical composition of spring water changes. In particular, in all spring water samples, pH, alkalinity, turbidity, total mineralization, and nitrate and nitrite content increased. Hardness exceeding the limit values in summer water samples decreased in autumn samples: 4.1 times in the water from the Hlibokiy Yar spring, 3.1 times in the spring water in Sarzhyn Yar, and in the spring water in the "Yunost" park with 4.2 times. In the Zhukovsky spring the water hardness has remained the same - 10 mmol / dm3.*

Keywords: *water supply, groundwater, spring water quality, natural springs, natural resources, water use.*

I. INTRODUCTION

The urgent issue today is to provide the population with quality drinking water. The Kharkiv region and directly the city of Kharkiv belong to the water scarce region. Centralized water supply provides all the needs of the population for drinking water. The quality of the resource that consumers receive by water supply is a problem for many cities and Kharkiv in particular. The population prefers spring of drinking natural water, considering them as the best alternative.

An important source of spring water is groundwater sources. Rain and melting water infiltrate the soil, which act as a kind of geochemical barrier for pollutants, and further enter the underground horizons where ground water is formed. Thus, it can be argued that their chemical composition is formed both under the influence of natural and anthropogenic factors. The discharge of water from aquifers occurs at the point of their exit to the surface, through various springs. These waters have always been in demand by the population and are considered to be much cleaner than in surface water. Therefore, the determination of the environmental safety of drinking spring water is relevant today and needs to be studied.

II. ANALYTICAL REVIEW OF LITERATURE

The study of groundwater was started by M. V. Lomonosov. In his writings, he formulated a number of scientific provisions on groundwater, outlined theories of their origin and described the process of circulation. The first information about the groundwater of Ukraine is in the works of I. F. Livakovsky, O. V. Gurov, N. D. Boryasyak, M. O. Sokolovsky. Already at the beginning of the twentieth century, the most studied hydrogeologically were the northern and northeastern regions of Ukraine [5].

The development of the volume of knowledge about hydrogeological conditions of Ukraine and groundwater in particular is connected with the theoretical works of V. I. Vernadsky, F. P. Savarensky, A. F. Lebedev. Questions of dynamics and significance of groundwater in the hydrosphere are highlighted in their works by M. M. Pavlovsky, G. M. Kamensky, N. I. Golstikhin and O.I. Lange. [5].

Modern ideas about the underground hydrosphere, the search for fresh groundwater, their protection against pollution, were developed and set out in the scientific works of N. M. Frolov, A. B. Sitnikov and others [5].

The first estimations of the amount of groundwater belong to the second half of the nineteenth and early twentieth centuries. Currently, according to A. Sokolov, there are 23.4 million km3 in the crust to the depths available for human exploration. This volume includes water in a free, solid, vapor state [6].

If speaking about terminology, we say "ground waters" as natural waters, which lay on the first from the surface of the earth a water-resistant layer, which is characterized by uniformity in lithological composition and filtration properties. Soil aquifers are unloaded into various surface watercourses and reservoirs. At the same time they also come to the bottom surface in the form of sources [6].

The issue of water quality supplied to the population by a centralized water supply network is an ongoing and urgent one. The main problems of such a system are cost demanding, interruption, but most importantly, water quality. Among the reasons for the deterioration of water quality we can mention the following: outdated water supply system, their sanitary status, vulnerability of the system to external factors (if contamination occurs at a certain interval of the network, all water supply systems further down the network, including the consumer - are at risk) [4].

In researching the issue of providing the Kharkiv residents with quality drinking water, scientific publications were analyzed, which highlight the current problems of water supply in cities. In particular, in the study N. B. Kravchenko et al. (2015) [7], it was determined that the population is actively using sources of natural drinking water for economic needs. The results of sociological surveys were presented in the paper: "The calculation of the rating of closed drinking water sources in Kharkiv by socio-economic indicators (without taking into account ecological indicators) showed that the best from the point of view of the consumer is the "Sarzhin Yar" spring, the worst - the spring in the "Yunost park" [7, p. 84-88]. Thus, this problem is more than urgent for Kharkiv residents and therefore requires continuous monitoring studies to determine compliance with drinking water requirements and to clarify their environmental safety [7].

