Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

PROCEEDINGS

ODESA, ONUT 2022

Ministry of Education and Science of Ukraine

Black Sea Universities Network

Odesa National University of Technology

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Proceedings

Odesa, ONUT 2022

UDC 001.8(063)

Black Sea Science 2022: Proceedings of the International Competition of Student Scientific Works / Odesa National University of Technology; B. Iegorov, M. Mardar (editors-in-chief) [*et al.*]. – Odesa: ONUT, 2022. – 749 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

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INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

1. FOOD SCIENCE AND TECHNOLOGIES

MONITORING OF DIFFERENT PUMPKIN VARIETIES FOR PECTIN PRODUCTION

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Abstract: *One of the most important tasks of our time is to improve the supply of the country's population with high-vitamin, environmentally safe food throughout the year. To reduce the ingress and content of various heavy metals and radionuclides into the human body through food products, the population of the country needs to ensure the safety of food products. The need for inexpensive, ecological melon products with a high content of pectin substances, carotene, and dietary fiber has increased. The highest content of such substances is distinguished by pumpkin. One of the most important ways to reduce the negative impact of the environment on human health is the creation of pectin-containing food products that have detoxifying properties, which contributes to the elimination of toxic substances and radionuclides.*
Keywords*: pectin, dietary fiber, pumpkin, bread, pumpkin variety Karina, pumpkin variety Aphrodite, pumpkin variety Mozoleevskaya 10.*

I. INTRODUCTION

According to the Quarterly Review of Food Hydrocolloids, since 1991, the world market has seen a steady increase in pectin consumption by an average of 3-3.5% per year. The most extensive and free-market today is the market of therapeutic and preventive food products enriched with low-methoxylated pectin, which can remove heavy metals, radionuclides, and pesticides from the human organism. Especially attractive in this group are pectin preparations. Pectin is recognized by the World Health Organization as a toxicologically safe product and is recommended as a corrector of human health. By Article 321 of the Labor Code of the Republic of Kazakhstan, employees who come into contact with inorganic lead compounds must additionally give out 2 grams of pectin in the form of canned plant foods, fruit juices, and beverages enriched with it (the actual content of pectin is indicated by the manufacturer.).

The market for pectin and pectin products is growing rapidly every year by 3-4%. Pectin is a special component of dietary fiber.

Kazakhstan, Russia, and the Central Asian republics do not have their pectin production.

Kazakhstan has a sufficient raw material base for the production of pectin drugs, in particular secondary raw materials. One rational way to solve this problem is to create a scientific and technological base of deep processing of sugar beets, apples, and melons with competitive products [1].

Global pectin production is concentrated in Europe, South America, Iran, and China (Fig.1).

