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Quality assessment of fish pastes of increased biological value

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Abstract. Providing the population of Ukraine with fish products is of particular relevance since their consumption level does not meet the recommendations for healthy nutrition. One of the directions that can solve this problem is to expand the range of fish pastes, which are affordable for a wide range of people. The aim of the study was to improve the formulation of fish pastes based on the meat of catfish (*Clarias gariepinus* (Burchell, 1822)), trout (*Salmo trutta fario*), pink salmon milt (*Oncorhynchus gorbuscha*), and plant-based raw materials, as well as to evaluate the new formulations based on a set of organoleptic indicators, flavour profile spectrum, energy value, and physicochemical research methods: moisture content – by drying the sample to constant weight; fat content – by the Soxhlet method; protein content – by the Kjeldahl method; ash content – by incineration of the sample. As a result of the research, the feasibility of combining the meat of the catfish, pink salmon milt and plant raw materials in the recipe composition of fish pastes was experimentally confirmed. Three new recipes for fish pastes were developed based on pre-salted and chopped catfish meat, trout and pink salmon milt, sautéed plant raw materials (onions, carrots), sunflower oil and spices. Studies of organoleptic indicators and the profile of the flavour spectrum determined the highest consistency indicators in fish pastes with catfish meat and pink salmon milt compared to the control and other formulations (9.5 ± 0.1 versus 8.5 ± 0.08 points). Regarding chemical composition, the fish paste samples were characterised by a high moisture content: 50.24 ± 0.17 in the experimental formulations versus 61.62 ± 0.84 in the control, % respectively. The protein content was 14.65 ± 0.19 in the paste with pink salmon milt versus 13.05 ± 1.18% in the control. The lipid content in the new paste formulations ranged from 32.12 ± 0.16 to 34.13 ± 0.21 versus 22.38 ± 0.17%, which determined their high energy value: 347.11-365.77 versus 253.64 Kcal/100 g in the control. The results of the studies showed the feasibility of combining catfish meat with pink salmon milt and vegetable raw materials in the formulation of fish pastes, which will expand the range of high-quality and valuable fish products

Keywords: catfish meat; pink salmon milt; plant raw material; organoleptic evaluation; descriptors; flavour spectrum; chemical composition

Introduction

Improvement of existing technologies for processing fish raw materials to create high-quality and safe food products has gained particular importance recently. This is due to the high nutritional value of fish raw materials, which contain essential amino acids, fatty acids, vitamins, macro- and microelements, and physiologically active carbohydrates. Providing the population of Ukraine with high-quality food products that meet modern FAO/WHO recommendations on the content of essential factors is one of the important tasks of innovative technologies (FAO/WHO, 2024). In this direction, the creation of food forms from natural raw materials using many ingredients is given special attention, because it allows combining raw materials of different origins to create products with specified properties of the biological value of protein, lipids, mineral components, and vitamin composition. On the other hand, relatively new types of aquaculture facilities, both in Ukraine and in the world, require the development of new technologies for their processing (FAO, 2022). Thus, in Ukraine and many countries around the world, the cultivation of the African catfish *Clarias gariepinus* (Burchell, 1822) from the family Clariidae is widespread (Sharylo *et al.*, 2020; Zadorozhnii, 2023). According to I. Bal (2024), modern technologies for processing this type of fish, as well as many freshwater fish, are

associated with the production of culinary products, cold and hot smoking, raw smoked sausages in combination with other aquatic organisms, animal and plant raw materials, smoked sausages using liquid smoke. Since many innovative technologies are associated with the production of minced meat systems, considerable attention is paid to ensuring their specific structure and consistency. N. Bozhko *et al*. (2021) proved that combining freshwater silver carp meat with duck meat improves the strength and elasticity of the system, water-binding and water-retaining capacity, and contributes to improving the structural, mechanical and organoleptic properties of sausage products. N. Walayat *et al.* (2022) determined the effectiveness of using cryoprotectants in minced fish products to improve their gelling ability. The improvement of sensory and structural features of minced fish-based systems is facilitated by the use of potato starch, and hydrolysate from fish swim bladder (Ernawati *et al*., 2021). The Ukrainian market is dominated by freshwater aquatic organisms (UIFSA, 2024). The improvement of meat properties for the production of high-quality canned products is the focus of the study by S. Arokiyaraj *et al*. (2024), which involves treating the raw material with various acids to ensure the maturation of the canned products.

Despite a significant amount of scientific research in the field of fish product technology, the issue of improving existing fish paste technologies based on the principles of food combinatorics using meat of different fish species and plant raw materials remains relevant. The work aimed to improve the recipe composition of fish pastes based on meat of Clarias catfish, trout, pink salmon milt and plant raw materials and to research organoleptic indicators, flavour spectrum profile and energy value of new fish paste recipes. The objectives of the work were to study the compatibility of fish raw materials, namely meat of Clarias catfish, trout, pink salmon milt, plant raw materials, to form the recipe composition of fish pastes, to determine organoleptic indicators, flavour spectrum profile and energy value of new recipes. The scientific novelty of the work lies in the formation of a recipe composition of high-quality fish pastes based on a complex of organoleptic indicators, palatability and energy value based on domestic raw materials.

Literature Review

Fish pastes are a snack food product made by physically or chemically grinding, mashing, mincing, or pressing the meat of fish or invertebrates, and mixing the minced mixture with ingredients of plant or animal origin to achieve a homogeneous consistency. In this context, the use of aquaculture objects – clarias catfish and trout to improve the formulation of fish pastes is of particular importance (Okonkwo *et al*., 2020; Knaus *et al*., 2021). The technology of pasty products allows for combining raw materials of different origins and, based on the principles of food combinatorics, forming products with specified properties of organoleptic indicators, biological and energy value, and structural and mechanical features (Lebska *et al.*, 2021).

