OPEN ACCESS
Potravinarstvo Slovak Journal of Food Sciences
Crossref Similarity Check

potravinárstvo®
Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 15, 2021, p. 296-305
https://doi.org/10.5219/1581
Received: 18 February 2021. Accepted: 5 April 2021.
Available online: 28 April 2021 at www.potravinarstvo.com

ISSN 1337-0960 (online)

USE OF AROMATIC ROOT VEGETABLES IN THE TECHNOLOGY OF FRESHWATER FISH PRESERVES

Nataliia Holembovska, Liudmyla Tyshchenko, Natalia Slobodyanyuk, Valentyna Israelian, Yuliya Kryzhova, Anastasia Ivaniuta, Oksana Pylypchuk, Alina Menchynska, Oksana Shtonda, Dmytro Nosevych

ABSTRACT

The expediency of using freshwater fish and aromatic root vegetables in the technology of preserves has been substantiated. Based on the organoleptic analysis, the compatibility of freshwater fish and aromatic vegetables as part of preserves has been determined. The conditions for pretreatment of salted semi-finished products to ensure their maturation as part of preserves have been theoretically substantiated and experimentally determined. It has been found that pretreatment of freshwater fish flesh with 1.0% and 1.5% malic acid for 60 minutes provides soft, tender and juicy consistency, which corresponds to an organoleptic rating of 5 points. Changes in the fatty acid composition of preserves are mainly associated with an increase in the amount of polyunsaturated fatty acids that have been introduced with linseed oil, which is a positive factor. It has been found that, in comparison with the control sample, the level of all mineral elements in preserves with aromatic root vegetables is significantly increased, with fiber present, which indicates the expediency of introducing aromatic root vegetables into this product to enrich it with essential mineral and carbohydrate elements to obtain a high-value and healthy food product. Enriching the formulation of preserves made of freshwater fish with a variety of herbal additives increases their nutritional value and allows to get a product of high value enriched with such vital nutrients as carbohydrates, calcium, potassium, phosphorus, sulfur, sodium, magnesium, manganese, and iron. Aromatic root vegetables such as horseradish, parsley, and ginger have been found to exhibit antiseptic properties and delay the activity of microbial enzymes as they content phenol. Therefore, the use of aromatic root vegetables helps to inhibit the oxidation and hydrolysis of fats, which may be due to the presence of phenols in their composition.

Keywords: preserves; linseed oil; aromatic root vegetables; hydrobionts; polyunsaturated fatty acid

INTRODUCTION

Providing the population with high-quality food products of increased nutritional and biological value is an urgent issue of today, due to a violation of the nutritional status, and a lack of several essential nutritional factors. In this regard, the concept of creating new food products, chemically balanced, enriched with functional components, and ensuring their immutability, health safety after technological processing, as well as during storage, is becoming increasingly important **(Sukhenko et al., 2017)**.

The current state of nutrition of the Ukrainian population requires the development and implementation of production technologies based on natural raw supplies and expected composition, for now, it is represented by products that do not meet the human needs for the key nutrition factors. In Ukraine, there is an increase in the volume of cultivation and fishing in freshwater facilities, the product range of which is limited to live and chilled fish. Organoleptic parameters of freshwater fish and their nutritional value require streamlining of technologies for its processing by combining it with vegetable raw products **(Golembovskaya and Lebskaya, 2015)**.

Carp are the fish that are mostly grown in the water farms of Ukraine. This type of fish contains a lot of protein with all essential amino acids, biologically effective fatty acids, but the flesh of this fish has a low percent, or no dietary fiber, and lacks several trace elements essential in nutrition following the requirements of modern nutritionology concepts. Besides, freshwater fish have a low taste property, which indicates the feasibility of their improvement **(Mushtruk et al., 2020a)**. There are aromatic root vegetables, grown in Ukraine, which are only partially used in the technology of fish products. Previous studies have found that the use of vegetable raw products in the technologies of freshwater hydrobionts, including aromatic root vegetables, facilitates the harmonization of organoleptic indicators, and obtaining food products with functional ingredients.

However, systemic studies in the activation of the maturation processes of freshwater fish in the composition of preserves have not been conducted. Thus, the development of the technology of preserves made of freshwater fish and aromatic root vegetables is an urgent issue, the solution of which will facilitate the production of high-quality and healthy biologically valuable fish products from the Ukrainian raw products and expand the range of products including freshwater fish.

The analysis of current trends in fish production technologies allows to identify the following key directions that are related to the technologies of multicomponent food products, improvement of technologies of preserves made of low maturity hydrobionts, the enrichment of the recipe composition, pretreatment of raw products in various ways, the application of physico-chemical and biotechnological techniques for the production of conventional foods made of fish such as canned food, preserves, pâté, salted, dried, culinary products and washed minced products for *surimi* production **(Shanina et al., 2020)**.