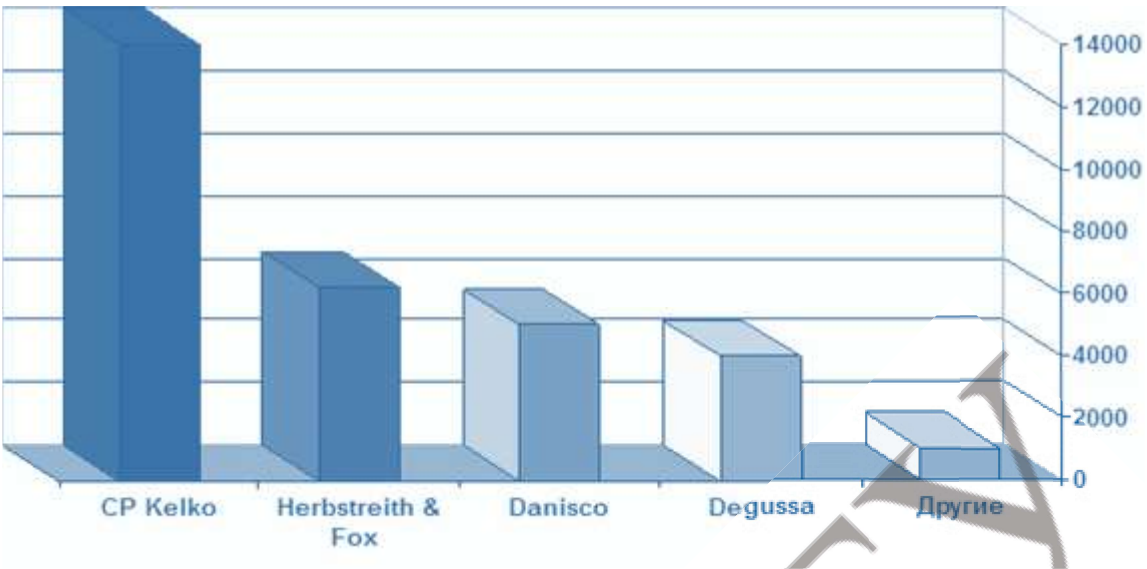

Fig.1. Major World pectin producers

II. LITERATURE ANALYSIS

2.1 The use of pectin's in the food industry

The use of pectin's in the food industry has reached enormous proportions. The main consumer of high-labeled pectin (about 80%) is the confectionery industry.

Compared to other gelling agents commonly used for confectionery, the use of pectin requires strict adherence to prescription and production parameters.

Pectin's are used as an additive to medicinal varieties of bakery and pasta; in the bakery - for baking non-stale varieties of bread.

Currently, pectin and its derivatives are increasingly used in baking as an anion-active, useful substance (PAV).

It has been established that the insertion of pectin into the dough affects the biological, colloidal, and microbiological processes of preparation of the dough. In addition, it has been found that the content of the petition of the finished bread is reduced in comparison with the original amount in the dough.

It should be noted that as the dosage of pectin increases, there is a decrease in the specific volume and decreases in the rest of the bread quality, which is due to the ability of the latter to bind the water, and in turn, has an impact on the dough's humidity and quality of bread.

The effect of pectin etherification on the quality of wheat flour bread has also been established.

The maximum improvement in the quality of bread with the addition of low-esterified pectin is associated with the presence in its molecule of a larger number of free carboxyl groups than that of high-esterified pectin. These groups are reactive, and, actively interacting with the components of the dough, form a large number of compounds, affecting the properties and quality of bread. Thus, in baking, it is possible to use highly esterified and low-esterified apple pectins, but in contrast to confectionery production, it is more appropriate to use low-esterified pectin.

The change in the parameters of the structural and mechanical properties of bread crumb with the addition of pectin in the amount of 0.05-1.0% of the flour weight

during storage indicates that bread with the addition of pectin becomes stale 1.04-1.9 times slower than bread without pectin, which is extremely important for increasing the sales period of bakery products [2].

The influence of apple pectins with a degree of esterification of 59-64, 76-78, and 38-44 % on the quality of custard cakes was studied.

The addition of high-esterified and low-esterified apple pectins improves the quality of gingerbread. The best quality is the gingerbread with the addition of low-etherified apple pectin in an amount of 0.1 % by weight of flour.

The main area of use of citrus pectins is dairy products (in particular, yogurts), where it is necessary to prevent the separation of milk proteins and whey at low pH values, as well as to provide a variety of textural properties, smoothness of structure and freshness of taste.

Low-esterified pectins are often used in fruit preparations for yogurt to create a soft, partially thixotropic texture of the jelly, sufficient to ensure a uniform distribution of the fruit, but still allow the free introduction of the fruit preparation into the yogurt. The texture of yogurt can be improved by adding small amounts of low-methoxylated pectin. However, it should be noted that low-methoxylated pectin does not prevent syneresis [3].

The introduction of pectin in fermented milk products can significantly increase their shelf life.

Pectin is also used in the production of ice cream, cheeses (to increase their moisture-absorbing capacity), and other products in the dairy industry [4].

Highly methoxylated pectin is used in concentrated fruit drinks to stabilize oil emulsions and suspensions of fruit particles.

The property of highly methoxylated pectins to change the consistency (viscosity) of products is used in recombined juices to restore the feeling of fresh juice in the mouth. Pectin is also used to create a natural consistency in instant fruit drinks. Based on pectins, a wide range of kissels, mousses, and gels have developed.

A wide range of functional properties: thickening, gelatinization, stabilization of food systems, complexation defines pectin as a biopolymer, valuable in many industries. Pectin is not only an effective, in some cases simply necessary, a food additive that forms the structure of food, but also a valuable medical drug.