Biochemical composition, specific indicators, alkalinity, rigidity and other indicators can directly affect the environmental quality of spring waters and, as a consequence, human health [8]. For example, the use of water with increased rigidity can lead to diseases of the gastrointestinal tract, cardiovascular diseases, skin diseases and can affect the strength of hair and nails. According to sociological surveys, the population regularly uses spring water without preparation (boiling or boiling) [9].

Hence – there is a necessity to monitor the quality of spring water, in accordance with the hygienic requirements for drinking water intended for human consumption [3].

III. OBJECT, SUBJECT MATTER AND METHODS OF RESEARCH

Annotation: Determination of the quality of drinking spring water of the city of Kharkiv to establish the level of safety for human consumption

Object of research: natural drinking spring waters of Kharkiv.

Subject of research: ecological quality and safety of spring waters of Kharkiv.

Research methods: field, laboratory, methods of atomic absorption spectrometry, statistical methods of data processing.

Tasks of work:

- perform field research, select samples of drinking spring water;
- carry out laboratory tests with the help of equipment and determine the main indicators of the chemical composition of Kharkov spring drinking water;
- to determine the variability of chemical indicators of spring water depending on the change of seasons;
- determine the environmental quality of spring water.

IV. WORK RESULTS

IV.1. Analysis of the results of the study of the quality of spring water selected in different seasons

To study the quality of drinking spring water, samples were taken at different seasons (summer and fall 2019) from groundwater springs located in Moscovsky (Hlibokiy Yar spring), Shevchenkivsky (spring Sarzhin Yar) and Kholodnogorsky (spring in “Yunost” park) districts, as well as on the territory of Zhukovsky village (Zhukovsky spring) within Kharkiv. Water from these springs is used by the townspeople for drinking and domestic purposes. Determination of spring water quality indices was performed on the basis of the Research Laboratory of Analytical Ecological Researches of the V. N. Karazin Kharkiv National University. Zhukovsky spring and spring in “Yunost” park are shown on the figures 1 and 2.

Figure 1. - Zhukovsky spring

Figure 2. - Spring in “Yunost” park

Analyzes of drinking water samples from city springs were performed according to the following indicators: pH value, electrical potential, nitrate content, chloride, ammonia, nitrite content, transparency, turbidity, water hardness [1].

The concentration of heavy metals (Fe, Zn, Cu, Mn, Cd, Cr) in water samples was determined using the MHA-915 MD atomic absorption spectrometer.

At the first stage of research in summer 2019, samples of drinking spring water were sampled in the field and the results of laboratory tests of their chemical composition were analyzed. The results are shown in table 1.

Table 1

Results of the study of drinking water from springs (summer 2019)

Indicator	Units of measurement	Spring name				MPC*
		Zhukovsky	Hlibokiy Yar	Sarzhin Yar	"Yunost" Park	
pH	-	6,85	6,264	6,672	6,456	6,5 - 8,5
Nitrates	*mg/dm^3*	34	40	34	41	50
Alkalinity	*mmol/dm^3*	8,1	4,8	6,5	8,5	0,6 – 0,5
Transparency	*point*	24	24	25	24	30
Ammonia	*mg/dm^3*	0,044	0,04	0,04	0,04	2,0
Nitrites	*mg/dm^3*	0,001	0,001	0,001	0,04	3,3
Turbidity	*mg/dm^3*	0,99	0,99	0,99	0,99	1,5
Hardness	*mmol/dm^3*	10	16,4	19,8	32,6	1,5 – 10
Electric potential	-	6,10	6,96	5,78	6,45	-
Fe	*mg/dm^3*	0,0201	0,000100	0,021000	0,002000	0,3
Zn	*mg/dm^3*	0,04	0,042800	0,008300	0,021000	0,1
Cu	*mg/dm^3*	0,0001	0,000600	0,000700	0,001500	1
Mn	*mg/dm^3*	0,0002	0,000300	0,000600	0	0,1
Cd	*mg/dm^3*	0	0	0	0	0,01
Cr	*mg/dm^3*	0	0	0	0	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

- indicators that exceed the standards.

