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1. FOOD SCIENCE AND TECHNOLOGIES

STUDY OF POSSIBILITY OF USING MALT EXTRACTS IN PRODUCTION OF PRESERVED PRODUCTS OF FUNCTIONAL PURPOSE

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Abstract. *Nowadays, the desire of people to buy not only tasty, but also healthy food is becoming obvious. These include a preserved product using sprouted grains and malt extracts. The article presents studies on the influence of the share of barley-malt extract and sprouted grain on the quality of the finished product. It is noted that the share of sprouted grain crops and malt extracts significantly affects the quality indicators of the preserved product, in particular organoleptic indicators. Criteria for evaluation of organoleptic properties of the finished product have been developed. Influence of technological parameters on organoleptic indices of preserved product is investigated. The quality of the product was evaluated according to organoleptic and physicochemical indices, nutritional and biological value, and the degree of satisfaction of the daily human need for vegetable protein contained in 100 g of preserved products was established. Formulas and technology for production of preserved products from a two-component composition based on sprouted wheat or bare-grained oats (40.0% – 50.0%) using malt extract (50.0% – 60.0%) are developed, which makes it possible to ensure quality of the product with high consumer properties satisfying the daily need for vegetable protein by 11.8% – 16.0%.*

Keywords: *sprouted grain, blanching, malt extract, component ratio, formulation design, technology, quality indicators.*

I. INTRODUCTION

Currently, the development and introduction of functional food products are of particular importance, which is due to the insufficient supply of vital nutrients to the population, such as vitamins, minerals, amino acids, and dietary fibers. Their shortage is observed among representatives of all sectors of society. One of the current areas is the development of technology for canned products from domestic raw materials, which would take into account the balance in the content of food and biologically active substances, has a functional orientation and contain a small proportion of sucrose in the product. Such technology includes the production technologies using malt extracts and sprouted grain.

Introduction of sprouted grain into the diet will help to increase immunity, compensate for vitamin and mineral deficiency, normalize acid-base balance. Unfortunately, in our country, sprouted grain has become widespread only in the bakery and dairy industries as a biologically active additive that increases the nutritional and biological value of the finished product.

The peculiarity of the sprouted grain is that it can be preserved without loss of quality at a reduced temperature for only a few days. In order to be able to store sprouted grain and transport it for a long time, it is necessary to use various methods of preservation.

Malt extract has a preserving effect, which is currently actively used in the food industry as a natural flavoring, stabilizer and preservative. However, malt extract is an excellent alternative to refined sugar, and due to the balance of easily digestible carbohydrates, protein, vitamin and mineral substances, amino acids, it has a therapeutic and preventive effect, which is expressed in the ability to normalize metabolic processes in the body's organs and systems, improve the digestion process, as well as increase physical and mental performance.

The purpose of this work is to develop the technology and formulations of a preserved product of functional purpose using malt extract and sprouted grain.

II. LITERATURE ANALYSIS

Malt extract is a product obtained by aqueous extraction of malts of cereals and/or legumes, thickened by vacuum evaporation to the required content of dry substances (70% – 80%).

A great contribution to the development of the scientific foundations of the production and use of malt extracts was made by Russian scientists Domaretsky V.A., Ermolaeva G.A., Ukrainian scientists Yemelyanova I.A., Korkotny E.A. and others.

An analysis of literary sources showed that preserved products using malt extract and sprouted grain raw materials are not produced in the Republic of Belarus and abroad.

Cereals and pulses account for the largest percentage of the harvested area for agricultural products. The current grain raw materials for the production of preserved products are wheat and bare-grained oats – for 2017, the sown area of wheat and oats amounted to 721 and 162 thousand hectares, respectively [1].

Wheat is one of the most ancient and most important crops cultivated by man. The value of wheat is that it can form gluten, which is of great importance for bakeries, pasta, semolina, etc., and also of its chemical composition and energy value is an excellent raw material for the food production [2–3].

Oats are one of the most popular cereals used in folk medicine. Due to its unique composition, the grain has many beneficial properties, helps to quickly eliminate the manifestations of many diseases, it can be used for therapeutic and preventive purposes [4].

The composition of grain raw materials and the germination technology have been sufficiently studied [5–15], however, for each grain variety and its further application, it is necessary to select optimal germination process parameters, which can create certain temporary, economic and technological difficulties.