The technology of pasty products is based on obtaining a minced emulsion with specific structural and mechanical properties. In this regard, many studies have been devoted to the factors that affect gelling and emulsifying ability. Thus, H. Luo *et al.* (2020) showed the feasibility of adding potato starch at levels of 8 and 5%, which improves the gel strength and taste of surimi. However, adding starch to minced meat products from washed minced fish contributes to an increase in carbohydrates, which reduces their nutritional value by reducing the content of proteins and essential amino acids.

Research by M. Sapatinha *et al.* (2025) determined the effectiveness of adding protein hydrolysates obtained after enzymatic hydrolysis of substandard fish caviar on the structural and mechanical properties of minced products from silver carp meat and enriched with fish

oil. It was shown that hydrolysates contribute to the strengthening of the structure of fish sausages, improve sensory properties and slow down fat oxidation and microbial spoilage. The use of hydrolysates of substandard fish caviar is seasonal. On the other hand, fish caviar can be at different stages of maturation, which are not controlled during manufacturing these products. Therefore, the use of this method in industrial conditions is very problematic. On the other hand, it is a very good idea to add caviar hydrolysates as a source of complete proteins, lipids and vitamins (Adebisi & Oshibanjo, 2019).

Fish pastes and other minced fish food products are subject to rapid spoilage. Non-thermal disinfection, such as cold plasma (CP), can be used to prevent the growth of microorganisms (Andoni *et al*., 2021). Using the example of chicken sausages, the effect of ultraviolet (UV) irradiation (for 200 and 400s) and CP (power 30 and 70 W for 200 and 400s) was investigated. CP had a greater effect on the appearance of sausages, effectively inhibiting the development of microorganisms and a longer shelf life. Non-thermal disinfection of sausages has significant advantages, because it does not cause lipid oxidation and denaturing changes in the protein component (Filho *et al*., 2021). Unfortunately, there is no industrial equipment for processing food products using CP, and the issues of digestibility of food products after this processing have not been studied.

Effective use of by-products from fish raw material processing opens up opportunities for new industries in the case of their deep processing. A. Ampitiya *et al.* (2023) showed the feasibility of extracting collagen from the skins of fish species such as yellowfin tuna (*Thunnus albacares*), seer fish (*Scomberomorus commerson)* and Asian sea bass (*Lates calcarifer*). The results of the studies indicate the possibility of using the extracted collagen as a structure-forming agent, including in minced fish products. The problem of unifying the quality of collagen extracted from the skin of different fish species and specific recommendations for its use in minced fish products remains.

A positive effect of the hydrolysate of the swim bladder gelatin (SBGH) of the fish *Labeo rohita* on the texture, sensory, microbial properties, and fat oxidation processes in cooked sausages enriched with polyunsaturated fatty acids has been determined (Cruz-López *et al.*, 2023). Adding 3% SBGH to minced sausage systems showed higher hardness, cohesion, stickiness, slowing down of fat oxidation processes and safety throughout the entire storage period at 4°C for 30 days compared to control samples. Based on these research results, it is recommended to add hydrolysates of swim bladder gelatin to minced fish in the manufacture of sausage products, which will help slow down oil oxidation and microbial spoilage and improve the structural and mechanical properties of sausages. The disadvantage of this work is the difficulty in preparing this raw material and its small amount to manufacture gelatin hydrolysates. The swim bladder is present only in bony freshwater fish, the total catch of which in Ukraine is significantly less than that of marine ones (Public report..., 2024).

The search for ways to optimise the recipe composition of minced meat products provides grounds for improving both the product's nutritional value and its structural and mechanical properties. Scientists N. Aukkanit *et al.* (2020) established the effects of different levels of *Hylocereus dragon fruit peel powder undulate* (DFPP) on the physical, chemical and sensory properties of emulsion sausages. In emulsion sausage samples, pork fat was replaced with 0.5, 1.0, 1.5, 2.0, and 2.5% DFPP. The sausage's moisture, ash, and crude fibre contents increased with increasing amounts of this additive. High-content DFPP increased sausage firmness, elasticity, stickiness and chewiness but reduced cohesion. The addition of 2.0% DFPP was recommended, which did not significantly affect the sensory evaluation of

appearance, taste, texture and overall acceptability. Based on the conclusions of the authors of this work, doubts arise about the feasibility of using DFPP instead of lard, because there is no comparative analysis of nutritional value. The feasibility of using pectin from apple peels using microwaves has been proven in model sausage systems (Aldemir *et al.*, 2024). It was determined that pectin emulsions show higher stability at a pectin mass fraction of 1.0%. Therefore, apple peel pectin can potentially be used for fat reduction in minced meat systems for sausage production.

Researchers S. You *et al.* (2022) established the effect of improving the nutritional value and sensory properties of fish sausages by adding 15% textured soy protein (TSP), 8% potato starch and 5% lard. During 180 days of storage, the moisture retention capacity, colour, and gel strength decreased, but weight losses during cooking and thawing were lower than the control. However, the processes of secondary lipid oxidation and the accumulation of protein degradation products were more pronounced. However, the basic nitrogen value was higher. Thus, these data allowed the authors to recommend the use of soy protein in fish sausages in order to improve the gel strength and sensory properties of fish sausages.

