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APPLICATION OF SENSOR ANALYSIS METHODOLOGY IN FISH SNACKS TECHNOLOGY FOR EXPRESS BARS WITH REGULATED HISTAMINE CONTENT

The object of research is the technology of fish snacks for express bars with a regulated histamine content for the rational correction of certain diets of the population. One of the most problematic places in the technology of fish fermented products is the accumulation of biogenic amines with toxic properties. An increased intake of histamine can cause the so-called «histamine» migraine (Horton's syndrome), headache (Harris' neuralgia, characterized by pain in the eyes, forehead, temporal part of the head, lacrimation, inflammation of the nasal mucosa) and other symptoms, including the gastrointestinal tract, sweat, increased secretion of gastric juice, increased heart rate, and decreased diastolic (lower) blood pressure. In addition, the appearance, namely the shape and color of snacks, reduces the attractiveness of snack products.

In the course of the study, methods of sensory analysis, standard methods for studying physical and chemical quality indicators were used. The chosen methodology makes it possible to timely correct technological processes for the production of fish snacks to obtain high-quality, safe food products with a harmonic sensory profile, as well as to control the accumulation of biogenic amines.

The obtained results of the research conducted allow to state that the proposed technological methods and the developed ingredient composition of the mince mixture in the production of snacks contribute to the expansion of the range of snack products for a healthy diet with high consumer properties that provide an attractive appearance, safety, and biological value. This is due to the fact that the consumer preferences for shape, color, usefulness and safety taken into account made it possible, based on the methodology of sensory analysis, to scientifically substantiate the choice of raw materials, form requirements for the appearance of finished products and containers used for packaging snacks. The main raw material for the production of snacks is fish from inland waters of Ukraine with a low-active enzymatic system and, accordingly, a small amount of low-molecular volatile substances involved in the formation of odor. The production process ensures a high sanitary level and the use of consumer packaging of small capacity, which meets the modern requirements of visitors to express bars. In addition, natural biopolymers of plant origin have been introduced into the recipe composition of the minced mixture, which allow to control the process of accumulation of biogenic amines.

Keywords: sensory analysis, fish snacks, express bars, nutritional value, biogenic amines, safety.

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1. Introduction

The preferences of modern consumers are in the plane of healthy products [1, 2]. Much attention is paid to the development of technological methods that contribute to the preservation of valuable components of raw materials without the addition of synthetic preservatives, dyes, flavor enhancers [3, 4]. The production of salted and dried fish products can be considered as a technology that provides a long shelf life of finished products due to low moisture content and controlled salt content. In a certain way

prepared fish raw materials can be processed into snack products. The snack industry is evolving to meet the needs of new consumers. The main trends in the development of the industry are health, well-being, naturalness, sustainability and convenience. High-protein, gluten-free, high-fiber foods reflect vegan «health and wellness, sustainability» trends; products without preservatives, flavor enhancers and fragrances belong to the «natural» trend. The culture of consumption of snack products is also growing, which is manifested in increased requirements for the availability of individual product packaging, the information content

of the label and the capacity of consumer packaging, and the development of express points, such as snack bars.

As a rule, for the production of fish snacks, marine small fish are used, which are disassembled into a «butterfly». The main disadvantage of such products is the accumulation of toxic substances due to the oxidation of lipids and biogenic amines during maturation and storage. In addition, there is an accumulation due to the transformation of high-molecular compounds into nitrogenous bases, free amino acids and other low-molecular compounds, such products are characterized by an excessive aroma and taste of the sea.

In accordance with the current global trend in the development of aquaculture, a promising raw material source for the production of fish snacks is fish from inland waters of Ukraine [5]. The objects of aquaculture in Ukraine include such species of fish as bighead and silver carp, carp, grass carp. The processing of such fish species will avoid a certain part of the problems in the technology of fish snacks for express points, namely snack bars.

Despite all these objective problems, the quality requirements of the products obtained must be constantly observed, and taking into account their constant rigidity. All this leads to the relevance of research aimed at developing the technology of fish snacks for express bars with a regulated histamine content using the methodology of sensory analysis.

Therefore, research to improve the technology of products for snack bars should be considered relevant. Therefore, the aim of the study is to improve the technology of fish snacks for histamine-controlled express bars based on the methodology of sensory analysis. This will improve the consumer properties of fish snacks due to their attractive appearance, guaranteed safety indicators and functional properties due to the sorption properties of hydrocolloids.