The results of spring water studies show that the pH ranges from 6.26 in the water samples from the Hlibokiy Yar spring to 6.85 in the Zhukovsky spring. All samples of spring water are characterized in terms of pH as neutral.

The measured electric potential indicates the level of mineralization of water. This parameter has no regulatory value. The highest level of mineralization was found in water from the Hlibokiy Yar source - 6.96, and the lowest in the water from the spring of Sarzhin Yar - 5.78. In this case, it can be argued that the highest content of dissolved salts is observed in the deep water of the Hlibokiy Yar.

The reference level of nitrates should not exceed 50 mg/dm^3. It ranges from 3.4 mg/dm^3 in the water of the Zhukovsky spring and in the water of the Sarzhin Yar spring to 4.1 mg/dm^3 in the water of the Kholodnogorsky spring. No excess samples were found in any of the samples.

In terms of transparency, spring water is rated on a 30 point scale [2], and the set values are 24 - 25 points, which is a sign of clear, transparent water with no impurities and low turbidity.

Ammonia and nitrite content were determined in the water samples. Ammonia was normal (up to 2.0 mg/dm^3) [2] and was the same in all samples - 0.04 mg/dm^3.

Nitrite concentration is 0.001 mg/dm^3 in all selected water samples at the rate of 3.3 mg/dm^3.

The results of the analyzes showed that the selected waters are characterized by increased hardness: in the water from the Hlibokiy Yar spring - 1.5 times, in the water of the Sarzhyn Yar spring - 2 times, and in spring water in Yunost Park - 3 times and is 32.6 mmol/dm^3. The indicator does not exceed the norm [2] only in the sample of water from Zhukovsky spring and is 10 mmol/dm^3.

Determination of heavy metal concentrations by atomic absorption spectrometry showed that no excess was detected according to MPC [2]. The content of Cd and Cr in the samples has not been determined. Deficiency of Cd consumption can adversely affect hydrocarbon metabolism, activation of a number of enzymes, synthesis in the liver of hippuric acid, as well as metabolism of Zn, Cu, Fe, Ca. Cr is an important trace element for the human body and regulates hydrocarbon metabolism and controls blood glucose.

Studies have shown that the highest levels of nitrates, nitrites, alkalinity and stiffness were detected in a sample of water from a spring in Yunost Park.

There is no reliable explanation for the reasons for these indicators, but attention should be paid to the sanitary condition of this spring. When sampling, the local population was interviewed for their personal experience after visiting this spring. It was found that only one of the three faucets brought out for use by the spring is suitable for water abstraction and is used by the public. And the water selected only from it on organoleptic indicators can be used as drinking. Other faucets come from poor quality water and are considered environmentally hazardous by users.

The second stage of the research was to analyze the samples selected from the investigated springs in October 2019. The obtained results are presented in Table 2.

Table 2.

Results of the study of water from sources (October 2019).

Indicator	**Units of measurement**	**Spring name**				**MPC***
		Zhukovsky	**Hlibokiy Yar**	**Sarzhin Yar**	**“Yunost” Park**	
pH	-	7,2	6,9	6,8	6,8	6,5 - 8,5
Nitrates	*mg/dm^3*	22	32	26	35	50
Alkalinity	*mmol/dm^3*	8,15	6,0	7,6	10,5	0,6 – 0,5
Transparency	*point*	24	24	24	24	30
Ammonia	*mg/dm^3*	0,04	0,2	0,04	0,04	2,0
Nitrites	*mg/dm^3*	0,001	0,2	0,001	0,001	3,3
Turbidity	*mg/dm^3*	1	1	1	1	1,5
Hardness	*mmol/dm^3*	10	4,0	6,2	7,65	1,5 – 10
Electric potential	-	5,74	7,08	6,17	6,85	-
Fe	*mg/dm^3*	0,00180	0	0,00240	0,00110	0,3
Zn	*mg/dm^3*	0,06210	0,09780	0,09360	0,08890	0,1
Cu	*mg/dm^3*	0,00010	0,00020	0,00020	0,00030	1
Mn	*mg/dm^3*	0,00030	0,00070	0,00010	0,00050	0,1
Cd	*mg/dm^3*	0	0,00010	0,00040	0	0,01
Cr	*mg/dm^3*	0,00010	0	0,00020	0,00050	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