Based on the analysis of scientific information [8, 13] on the technology for producing preserved products from sprouted grain, it is noted that depending on the type of grain and the preservatives used, there are significant differences in the technology for producing preserved products at the stage of blanching and mixing of ingredients.

Analysis of literary sources [14–15] showed that a descriptor-profile method of tasting analysis is used to solve various production and research problems, including the development of a new product with given properties. The importance was attached not only to the nutritional valye, but also to the emotional customers' perception of the

product. Zavorokhina [15] developed a methodology for modeling soft drinks, which allows to obtain products with given preferences taking into account the sensory preferences of consumers and using a descriptor-profile method. However, when designing any product, a certain approach is required taking into account the individual characteristics of the product.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of the study is the process of production of preserved product, the subject of the study is technological parameters and consumer properties of preserved products.

The objects of experimental research in the work were:

– freshly grown wheat malt (2018 harvest, Mogilev);

– freshly grown oat malt obtained from bare-grained oats (Lakome LLC, Russian Federation);

– malt barley extract (Polotsk drinks and concentrates, Republic of Belarus);

– developed preserved products using sprouted grain and malt extract.

The production of prototypes was carried out in the laboratory of the Department of Commodity Science and Trade Organization at the Mogilev State University of Food Education.

Preparation and conduct of tests were carried out using standard and special methods.

Soaking of grain was carried out by air-water method, germination – in air thermostat. Blanching of the sprouted grain was carried out at 85 °C for 20 to 60 minutes. The ratio of blanched sprouted grain (using bare-grained oats or wheat) and liquid barley-malt extract in the product were varied as follows (grain:extract): 33:67, 40:60, 50:50, 60:40, 67:33 %. Mixing grain and extract was carried out at a temperature of 78 °C.

Organoleptic grain indices were determined according to the standards 10967 [16], extracts and preserved product – 6687.5 using profile method [17–18], grain humidity – according to the standards 13586.5 on moisture analyzer MAC 50 [19], titrated acidity of preserved product – according to the standards 6687.4 [20].

The content of dry substances in the "pouring" was determined by refractometric method using the device IRF-454 [21], protein by Kjeldahl method using Kejeltec 2000 automatic installation [22], vitamins B_1 and B_2 – by fluorometric method on the fluid analyzer "Fluorate F-02" according to, zinc, copper and iron – by an atomic emission method on a spectrometer of MDR-3 Lomo according to TR (technical requirements) BY 1472936.001, essential amino acids - using high performance liquid chromatography on an Agilent 1200 chromatograph.

The following methods were used in the development of criteria for assessing organoleptic properties of preserved products:

– consent method (when developing a panel of descriptors for modeling the flavor profile of preserved products);

– sensory SWOT analysis (in case of identification of strengths and weaknesses related to ergonomic and social features of preserved products);

– ranking (when determining the most significant organoleptic indicators);

– verbal scale.

When assessing the nutritional value of the product, an integral score (IS) was used, which is a number of calculated values expressed in %, characterizing the degree of compliance of the evaluated product with an optimally balanced daily diet, taking into account the energy content and the most important qualitative indicators:

$$IS = \frac{I}{I_{BFF}} \cdot 100, \quad (1)$$

I – value of the corresponding indicator in the tested product;
I_{BFF} – value of indicator in balanced feeding formula.

Calculation of biological value was carried out according to the criteria of N.N. Lipatov and A.I. Rogov, based on the development of the Mitchell-Block principle [23]. Using this principle, the amino acid composition and its balance in preserved products were evaluated.

The biological value (BV) of the food protein, %, was determined by the formula

$$BV = 100 - FDAS, \quad (2)$$

FDAS – amino acid score difference factor (%).

$$FDAS = \frac{\sum_{i=1}^{k} \Delta DAS_i}{k}, \quad (3)$$

k – amount of essential amino acids;
DAS_i – the difference between the amino acid score value of the *i*-essential amino acid and the amino acid value of the first limiting amino acid.