The record shows that the use of enzymatic agents during fish salting makes it possible to obtain good quality products from immature fish species. It is possible to use expensive enzymatic agents in the production of fish preserves, made of plant and microbial raw supplies, for example, culture liquid *H. Mediteranei* to soften pollock flesh or the proteolytic enzyme preparation *Sal Intersor EC* for the production of fish fillet preserves.

These scientists' works highlight the fact that some marine hydrobionts contain highly active complexes of proteolytic enzymes that can be widely used. The muscle tissue of freshwater fish has a low level of activity of its proteinases, which does not allow achieving the desired degree of maturation without additional application of proteolytic enzyme preparations that intensify this process **(Shanina et al., 2019)**.

S. L. Chernyavskaya has developed the technology of a proteolytic enzyme preparation from zebra mussel, proving the effectiveness of using Protofermol proteolytic enzyme preparation from a zebra mussel, bivalve mollusk, without preliminary separation of the flaps to intensify the maturation process of preserves made of Baltic herring pieces **(Chernyavskaya et al., 2019)**.

Bùi Xuân Đông has developed a new range of preserves made of fillets of pond fish species, whose enzyme system of muscle tissue was activated by injecting an enzyme preparation derived from their internal organs **(Bùi, 2011)**.

Similar studies were conducted by T. J. Park and co-authors **(Park et al., 2020)**, which highlighted the production of proteolytic enzyme preparations from the entrails of pond fish such as carp, silver carp, grass carp, and pike. O. P. Dvorianynova, in collaboration with other scientists, obtained an enzyme complex from the muscle tissue of pond carp, and determined the proteolytic activity of the obtained enzymes **(Dvoryaninova et al., 2010)**. Other authors theoretically substantiated and experimentally confirmed the expediency and effectiveness of using new methods for intensifying and regulating the maturation of preserves made of poorly maturing fish species by introducing white cabbage as a source of plant proteases, and the enzyme preparation *Sal Intensor EC* of proteolytic action into the formulation.

T. A. Davletshyna substantiated the mechanism of the antimicrobial drug action on microorganisms, their proteolytic and lipolytic enzymes, which reduce bacterial contamination of semi-finished products and finished fish products **(Davletshina et al., 2019)**.

Technologies for the production of non-fish preserves, namely squid and whelk ones, which are low-maturing raw products for the production of preserves, were of considerable interest, too **(Saltanova and Malinovskaya, 2012)**. The technology of making preserves using these shellfish involves the pretreatment of raw products by blanching, or the use of gamma radiation to soften the flesh.

The effectiveness of processing fish preserves with orange juice, which helps them mature, has been highlighted. The use of orange juice as a dietary supplement provides the product with functional properties, as it enriches the preserves with biologically active substances, C, PP, B vitamins, beta-carotene, as well as potassium, calcium, iron, and selenium.

The considered fish raw products' technologies speak for the prospects for improving the preserves technologies, as products that preserve the natural properties of raw products to a greater extent due to the absence of heat processing.

Thus, the change in the structure of fishing, the general trend of reducing the catch of conventional marine fish species, an increase in the number of freshwater fish as aquaculture objects makes it necessary to improve complex technologies for processing raw products and expand the range of freshwater fish food products. One of the promising ways to address these issues is to develop the technology of freshwater fish preserves enriched with vegetable ingredients, based on the principles of food combinatorics. The use of aromatic root vegetables is one of the priority areas of research in the future.

Scientific hypothesis

The concept of creating new food products that are balanced in chemical composition and enriched with functional components and ensuring their health safety after technological processing, as well as during storage, is becoming increasingly important. Based on the generalization of the theoretical content, the expediency of aromatic root vegetables in the technology of freshwater fish preserves has been substantiated, which facilitates the maturation of salty semi-finished products and allows to obtain a food product with high organoleptic properties and increased biological value.

MATERIAL AND METHODOLOGY

Samples

Study of preserves of control and experimental samples (preserves with ginger, horseradish, and parsley) was carried out using the following raw products: live fish of spring and autumn catch (carp) according to **DSTU 2284 (2010)**, grown in reservoirs of Cherkasyrybhosp PJSC; table salt according to **DSTU 3583 (2015)**; ground allspice according to **GOST ISO 973 (2016)**; ground black pepper according to **DSTU ISO 959-1 (2008)**; cloves according to **DSTU ISO 2254 (2008)**; sunflower oil according **to DSTU 4492 (2017)**; bay leaves according to **GOST 17594 (1981)**; parsley root (*Petroselinum crispum*) according to **DSTU 6010 (2008)**; ginger root (*Zingiber officinale*) according to **DSTU ISO 1003 (2018)**; horseradish root

(*Armoracia rusticana*) according to **DSTU 294 (1991)** from farmlands of Cherkasy and Kyiv regions; table vinegar according to **DSTU 2450 (2006)**; linseed oil according to **TU U 15.4-14235416-001 (2010)**.