In recent decades, developments have been actively carried out in the direction of using low-value fish raw materials for the production of dried products, which include fish snacks, salted and dried fish in small packages, food fish meal, dry fish hydrolysates, concentrates, etc. Dry fish products contain complete proteins of animal origin, they can be used directly for food or for enrichment of traditional flour, cereal and vegetable dishes with deficient amino acids. This need for enrichment is due to the fact that a significant part of the population lacks complete animal protein as a result of the wide distribution of food products made from genetically modified raw materials and counterfeit products [6–8].

Known experiment with the use of fish powder made from the exudates of low-value fish and shrimp to increase the protein content and taste of the extruded product. It has been established that such ingredients can be used for the preparation of extruded snacks with high protein content [9].

The authors have developed a technology for preparing fish and vegetable grits from minced Azov goby. The resulting dry mass can be used as a protein ingredient for culinary products, as a reserve product due to its high stability during long-term storage [10].

Along with traditional fish products, the range of new types is significantly expanding, which is associated with the needs of buyers in original types of products. The introduction and development of a new product range also contributes to the competitiveness of the enterprise. Non-traditional food products from raw materials of water origin include freeze-dried products, chips.

A feature of the technology of fish snacks is the use of structure formers. The technology of pond fish chips is

proposed. It was proposed to use fish collagen emulsion from the skin of pond fish, potato starch, and sodium pyrophosphate as a structurant [11].

There is also known a method for preparing dried-fried products such as crackers, brushwood, chips, the basis of which is evaporated fish or mussel broths, mixed with boiled chopped cereals, starch, sugar, baking soda, citric acid and crushed. The resulting mass is packed into leaves, boiled with hot steam, cooled, cut into drying plates and fried [12].

The problem solved by the invention is to develop a method for creating a previously unknown fish delicacy – dried smoked fish straw [13]. The technical result obtained as a result of the implementation of the invention is to expand the range of gourmet products. The method for preparing smoked fish straws includes the first washing, disassembling into fillets, the second washing, salting the fillets, the first drying, cutting into strips, the second drying and digging the straws. It is preferable to use fish of the cod or Far Eastern salmon family. Smoked straws are packed in bags in portions weighing no more than 0.1 kg. The composition of the gel-forming composition includes fish broth from the waste of the Baikal omul fish fillet production, a protein preparation of animal origin, a phosphate-containing additive «Bioton-Phos», carrageenan, alginates and sodium glutamate, ascorbic acid, vegetable oil and salt [14]. The main disadvantages are the complexity of technological operations and the toxic elements of smoke, the scarcity of raw materials.

Dried fish products remain a major component of production, trade, diet and cuisine around the world, especially in the Global South. The dried fish sector employs millions of people, especially women, who make up the majority of the fish drying workforce in many places. Thus, the relevance of scientific research, which is to be solved in the study of salted and dried fish products, is emphasized [15].

Today, the industry is focusing on the development of ready-to-eat innovative snacks that are reduced in fat, cholesterol, and sodium or supplemented with lipids with an improved fatty acid profile, fiber sources, or probiotics [16].

Thus, the results of the analysis allow concluding that the feasibility of research is to improve the consumer properties of fish snacks based on the developed recipe, which includes natural hydrocolloids, namely sodium alginate, from freshwater fish. Such a composition will make it possible to obtain fish snacks with high organoleptic characteristics. The problem under study will expand the range of snack fish products with regulated histamine content.

2. Materials and Methods

The object of research is the technology of fish snacks, *the subject of research* is the recipe of the minced mixture for the production of snacks, the quality indicators of minced fish and the safety indicators of finished products, the methodology of sensory analysis in the technology of fish snacks.

A feature of the technology of structured fish snacks is the preparation of minced mixture.

For research, small size groups of silver carp weighing 0.3–0.5 kg were used as the least attractive product on the consumer market of chilled and live fish. A large number of intermuscular bones reduces the consumer properties of fish. Sorted by quality and size, the fish is subjected to an instant and disassembled into a carcass to remove inedible parts. Minced fish is obtained on a fish separator, which mechanically removes large bones and backbone, and grinds muscle

tissue through a perforated drum with a hole diameter of 3 mm. The crushed minced meat is served for further fine grinding by cutting, which is combined with mixing with the main components of the recipe. The prepared stuffing mass is sent to the refrigerator for hydrocolloids to swell and structure to form. Snacks in the shape of fish are obtained by stamping and dried in a convective dryer.