2.2 Pumpkin is a source of pectin

Pumpkin (Cucurbita) is an annual plant in the pumpkin family. The fruits are large fleshy pumpkins with numerous flat yellowish-white seeds. It is worth noting the good resistance of the pumpkin to drought. The fruit pulp of pumpkin contains dry substances (15-18 %), sugars (8-10 %), pectin substances, nitrogenous compounds, salts of potassium, calcium, magnesium, iron, vitamins C, B, B2, PP and provitamin A; in seeds - fatty oil (36-52%), phytosterols, organic acids, resins, fiber (0.7%), a little organic acid.

The fruits of vegetable pumpkins contain up to 14% of sugars, especially a lot of easily digestible glucose. They also contain starch, pectin substances, and fats. The calorie content of a pumpkin is from 170 to 316 calories per kilogram of fruit. Of the

minerals in the pumpkin, there are especially many salts of potassium, phosphorus and calcium, which are vital for the human organism. They also contain a lot of copper, cobalt, and other trace elements [5].

The content of pectin in fruits and vegetables is (g/100 g of the product):

Beets 0,7–2,0
Watermelons 1,0–1,5
Melon.....1,0-1,5
Pumpkin 2,6–9,3
Pumpkin 2,2-2,4

Karina is a large-fruited pumpkin selected by the Kazakh Research Institute of Potato and Vegetable Farming. The variety is long-leaved, the fruits are round-flattened, medium-sized, gray and green, less often variegated, pinkish when stored. The flesh of the fruit is bright orange, dense, medium-thick, very sweet. The average weight of the fruit is from 2 to 10 kg. The seeds are cream-colored, leathery, with a dense rind. The variety is medium-ripe, yielding. Keeping quality and transportability are high.

Mozoleevskaya 10-hard-edged pumpkin of selection of the Kazakh Research Institute of Potato and Vegetable farming. The plants are long-leaved, the fruits are cylindrical, with ribbing at the peduncle, light orange when fully ripe. The pattern is in the form of wide mottled stripes, initially dark green, and when fully ripe - dark orange. The flesh is yellow or cream, 3-5 cm thick, medium-density, slightly sweet. The seed nest is large. The seeds are medium oval, yellowish-cream with a rim. The average weight of the fruit is 4.5-7.0 kg. The variety is medium-ripe (102-117 days), productive, with high commercial qualities and good taste. Keeping quality and transportability are high.

Aphrodite (nutmeg pumpkin) - TK-17, KON-898, selected by KazNIIKO, the sample was obtained from the originator. The fruits are elongated, with a swollen end, of the "intercept" type. The tail part of the fruit occupies up to 2/3 of its entire length and has no voids. The color of the fruit is orange with a pattern in the form of brown indistinct torn stripes. When fully matured, the pattern disappears. The flesh is thick orange, sweet, dense. The surface of the fruit is smooth, with a powdery-bluish waxy coating, the peduncle is ribbed. The average weight of the fruit is 5-8 kg. The variety is medium-ripe for table consumption.

2.3 The process of obtaining pectin

The process of obtaining pectin consists of several stages. To begin with, the preparation of pectin-containing raw materials is carried out, then – extraction-hydrolysis of raw materials with mineral or organic acids. Extraction is an important step in the production of pectin. By evaporation in a vacuum, the extract is filtered, the filtrate is clarified, and then the extract is concentrated. The precipitation of pectin substances reproduced using polyvalent metal salts of aliphatic alcohols. At the next stage, the raw pectin is cleaned with alcohol and dried, crushed and mixed with sugar to a standard degree of strength.

Raw materials for pectin production should contain a minimum amount of reducing sugars, since the reaction with amino acids produces colored products (melanoidins) (Fig.2) [6].