According to the results of a study of water from springs, the pH ranges from 6.8 in Sarzhyn Yar and in Yunost Park to 7.2 in Zhukovsky spring. The indicator is not characterized by a large amplitude of changes among different spring.

Total mineralization ranges from 5.74 mg/dm^3 in the Zhukovsky spring to 7.08 mg/dm^3 in the Hlibokiy Yar.

The nitrate content does not exceed the limit values and ranges from 22 mg/dm^3 in Zhukovsky spring to 35 mg/dm^3 in the spring of "Yunost" park.

Transparency is the same in all samples and reaches a high value - 24 out of 30 possible points. And turbidity, respectively - 1 mg/dm^3, the water samples are almost completely transparent.

Ammonia content in all water samples from the springs becomes 0.04 mg/dm^3, except for the Hlibokiy Yar - 0.2 mg/dm^3. All measured values meet standards [2].

The determination of nitrites also showed compliance with the standards and, like ammonia, differed only in the Hlibokiy Yar - 0.2 mg/dm^3 and in all other springs - 0.001 mg/dm^3.

According to the results of the analysis of autumn water samples, none of the samples is characterized by increased hardness and range from 10 mmol/dm^3 in water samples from Zhukovsky spring to 4 mmol/dm^3 - in water from the Hlibokiy Yar spring. Heavy metals in water springs do not exceed the standards.

IV.2. Spring water quality dynamics

Within the final - the third stage of the research, the changes that occurred in the chemical composition of the waters and the studied springs were analyzed. The results are shown in Tables 3 and 4.

Table 3

The results of the dynamics of the chemical composition waters of the Zhukovsky spring and the Hlibokiy Yar spring

Indicator	Units of measurement	Spring name				MPC*
		Zhukovsky		Hlibokiy Yar		
		Summer	Fall	Summer	Fall	
pH	-	6,85	7,2	6,264	6,9	6,5 - 8,5
Nitrates	*mg/dm^3*	34	22	40	32	50
Alkalinity	*mmol/dm^3*	8,1	8,15	4,8	6,0	0,6 – 0,5
Transparency	*point*	24	24	24	24	30
Ammonia	*mg/dm^3*	0,044	0,04	0,04	0,2	2,0
Nitrites	*mg/dm^3*	0,001	0,001	0,001	0,2	3,3
Turbidity	*mg/dm^3*	0,99	1	0,99	1	1,5
Hardness	*mmol/dm^3*	10	10	16,4	4,0	1,5 – 10
Electric potential	-	6,10	5,74	6,96	7,08	-
Fe	*mg/dm^3*	0,0201	0,00180	0,000100	0	0,3
Zn	*mg/dm^3*	0,04	0,06210	0,042800	0,09780	0,1
Cu	*mg/dm^3*	0,0001	0,00010	0,000600	0,00020	1
Mn	*mg/dm^3*	0,0002	0,00030	0,000300	0,00070	0,1
Cd	*mg/dm^3*	0	0	0	0,00010	0,01
Cr	*mg/dm^3*	0	0,00010	0	0	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

___ - indicators that exceed the standards.

With the change of seasons, and accordingly the temperature regime, the chemical indicators of water from the springs have changed.

In water from Zhukovsky spring and Hlibokiy Yar increased the pH, alkalinity, turbidity. Nitrate content decreased from 34 mg/dm^3 to 22 mg/dm^3 in water samples from Zhukovsky spring and from 40 mg/dm^3 to 32 mg/dm^3 in water from the Hlibokiy Yar spring.