Another method of [24] determining the biological value of proteins is to determine the index of essential amino acids (IIAA):

$$IIAA = \sqrt[n]{\frac{Lys_t}{Lys_r} \times \frac{Trp_t}{Trp_r} \times \frac{Val_t}{Val_r} \times \frac{Ile_t}{Ile_r} \times \frac{Leu_t}{Leu_r} \times \frac{Met_t}{Met_r} \times \frac{Thr_t}{Thr_r} \times \frac{Phe_t}{Phe_r}}, \quad (4)$$

n – is the amount of essential amino acids;
Lys $_{t/r}$ – lysine content in test sample/reference model;
Trp $_{t/r}$ – tryptophan content in the test sample/reference model;
Val $_{t/r}$ – valine content in test sample/reference model;
Ile $_{t/r}$ – isoleucine content in the test sample/reference model;
Leu $_{t/r}$ – leucine content in the test sample/reference model;
Met $_{t/r}$ – methionine content in the test sample/reference model;
Thr $_{t/r}$ – threonine content in the test sample/reference model;
Phe $_{t/r}$ – phenylalanine content in the test sample/reference model.

The minimum score or utilitarian coefficient of the essential amino acid (proportion of units) was determined by the formula:

$$A_i = \frac{S_{min}}{S_i} \quad (5)$$

S_{min} – minimum score of essential amino acid of the evaluated protein relative to physiologically necessary norm (reference) or fraction of units;

S_i – score of the *i*-th amino acid with respect to the physiologically necessary norm (reference) or fraction of units

$$S_{min} = \frac{M_i}{M_{si}} \quad (6)$$

M_i – essential amino acid content in the product;

M_{si} – content of essential amino acid corresponding to physiologically necessary norm (standard).

The amino acid composition balance factor is U (Rc). Reflecting the balance of essential amino acids with respect to the standard, fractions of units:

$$U = \frac{S_{min} \cdot \sum_{i=1}^{k} M_{si}}{\sum_{i=1}^{k} M_i} \quad (7)$$

In the case where $S_{min} \leq 1$ (в долях единиц), the rational coefficient of the amino acid composition was determined by the formula:

$$R_c = \frac{\sum_{i=1}^{k} M_i \cdot A_i}{\sum_{i=1}^{k} M_i} \quad (8)$$

M_i – the amount of the *i*-essential amino acid in 1 g of the test protein or product;

A_i – utilitarian coefficient of the *i*-th essential amino acid.

Analytical determination for each test are executed in 3-fold repeatability. Experimental data processing was carried out by methods of mathematical statistics with use of standard computer programs.

IV. RESULTS

Influence of technological modes of soaking, germination, blanching on process duration, moisture content and organoleptic indices of wheat and bare-grained oats is studied.

The optimal soaking and germination regime for wheat was determined (air-water method, soaking at a temperature of 12 °C – 14 °C, duration of 32 hour until the degree of soaking is reached 45.2%, germination at a temperature of 16 °C – 18 °C, duration – 3 day) and bare-grained oats (air-water method, soaking at temperature 14 °C – 16 °C, duration of 24 hour until the degree of soaking is reached 45.3%, germination at temperature 16 °C – 18 °C, duration – 2 day), allowing to obtain uniform

growth of grain germ sprout at established humidity of 45.0% and providing sufficient organoleptic indices of sprouted grain.

An optimal blanching regime (at 85 ° C, 30 minutes) of wheat and bare-grained oats was determined, which allows to obtain grain with fewer damaged grains and provides high quality characteristics of the blanched grain.

The consent method was used to perform a descriptive analysis of the preserved product flavor. In the consent method, testers work as a group of testers to achieve an agreed description of the product flavor. The essential point in this method is that the team leader is also one of the experts.

The focus group included five trained testers who have experience in the field of commodity expertise, food technology, functional and specialized products.

During the in-depth interview with each tester, a conversation was held about the characteristics of the preserved product using malt extracts and sprouted grain with their focus on the organoleptic features of the food product, while taking into account the correct and objective interpretation of the concepts. So, the hedonic description of taste – density, flavor, intensity, corresponds to such an objective description as saturation of taste; strong smell, fragrant, bright as the severity of the aroma.

As a result, a group of testers identified 32 characteristics of descriptors, descriptive characterizing the general profile of the preserved product: 11 characteristics for assessing appearance, 6 for assessing aroma, 10 for assessing taste, 3 for assessing consistency and 2 for evaluating emotional customers' perception of the product.

In the next step, the significance of the selected descriptors was determined by the rank method.