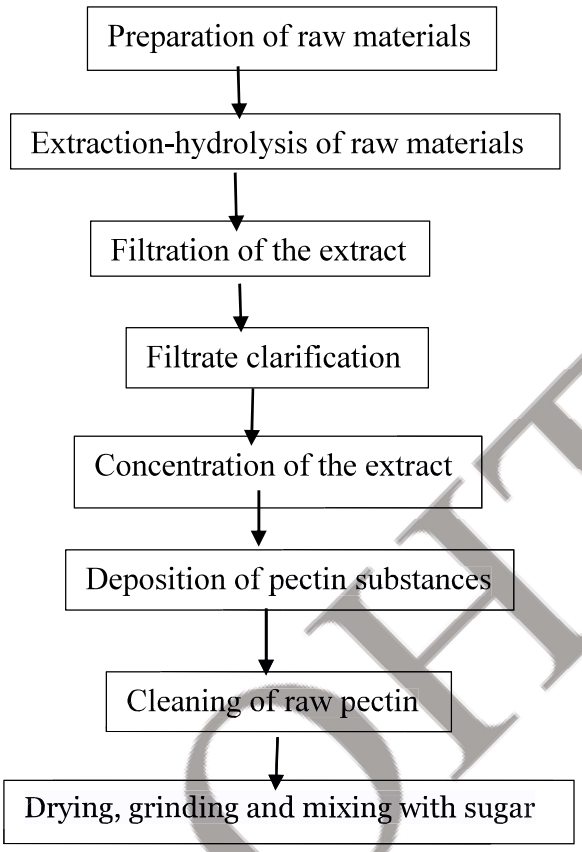

Fig. 2. Stages of pectin production

2.4 Detoxifying properties of pectins

Pectin not only forms a jelly consistency, but also has radioprotective and detoxifying properties, and, therefore, belongs to multifunctional additives.

Pectin has acquired particular importance recently, when it was found that it can form insoluble complexes, remove toxic metals from the human body and long-lived (with a half-life of several decades) isotopes of strontium, cesium, etc. In addition, pectin can absorb and remove from the body biogenic toxins, xenobiotics, anabolic, metabolic products and biologically harmful substances that accumulate in the body. It is recognized in most countries as a valuable food ingredient that has no restrictions on use [7].

In addition to radioprotective and detoxifying properties, clinical studies have shown the ability of pectin to reduce the allergic effects associated with the environmental situation, regulate metabolism and the functions of the digestive organs.

Pectin acts as a radioprotector and is recommended as an additive in food products to give them detoxication properties [8].

III. OBJECT AND METHODS OF RESEARCH

The main objects in the work are the most popular varieties of pumpkins: Aphrodite, Karina and Mozoleevskaya 10 (Fig.3).

a) Aphrodite variety b) Karina variety c) Mozolevskaya 10 variety

Fig. 3. Pumpkin varieties used in the work

Methods

We analyzed samples of melon crops and selected and determined the following quality indicators in pumpkin:

1 The content of pectin
2. Sugars
3. Acid content
4. Dry matter content
5. Degree of esterification

The main methods of analysis of pectins are related to their physical and chemical properties, as well as their structural features. For the characterization of pectins, the main indicators are total ash content, molecular weight, provide component, degree of esterification, the content of free carboxyl groups, binding capacity, etc.

Determine the total ash content of absolutely dry substance is carried out taking into account mass loss during drying of raw materials or subject to the humidity of raw materials, by ashing.

Determination of the mass fraction of dry substances was carried out by drying the suspension in the drying cabinet by the accelerated method.

The determination of the mass fraction of sugars was carried out by the cyanide method, which is based on the ability to reduce sugars to reduce potassium ferrocyanide in an alkaline medium to ferrocyanide:

$C_6H_{12}O_6+6K_3[Fe(CN)_6]+6KOH—> (CHOH)_4(COOH)_2+6K_4[Fe(CN)_6]+ 4H_2O$

IV. RESULTS

The study of the anatomical composition of three varieties of pumpkin was carried out to select the most optimal variety from them, to recommend further production of pectin from secondary raw materials of pumpkin processing (pumpkin pulp).

Global consumption of pectin is growing rapidly. In the world, the potential reserves of raw materials (apple pomace and citrus peel) for pectin production allow

its main producers to plan an annual increase in pectin production by about 3.8 %, but the search for new sources of pectin-containing raw materials is an important task of science that provides the pectin industry [9].

According to figure 4, the safety indicators of domestic varieties of pumpkins do not exceed the permissible standards.