Ready snacks are packaged in consumer containers weighing 30–50 g.

The following methods were used for development:

- sampling for organoleptic and physico-chemical parameters, mass fraction of moisture by drying the sample to a constant mass at a temperature of 105 °C, mass fraction of table salt in accordance with GOST 7631-85, GOST 7636-85;
- selection, training of testers and control over their activities in accordance with DSTU ISO 8586:2012;
- sensory studies were carried out in accordance with ISO 6658:2005, Sensory analysis – Methodology – General guidance, IDT.

Generalization of tasting assessments of product quality was carried out by averaging according to the formula:

$$X = \frac{\sum_{i=1}^n X_i}{n}, \quad (1)$$

where $\sum_{i=1}^n X_i$ – the sum of tasters' ratings for a specific indicator (appearance, taste, etc.) of one product sample, points; n – the number of tasters.

To characterize the dispersion of the population of tasters' ratings, the standard deviation for each unit indicator is determined by the formula:

$$S = \sqrt{\frac{\sum_{i=1}^n X_i^2}{n} - X^2}, \quad (2)$$

where $\sqrt{\frac{\sum_{i=1}^n X_i^2}{n}}$ – the sum of the squares of the tasters' scores, points; X^2 is the square of the average value of the indicator marks, points.

The standard deviation S characterizes the consistency of expert opinions with the homogeneity of the analyzed samples. If S on a 5-point scale is not more than ± 0.5 points, the assessment is unambiguous; if the deviation is ± 1 or more, the assessment is heterogeneous, which indicates a low preparation of the tasters.

If the experts' opinions are consistent, then the complex quality indicator Q is calculated using the formula:

$$Q = \sum_{i=1}^n X_i \cdot K, \quad (3)$$

where $\sum_{i=1}^n X_i$ – the sum of tasters' ratings for a specific indicator (appearance, taste, etc.) of one product sample, points; K is the weight coefficient.

When developing a 100-point scale, it was taken into account that the zone of positive assessments should be at least 80 %.

Significance coefficients are used in connection with the different significance of individual indicators in the overall perception of the commercial quality of products.

All tasters received tasting sheets, a copy of the organoleptic evaluation scale for fish snacks.

According to single and complex indicators, according to the criteria developed earlier, the quality category of the evaluated products is established, given in Table 1.

Quality categories of fish snacks

Table 1

Excellent quality	100–81 points
Good quality	80–61 points
Satisfactory quality	60–41 points
Unsatisfactory quality	40 points and lower

According to the resulting sensory studies, the scores determine the category of quality. For further research, only samples are selected that are considered to be of excellent quality and have at least 81 points.

3. Results and Discussion

It was found that during the production of fish products, in the technology of which maturation processes are present, there is an accumulation of low molecular weight compounds that affect organoleptic and safety indicators [17, 18]. When substantiating the choice of raw materials for fish snacks, preference is given to fish species with low enzymatic activity, since the technology of finished products is significantly more complicated and the shelf life is reduced due to lipid oxidation and accumulation of toxic compounds [17].

The choice of raw materials for the production of fish snacks is determined by the prospects for the development of aquaculture in Ukraine. The activity of the complex of peptide hydrolases of fish from inland waters, which are proposed to be used in the technology of fish snacks, has been studied. Enzymatic processes in muscle tissue occur under the action of their own enzymes, enzymes of microorganisms and entrails. The research results are presented in Fig. 1.

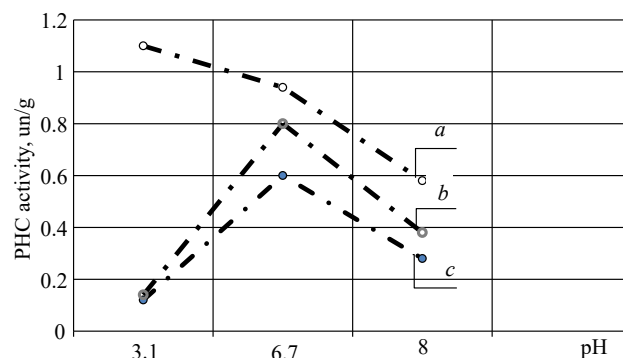


Fig. 1. Determination of the activity of peptide hydrolase complexes (PHC): a – Black Sea sprat; b – carp; c – silver carp