Chemicals

Petroleum ether (excise, AR grade, Khimlaborreaktyv LLC, Ukraine).

Nitric acid (A brand, CP, Khimlaborreaktyv LLC, Ukraine).

Potassium dichromate (AR grade, Khimlaborreaktyv LLC, Ukraine).

Hydrochloric acid (A brand, AR grade, Khimlaborreaktyv LLC, Ukraine).

Sodium hydroxide (A brand, AR grade, Khimlaborreaktyv LLC, Ukraine).

Sodium tripolyphosphate (technical, p 85%, Khimlaborreaktyv LLC, Ukraine).

Sulfuric acid (A brand, CP, Khimlaborreaktyv LLC, Ukraine).

Instruments

Drying cabinet **(**SNOL, Khimlaborreaktyv LLC, Ukraine).

Muffle furnace (SNOL, Khimlaborreaktyv LLC, Ukraine).

Fat analyzer (SOX 406, Khimlaborreaktyv LLC, China).

Mineralizer (Velp Scientifica, Khimlaborreaktyv LLC, Italy).

Distiller for steam distillation (Velp Scientifica UDK 129, Khimlaborreaktyv LLC, Italy).

Fiber extractor (FIWE Raw Fiber Extractor, Khimlaborreaktyv LLC, Italy).

Atomic absorption spectrophotometer (Shimadzu AA-6200, SPEKTROLAB LLC, Ukraine).

Gas chromatograph (Kupol_55, Shimadzu Corporation, Japan).

Amino acid analyzer (LC-2000, Biotronik, Khimlaborreaktyv LLC, Ukraine).

Laboratory Methods

Characterizing of the chemical composition of fish preserves has been carried out according to the following methods: the mass fraction of moisture by drying the product sample down to a fixed weight at a temperature of 100 – 105 °C according to **DSTU 8029 (2015)**; the mass fraction of ash by weight method, after mineralization of the product's sample weight in a muffle furnace at a temperature of 500 – 600 °C according to **DSTU 8718 (2017)**; the mass fraction of lipids by Soxhlet method, which consists in the fact that fat is weighed after its extraction with a solvent from the dry sample weight in the Soxhlet apparatus, based on determining the change in the sample's weight after fat extraction with a solvent by **DSTU 8718 (2017)**; the mass fraction of protein by determining the total nitrogen by the Kjeldahl method. Cinefaction of samples was performed on the Velp Scientifica DK6 series (Italy) with a vacuum pump (JP). Distillation was made on a steam distillation device Velp Scientifica UDK 129 (Italy), **DSTU 8030 (2015)**.

Determination of the fiber's mass fraction was carried out by removing acid-alkaline-soluble substances from the product and determining the residue weight, conventionally fiber following **DSTU 8844 (2019)**.

Determination of the fatty acid content was carried out by chromatographic method on the Kupol 55 chromatograph (Russia) to **GOST ISO 17764-1 (2015)**.

The mineral composition (the content of potassium, calcium, magnesium, phosphorus, manganese, and so on) was determined by atomic emission spectrometry with inductive plasma, and the content of heavy metals (lead, cadmium, arsenic, mercury, copper, and zinc) was determined by atomic absorption spectrometry according to **DSTU EN ISO 11885 (2019).**

Description of the Experiment

Sample preparation: After deboning, the carp fillet was salted in brine at room temperature for 24 hours until it was 5% salty. Then the fillet was portioned into pieces and placed in plastic jars with vegetable raw products added (parsley, ginger, horseradish). Recipes for preserves of test samples consisted of carp meat – 75% and pickle solution – 25%. Preserve samples were stored in plastic containers with a capacity of 200 mL at a temperature ranging from 0 to +4°C (Figure 1). The control sample, ginger preserves, horseradish preserves, and parsley preserves were sent for analysis. Then, an average sample was taken from each unit, which was then characterized after grinding by the total chemical composition, energy value, mineral content, amino acid composition of proteins, and fatty acid

Figure 1 Preserves with carp with the addition of spicy-aromatic roots.

composition of lipids.

Number of samples analyzed: In the study of the samples, four types of preserves were used: a control without the addition of spicy-aromatic root crops and three samples with the addition of ginger, horseradish and parsley.

Number of repeated analyses: Each study was carried out five times with the number of samples being four, which amounted to twenty repeated analyses.

Number of experiment replication: The study was repeated 5 times, with the experimental data processed using mathematical statistics methods.