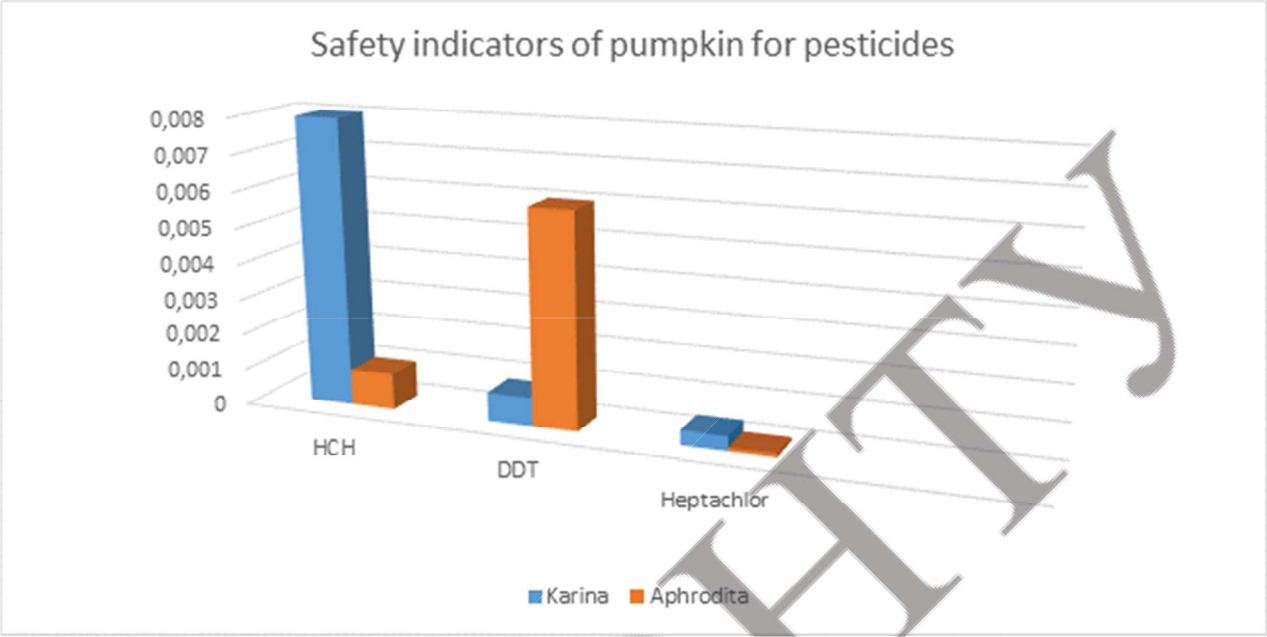

Fig. 4. Safety indicators of pumpkin varieties used in the work

According to GOST 30349-96, the indicators of pesticides do not exceed the norm. Hexachlorane in the Carina variety is 0.08%, and in the Aphrodite variety is 0.001%, which does not exceed the norm of 0.5%. Insecticide (DDT) was not found in both varieties of pumpkin, which also corresponds to regulatory documents. Heptachlor 0.0004% and 0.001%, respectively, in the varieties Carina and Aphrodite. The norm for this pesticide is less than 0.002%.

The functional orientation of the studied varieties is determined by the fractional composition of sugars (Figure 5).

