

UDC: 639.38:597.551.2

BIOLOGICAL VALUE AND CONSUMER PROPERTIES OF FISH PASTES

DOI: <https://doi.org/10.15673/fst.v15i3.2121>

Article history

Received 14.03.2021

Reviewed 25.04.2020

Revised 25.06.2021

Approved 31.08.2021

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Cite as Vancouver style citation

Menchynska A, Manoli T, Tyshchenko L, Pylypchuk O, Ivanyuta A, Holembovska N, et al. Biological value and consumer properties of fish pastes. Food science and technology. 2021;15(3):52-62. DOI: <https://doi.org/10.15673/fst.v15i3.2121>

Цитування згідно ДСТУ 8302:2015

Biological value and consumer properties of fish pastes / Menchynska A., et al // Food science and technology. 2021. Vol. 15, Issue 3. P. 52-62 DOI: <https://doi.org/10.15673/fst.v15i3.2121>

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Introduction. Formulation of the problem

Today's diet of Ukrainian people lacks many indispensable nutritive factors. A promising direction in providing proper nutrition is the development of multicomponent products based on combining raw materials of plant and animal origin, with the adequate human needs taken into account in accordance with modern requirements of food science.

Ukraine's fisheries make a significant contribution to the country's food security. At present, Ukraine has 80.0% of its own raw materials represented by freshwater fish, namely aquaculture products. Food technology has to adapt to changes in the raw material base and in the species composition of fish raw materials, to the development of freshwater fish

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Abstract. The paper presents a study of the quality parameters of fish pastes and confirms their value as food products with optimised nutritional and biological characteristics. Sensory evaluation of fish pastes has shown that the samples developed have higher consumer properties compared with the control sample. The results of the profile analysis by the flavour method show that the paste *Ikrynka* is the closest to the ideal taste profile. The findings on the chemical composition characterise fish pastes as products with high nutritional value due to the significant content of proteins and lipids. The paste *Ikrynka* contains 12.68% of proteins, and the paste *Zakusochna* 13.43%, which is at the level of the control sample (13.05%). The mass fraction of lipids in the experimental samples exceeds the control: in the paste *Ikrynka*, the lipid content is 40.06%, in *Zakusochna*, it is 36.64%, and in the control sample, the proportion of lipids is 11.41%. The results of studying the amino acid composition of proteins show that in the test samples, all essential amino acids are present. They are well-balanced, which indicates their high biological value and makes the pastes easily assimilated by the human body. The study of the fatty acid composition of lipids present in the fish pastes shows that in the samples developed, polyunsaturated fatty acids predominate: their share in the paste *Zakusochna* is 44.23%, and in *Ikrynka*, 48.42%. By the ratios of the fatty acids $C_{18:2}:C_{18:1}$, $C_{18:2}:C_{18:3}$, and $\omega_6:\omega_3$, both samples of pastes are equivalent to ideal fat, which indicates high biological effectiveness of lipids in fish pastes. It has been found that the pastes *Ikrynka* and *Zakusochna* are high in vitamin E (1.83 mg/100 g and 1.64 mg/100 g respectively) due to a significant amount of vegetable oil in their composition. *Ikrynka* contains quite a lot of carotenoids (3.47 mg/100 g) due to the presence of carrots in its composition. The results of studying the mineral composition show that the samples of pastes developed are a source of zinc.

Keywords: fish paste, roe, silver carp, common carp, flavour method, chemical composition, fatty acids, vitamins.

farming. It becomes important to develop food products based on available domestic raw materials. Analysis of the market of fish raw materials and products in Ukraine shows a significant share of fresh and chilled freshwater fish, which is represented mainly by the common carp and the silver carp. In places where these raw materials are sold, a significant amount of cooled and frozen roe of these species of fish is accumulated. Roe contains highly digestible complete proteins, lipids, with unsaturated fatty acids and a lot of phospholipids dominating in their composition. Roe is also rich in vitamins, macro- and microelements [1]. Even so, freshwater fish roe looks unattractive, tastes and smells of ooze, that is why it is hardly popular with consumers. However, it is a valuable raw material for the development of food products with improved organoleptic characteristics,

increased nutritional and biological value. These products can be fish pastes based on a combination of fish and vegetable raw materials.

Analysis of recent research and publications

The technology of paste products allows developing products with a wide range of flavours and aromas, depending on the type of raw material, ingredients and flavourings added. They are a convenient structural and aggregate modification to create products of a required composition, balanced by the main ingredients, and enriched with bioactive substances. Fish paste products include pastes, pâtés, creams, mousses.