It was noted that the most important descriptors in assessing the organoleptic characteristics of preserved products were the uniformity of the grain coating with extract, the saturation of golden color, uniformly colored golden brown color and whole grain, the severity of apple, honey and caramel aroma, the sweetness and saturation in taste of such "shades" as apple, honey and malt, harmonious taste.

For the tasting of model samples of preserved products, the universal 5-point verbal scale is optimal: 0 – no sign, 1 – only recognizable or felt, 2 – weak intensity, 3 – moderate intensity, 4 – strong, 5 – very strong intensity, which is adapted to evaluate the preserved product using malt extract and sprouted grain (Figure 1).

It should be noted that the "naturality" of the extract refers to how the tester or consumer perceives the product in chemical composition, for example, a subtle green cast may be perceived as not natural; "relevance" means how this product is perceived as by external signs, for example, as a separate product – replacing granola bars, or the ingredient – replacing syrup in ice cream.

The next step was to conduct a tasting assessment of model preserved products depending on the proportion of sprouted wheat grains or bare-grained oats and malt extract according to the developed panel of descriptors. The proportion of sprouted grain and malt extract ranged from 33 to 67% (grain: extract – 33:67, 40:60, 50:50, 60:40, 67:33). The received averaged scores were multiplied by significance factors and converted to a 5-point scale. The results are shown in Figure 2.