The water hardness of 10 mmol/dm^3 remained unchanged only in the water from the Zhukovsky spring, and the total mineralization and ammonia content decreased from 6.1 mg/dm^3 to 5.74 mg/dm^3 and from 0.44 mg/dm^3 to 0.40 mg/dm^3, respectively.

Ammonia levels in water from the Hlibokiy Yar spring increased from 0.04 mg/dm^3 to 0.2 mg/dm^3, as well as the level of total mineralization from 6.96 mg/dm^3 to 7.08 mg/dm^3.

The water hardness index from the Hlibokiy Yar spring decreased from 16.4 mmol/dm^3 to 4 mmol/dm^3. In the summer of June, the rate of rigidity exceeded the norm by 1.5 times, and in the fall - the figure was within the norm [2].

Table 4

Dynamics of chemical composition of waters
from a source in Sarzhin Yar and from a spring in Yunost Park

Indicator	Units of measurement	Spring name				MPC*
		Sarzhin Yar		"Yunost" Park		
		Summer	Fall	Summer	Fall	
pH	-	6,672	6,8	6,456	6,8	6,5 - 8,5
Nitrates	*mg/dm^3*	34	26	41	35	50
Alkalinity	*mmol/dm^3*	6,5	7,6	8,5	10,5	0,6 – 0,5
Transparency	*point*	25	24	24	24	30
Ammonia	*mg/dm^3*	0,04	0,04	0,04	0,04	2,0
Nitrites	*mg/dm^3*	0,001	0,001	0,04	0,001	3,3
Turbidity	*mg/dm^3*	0,99	1	0,99	1	1,5
Hardness	*mmol/dm^3*	19,8	6,2	32,6	7,65	1,5 – 10
Electric potential	-	5,78	6,17	6,45	6,85	-
Fe	*mg/dm^3*	0,021000	0,00240	0,002000	0,00110	0,3
Zn	*mg/dm^3*	0,008300	0,09360	0,021000	0,08890	0,1
Cu	*mg/dm^3*	0,000700	0,00020	0,001500	0,00030	1
Mn	*mg/dm^3*	0,000600	0,00010	0	0,00050	0,1
Cd	*mg/dm^3*	0	0,00040	0	0	0,01
Cr	*mg/dm^3*	0	0,00020	0	0,00050	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

- indicators that exceed the standards.

After analyzing the dynamics of changes in chemical indicators of the sspring waters of Sarzhin Yar and water from the spring of "Yunost" park, it can be stated that the pH increased to 6.8 in the waters of both springs, the alkalinity index increased by 1 unit in the water of the Sarzhin Yar spring and by two units in the water of the "Yunost" park spring, and reached 7.6 mmol/dm^3 and 10.5 mmol/dm^3 respectively, turbidity, and total mineralization. At the same time, indicators of nitrate content, stiffness and nitrite content in the "Yunost" park spring decreased. Ammonia, transparency, and nitrite content in Sarzhin Yar remained unchanged.

It can be concluded that the most affected value is water hardness. The dynamics of the indicator is shown in Figure 3.