Fish pastes are made from herring, mackerel, salmon fish, rejected as mechanically damaged, as well as from small and low-value species of fish. Besides, the technology of pastes combines different types of fish raw materials. Raw materials used are mainly salted or blanched. The technology of making paste from salted herring and Atlantic salmon (RF No. 2537502) involves preparation of raw fish and auxiliary materials (butter, cheese, broccoli, bell peppers, carrots, and pokeberries), grinding, packaging. There are fish pastes with blanched Alaska pollock and mince from low-value and conditionally edible parts of Norwegian salmon with boiled carrots and fried onions added [2]. These technologies provide fish pastes rich with a diverse composition and bright taste.

Paste products made from comminuted flesh of fresh sea or ocean fish or from fish mince are common, too. Their technology involves grinding the meat of fresh fish to obtain a homogeneous mass, adding additional ingredients, homogenising the mixture, packing, and ordinary heat-treating or smoking. Finished products have high taste properties [3]. In Korea and Japan, pasty products made from washed mince surimi are especially popular. The quality and functionality of surimi pastes are usually improved by using various food additives from seafood, vegetables, fruit, and animal raw materials [4].

There are recipe of pastes that, besides fish meat, include milt and liver [5]. The food products obtained have high nutritional and biological value, a peculiar taste. The disadvantage of these products is the low mechanostuctural and antibacterial properties.

Roe is a valuable raw material for the manufacturing of paste products. Fish roe pastes and oils are made from capelin, herring, salmon, flounder, merluccius roe. A traditional Greek snack is cod roe paste, tarama. The technology of paste products allows using substandard roe, thus provides a comprehensive use of raw materials [6, 7]. The main disadvantage of the existing technologies of roe pastes is not using the valuable and available fish raw materials, freshwater fish roe and meat. In the study of the quality of fish roe-based pastes, considerable attention is paid to the sensory properties and oxidation of lipids. Development and improvement of the quality of paste products based on freshwater fish roe need theoretical and practical research.

A significant part of fish paste products is pâtés due to their nutritional properties and unique sensory characteristics. The key issues of the fish pâté technology, too, are the improvement of organoleptic and rheological parameters [8]. The studies in this area include the development of salmon pâté, where the sodium content is reduced by replacing table salt without loss of the quality and safety of finished products [9]. Many scientists focus on expanding the raw material base for the manufacture of paste products, on replacing traditional raw materials with others, including freshwater fish species [10,11].

Fish and roe oils, creams, mousses are also popular paste products. The peculiarity of these products is the combination of high nutritional value and a light, pleasant texture. That is why the selection of a fatty base (butter, oil, mayonnaise), available fish raw materials, and their ratio to ensure the appropriate rheological and sensory characteristics are the object of research by domestic and foreign scientists [12-14].

In the technology of paste products, there are trends that are still of current importance. They include the development of multicomponent products by combining different raw materials, in order to increase the nutritional and biological value. The value of paste products is increased by adding non-fish raw materials of aquatic origin, animal and vegetable raw materials, including fruit and vegetables, spicy-aromatic root crops, high-protein secondary products of plant processing [3,15-17]. There is a technology of fish pâté from pike and bream, which additionally contains pumpkin, vegetable oil, and algae [15]. Two recipes of pâtés from smoked tench meat were developed (one included olive oil, and the other contained mascarpone cheese), and their safety, nutritional and sensory properties were studied [16]. The positive effect of red ginseng powder on the sensory properties and lipid oxidation of fish pastes was established [17].

Analysis of paste products technologies showed that aromatic plants or their extracts were used as ingredients in their recipes. This improved not only the taste and aromatic characteristics of finished products, but also their quality and safety [18-20]. It was studied how oregano essential oil helped extend the shelf life of the roe paste *tarama* stored at 4°C [21].

In recent years, lactic acid microorganisms have been used in the technology of paste products. It has been proved that their use promotes the formation of harmonious smell and taste in minced products, and they also act as preservatives. There are technologies of fish pastes and pâtés, including those from freshwater fish, using different protective cultures for biopreservation [22-26]. The disadvantage of these technologies is the increased cost of manufacture of paste products.

An important task in developing paste-like emulsion products is ensuring a stable structure and appropriate consistency of the finished product. In order to improve the rheological properties of paste products, emulsifiers and thickeners are used, along with the appropriate technological processes and conditions of their preparation. Hydrocolloids from

plants and seafood (carob gum, pectin, maize phosphate starch, carboxymethyl starch, sodium alginate, agar-agar, carrageenan, chitin, chitosan) are used to regulate the consistency and improve the functional properties of paste products [27-29]. Gelatine extract and milk concentrate [30], carotenoid extract [31] can be used as additives.