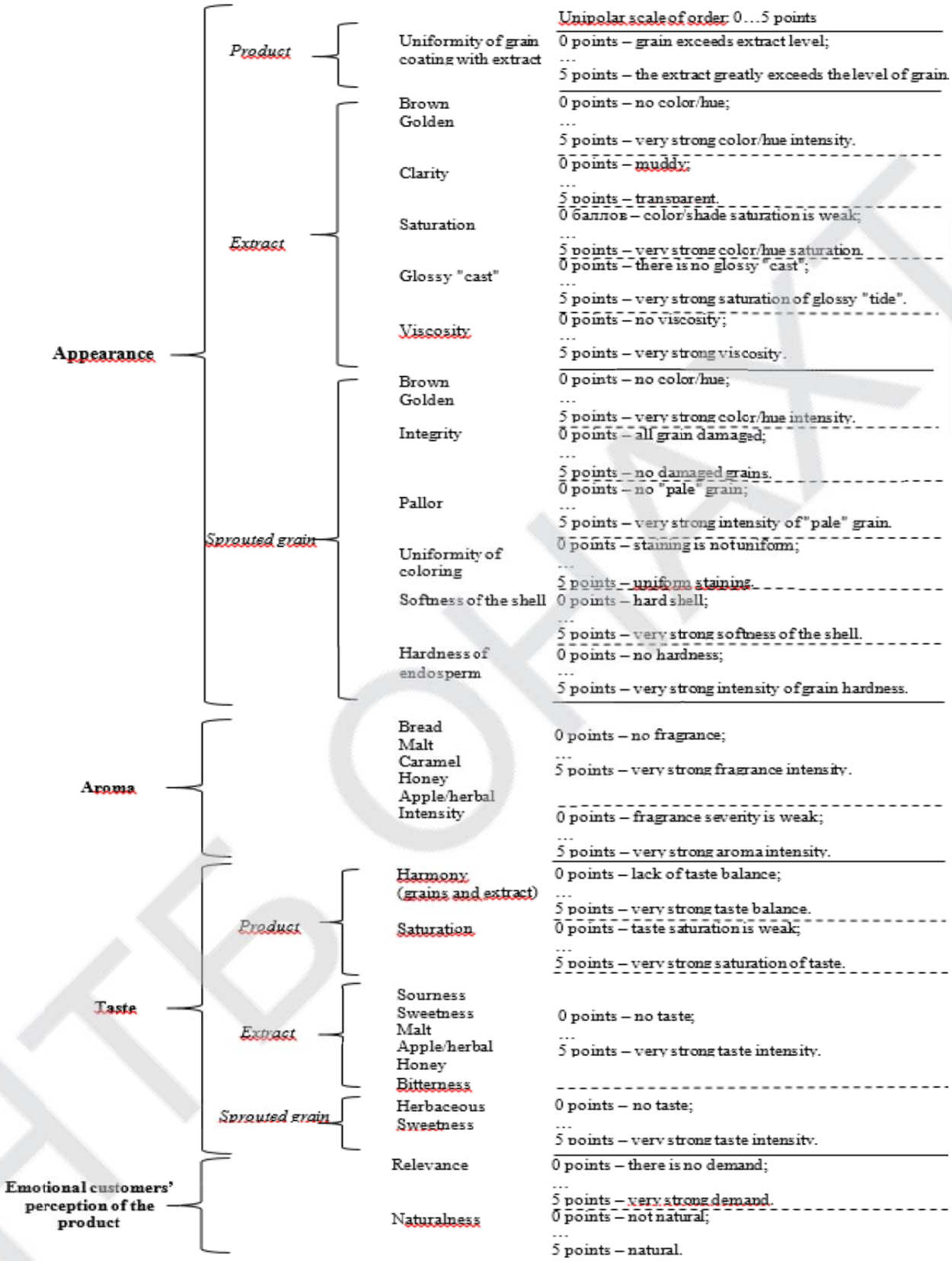
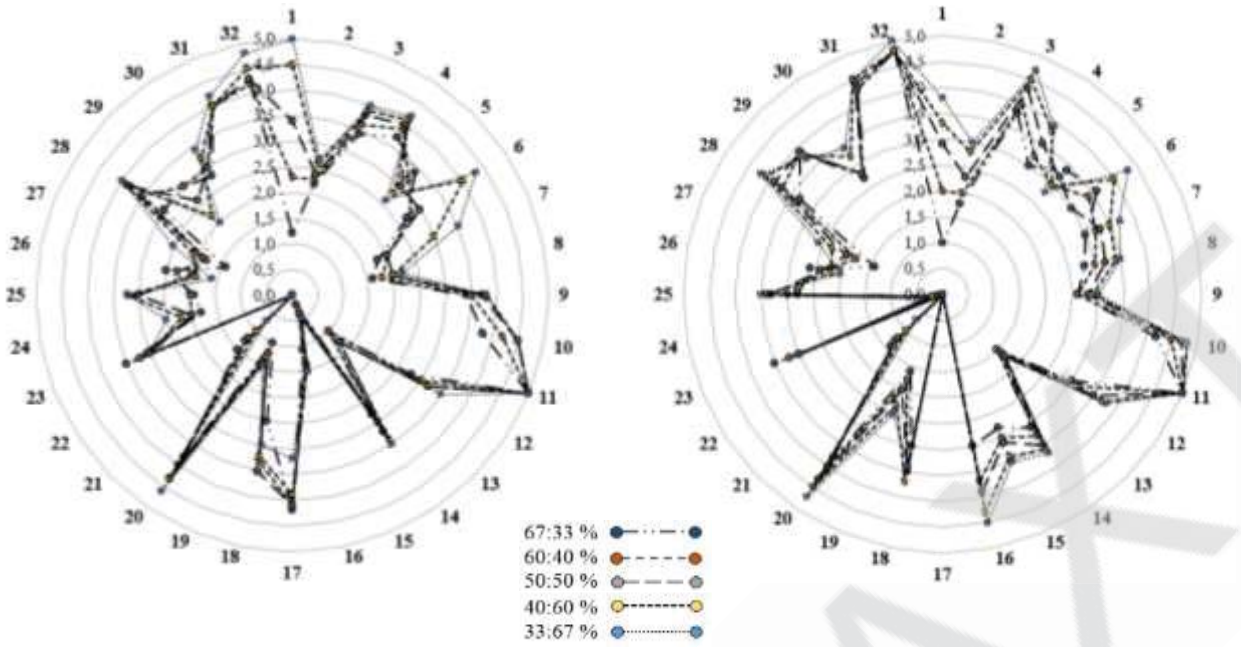


Fig. 1. Model of consumer properties for preserved product using sprouted grain



using bare-grained oats using wheat

1 – uniformity of grain coating with extract, 2 – clarity of extract, 3 – color saturation, 4 – brown color, 5 – golden color, 6 – glossy cast, 7 – brown color of grain, 8 – golden color of grain, 9 – pallor of grain, 10 – uniformity of grain coloring, 11 – grain integrity; 12 – aroma intensity, 13 – bread aroma, 14 – malt aroma, 15 – caramel aroma, 16 – honey aroma, 17 – apple (herbal) aroma; 18 – harmony of tastes, 19 – saturation of taste, 20 – sweetness, 21 – sourness, 22 – bitterness, 23 – apple (herbal) taste, 24 – honey taste, 25 – malt taste, 26 – herbaceous of grain, 27 – sweetness of grain; 28 – extract viscosity, 29 – softness of grain shell, 30 – hardness of grain endosperm; 31 – relevance, 32 – naturalness