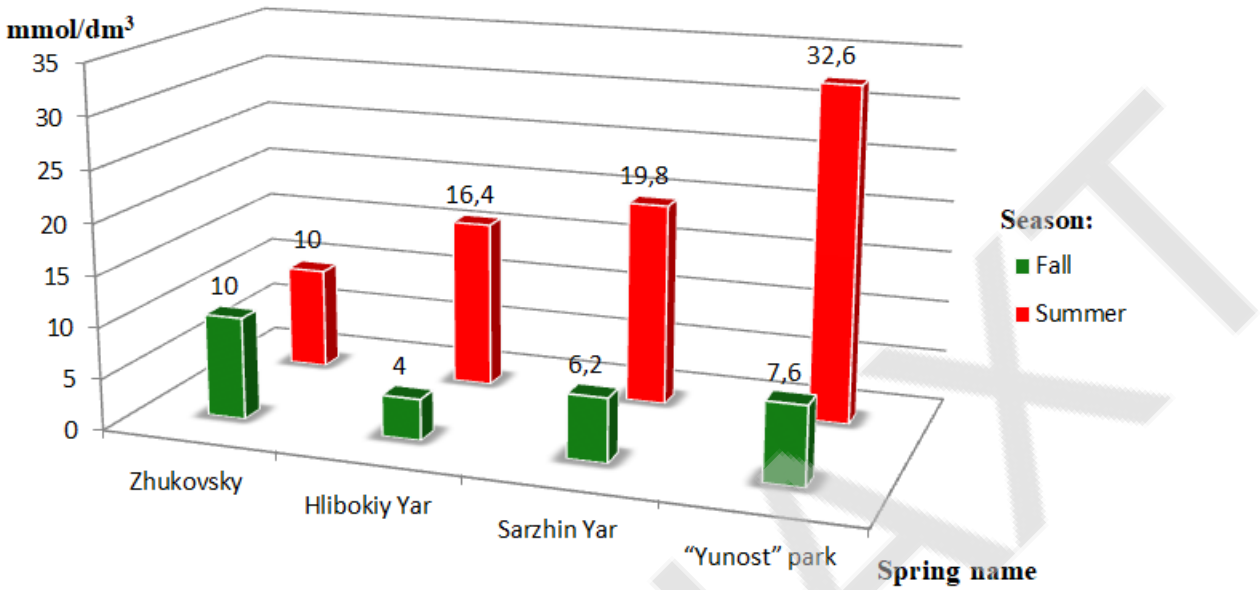

Figure 3. - Dynamics of spring water hardness index
(Summer - Fall 2019)

Experimentally, it is certainly proved that the hardness of spring water increases in summer and decreases in fall. Considering the dependence of groundwater on rainwater and meltwater that run-off through the earth's surface. Studying the dynamics of the change in the water hardness index, we see that the underground aquifer, which is discharged through the Zhukovsky spring, is the least connected to the water that is leaking, because the hardness has not changed with the change of the seasons. The water hardness index in other sources has dropped to a safe level for consumption.

V. CONCLUSIONS

As a result of the conducted research it was established the following:

1. Spring water is one of the most valuable resources for the population produced by groundwater. Determining their quality is an important aspect of environmental monitoring. In order to establish the environmental safety of the Kharkiv spring water, four water samples from four popular drinking water springs in the summer and autumn were selected.

2. Analyzes of selected samples of spring drinking water in the city of Kharkov were carried out according to the main indicators of chemical composition: pH level, total mineralization, nitrate content, nitrite content, ammonia, alkalinity, rigidity. The concentration of heavy metals (Fe, Zn, Cu, Mn, Cd, Cr) was determined on the atomic absorption spectrometer of MGA-915 MD. Indicators of the chemical composition of spring waters meet the standards, except for exceeding the stiffness index in summer water samples: from the Hlibokiy Yar - 1.5 times, in the water of the spring in Sarzhyn Yar - 2 times, and in spring water in "Yunost" park - in 3 times and is 32.6 mmol/dm^3. The indicator does not exceed the norm only in the sample of water from Zhukovsky spring and is 10 mmol/dm^3.

3. It is established that the composition of spring waters changes throughout the year. The pH, alkalinity, turbidity, and general mineralization are increasing. The content of nitrates and nitrites is reduced. Given the excess of water hardness in the samples taken in the summer, it should be noted that in the autumn the indicator normalized and decreased in the water from the Hlibokiy Yar spring - 4.1 times, in the spring water in Sarzhyn Yar 3.1 times, and in the spring water in the "Yunost" park with 4.2 times. Only the water hardness of the Zhukovsky spring remained stable and is 10 mmol/dm^3, both in summer and autumn samples.

4. The analysis of the quality and environmental safety of the samples showed that the quality of spring water changes with the seasons. In the summer, the quality of the spring water under study is lower due to the high water hardness index. It can be assumed that the hardness increases with the increase in ambient air temperature in summer. Rainfall decreases, moisture evaporates, and the quality of fluid infiltrating the soil and entering aquifers deteriorates. Therefore, water from these springs should be further treated for domestic use. You can use sedimentation or filtering as recommendations.

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