Some researchers believe that stabilisation of minced products, including pastes, requires simultaneous use of emulsifiers or thickeners of different chemical nature. Technologies of low-fat emulsions and moulded fish products based on binary compositions have been developed: chitosan – soya protein isolate; homogenised laminaria – soya protein isolate; minced fish muscle tissue – starch. It was found that the simultaneous use of emulsifiers and thickeners of different chemical nature expanded the functional and technological properties of a binary structurant, increased the water-retaining, water-absorbing and fat-absorbing capacity of minced fish, the yield of finished moulded products, allowed obtaining stable emulsions with the fat content not more than 35% [27-29].

According to the patent (US No. 20070254066), the consistency of fish pastes can also be regulated by adding enzyme preparations of animal, microbial, and vegetable origin. They break down the biopolymer components of the raw materials and improve the mechanostructural, taste, and aromatic characteristics of the products.

It is known that the protein and lipid components of fish roe have emulsifying and structuring properties [32-34]. This encourages using roe in the technology of paste products without the additional introduction of structure regulators to ensure the appropriate consistency of the finished product.

Despite the wide global range of paste products and experience in their production, their manufacture in Ukraine is still a problem. Our country lacks

developments of fish pastes of high biological value based on a combination of fish and vegetable raw materials. Therefore, the development of multicomponent pastes based on freshwater fish roe with vegetable ingredients is a task of current importance. It will help to solve the problem of fuller use of domestic fish raw materials, providing Ukrainian people with high-quality fish products of increased biological value and efficiency, and expanding the range of fish products.

The **purpose** of the work is to determine the nutritional and biological value of multicomponent fish pastes based on roe, freshwater fish meat, sea fish roe, and vegetable raw materials. To achieve this purpose, the following research **objectives** were set:

- to study the organoleptic characteristics of the fish pastes and evaluate their taste by the method of flavour profile;
- to study the chemical, amino acid, fatty acid, vitamin, and mineral composition of the fish pastes.

Research materials and methods

The materials of the study were pastes based on roe, freshwater fish meat, sea fish roe, and vegetable raw materials. The following raw materials were used to make the pastes: live silver carp (*Hypophthalmichthys*) and common carp (*Cyprinus carpio*), according to DSTU 2284-2010, chilled and frozen raw roe of silver carp and common carp, refined sunflower oil (DSTU 4492:2005), fresh carrots (DSTU 7035:2009), fresh beetroots (DSTU 7033:2009), onions (DSTU 3234-95), table salt *Extra* (DSTU 3583-97), white granulated sugar (DSTU 4623:2006), apple vinegar (DSTU 2450:2006), and mustard (DSTU 1052:2005). The compositions of the pastes (Table 1) have been developed by mathematical modelling to form a food product providing 10% of the daily human requirement for essential nutrients.

Table 1 – Composition of the recipes of the pastes based on freshwater fish roe

Ingredients	Content of the ingredients required to make paste, %		
	Control	<i>Ikrynka</i>	<i>Zakusochna</i>
Minced fish	70.0	–	15.0
Common carp roe	–	40.0	–
Silver carp roe	–	–	40.0
Capelin roe	–	15.0	–
Fresh carrots	–	9.0	–
Beetroots	–	–	7.0
Onions	5.0	–	1.5
Sunflower oil	6.8	30.0	30.0
Salt	3.0	3.0	3.0
Sugar	0.5	1.0	1.5
Apple vinegar	–	1.0	2.0
Acetic acid 9%	0.2	–	–
Mustard	–	1.0	–
Tomato paste 30%	10.0	–	–
Spices	0.1	–	–
Water	4.4	–	–
Total	100.0	100.0	100.0

The control was the roe-free fish paste. Its recipe is given in Table 1. The technology of fish pastes includes the addition of pre-prepared raw materials (salted, heat-treated, and finely ground roe and fish meat, heat-treated and ground vegetable raw materials) and gradually emulsified oil.

The following reagents were used for the study: petroleum ether (excise, AR grade, *Khimlaborreaktiv* LLC, Ukraine), nitric acid (brand A, CP, *Khimlaborreaktiv* LLC, Ukraine), potassium dichromate (AR grade, *Khimlaborreaktiv* LLC, Ukraine), hydrochloric acid (brand A, AR grade, *Khimlaborreaktiv* LLC, Ukraine), sodium hydroxide (brand A, AR grade, *Khimlaborreaktiv* LLC, Ukraine), sodium tripolyphosphate (technical, p 85% *Khimlaborreaktiv* LLC, Ukraine), sulphuric acid (brand A, CP, *Khimlaborreaktiv* LLC, Ukraine), chloroform and methanol for chromatography (Merck, Germany).