Fig. 2. The general portrait of preserved product depending on the proportion of sprouted grain in preserved product

Comparing the portraits, it is noted that when the proportion of sprouted grain in the preserved product increases, the grain coating with extract, pallor and hardness of the grain, the clarity of the extract, glossy casting, brown intensity and the severity of malt-apple aroma decreases. It was found that the most saturated brown color with a glossy cast, sweet apple-honey taste with light sourness, prominent apple-honey-malt aroma, high relevance and naturalness the samples were characterized in ratios of 33:67% and 40:60%, the harmony of sweet-sourness taste in the product was observed at ratios of 60:40% and 50:50%. It should be noted that in the ratio of 40:60% and 50:50%, the extract completely covers the grain, which promotes uniform saturation of the grain with the extract and better preservation of the product.

After studying the model samples of the preserved product, a conversation was held about the weaknesses and strengths of the organoleptic characteristics of the product. Sensory SWOT analysis showed that essential for potential consumers is mainly a pleasant apple (using sprouted bare-grained oats) and honey (using sprouted wheat) aroma, a sweet taste with light sourness, golden brown color, significant functionality and usefulness of the product; weakness – unpleasant aftertaste, non-harmonic sweet or sour taste with bitterness, turbidity of the product.

In the next step, the testers noted the most preferred intensity of the descriptor in the analyzed products. The received averaged scores were multiplied by the

significance factor and converted to a 5-point scale. Based on the results of focus group preferences, a general portrait of the "ideal" preserved product was developed, presented in Figure 3.