The use of various additives to improve the emulsification ability of minced meat products contributes to the improvement of technologies and the quality of the final product (Pelykh *et al.*, 2020). The addition of regular and defatted fenugreek seed powder *Trigonella Foenum-Graecum* (TFg and DTfg, respectively) at 2.0% and 4.0% to meat emulsions determined their impact on improving the quality of emulsion-type meat products with vegetable oils as substitutes for animal fat (Patriani *et al.*, 2023). Cooking losses and fat and liquid separation were lower in TFg, and Dtfg samples combined with starch. Lipid oxidation was higher in samples with TFg than with Dtfg or starch. Hardness, chewiness and stickiness were lower in TFg and Dtfg samples than in starch samples. These results show that TFg powder is a promising raw material for improving the quality of emulsion-type meat products with vegetable oils as animal fat substitutes. The disadvantage of these studies is the lack of data on the change in the biological value of the final product when using these additives.

Thus, E. Alagöz & C. Sarıçoban (2024) studied the effects of roasted and unroasted turpentine (*Pistacia terebinthus*) on the colour, emulsion capacity, fluidity, emulsion stability, microstructure and textural properties of meat emulsions. Meat emulsions were created by adding roasted and unroasted turpentine to beef in amounts of 0.0, 0.1, 0.3, and 0.5%. Emulsion capacity and stability increased with the addition of turpentine, with the highest value of emulsion capacity (233.50 ml oil/g protein) and stability (74.50%) observed at a turpentine concentration of 0.3%. The use of roasted turpentine contributed to an increase in emulsion stability and sample capacity compared to unroasted. Thus, it is recommended to add turpentine to emulsion-type products with a high-fat content, which will contribute to improving technological and functional properties. The authors of this study did not consider the hypothetical mechanisms of the influence of turpentine additives on the emulsion properties of minced meat products.

Researchers N. Bozhko *et al.* (2021) proved the feasibility of combining the meat of freshwater silver carp (*Hypophthalmichthys molitrix*) with duck meat (*Anas platyrhynchos*) in the composition of semi-smoked sausages. The optimal recipe with the highest quality indicators of semi-smoked sausages from duck meat and freshwater aquaculture fish at a ratio of 50:30 was determined, which provides improved strength and elasticity of the system, water-binding and water-retaining capacity, sensory evaluation indicators, and an ideal protein: fat ratio (1:1). It would be desirable to assess the nutritional value of the final product.

The original design of the fish paste recipe was created by A. Menchynska *et al.* (2021). Based on theoretical studies, using carp meat with caviar of freshwater carp and sea fish - capelin and sunflower oil is justified. It is shown that due to the high content of phospholipids in fish caviar and sunflower oil, which are natural emulsifiers, the elasticity of the minced meat system is ensured, the organoleptic properties and the spectrum of the palatability profile are improved. Also, due to the content of biologically valuable essential amino acids, and fatty acids of the omega three family in this raw material, these fish paste recipes belong to health food products.

The effectiveness of combining fish raw materials of different origins in the minced meat system has been shown in the studies of A. Menchynska *et al.* (2021). The feasibility of using catfish meat as a raw material for the production of fish sausages has been theoretically substantiated and experimentally confirmed. The authors have developed a recipe composition of minced meat systems for the production of raw smoked fish systems based on catfish meat with the addition of mackerel, scallops and lard. Combining raw materials of different origins contributes to an increase in nutritional value. However, the developed recipes for fish sausages belong to the "elite" food products and are not available to a wide range of the population.

The preliminary preparation of raw materials before manufacturing finished products significantly affects the quality of the finished product. In this regard, research by S. Kunnath *et al.* (2022), determined the effect of high pressure on modifying the structure and functional properties of minced products from pink perch meat (*Nemipterus japonicus*). Fish mince significantly changed in viscosity when processed at 200, 400, and 600 MPa. In contrast to thermal gels, pressure-induced gels were smooth, white, and elastic. Reduction of reactive SH groups, which participate in forming gels and emulsions, occurred in samples treated at 400 and 600 MPa due to the formation of disulfide bonds. The use of pressure contributed to the reduction of microbial contamination by 2-3 logarithmic cycles. It is recommended to treat minced meat with a pressure of 200 MPa, which does not significantly affect the quality of the structure and functional properties of the protein. Unfortunately, the authors did not study changes in the biological value of the product after this treatment.

L. Chen *et al.* (2024) proposed a combined processing of fish raw materials that contributes to the preservation of its sensory properties. The effect of different temperatures (18, 20 and 50°C) on raw pieces of grass carp (*Ctenopharyngodon idella*) under pressure of 300, 400 and 500 MPa. Increasing pressure caused shrinkage of fibres and compaction of the structure, but the content of myofibrillar proteins decreased with increasing temperature. The results of these studies will help control the quality of fish and will contribute to the development of appropriate means to improve the quality of both raw materials and food products from fish.

Thus, modern technologies of minced products, as the basis for the manufacture of sausage and pasty food products, are associated with the improvement of their recipe composition by using ingredients that are not traditional for these products, as well as with the use of structure-forming agents to ensure the emulsion and gel structure typical for these products. However, many issues regarding the expansion of the spectrum of use of new types of raw materials and a comprehensive assessment of the palatability and nutritional value of minced products remain unresolved. The purpose of these studies was to improve the recipe composition of fish pastes based on domestic raw materials – meat of catfish, trout and pink salmon milt, organoleptic evaluations, characteristics of the spectrum of the flavour profile and energy value of the products were carried out.