The maximum activity is shown by acid proteases for several Black Sea and is 1.1 units/g. All groups of silver carp proteases have the lowest enzymatic activity (from 0.12 units/g for acidic proteases to 0.6 units/g for neutral proteases). The activity of neutral carp proteases is close to the activity of the proteases of the Black Sea and is 0.8 and 0.94 units/g, respectively. Higher activity of silver carp is characteristic of neutral proteases and is 0.6 units/g, which corresponds to the pH value of fresh

untreated muscle tissue of silver carp, which is sufficient for the formation of a complex of volatile aromatic compounds, but will not contribute to the accumulation of excessive odor in the finished product.

Simultaneously with the maturation processes, the formation of biogenic amines occurs. Since biogenic amines are among the factors that disrupt the stability of the organism along with technogenic factors, it is important to introduce food additives with adaptogenic and immunogenic properties into the composition of products.

It has been established that groups of plant biopolymers with high physiological activity create complexes with heavy and radioactive metals, phenols, amines and the ability to remove them from the body. It is proposed to use in the recipe of minced mixture for the production of molded fish snacks [19].

The control sample was without the addition of functional biopolymers. The experimental sample contained 1.35 % sodium alginate, which provides dietary and preventive properties [20]. When storing fish snacks, the control sample at the end of the shelf life contained 80 mg/kg of histamine, which is close to the maximum allowable content of fish products.

The experimental sample is characterized by a histamine content of 32.5 mg/kg, two times less than in the control sample (Fig. 2).

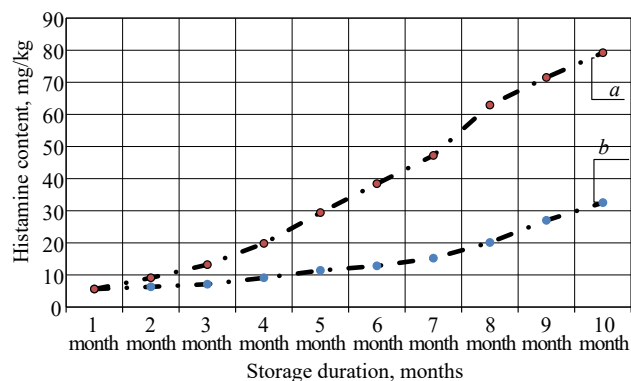


Fig. 2. Effect of hydrocolloids on histamine content: a – without addition of hydrocolloids; b – with the addition of hydrocolloids

In the technology of structured snacks, it is necessary to use substances that have a structure-forming ability for a certain consistency of the final product and improve consumer properties.

One of the widely used hydrocolloids is sodium alginate obtained by alkaline extraction of brown algae. Sodium alginate has a wide range of therapeutic and prophylactic properties, which leads to its wide application in medicine, biotechnology, and various branches of the food industry [19]. It has been established that the active elements of seaweed are absorbed almost completely, since their composition is close to that of human plasma. Preparations based on seaweeds are widely used in medical and preventive practice. Seaweed alginic acid is characterized by the ability to restore the immune system and increase the resistance of the human body to infections. Alginates can be used in those regions of the country where there is the largest concentration of non-ferrous and ferrous metallurgy enterprises, in cities where a high lead content is found in the environment, as preparations with sorption properties. The sorption activity of sodium alginate

makes it possible to bind and remove heavy metals and radionuclides from the body; removal of strontium isotopes has a high activity [20].

Sodium alginate is a highly hydrophilic, biocompatible biopolymer of plant origin that provides a high viscosity of the structure at low concentrations, has a pronounced neutral taste, the pH values of its solutions are close to neutral, corresponding to the pH value of fish products. Gels formed by sodium alginate are thermally non-reversible and have relative acid resistance [20].

The formation of a jelly structure in alginate solutions occurs with the participation of bivalent metal ions through the interaction of molecules with each other in the zones of ionotropic gelation [20]. When gelling alginates, important factors are: the concentration of alginate, its chemical composition and molecular weight; the ratio between the substances involved in the process of gelling (calcium salts as a source of ions, complexing agents: phosphates, citrate, acids, etc.). The fast flow and irreversibility of the coupling reaction between polyvalent cations and alginates is a problem in the technology for the production of alginate jelly. In the process of autolytic maturation, free calcium is released, the mass fraction of which satisfies the conditions of ionotropic gelling formation, established by experimental studies in Table 2.