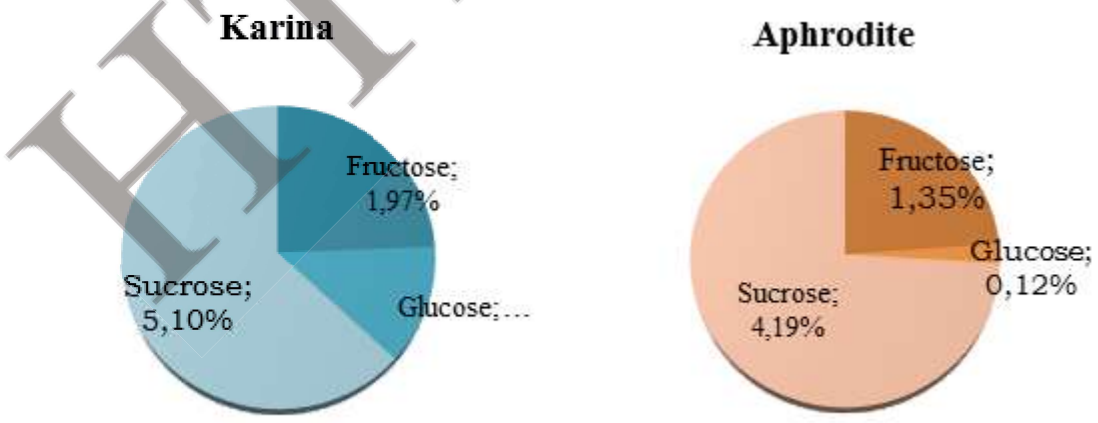

Fig. 5. Fractional composition of sugars in the studied pumpkin samples

It was found that the Karina variety is distinguished by the total sugar content (8.1%, against 5.7% - in Aphrodite). The fractional composition is dominated by sucrose (5.1 and 4.2%, respectively). The glucose content is 8.6 times lower in the Aphrodite variety (0.12%) than in the Carina variety (1.03%). At the same time, the fructose content in the Aphrodite variety is 31.5% less than in the Carina variety.

However, the study of the fractional composition of organic acids showed that the Carina variety has 3 times more tartaric acid than Aphrodite. Natural tartaric acid has antioxidant properties and has a beneficial effect on the metabolic and digestive processes in the body. Citric and lactic acids are absent in both varieties, and they do not differ in the content of malic acid (0.01%) and its content is very low. It is known that malic acid plays an important role in the metabolic processes of the human body. It promotes the full absorption of iron, interacts with vitamins, and is soluble in water.

As shown in fig. 6, relatively high content of succinic acid was found (0.027%-0.028%). The results of previous studies have shown that succinic acid is an adaptogen (increases the body's resistance to adverse environmental factors), which is a positive factor in the development of functional products [10].

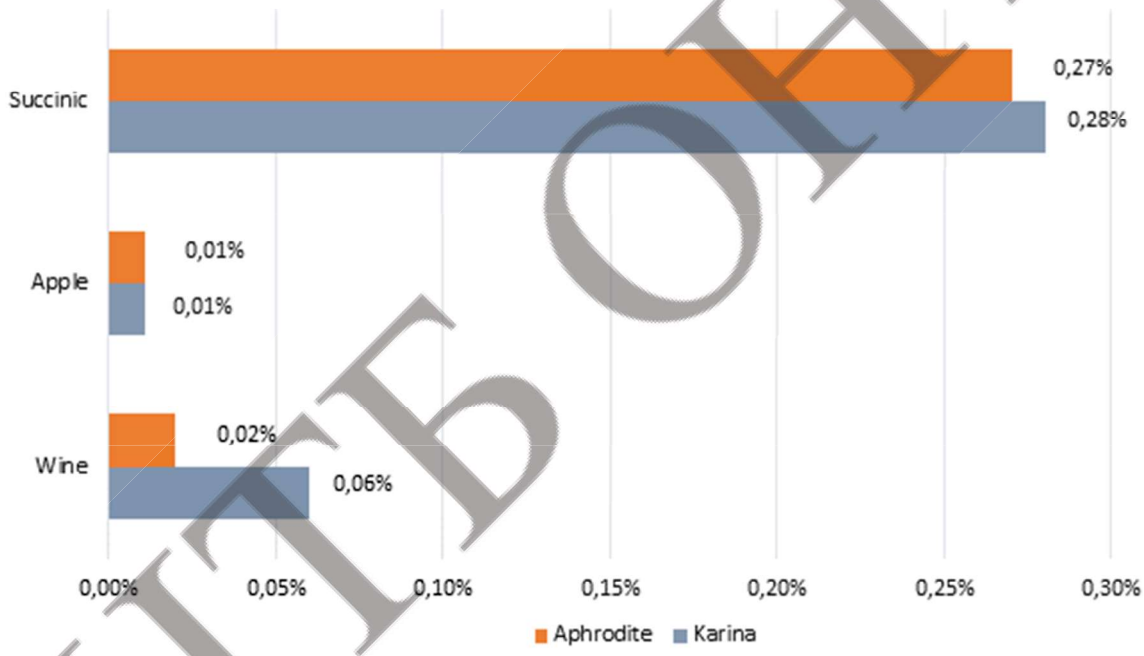

Fig. 6. Fractional composition of organic acids in the studied pumpkin samples

So, the total content of pectin in terms of absolutely dry matter in the Carina variety was 15.8%, Aphrodite-21.8 %. The studied pumpkin varieties (Carina and Aphrodite) were characterized by a high content of insoluble protopectin-11.88 and 15.5% and a lower content of soluble hydratopectin-3.96 and 6.30%, respectively (fig. 7).