Materials and Methods

The research was conducted during 2023-2024 in the laboratory of the Department of Meat, Fish and Seafood Technology of the Faculty of Food Technology and Quality Control of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine. The formulation of the fish pastes was based on an assessment of the compatibility of raw materials, namely – Clarias catfish meat from aquaculture in Ukraine, trout, pink salmon milt, vegetables (onions, carrots), sunflower oil, tomato paste and spices. The control recipe used was the one from the experiments by A. Menchynska *et al*. (2021). The fish was cut into fillets, salted with 5% salt for 24 hours at room temperature and ground on a cutter to a particle size of up to 1 mm. Pink salmon milt was thawed at room temperature for 4-6 hours, dry-salted with 5% salt for 12 hours at 4°C and ground to 1 mm. Onions and carrots were ground and sautéed in sunflower oil. The compatibility of raw materials was assessed based on combining fish meat and pink salmon milt in different ratios, the recipe composition of fish pastes was formed and the ingredients were dosed in a certain amount. Emulsification of the minced mixture was carried out by gradually adding sunflower oil in accordance with the amount specified in the recipe (Table 1).

Table 1. *Formulation of fish pastes*

Ingredients	Quantity of ingredients, %			
	control (Menchynska *et al*., 2021)	sample 1	sample 2	sample 3
Carp meat	70.0	-	-	-
Clarias catfish meat	-	30.0	45.0	30.0
Trout meat	-	30.0	15.0	15.0
Salted milt	-	-	-	20.0
Carrot	-	9.0	9.0	5.0
Sautéed onion	5.0	5.0	5.0	5.0
Tomato paste 30%	10.0	10.0	10.0	10.0
Sunflower oil	6.8	12.2	12.2	12.7
Table salt “Extra”	3.0	3.0	3.0	1.5
Sugar	0.5	0.5	0.5	0.5
Acetic acid 9%	0.2	0.2	0.2	0.2
Ground black pepper	0.05	0.05	0.05	0.05
Ground allspice	0.02	0.02	0.02	0.02
Ground coriander	0.03	0.03	0.03	0.03
Water	4.4	-	-	-
Total	100.0	100.0	100.0	100.0

Source: authors’ development

For the organoleptic analysis of fish pastes, a five-point scale was developed in accordance with the recommendations (Tkachenko *et al*., 2020). The assessment results were expressed in points on a conditional scale with an increasing sequence of numbers (Table 2). Organoleptic evaluation of fish caviar-based pastes was carried out according to the following indicators: appearance, colour, taste, smell, and consistency.

Table 2. *Scoring scale for organoleptic evaluation of fish pastes*

Indicator	Indicator characteristics	Point
Appearance	Homogeneous, pasty mass without grains	5
	Homogeneous, pasty mass, slightly grainy	4
	Heterogeneous mass, moderate granular mass	3
	Heterogeneous mass, very granular mass	2
	Heterogeneous, highly granular mass with a large number of foreign impurities and lumps	1
Colour	White or light orange or light pink, uniform throughout the mass	5
	With a greyish tint, uniform throughout the mass	4
	With a greyish tint, slightly heterogeneous throughout the mass	3
	Grey with orange or pink flecks, non-uniform throughout the mass	2
	Dark grey, non-uniform throughout the mass, with dark inclusions	1
Consistency	Homogeneous, pasty without grains	5
	Homogeneous, pasty with single grains	4
	Heterogeneous, moderate grainy	3
	Heterogeneous mass, very granular	2
	Heterogeneous, lumpy	1
Taste	Harmonious, typical of this type of product, with a caviar flavour, the taste of freshwater fish is not felt	5
	Harmonious, typical of this type of product, the taste of freshwater fish is barely noticeable	4
	Harmonious, typical of this type of product, the taste of freshwater fish is moderately pronounced	3
	Fishy, with a hint of vegetable components, no milty taste	2
	Strongly pronounced fishy flavour, the taste of other components is almost not felt	1
Scent	Pleasant, typical of this type of product with a milty aroma	5
	Slight fishy smell	4
	Fishy smell moderately pronounced	3
	The fishy smell is strongly pronounced	2
	The fishy smell is very strongly pronounced	1

Source: authors' development

When assessing the consistency of fish pastes, tenderness, homogeneity, and uniformity were determined. To determine the smell, typicality, intensity, and the presence of specific and other foreign odours were determined. The total chemical composition of fish pastes was determined by moisture, protein, fat and ash content. The mass fraction of protein was determined by the total nitrogen content by the Kjeldahl method by the requirements of DSTU 8030:2015 (2017). Mineralisation of samples was carried out in a digester Velp Scientifica series DK6 (Italy) with a vacuum pump (JP). The distillation process was carried out on the apparatus Velp Scientifica UDK 129. The mass fraction of lipids wasdetermined using the Soxhlet extraction-weight method on the Soxhlet SOX 406 Fat Analyzer, according to DSTU 8717:2017 (2019). Mass fraction of ash-by weight method after mineralisation of the sample in a muffle furnace at a temperature of 500-600°C according to DSTU 8718:2017 (2019). Mass fraction of moisture – by drying the samples to constant mass at 100-105°C (DSTU 8029:2015, 2017). The caloric content of fish pastes was determined using a calculation method.

The taste of fish pastes was evaluated using flavour spectrum profilographs in accordance with the descriptors developed by the authors according to DSTU ISO 6564:2005 (2006). To substantiate the feasibility of combining

freshwater fish meat with pink salmon milt and raw materials of plant origin, an organoleptic assessment of the compatibility of these ingredients in fish pastes was carried out. Experimental studies were carried out in 3 replicates, the reliability of differences was assessed using the Student's t-test at $P \leq 0.05$.

Results

Organoleptic assessment of the quality of a food product forms the first impression of the consumer. The results of studies of the comparative characteristics of experimental samples of fish pastes of different formulations (1, 2, 3) in comparison with the control (C) are given in Table 3.