The organoleptic parameters were determined by the profile method using a 5-point scale, the flavour analysis was carried out by the flavour method according to ISO 11036:1994. In order to study the taste of fish pastes, descriptors of the sensory profile were chosen, and the “ideal” sensory profile (standard) was determined. To create an “ideal” sensory profile, a consumer tasting was conducted to obtain data on the desirability of the descriptors by the five samples of the scale of their intensity. The sensory studies were performed by a group of trained tasters consisting of 20 people aged 18 to 30. The results of the studies have formed the flavour profile of the paste samples developed and of the control.

The chemical composition of the pastes was studied by the following methods: mass fraction of moisture by drying the product sample to a constant weight in an oven SNOL (Labimpex LTD, Ukraine) at 100–105°C (DSTU 8029:2015), mass fraction of ash by the weight method after the mineralisation of a portion of the product in a muffle furnace SNOL (Labimpex LTD, Ukraine) at 500–600°C (DSTU 8718:2017), mass fraction of lipids by the Soxhlet extraction–weight method (DSTU 8718:2017) with a SOX 406 Fat Analyser (Hanon Instruments, China), mass fraction of protein by the Kjeldahl method of determining total nitrogen, which is based on the ability of organic matter of a sample to be oxidised with concentrated sulphuric acid in the presence of a catalyst (DSTU 8030:2015); the samples were reduced to ash using a DK6 digester (Velp Scientifica, Italy) with a vacuum pump JP, and distillation was carried out using a steam distillation apparatus UDK 129 (Velp Scientifica, Italy).

The mass fraction of amino acids was determined by ion-exchange liquid-column chromatography with an automatic analyser T 339 (Microtechnics, Czech Republic), that of tryptophan by colourimetry preceded by alkaline hydrolysis [35]. The fatty acid composition of lipids was studied by the chromatographic method

(DSTU ISO 15304:2007) using a gas chromatograph HRGC 5300 (Carlo Erba Instruments, Italy). Lipid extraction was performed by the methods of Folch and of Bligh and Dyer [36].

The vitamin composition of the pastes was studied by the following methods: mass fraction of retinol by the anhydride method (DSTU 4940:2008), that of carotenoids by spectrophotometry (DSTU ISO 6558-2:2004) on a spectrophotometer SF-26 (Russia), mass fraction of tocopherol by thin layer chromatography (DSTU EN 12822:2005), mass fraction of thiamine (B_1) by oxidation of thiamine to thiochrome, extraction of the latter into an organic solvent and measurement of the fluorescence intensity at 273 nm (DSTU 7988:2015) on a spectrofluorometer LS-50 (Perkin Elmer, USA). The mass fraction of riboflavin (B_2) was measured using riboflavin-binding apoprotein from chicken egg white (DSTU 7988:2015), mass fraction of niacin (PP) by the photometric method using acid hydrolysis (DSTU 2117-93) on a spectrophotometer SF-26 (Russia).

The mineral composition was determined by atomic emission spectrometry with inductive plasma (DSTU ISO 11885:2005) on the IRIS Interpid II XSP (Thermo Elemental) (USA).

Results of the research and their discussion

The sensory characteristics of food products are an important criterion for assessing consumer perception of finished products. They depend on the type of raw materials used in their manufacturing and on the cooking technology.

According to organoleptic evaluation, the pastes *Ikrynka* and *Zakusochna* received a higher overall score compared to the control sample (22.1, 21.7, and 19.5 respectively) due to their improved appearance, colour, consistency, taste, and aroma. The colour of the pastes was uniform and was determined by the addition of vegetable components. The samples had a pleasant, moderately intense smell and taste, characteristic of this product, depending on the components added. Fish taste and smell were barely noticeable in the experimental samples, compared with the control. The consistency of the test samples was pasty, homogeneous. The taste of the paste products can be described as harmonious, pleasant, characteristic of a product of this type, depending on the components added, without off-flavours. To characterise the taste of the fish pastes, a profile analysis has been performed by the flavour method based on selected descriptors. In order to visualise better the results for each of the samples, detailed organoleptic profiles of the flavour were developed, and a comparison with the “ideal” profile was performed (Fig. 1–2).

The results of the profile analysis show that the sensory profile of the paste *Ikrynka* is the closest to the “ideal” profile and confirm the sensory assessment.

One of the main parameters of food quality is the nutritional value, which is characterised primarily

by the chemical composition of a product. The chemical composition and calorific value of the fish pastes are given in Table 2.