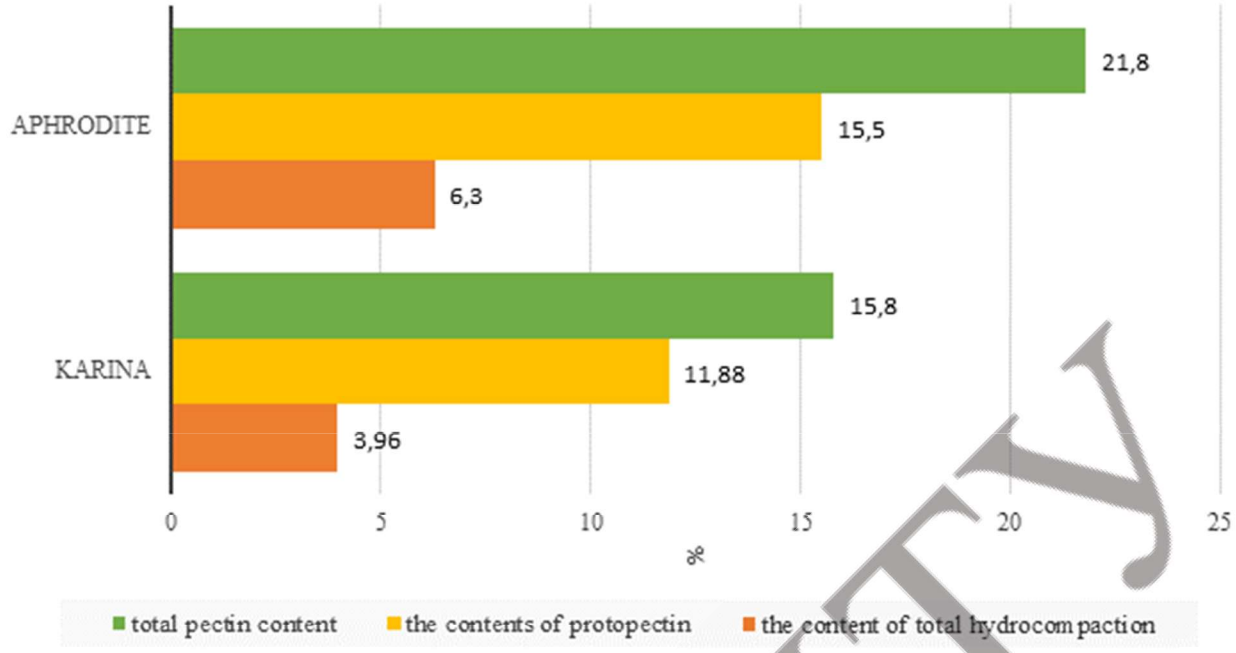

Fig. 7. Total content and fractional composition of pectin substances in the studied objects of research, % to absolutely dry matter

The results of studies of the analytical characteristics of the isolated pectins showed that the content of free carboxyl groups of pectin samples isolated from pumpkin pulp varieties Aphrodite and Karina practically do not differ. At the same time, the degree of esterification is slightly lower in the Karina variety (37.94%) in comparison with the Aphrodite variety (43.27%) (Figure 8). Thus, the isolated pectins from both studied pumpkin varieties should be classified as low-esterified (E less than 50%).