Table 3. *Comparative evaluation of organoleptic indicators of fish pastes of different formulations, in points*

Samples	Indicator characteristics and its points					
	Appearance	Aroma and taste	Consistency	Structure	Colour	Overall rating
C	Typical fish paste (4.3±0.7)	Typical for this type of product (3.6 ± 0.5)	Pasty, smearing (4.0 ± 0.3)	Homogeneous, with inclusion of muscle fibres (4.0 ± 0.1)	Light grey with a pink tint (4.2 ± 0.1)	20.1 ± 0.4
1	Typical fish paste (4.5 ± 0.2)	Typical for this type of product (3.9 ± 0.2)	Pasty, smearing (4.3 ± 0.4)	Homogeneous, with inclusion of muscle fibres (4.0 ± 0.2)	Light pink uniform throughout the mass (4.5 ± 0.1)	21.2 ± 0.5
2	Typical fish paste (4.7 ± 0.4)	Typical for this type of product (4.2 ± 0.1)	Pasty, smearing (4.3 ± 0.5)	Homogeneous, with inclusion of muscle fibres (4.0 ± 0.1)	Light pink uniform throughout the mass (4.7 ± 0.4)	21.9 ± 0.3
3	Typical fish paste (4.9 ± 0.2)	Typical for this type of product (4.5 ± 0.1)	Pasty, smearing (4.9 ± 0.3)	Homogeneous without inclusions (4.9 ± 0.1)	Light pink, uniform throughout the mass (4.9 ± 0.1)	24.1 ± 0.1

Source: authors' development

In appearance, all fish paste samples met the requirements for this product. The aroma and taste were also characteristic of fish pastes due to the fact that they included crushed salted fish raw materials: in the control sample from carp, in 1 and 2 – catfish and trout meat, in 3 – catfish, trout meat and pink salmon milt. A comparative analysis of the organoleptic indicators of fish pastes of different recipes shows that the overall score was better for fish paste based on catfish, trout and pink salmon milt 24.1 versus 20.1 in the control sample and 21.2 and 21.9 in recipes with a combination of catfish and trout meat, respectively. The control sample and samples No. 1 and No. 2 were characterised by a homogeneous consistency but with the inclusion of muscle tissue. A comparative characteristic of the chemical composition of fish pastes of different formulations is shown in Figure 1.

The moisture content in the control sample of fish paste was 61.62 ± 0.84%, which is 11% higher than that in the experimental ones. The amount of protein in the control sample was 13.05 ± 0.18%, which is less than in the experimental ones by an average of 1%, the number of mineral compounds ranged from 1.34 to a certain lesser amount in sample No. 3. The level of lipids was from 22.38 ± 0.17 to 34.13 ± 0.21 and in the experimental samples it was 10% higher than in the control, which ensured their high energy value (Fig. 2).

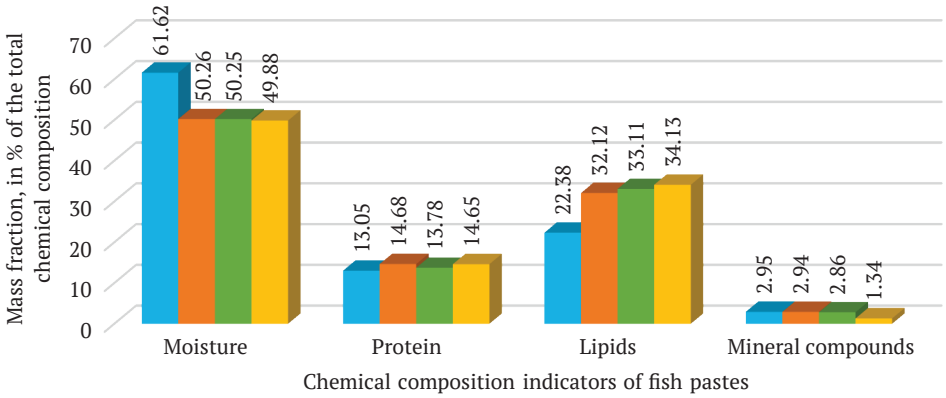

Figure 1. Comparative characteristics of the chemical composition of fish pastes of different formulations

Source: authors' development

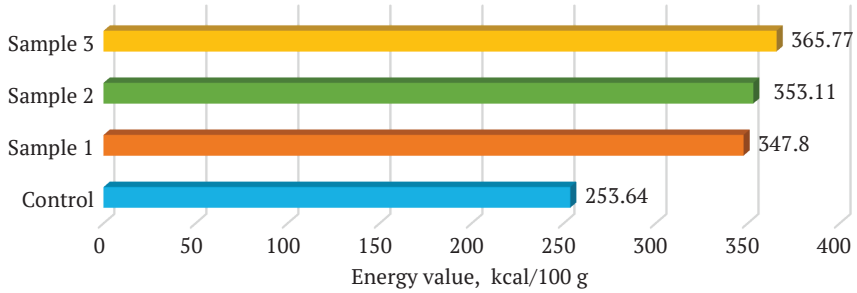

Figure 2. Estimation of the energy value of fish pastes of different formulations, kcal/100 g

Source: authors' development

Analysis of the results showed that sample No. 3 had the highest energy value, which is 365.77 kcal versus 253.64 kcal in the control and 353.11 kcal in sample No. 2 and 347.8 kcal in sample No. 1. To assess the palatability of fish pastes, the flavour spectrum profile method was used, which is one of the group of methods for describing sensory characteristics and is considered fundamental for many other descriptive methods. The concept of flavour is understood as the combined effect of taste properties, aromatic perception and tactile sensation in the oral cavity (DSTU ISO 6564:2005, 2006).