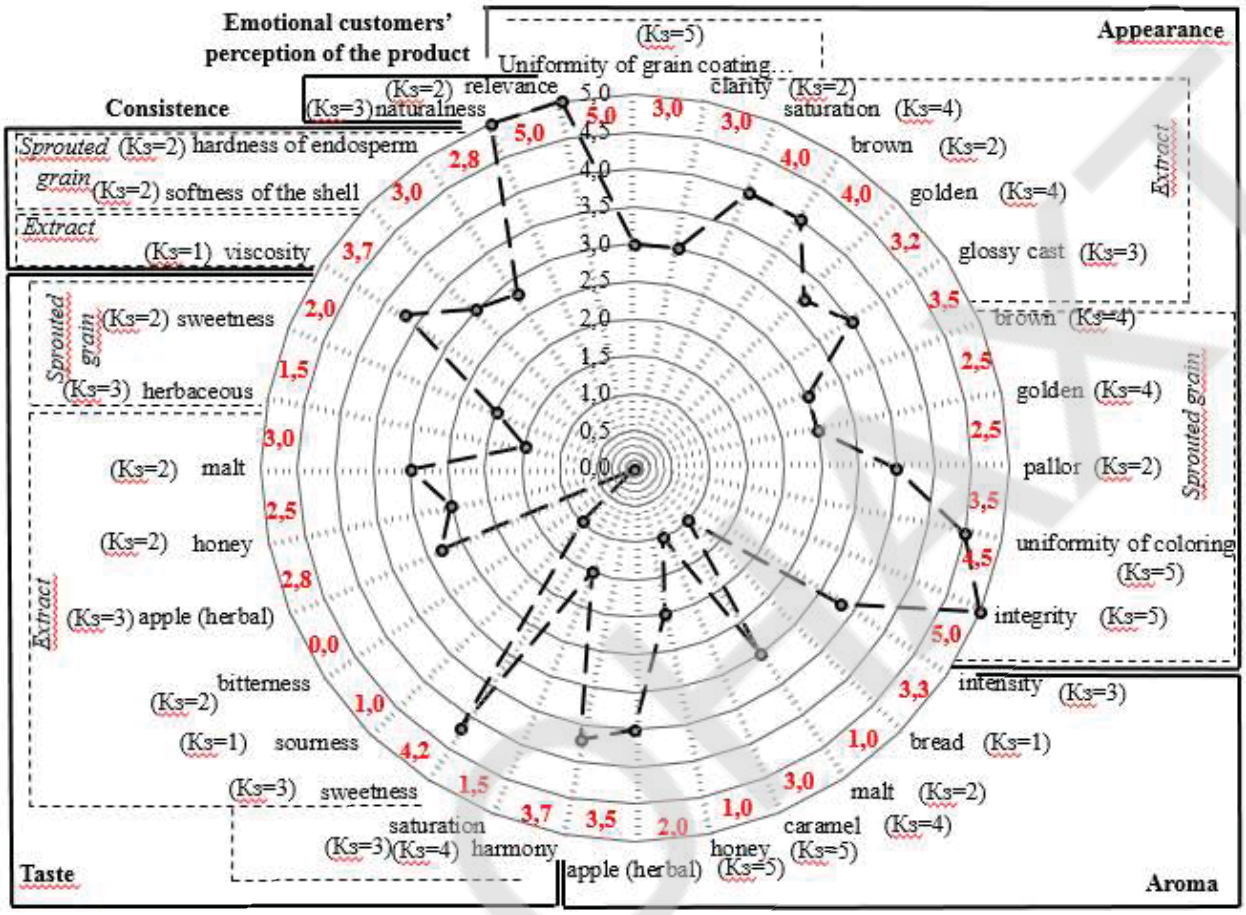


Fig. 3. General portrait of «ideal» preserved product, taking into account weighting factors (Кз)

As can be seen from the results presented in the Figure 5, the "ideal" portrait of the preserved product was characterized as clarity with light opalescence, with strong brown saturation, moderate golden intensity with a glossy cast, with strong vicosity, uniformly colored whole grain, with strong apple severity and moderate malt aroma intensity, harmony of sweet taste with light sourness, moderate saturation of apple-malt taste, with a weak intensity of sweet-herbal taste of the grain, moderate hardness of the grain, lack of bitterness.

Comparison of variations of the preserved product model samples relative to the "ideal" portrait made it possible to recommend the following ratio of ingredients in the preserved product: using sprouted bare-grained oats – 50:50%, using sprouted wheat – 40:60%.

Organoleptic assessment was carried out and physicochemical indices of the developed preserved products were determined. The results are compiled in tabl. 1–2.

Tabl. 1. Organoleptic indices of preserved products

Quality indicators	Sprouted bare-grained oats with malt extract	Sprouted wheat with malt extract
Appearance	Sprouted grains without damage, not cracked, well preserved their shape and evenly distributed in the extract. Extract with glossy surface, without haze. The color of the grain is light to dark brown with a golden tint, the extract is brown.	
Taste and aroma	Mild sweet taste of the extract with honey-malt aroma.	
	The grains are slightly sweet, with light notes of the taste of the extract. There is no foreign taste and smell.	
Consistence	The extract consistency is liquid. Small grain hardness is felt.	

Tab. 2. Physicochemical indices of preserved products

Quality indicators	Sprouted bare-grained oats with malt extract	Sprouted wheat with malt extract
Weight fraction of dry substances,%	53,1	58,4
Acidity, acid units	27,1	25,3
Share of sprouted grain in composition,%	50,0	40,0
Percentage of "pouring" in composition,%	50,0	60,0
Weight fraction of protein,%	6,4	4,7

The degree of satisfaction of a person's daily need for vegetable protein contained in 100 g of preserved products is determined. It is noted that for the preserved product "Sprouted bare-grained oats with malt extract" the daily need for vegetable protein is 16.0% satisfied, for the preserved product "Sprouted wheat with malt extract" – 11.8%.

The biochemical composition (tabl. 3) of preserved products in different compositions was studied and the integral, amino acid rate and biological values (tabl. 4) of the obtained products were calculated.