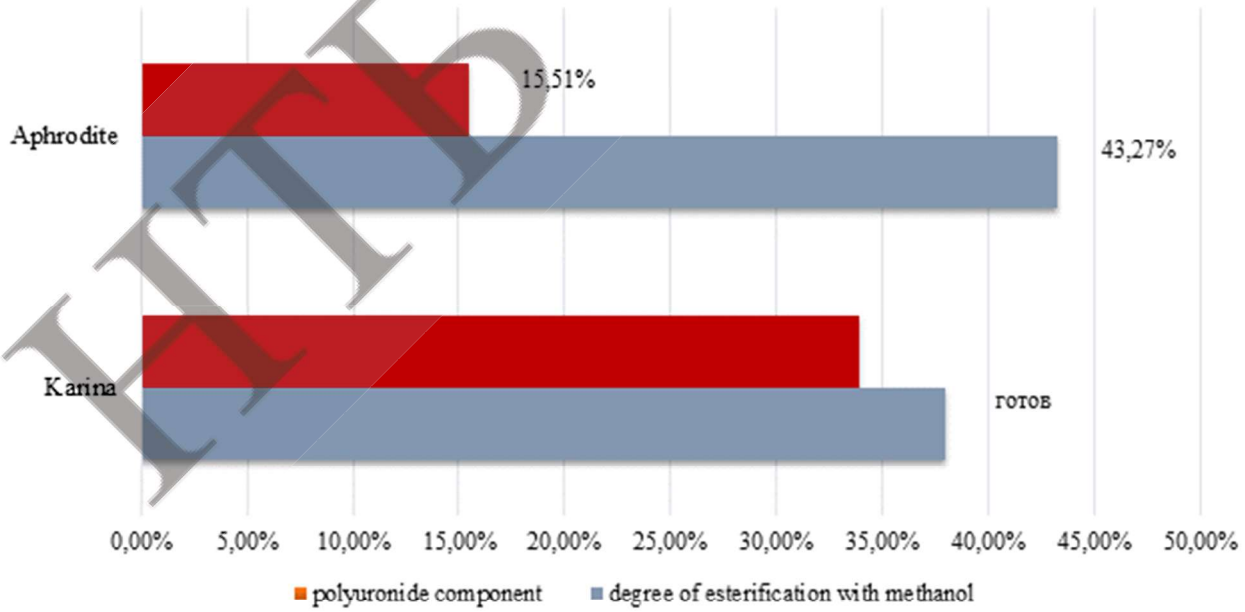

Fig. 8. Analytical characteristics of the pumpkin pulp varieties

It is known that the complexing properties of pectin substances depend on the content of free carboxyl groups, i.e., the degree of esterification of carboxyl groups

with methanol. The degree of esterification determines the linear charge density of the macromolecule, and, consequently, the strength and method of cation bonding.

With a decrease in the degree of esterification, that is, with an increase in the charge of the macromolecule, the bond of pectin substances with cations increases. Therefore, it is possible to predict a large complexing capacity for the Karina variety.

From the presented data, it follows that the total content of pectin substances is distinguished by the pumpkin of the Aphrodite variety (21.8%).

Thus, studies have shown that pumpkin can be used as an effective raw material for the production of pectin.

V. CONCLUSIONS

The state of the environment in many regions of the world, accompanied by pollution of the environment and food products with toxic substances, requires food safety and requires the expansion of the production of pectin and pectin-containing products as natural detoxifiers.

The demand for inexpensive melon-growing products, which are characterized by a high content of pectin substances, carotene, and dietary fiber, has significantly increased. The highest content of such substances is distinguished by pumpkin.

1. The results of studies of varietal characteristics of pumpkins in Kazakhstan have shown that the most promising and productive varieties are Karina and Aphrodite, which are characterized by a high content of mineral and biologically active substances, and in terms of food safety meet the requirements of regulatory documents.

2. The study of the fractional composition of organic acids showed that the Carina variety has 3 times more tartaric acid than Aphrodite. Citric and lactic acids are absent in both varieties, and they do not differ in the content of malic acid (0.01%) and its content is very low. Relatively high content of succinic acid was found in both varieties (0.027%-0.028%).

3. The pectin content in terms of absolutely dry matter in pumpkin pulp of the Karina variety was determined to be 15.8%, Aphrodite-21.8%, while their fractional composition of pectins was characterized by a high content of insoluble (protopectin) - 11.88 and 15.5% and a lower content of soluble (hydratopectin) - 3.96 and 6.30 %, respectively.

4. Studies have shown that the degree of esterification is slightly lower in the Carina variety (37.94%) in comparison with the Aphrodite variety (43.27%). Thus, the isolated pectins from both studied pumpkin varieties should be classified as low-esterified (E less than 50%). However, with a decrease in the degree of esterification, the complex-forming activity increases, which characterizes the Carina variety with higher detoxification properties.

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