Analysis of the research results shows that the chemical compositions of the experimental formulations differ significantly from that of the control sample: they have high calorific value due to the decreased moisture level and increased fat content. *Ikrynka* contains 12.68% of proteins, and *Zakusochna* 13.43%, which is at the level of the control sample (13.05%). The mass fraction of lipids in the experimental samples exceeds that in the control: the lipid content of *Ikrynka* is 40.06%, of *Zakusochna* 36.64%, and in the control sample, the proportion of lipids is 11.41%. The calorific value reflects the amount of energy the body receives from proteins and fats in the product. *Ikrynka* is characterised by a higher calorific value (411.26 kCal/100 g), compared with *Zakusochna* (383.48 kCal/100 g) and with the control sample (154.89 kCal/100 g), due to its higher lipid content.

An important parameter that characterises the biological value of protein is the amino acid score,

which shows the equivalence of its amino acid composition to the ideal protein (Table 3).

The data in Table 3 indicate the presence of limiting amino acids in the proteins of the fish pastes under study. Tryptophan limits in all the samples, *Ikrynka* is inferior to the ideal protein in the isoleucine content, *Zakusochna* is inferior in the valine content, and in the control sample, these amino acids are both below the recommended norm. According to the research results, the amino acid composition of proteins of the experimental paste samples is more equivalent to the ideal protein, compared with the control. The increased content of amino acids in the experimental samples, as compared with the control, is due to the peculiarities of the chemical composition of the raw materials, namely, roe of carp and capelin [1].

To assess the nutritional adequacy of the protein components of the pastes as for the potential degree of their digestibility, the biological value parameters and criteria have been calculated. They are presented in Table 4.

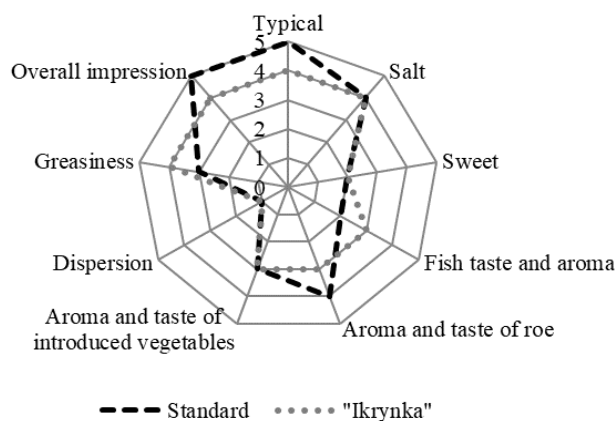


Fig. 1. Profilogram of the flavour and texture of the paste *Ikrynka*

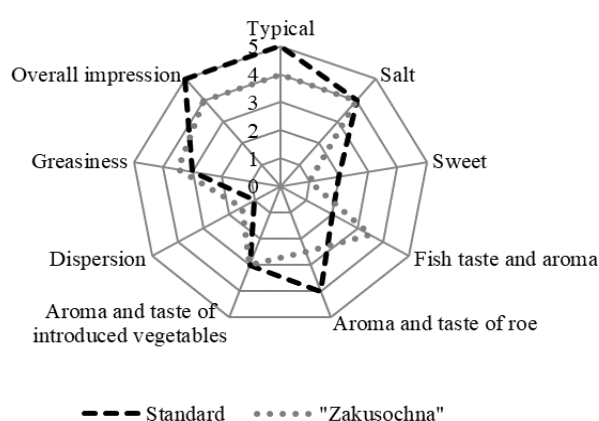


Fig. 2. Profilogram of the flavour and texture of the paste *Zakusochna*

Table 2 – Chemical composition of the fish pastes (n=5, p<0.05)

Paste	Content, g/100 g				Calorific value, kCal/100 g
	moisture	protein	lipids	mineral substances	
Control	72.49±0.84	13.05±0.18	11.41±0.20	3.05±0.09	154.89
<i>Ikrynka</i>	44.32±0.19	12.68±0.16	40.06±0.26	2.94±0.10	411.26
<i>Zakusochna</i>	46.86±0.15	13.43±0.19	36.64±0.21	3.07±0.09	383.48

Table 3 – Amino acid score of the fish pastes

Amino acid	Amino acid score of the fish pastes, %		
	Control	<i>Ikrynka</i>	<i>Zakusochna</i>
Valine	81	109	96
Isoleucine	84	91	100
Leucine	120	143	156
Lysine	107	120	119
Methionine + cystine	114	228	109
Threonine	104	108	124
Tryptophan	84	99	97
Phenylalanine + tyrosine	131.5	120	100