Tabl. 3. Biochemical composition of preserved products

Name indicator	Combinations				Daily demand, I_{BFF}
	Sprouted bare-grained oats with malt extract (50:50%)		Sprouted wheat with malt extract (40:60%)		
	I	IS, %	I	IS, %	
Vitamins, mg/100 g:					
B_1		27		19	1,5
B_2		20		24	1,8
Minerals, mg/100 g:					
Zn	2,57	21	1,59	13	12,0
Cu	0,58	58	0,45	45	1,0
Fe	9,60	69	1,56	11	14,0[1]

[1]The average value of the norm of physiological need for iron for men and women

Tabl. 4. Results of calculation of biological values of preserved products

Essential amino acid	Content in preserved product, mg/100 g "ideal protein"								
	by FAO/ WHO	Sprouted bare-grained oats with malt extract (50:50 %)				Sprouted wheat with malt extract (40:60%)			
		mg/100 g "perfect protein"	Cscore, %	ΔDAS, %	A_i	mg/100 g "perfect protein"	Cscore, %	ΔDAS, %	A_i
Valine	5000	4661	93	58	0,38	2495	50	27	0,46
Isoleucine	3500	3295	82	47	0,43	2173	54	31	0,42
Leucine	4000	5810	83	48	0,42	3864	55	32	0,42
Lysine	7000	2920	53	18	0,66	1711	31	8	0,74
Methionine	6000	1227	35	0	1,00	804	23	0	1,00
Threonine	5500	2554	64	29	0,55	1787	45	22	0,51
Tryptophan	4000	1292	129	94	0,27	966	97	74	0,24
Phenylalanine	1000	4565	76	41	0,46	2759	46	23	0,50
IIAA	0,76					0,49			
FDAS, %	42					27			
BV, %	58					73			
U (R_c)	0,48					0,50			

Analyzing the data compiled in Table 4, it can be seen that the value of the amino acid rate difference coefficient varies between 27% and 42%. According to the calculated amino acid score values, the biological value of proteins of preserved products from sprouted grains (bare-grained and wheat oats) and malt extract was 73% and 58%, respectively. Essential amino acids are most balanced towards the physiologically necessary norm (standard) in the protein complex of the preserved wheat product sprouted with malt extract (40:60%) (U = 0.50). The higher the index of essential amino acids, the greater the mass of essential amino acids in the test samples. The obtained index less than 1 shows that in the tested samples the sum of essential amino acids is lower than in the daily demand. The bulk of essential amino acids in preserved products are leucine, valine, phenylalanine and isoleucine.

Thus, the obtained preserved products (100 g) satisfy the daily need for vitamin B_1 by 19% – 27%, B_2 – 20% – 24%; zinc – 13% – 21%, copper – 45% – 58%, iron – 11% – 69%; with amino acid score of valine – 50% – 93%, methionine – 23% – 35%, isoleucine – 54% – 82%, leucine – 55% – 83%, phenylalanine – 46% – 76%, lysine – 31% – 53%, threonine – 45% – 64%, tryptophan – 97% – 129%, and allow to attribute the obtained products to functional food products.

The cost of the preserved product amounted to 3.03-3.05 bel. rub. for 0.25 kg, which is 2.5 times lower compared to similar products – products of healthy and functional nutrition (muesli bars, whole grain cereals, bread from wheat seedlings, etc.) sold on the consumer market.

V. CONCLUSIONS

Optimal modes of soaking, germination, blanching for wheat and bare-grained oats are determined, which allow to obtain uniform growth of grain germ sprout and obtain grain with less damaged grains, which provides sufficient quality characteristics of blanched grain.

As a result, a panel of descriptors is formed, taking into account the organoleptic indicators and emotional customers' perception of the preserved product using sprouted grain and malt extract. Characteristic was given to descriptors and significance coefficients of each feature were determined. A comparative evaluation of the preserved product was carried out depending on the proportion of sprouted grain and malt extract. An "ideal" portrait of the preserved product has been developed taking into account the strengths and weaknesses of the product, which allows to model the consumer characteristics of the product and correct undesirable shades and flavors at the stage of development of new products. The following ratios of ingredients are recommended for production of preserved product: 40% – 50% of sprouted grain and 50% – 60% of extract. Quality indicators of the product are characterized by high consumer properties: 100 g of preserved product satisfies the daily need for vitamins (B_1, B_2) and minerals (zinc, copper, iron) of more than 10%, which makes it possible to attribute the obtained products to functional food products.

As a result of a comprehensive evaluation of the preserved product, draft technical conditions prepared BY 700036606.131-2020 "Preserved product. Sprouted grain in malt extract", process instruction BY 700036606.180-2020 "Process instruction for production of preserved product using sprouted grain and malt extract" and 2 formulations BY 700036606.284-2020 "Sprouted bare-grained oat in malt extract", BY 700036606.285-2020 "Sprouted wheat in malt extract".

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