The flavour spectrum profile method is an attempt to characterise "flavour", taking into account all the descriptors that form the overall impression of the product. The use of this method allows for describing the overall impression of the product based on five main criteria: the nature of the descriptors, their intensity, the order in which these descriptors appear, aftertaste, and their completeness (a phenomenon expressed by the overall impression of the compatibility of the product's components). During the study, descriptors of the organoleptic profile were developed and the "ideal" organoleptic spectrum of the profile (standard) was determined. To build the "ideal" organoleptic spectrum of the profile, a consumer tasting was conducted to obtain data on the level of desirability of the intensity of the descriptors according to five samples of their intensity scale. The results of the profile analysis of the palatability of fish pastes are given in Table 4.

Table 4. *Profile analysis of palatability of fish pastes*

Descriptors	Intensity of characteristics of different fish paste formulations, points				
	Standard	Control	1	2	3
Aroma and taste characteristics					
harmonious	5.0	4.5	4.0	5.0	5.0
fishy	5.0	3.0	4.0	4.0	4.5
typical	4.0	3.0	4.0	4.0	4.0
sweet	1.5	1.0	1.0	1.0	1.0
salty	2.8	2.5	2.5	2.5	2.8
with the aroma and taste of added vegetables	3.0	3.0	3.0	3.0	3.0
Characteristics of the structure					
pasty	5.0	4.0	4.0	4.0	5.0
homogeneous	3.5	3.0	3.0	3.0	3.0
heterogeneous with inclusions	1.5	1.0	1.0	1.0	-
Consistency					
tender, juicy	3.5	2.5	2.0	3.5	3.5
dry	1.5	2.5	2.0	1.5	1.0
General impression	5.0	3.5	3.0	3.5	5.0
Total points	41.3	33.5	33.5	36.0	37.8

Source: authors' development

Harmonious aroma and taste with an intensity of 5.0 points is characteristic of the standard and samples No. 2 and No. 3. A lower number of points was received by Sample No. 1 and the control sample: 4.0 and 4.5, respectively. The descriptors "fish aroma and taste" were more pronounced in recipe No. 3 – 4.5 points compared to the standard sample of 5.0 points and other samples – 4.0 in samples No. 1, 2 and in the control – 3.0 points. According to the descriptor "typical", all fish paste samples, except for the control sample, received the same number of points – 4.0. The control sample – 3.0 points. "Sweet taste" was the same for all experimental samples and was 1.0 points compared to 1.5 in the standard. The descriptor "salty" was characterised by the same number of points in the standard and sample No. 3 – 2.8 points. The other samples received 2.5 points. The number of points in all samples of fish pastes according to the descriptor "with the aroma and taste of added vegetables" had the same rating – 3.0 points.

According to the descriptors of the structure, the best "pasty" was determined in the fish paste sample No. 3 – 5 points, as in the standard. Other samples received a score of 4.0 points. The homogeneous structure of fish pastes was determined in all samples, but not better than the standard and was 3.0 points. The descriptors "heterogeneous with inclusions" were determined in all samples, except No. 3. The descriptor "tender, juicy consistency" received the highest number of points in the fish paste samples No. 2 and No. 3, – 3.5 points, that is, on a par with the standard. The dry consistency was expressed to a greater extent in sample No. 3. The descriptor "general impression" was the same between the standard and sample No. 3 and was 5.0 points. According to the "total points", the highest number of 37.8 points was received by sample No. 3 with pink salmon milt compared to the standard – 41.30 and 33.5 and 36.0 in other experimental formulations. For a more visual perception of the research results, detailed organoleptic spectra of the flavour profile of each sample were constructed and compared with the "reference" profile of fish paste (Fig. 3-6).

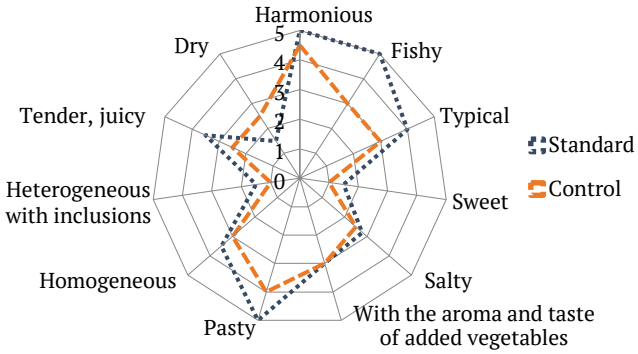

Figure 3. Profilogram of the flavour profile spectrum of the standard and control samples of fish pastes

Source: authors' development

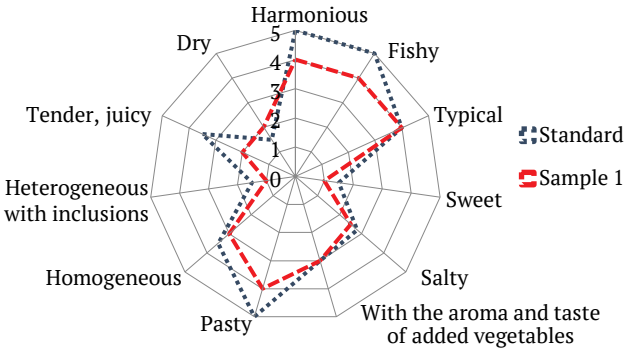

Figure 4. Profilogram of the flavour profile spectrum of the standard and sample fish paste according to recipe No. 1

Source: authors' development

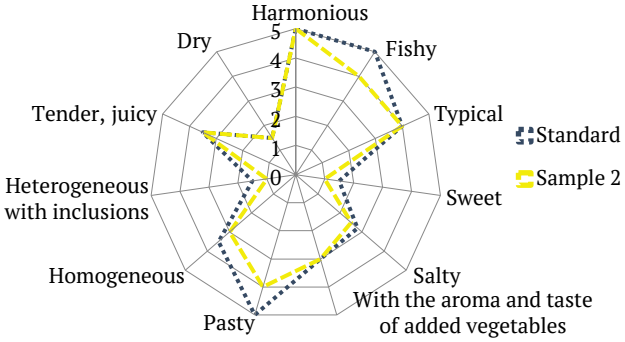

Figure 5. Profilogram of the flavour profile spectrum of the standard and sample fish paste according to recipe No. 2