Table 4 – Biological value parameters of proteins of the pastes

Parameter	Biological value of proteins of the pastes			Recommended values [37]
	Control	<i>Ikrynka</i>	<i>Zakusochna</i>	
Potential biological value, %	68.27	72	85	100
Coefficient of differences of the amino acid composition, %	31.73	28	15	0
Coefficient of utilisation of the amino acid composition	0.7	0.7	0.8	$U \rightarrow 1.0$
Coefficient of comparable excess, g/100 g of protein	0.16	0.15	0.08	$\sigma_c \rightarrow 0$

The results of the calculation of the biological value parameters show a high level of amino acid balance, high utilisability and good absorption of fish paste proteins by the human body. The potential biological value of the pastes is characterised by high values, 72% and 85% respectively, which indicate a high level of amino acid balance. According to the coefficient of amino acid differences, proteins of *Zakusochna* will potentially be utilised to a greater extent. They have a smaller value of this parameter, compared with proteins of *Ikrynka* and the control (15% v 28% and 31.73% respectively). The utilisation coefficient of the amino acid composition of the

control and the experimental samples is 0.7 and 0.8, which indicates that amino acids of these products are highly utilisable by the body. The low comparable excess values of the control and the experimental samples (0.16 g/100 g, 0.15 g/100 g, and 0.08 g/100 g of protein) show that proteins are well absorbed by the body.

The functional features and biological effectiveness of food lipids are determined by their fatty acid composition. Table 5 shows how the content of fatty acids of lipids in the pastes complies with the recommended norms of their consumption.

Table 5 – Compliance of the fatty acid composition of lipids in the pastes with the recommended norms of their consumption (n=3, p<0.05)

Fatty acids	Mass fraction of fatty acids, % of the amount of fatty acids			Recommended amount, g/day [38]
	Control	<i>Ikrynka</i>	<i>Zakusochna</i>	
1	2	3	4	5
Saturated, including	37.33	18.64	22.95	25
Myristic (C _{14:0})	7.08	2.51	0.30	–
Pentadecanoic (C _{15:0})	1.63	0.12	0.11	–
Palmitic (C _{16:0})	12.94	10.41	13.38	–
Heptadecanoic (C _{17:0})	1.99	0.27	0.29	–
Stearic (C _{18:0})	11.05	3.62	6.68	–
Isostearic (C _{18:0 iso})	0.54	0.03	0.04	–
Arachinic (C _{20:0})	0.50	0.33	0.35	–
Genicosanoic (C _{21:0})	0.54	0.18	0.20	–
Behenic (C _{22:0})	0.79	1.17	1.19	–
Lignoceric (C _{24:0})	0.27	–	0.41	–
Monounsaturated, including	39.01	32.94	32.79	30
Myristoleic (C _{14:1})	0.53	0.04	0.02	–
Pentadecenoic (C _{15:1})	0.03	0.02	0.03	–
Palmitoleic (C _{16:1})	1.04	0.90	1.20	–
Heptadecenoic (C _{17:1})	1.79	0.13	0.14	–
Oleic (C _{18:1})	35.62	30.17	30.84	–
Gondic (C _{20:1})	–	1.68	0.43	–
Nervonic (C _{24:1})	–	–	0.13	–
Polyunsaturated, including	17.66	48.42	44.23	11
Hexadecadienoic (C _{16:2}) □ ₆	0.45	0.09	0.08	–
Linoleic (C _{18:2}) □ ₆	12.84	39.10	38.20	–
Linolenic (C _{18:3}) □ ₃	1.11	2.87	3.54	–
Eicosatrienic (C _{20:2})	–	0.05	0.06	–
Arachidonic (C _{20:4}) □ ₆	2.88	1.60	0.65	–
Eicosapentaenoic (C _{20:5}) □ ₃	–	1.15	0.60	–
Docosatrienic (C _{22:3})	0.05	0.05	0.03	–
Docosapentaenoic (C _{22:5}) □ ₃	0.19	0.03	0.07	–
Docosahexaenoic (C _{22:6}) □ ₃	0.14	3.51	1.00	–
Not identified	–	–	0.03	–

Analysis of the fatty acid composition has shown that in the paste products developed by us, the predominant fatty acids are polyunsaturated fatty acids, or PUFA (44.23% of them in *Zakusochna* and 48.42% in *Ikrynka*), and ω_3 fatty acids, which indicates high biological effectiveness. In the control sample, monounsaturated fatty acids (MUFA) predominate. In all samples, the main fraction of PUFA is essential linoleic acid. Its content in the experimental pastes is almost at the same level, which is three times as high as it is in the control sample. A significant proportion of PUFA is biologically effective linolenic and docosahexaenoic fatty acids. The experimental samples of pastes, unlike the control one, contain valuable eicosapentaenoic acid. The content of arachidonic acid in the control sample is by 1.8 times higher than in *Ikrynka* and by 4.4 times higher than in *Zakusochna*.