Table 2

Experimental recipes for minced mixtures for snacks, %

Recipe Ingredients	Recipe No. 1	Recipe No. 2	Recipe No. 3	Recipe No. 4
Minced fish	89.3	89.6	90	88.9
Salt	4.4	4.4	4.4	4.4
Paprika	4.6	4.6	4.6	4.6
Sodium alginate	1.7	1.4	1	2.1
Total, %	100	100	100	100

In order to determine the effect of the mass fraction of hydrocolloids on the texture formation of snacks, the content of table salt and paprika was left unchanged in the recipe.

Based on the recommendations of the FAO/WHO expert committee, the content of alginic acid and its salts in food products without health risks is 25 mg per 1.0 kg of human body weight, therefore formulations No. 2 and No. 3 were chosen for further sensory studies.

The methodology of sensory analysis of food products involves determining which characteristics are inherent in aroma, taste and texture. In accordance with DSTU ISO 8586:2012 «Sensors analysis – General guidelines for the selection, training and monitoring of selected assessors and expert sensors assessors. Organoleptic analysis. General guidelines for the selection, training of testers and monitoring their activities», a plan was developed for the selection, training and monitoring of sensory sensitivity of testers to solve the problem of assessing the quality of fish snacks made according to the proposed recipes.

The recommended standard selection procedure includes the recruitment and screening of «non-trained assessors», familiarization of selected candidates with predicted work, as a result of which they can be called «trained assessors», selection among «trained assessors» of those who are able to conduct discrimination tests, tests for ranking and applying scales and categories in evaluating products, as well as those who may later become «selected assessors»,

perhaps training «selected assessors» so that they can become «expert assessors».

Let's choose an internal method of recruiting testers, since each tester had the necessary theoretical training and sufficient experience in practical work with sensory studies. Each of the testers passed the taste sensitivity testing of tasters in accordance with the national standard DSTU ISO 3972:2004, which is an identical translation of ISO 3972:1991 «Sensory analysis – Methodology – Method of investigating sensitivity of taste». ISO 3972:2011 is currently relevant. The test methods described can be used to train experts to recognize and distinguish between tastes, to educate experts on the concept of thresholds and to teach them to separately recognize types of thresholds, to educate experts on their own taste sensitivities. These methods have been used as a periodic means of monitoring the taste sensitivity of experts who are already members of the panel and perform sensory studies.

Based on the internal recruitment, a mixed commission was formed. Among the testers were both women and men from 18 to 35 years old. All studies were conducted according to established standards. After the test, information was provided on the samples participating in the study, as well as informed on exactly how such information will be processed and used.

The organoleptic characteristics of goods cannot be expressed in physical dimensions. The characteristics of taste, smell, texture and other sensory indicators are given in a descriptive form. To translate these descriptive characteristics

into quantitative ones, dimensionless scales are used in peer review. The most common type of quantitative assessment of the quality of sensory indicators of food products is scoring. It allows to set the level of shared (for individual indicators) or general (for a set of indicators) quality of the evaluated products and express it as a numerical value. When using a scientifically based scoring system, the appropriate qualifications of the tasters and compliance with all requirements for the application of this method, it allows to get fairly objective, reliable and probable results.

When developing the scoring scale, a nomenclature of single indicators characterizing the organoleptic properties of snacks was chosen, a table diagram was developed with a verbal description of each indicator for all quality levels of the scale, the coefficients of significance of each organoleptic quality indicator were established, and criteria were established for different categories of product quality. After a preliminary discussion of the developed elements of the scoring scale, the developed scale was tested twice on several product samples. This stage included the assessment in points of single quality indicators by means of the corresponding sense organs, the calculation of complex indicators for each sample.

To conduct a sensory assessment of snacks, the testers were instructed about the impossibility of using flavored cosmetics, perfumes, drinking coffee, and smoking.

The organoleptic indicators of snacks include: appearance, taste and smell, color, consistency and established quality gradations, scores corresponding to these gradations (Table 3).