Source: authors' development

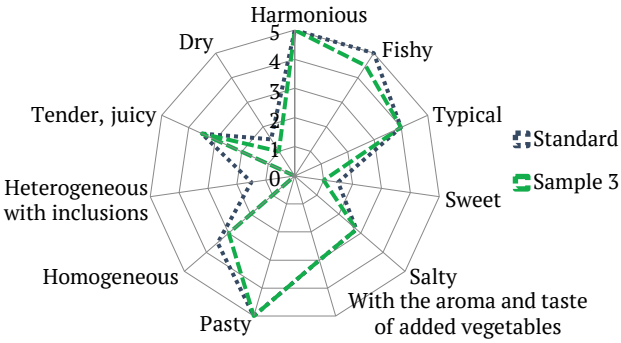

Figure 6. Profilogram of the flavour profile spectrum of the standard and sample fish paste according to recipe No. 3

Source: authors' development

According to the results of the analysis of the spectra of the flavour profile, the profile of fish paste made according to recipes No. 3 and No. 2 is most similar to the reference one. Thus, as a result of the conducted evaluation of ingredient compatibility in fish pastes using the flavor profile spectrum method, it was established that the formulation of the paste made from minced salted meat of two types of freshwater fish – Clarias catfish and trout – along with pink salmon milt and vegetables, enhances flavor and aromatic characteristics and improves the consistency of fish pastes. It was determined that salted pink salmon, carrots and onions are especially harmoniously combined with salted minced meat from fish meat.

Discussion

Fish products occupy an important place in human nutrition due to the content of essential amino acids, fatty acids, vitamins, micro- and macroelements. These nutritional factors in fish raw materials provide plastic and energy metabolism, can serve as a substance for medicines and have a preventive effect on many diseases (Bal-Prylypko *et al.*, 2024).

The authors improved the recipe composition of fish paste based on the meat of catfish, trout, onion, carrot, tomato paste, sunflower oil and spices. The organoleptic evaluation of the improved recipes of fish pastes based on the meat of catfish, trout, and pink salmon milt determined high quality indicators in terms of appearance, aroma, taste and consistency. These indicators are the best in the formulation with pink salmon milt, amounting to 24.1 ± 0.1 against 20.1 ± 0.4 points in the control and exceed other formulations based on catfish and trout meat (formulation No. 1 – 21.2 ± 0.5 and No. 2 – 21.9 ± 0.3). The developed recipe for fish pastes, according to organoleptic indicators, is consistent with the results of previous studies of fish pastes based on a combination of raw materials of freshwater and marine origin (Menchynska *et al.*, 2021). In these studies, the principle of combining raw materials was used not only in terms of the content of sources of biologically valuable protein and fatty acids of the ω-3 family but also in terms of the content of phospholipids. According to the data of A. Menchynska *et al.* (2021) the content of this fraction in capelin caviar lipids is up to 40%. The emulsifying properties of fish pastes are also provided by the introduction of sunflower oil, which, due to its high content of phospholipids, also exhibits emulsifying properties. According to the results of the current study, sunflower oil is present in the formulation from 12.2 to 12.7%, in contrast to 30% in the formulations of the above-mentioned authors. An additional

emulsifying effect in the current study is provided, according to the authors, by the properties of pink salmon milt. It can be assumed that these properties of fish paste formulation No. 3 are due to the taste properties of catfish meat and pink salmon milt.

According to the chemical composition, the protein level is higher in fish paste formulations with catfish, trout and pink salmon milt compared to those using only carp meat, as in the control. Thus, in the control formulation, the protein content is 13.05 ± 0.18, in the experimental formulations – from 13.78 ± 0.19 to 14.68 ± 0.16% of the total chemical composition. According to A. Menchynska *et al.* (2021), the protein content in fish pastes based on raw materials such as carp meat, silver carp meat and caviar, capelin caviar with vegetables and spices contains less protein – 12.68 ± 0.16 and 13.48 ± 0.19%. The highest amount of lipids was determined in the current study of the fish paste recipe with pink salmon milt – 34.13 ± 0.21%, in the study by A. Menchynska *et al.* (2021) based on fish caviar – 40.06±0.26%. These differences in chemical composition determine the difference in energy value. Thus, the highest energy value was obtained by a sample of fish paste with pink salmon milt – 365.77 kcal /100 g (Fig. 2) against the highest value of this indicator in pastes based on capelin and silver carp caviar – 411.26 kcal/100 g. The amount of lipids in carp, silver carp and capelin caviar is on average 3.91; 5.93; 13.88%. Pink salmon milt is characterised by a low lipid content – 2.10% (14, 15). Additionally, sunflower oil was used in the experimental paste formulations: based on catfish meat – 12.7%, based on fish caviar – 30%. Therefore, the lipid content in caviar-based fish pastes was higher. The protein-to-lipid ratio in the current study was 1:1.7 in the control, in samples No. 1, 2, 3 – 1:2.2, 1:2.40, and 1:2.33, respectively. These data are not consistent with the results of previous studies by the authors A. Menchynska *et al.* (2021) on fish pastes when using other raw materials, where this ratio in fish paste "Ikrynka" was 3.15; in "Zakusochna" – 2.72.