The main representative of MUFA is oleic acid. Its content in both samples of pastes is about 30%, and in the control sample, 35.62%. Among the saturated fatty acids, palmitic acid predominates, and stearic fatty acid makes up a significant proportion.

For the absorption of lipids, important parameters are not only the content of certain groups of fatty acids, but also their ratios, which characterise the biological effectiveness of lipids (Table 6).

The ratios of SFA:MUFA:PUFA in the experimental samples and in the control do not meet the requirements for ideal fat. In both samples of the pastes developed, the PUFA content exceeds the recommended ratios according to the daily needs [39]. By the ratios of fatty acids $C_{18:2}:C_{18:1}$ and $C_{18:2}:C_{18:3}$, both samples of pastes are equivalent to ideal fat. The ratio of fatty acids $\omega_6:\omega_3$ for the paste *Zakusochna* is

7.5:1, for the paste *Ikrynka*, it is 5.4:1, and for the control sample, 11:1, with the recommended value 4:1–10:1. This indicates the high biological effectiveness of lipids in fish pastes. Thus, pastes based on freshwater fish roe and meat are a source of PUFA and of ω_6 and ω_3 fatty acids for the human body and are products with functional ingredients for the correction of lipid metabolism.

Indispensable nutrients in the human diet are vitamins. The human body synthesises almost none of them, so they should be regularly supplied in quantities that meet the body's daily physiological needs. The vitamin compositions of the pastes based on fish roe are given in Table 7.

The pastes *Ikrynka* and *Zakusochna* are high in vitamin E, slightly higher than the adequate consumption level (by 1.2 and 1.1 times respectively), due to the significant amount of sunflower oil in their recipe. The content of vitamin PP in the control and in the paste *Zakusochna* is perfectly equivalent to the recommended level, and the consumption of *Ikrynka* satisfies the need for niacin by 81%. *Ikrynka* contains a significant amount of carotenoids (3.47 mg/100 g) due to the presence of carrots in its composition. Therefore, when consuming the paste *Ikrynka*, 10% of a person's daily need for carotenoids is met by 231%.

One of the important criteria for the nutritional value of fish roe-based pastes is the study of the content of the main macro- and microelements in their composition. According to the content of mineral elements, it has been calculated how well the pastes satisfy the daily need for macro- and microelements (per 100 g of product) (Table 8).

Table 6 – Parameters of biological effectiveness of lipids in the pastes

Lipids	Ratio				
	SFA:MUFA:PUFA	PUFA:SFA	$C_{18:2}:C_{18:1}$	$C_{18:2}:C_{18:3}$	$\omega_6:\omega_3$
Ideal fat [39]	1:1:1	0.2–0.4	>0.25	>7.0	10:1–4:1
Control	1:1.04:0.47	0.47	0.36	11.57	11:1
<i>Zakusochna</i>	1:1.42:1.92	1.93	1.24	10.79	7.5:1
<i>Ikrynka</i>	1:1.7:2.6	2.6	1.29	13.62	5.4:1

Table 7 – Vitamin compositions of pastes based on fish roe (n=3, p<0.05)

Vitamins	Adequate consumption level, mg; 10% of daily needs [38]	Vitamin content, mg/100 g of product		
		Control	<i>Ikrynka</i>	<i>Zakusochna</i>
Thiamine (B ₁)	0.17	0.09	0.06	0.09
Riboflavin (B ₂)	0.20	0.07	0.05	0.06
Niacin (PP)	2.00	2.00	1.62	2.01
Vitamin E	1.50	0.77	1.83	1.64
Vitamin A	0.10	0.03	0.03	0.01
Carotenoids	1.50	0.01	3.47	0.02

Table 8 – Degree of satisfying the daily need for macro- and microelements by the pastes (n=3, p<0.05)

Mineral elements	Adequate consumption level, mg; 10% of daily needs [38]	Content, mg/100 g of product		
		Control	<i>Ikrynka</i>	<i>Zakusochna</i>
Calcium	125	21.160±0.480	11.528±0.370	17.120±0.410
Potassium	250	36.584±0.542	87.000±0.810	38.422±0.630
Iron	1.5 – women; 1.0 – men	0.245±0.005	0.542±0.005	0.544±0.005
Zinc	1.2	1.604±0.005	1.246±0.006	1.802±0.007

According to the data in Table 8, consuming 100 g of *Ikrynka* satisfies the 10% adequate level of daily need for zinc by 104%, and consuming *Zakusochna* by 150%, which is within acceptable levels. Zinc protects cell membranes from oxidation, ensures calcium transport through them and normal functioning of the endocrine system, which confirms the value of the pastes. The presence of roe in the experimental samples increases their degree of supplying the body with iron, as compared with the control. Consumption of the pastes *Ikrynka* and *Zakusochna* satisfies the need for iron by 36% for women and by 54% for men.