Table 3

Establishing quality gradations for fish snacks and assigning points to them

Name of indicator	Significance factor	Points	Characteristics of the indicator
Appearance	3.0	5	Levels, smooth snacks, uniform in size and shape, free from inclusions of skin, bones, lumps of hydrocolloids and other components
		4	Levels, smooth snacks, of the same size and shape, single inclusions of skin, bones, lumps of hydrocolloids and other components
		3	The presence of cracks, single broken pieces of snacks, inclusions of skin, bones, lumps of hydrocolloids and a rough surface
		2	Uneven snacks, the presence of cracks, broken snacks, a significant amount of skin inclusions; bones, lumps of hydrocolloids
		1	Uneven snacks of various shapes, the presence of cracks and broken snacks more than 50 %, a significant number of skin inclusions; bones, lumps of hydrocolloids
Taste and smell	9.0	5	Harmonious, moderately salty with a taste of additives, the smell is characteristic of this type of fish and additives
		4	Pleasant, harmonious, too (not enough) pronounced taste of salt and taste of additives, the smell characteristic of this type of fish and additives
		3	Pleasant, with a slight aftertaste of unripe (overripe) salted fish, a barely audible taste and smell of oxidized fat, a strong smell characteristic of this type of fish and additives
		2	Pronounced taste and smell of unripe (overripe) fish, taste and smell of oxidized fat, unexpressed smack of spices
		1	Inharmonious, with a strongly perceptible taste and smell of immature (overripe) fish, a pronounced taste and smell of oxidized fat, without a taste of spices
Color	2.0	5	Uniform, pleasant, characteristic of suitable additives, closely imitating the color of salmon fish
		4	Uniform, pleasant, characteristic of suitable additives, slightly out of color with salmon fish
		3	Not quite uniform, pleasant, characteristic of suitable additives not corresponding to the color of salmon fish, with some darkening
		2	Not uniform, does not match the color of salmon fish
		1	Dark, uncharacteristic, with a lot of inclusions
Consistency	2.0	5	Suitable for fish snacks, easy to chew, not sticky after chewing
		4	Suitable for fish snacks, easy to chew, inelastic, not sticky after chewing
		3	Good for fish snacks, easy to chew, somewhat brittle (or somewhat rubbery and somewhat sticky when chewed)
		2	Unsuitable for fish snacks, consistency is not uniform, brittle (or rubbery, sticky after chewing)
		1	Differs from the consistency of fish snacks, heterogeneous, with a slippery sticky surface, does not chew

After evaluating the quality of products, the results of sensory studies were processed and analyzed.

The results of the experts showed that the tasting committee is competent, since the standard deviation S is not more than 0.5 points, which indicates the consistency of the experts' opinions. After evaluating the quality level of two selected samples of fish snacks, the tasting commission found that sample No. 2 received a «Satisfactory» rating, since it scored 79.7 points, and sample No. 3 received a «Cancel» rating during the tasting and scored 94.5 points.

The strengths of this study are that the proposed developments of fish snacks for express bars contribute to the expansion of the assortment with the promotion of the culture of consumption of fish products from the raw materials of inland waters of Ukraine, which meets the requirements of the modern catering visitor for safety, usefulness of the finished product and convenience of packaging.

The weaknesses of this study are associated with the use of a natural structure-forming agent – sodium alginate, which is currently an exported ingredient due to the lack of a Ukrainian raw material source.

Additional opportunities when using the above results in public catering are the improvement of technology through the use of Ukrainian aquaculture objects as raw materials with the addition of only natural ingredients to the recipe, which help reduce biogenic hazards.

The developments proposed in this paper are of a practical nature, however, they require a socio-economic justification to form the foundations for the development of the express catering industry.

4. Conclusions

1. To justify the choice of raw materials for the production of structured fish snacks, it was found that all groups of silver carp proteases have the least enzymatic activity; sufficient to form a complex of volatile aromatic compounds, but will not contribute to the accumulation of excessive odor in the finished product.

2. A positive effect of hydrocolloids on the content of histamine during storage was established and it was shown that during storage of fish snacks: the experimental sample at the end of the shelf life contains 32.5 mg/kg of histamine, which is three times less than the maximum allowable.

3. The point method of sensory analysis made it possible to develop and scientifically substantiate the formulation of fish snacks containing 90 % minced fish, 4.6 % paprika, 4.4 % salt, 1 % sodium alginate. According to the statistical processing of the tasting results, the studied samples under number 3 showed the best complex organoleptic assessment, which amounted to 94.5 points. Such results allow to conclude that it is expedient to choose the developed recipe for compiling a minced mixture in the technology of silver carp snacks.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

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