The analysis of the spectrum profile of fish pastes confirmed the data of the organoleptic evaluation and is consistent with the results of previous studies of fish pastes based on other raw materials – carp, silver carp and capelin caviar (Menchynska *et al.*, 2021). It has been determined that the formation of a "bouquet" of harmonious aroma and taste is influenced by the combination of fish, vegetable raw materials, sunflower oil, tomato paste, spices and, of course, the features of its preliminary preparation and the sequence of combination.

In the fish paste recipe developed by the authors, the organoleptic compatibility of the raw materials was determined. Theoretical studies have shown that sulfur-containing amino acids – methionine and cysteine – participate in the formation of a pasty, plastic and homogeneous consistency (Kunnath *et al.*, 2022). According to the results of research by A. Menchynska *et al*. (2021) fish raw materials, namely silver carp meat, contain a total amount of methionine with cystine of 3.35, carp caviar – 6.22, silver carp – 3.95, capelin – 5.24 g/100 g of protein, which ensures that the content of these acids in the recipe composition of experimental fish pastes is at a sufficiently high level – 7.98 and 3.82 g/100 g of protein. According to T. Lebska *et al*. (2021), the meat of the Clarias catfish is characterised by the presence of sulfur-containing amino acids at the level of 4.40 g/100 g of protein, which can contribute to the formation of the gel structure and provide a tender and juicy consistency of fish pastes. Thus, in the formation of a tender and creamy consistency of fish pastes, according to the authors of the current study, both a sufficiently high content of sulfur-containing amino acids and the presence of natural emulsifiers – phospholipids in the lipid composition of the raw material are involved.

Conclusions

Fish products occupy an important place in the structure of nutrition of the population of Ukraine, however, the level of its consumption does not correspond to the recommended levels for healthy nutrition. Therefore, the urgent task is to improve existing technologies for the production of fish products and expand the range. In this regard, the use of Ukraine's aquaculture resources, namely, catfish and trout, is of particular importance. In this aspect, an important place is occupied by multi-component food products, the creation of which is achieved by combining raw materials of different origins in order to provide humans with the necessary irreplaceable and replaceable nutritional factors. The technology of fish pastes allows creating such products based on the organoleptic compatibility of raw materials and their preliminary preparation (salting, grinding, heat treatment, etc.) and a specific sequence of mixing ingredients.

The authors conducted a study to improve the formulation of fish pastes based on the meat of the catfish, trout, pink salmon milt, vegetable raw materials and spices. The organoleptic assessment determined the compatibility of the raw materials. According to the nutritional value indicators, fish pastes are characterised by a high lipid content – 34.13 ± 0.21%, proteins – 14.68 ± 0.16% and energy value at the level of 364.77 kcal/100 g. Descriptors of the flavour spectrum were developed to characterise the aroma, taste, structure and consistency of fish pastes. Profile analysis based on the totality of structure and consistency indicators determined the highest quality of fish pastes based on the meat of the catfish and pink salmon milt compared with control samples and combinations of other raw materials. The influence of the content of sulfur-containing amino acids and phospholipids in raw materials on the formation of a tender and juicy consistency of fish pastes is discussed. Thus, the feasibility of expanding the range of food fish products based on Ukrainian aquaculture is proven. Further research will be aimed at determining the pre-treatment regimes of raw materials to ensure their safety and quality.

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Conflict of Interest

None.

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Анотація. Забезпечення населення України рибними продуктами набуває особливої актуальності, оскільки рівень їх споживання не відповідає рекомендаціям щодо оздоровчого харчування. Одним з напрямів, що здатен вирішити цю проблему, є розширення асортименту рибних паст, які за вартістю доступні широкому колу населення. Мета роботи полягала в удосконаленні рецептурного складу рибних паст на основі м'яса кларієвого сомика (*Clarias gariepinus* (Burchell, 1822)), форелі (*Salmo trutta fario*), молок горбуші (*Oncorhynchus gorbuscha*), рослинної сировини, а також в оцінці нових рецептур за комплексом органолептичних показників, профілю спектру флейвору, енергетичної цінності, фізико-хімічних методів досліджень: вміст вологи – методом висушування

зразка до постійної маси; вміст жиру – методом Сокслета; вміст білка – методом К'єльдаля; золи – спалюванням наважки. В результаті досліджень експериментально підтверджено доцільність поєднання у рецептурному складі рибних паст м'яса кларієвого сомика, молок горбуші та рослинної сировини. Розроблено три нових рецептури рибних паст на основі попередньо солених та подрібнених м'яса сомика, форелі і молок горбуші, пасерованої рослинної сировини (цибулі, моркви), олії соняшникової та спецій. Дослідження органолептичних показників та профілю спектру флейвору визначили найбільш високі показники консистенції у рибних паст з м'ясом сомика та молоками горбуші в порівняні з контролем та іншими рецептурами (9,5 ± 0,1 проти 8,5 ± 0,08 балів). За хімічним складом зразки рибних паст характеризувались високим вмістом вологи: 50,24 ± 0,17 в експериментальних рецептурах проти 61,62 ± 0,84 у контрольної, % відповідно. Вміст білку складав 14,65 ± 0,19 у пасті з молоками горбуші проти 13,05 ± 1,18 % у контрольної. Вміст ліпідів у нових рецептурах паст коливався від 32,12 ± 0,16 до 34,13 ± 0,21 проти 22,38 ± 0,17 %, що визначило високі показники їх енергетичної цінності: 347,11-365,77 проти 253,64 Ккал/100 г у контрольної. Результати досліджень показали доцільність поєднання у рецептурі рибних паст м'яса сомика з молоками горбуші та рослинною сировиною, що дозволить розширити асортимент якісної та корисної рибної продукції

Ключові слова: м'ясо сомика; молока горбуши; рослина сировина; органолептична оцінка; дескриптори; спектр флейвору; хімічний склад