Conclusion

Based on the analysis of the experimental findings, it has been established that fish pastes based on common carp and silver carp roe, silver carp meat, capelin roe, and vegetable raw materials are characterised by increased nutritional and biological value.

According to sensory evaluation, the pastes *Ikrynka* and *Zakusochna* received a higher overall score compared with the control sample (22.1, 21.7, and 19.5 respectively) due to their improved appearance, colour, consistency, taste, and aroma. Profilograms of the flavour and texture of the fish pastes confirm the sensory evaluation.

The high nutritional value of the fish pastes is due to the high content of proteins and lipids.

The results of studying the amino acid composition of the samples indicate the presence of all essential amino acids, confirm the high biological value of proteins of the pastes developed, their great utilisability, and good assimilation of fish paste proteins by the human body.

Study of the fatty acid composition of lipids of the fish pastes shows that in the samples developed, polyunsaturated fatty acids are predominant. A significant proportion of them is made up by biologically effective linolenic and docosahexaenoic fatty acids. The ratios of fatty acids $C_{18:2}:C_{18:1}$, $C_{18:2}:C_{18:3}$, and $\omega_6:\omega_3$ are equivalent to ideal fat, which indicates the high biological effectiveness of lipids in the fish pastes.

The vitamin composition of the pastes developed is characterised by the increased content of vitamin E and carotenoids in comparison with the control. The results of studying the mineral composition show that the samples of pastes developed are a source of such macro- and microelements as zinc, calcium, potassium, and iron.

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БІОЛОГІЧНА ЦІННІСТЬ ТА СПОЖИВНІ ВЛАСТИВОСТІ РИБНИХ ПАСТ

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Анотація. Роботу присвячено дослідженню показників якості рибних паст, що підтверджує їхню цінність, як оптимізованих за показниками харчової та біологічної цінності продуктів харчування. У результаті органолептичної оцінки рибних паст встановлено, що розроблені зразки характеризуються більш високими споживними властивостями порівняно з контролем. Результати профільного аналізу за методом флейвора свідчать, що паста «Ікринка» найбільшою мірою відповідає ідеальному профілю смаковитості. Результати дослідження хімічного складу, характеризують рибні пасти як продукти з високою харчовою цінністю за рахунок значного вмісту білків та ліпідів.

Паста «Ікринка» містить 12,68% білків, паста «Закусочна» – 13,43%, що знаходиться на рівні контрольного зразку (13,05%). Масова частка ліпідів в дослідних зразках перевищує контрольний, так у пасті «Ікринка» вміст ліпідів складає 40,06%, у пасті «Закусочна» – 36,64%, а в контрольному зразку на частку ліпідів припадає 11,41%. Результати дослідження амінокислотного складу білків показують присутність у дослідних зразках усіх незамінних амінокислот, їх збалансованість, що свідчать про високу біологічну цінність та добре засвоєння рибних паст організмом людини. Дослідження жирнокислотного складу ліпідів рибних паст показує, що у розроблених зразках переважають поліненасичені жирні кислоти, частка яких у пасті «Закусочна» становить 44,23%, у пасті «Ікринка» – 48,42%. За показниками співвідношення жирних кислот C18:2:C18:1 і C18:2:C18:3 та жирних кислот родин ω6:ω3 обидва зразки паст відповідають ідеальному жиру, що свідчить про високу біологічну ефективність ліпідів рибних паст. Встановлено, що паста «Ікринка» та паста «Закусочна» характеризуються високим вмістом вітаміну Е (1,83 мг/100г та 1,64 мг/100г, відповідно) через використання значної кількості у рецептурному складі рослинної олії. Паста «Ікринка» містить значну кількість каротиноїдів (3,47 мг/100г) завдяки присутності у її складі моркви. Результати дослідження мінерального складу свідчать, що розроблені зразки паст виступають джерелом цинку.

Ключові слова: рибна паста, ікра, товстолобик, короп, метод флейвору, хімічний склад, жирні кислоти, вітаміни.

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