Statistical Analysis

The statistical analysis data were performed by Microsoft excel and Statistica 15. The accuracy of the obtained experimental data was determined using the Student's t-test with a confidence coefficient ≤ of 0.05 with several parallel definitions of at least 5. Linear programming problems were solved using the MS Excel table processor's 'Search for a solution' setting (Excel Solver).

RESULTS AND DISCUSSION

Previous research has shown that the use of vegetable raw materials **(Rodak and Fil, 2016; Pobedash, 2020; Paska et al., 2020; Fedorova and Kuzmenko, 2015; Shubina et al., 2019; Fedorova and Dasheev, 2017; Shubina et al., 2017)** and, including spicy-aromatic roots, in the technology of freshwater aquatic organisms contribute to the harmonization of organoleptic characteristics.

The results of studies of the chemical composition of carp preserves and aromatic root vegetables are shown in Table 1. It should be noted that the mineral composition of the test samples differs from that of the control sample, which is due to the content of minerals in vegetable additives (ginger, horseradish, parsley), which in combination with fish raw products enrich the preserves. If we compare with the studies **(Shulgina et al., 2017; Alekseeva, 2019)** of other authors who do not add vegetable raw materials, we get a much lower mineral content of an average of 1.4%.

The fatty acid composition was determined in preserves with sunflower oil and a mixture of sunflower oil and linseed oil in a ratio of 1:1. Similar studies **(da Silva et al., 2019; Lansing et al., 2018; Fernandez et al., 2019; Eveleva and Cherpalova, 2019; Brazhnaya, 2016)** describe similar studies, but the authors used different types of oils (sunflower and olive, soybean and sunflower, corn and others) and the ratio of oils (1:2, 1:3, 1:5 and 1:10). The fatty acid composition of preserves with sunflower oil is shown in Table 2.

According to experimental data, the content of all FA groups in the preserves studied is exceeded in all groups, but the control sample, in which the sum of saturated acids

Table 1 Characteristics of the chemical composition of fish preserves.

Sample of preserves	Mass fraction, %				
	moisture content	**protein**	**fat**	**mineral substances**	**fiber**
Control sample	70.49 ±1.88	11.85 ±0.73	9.36 ±0.65	8.29 ±0.61	-
Preserves with ginger	66.90 ±1.47	11.93 ±0.74	10.61 ±0.98	9.55 ±0.23	0.03 ±0.03
Preserves with horseradish	65.61 ±1.78	11.88 ±0.81	11.99 ±1.05	9.93 ±0.41	0.05 ±0.03
Preserves with parsley	67.65 ±1.69	11.68 ±0.31	10.01 ±0.75	10.15 ±0.66	0.14 ±0.03

Note: ($n = 5$, $p \leq 0.05$)

Table 2 Fatty acid composition of lipids of preserves made of carp and aromatic raw products with sunflower oil.

Fatty acids	FA code	Content of fatty acids, % of their total amount				Recommended quantity, g/day (Onishchenko, 2004)
		Control sample	**Preserves with ginger**	**Preserves with horseradish**	**Preserves with parsley**	
Saturated fatty acids, incl.		**24.80**	**29.92**	**30.78**	**29.93**	**25**
myristic acid	14:0	0.09	0.12	1.07	0.08	
palmitic acid	16:0	20.52	25.63	25.44	25.59	
stearic acid	18:0	3.64	3.59	3.62	3.57	
arachic acid	20:0	0.14	0.14	0.18	0.15	
nonadecanoic acid	19:0	0.41	0.45	0.47	0.54	
Monounsaturated fatty acids, incl.		**33.14**	**38.05**	**38.13**	**38.17**	**30**
palmitooleic acid	16:1	5.10	5.09	5.11	5.12	
ω_9 oleic acid	18:1	15.85	20.79	20.85	20,88	
ω_9 elaidic acid	18:1	12.14	12.15	12.15	12.17	
gadoleic acid	20:1	0.06	0.02	0.02	0.02	
Polyunsaturated fatty acids, incl.		**12.83**	**14.06**	**13.16**	**14.12**	**11**
linolenoic acid ω_3	18:2	6.09	7.15	6.15	7.17	
linoleic acid ω_6	18:3	6.09	6.26	6.30	6.30	
eicosadienoic acid	20:2	0.64	0.65	0.71	0.65	
Unidentified		**29.23**	**17.98**	**17.93**	**17.79**	

Table 3 Fatty acid composition of lipids of preserves made of carp and aromatic raw products with sunflower and linseed oil.

Fatty acids	FA code	Content of fatty acids, % of their total amount				Recommended quantity, g/day (Onishchenko, 2004)
		control sample	preserves with ginger	preserves with horseradish	preserves with parsley	
Saturated fatty acids, incl.		**24.80**	**10.05**	**10.09**	**10.82**	**25**
tridecanoic acid	13: 0	-	0.17	0.21	0.33	
palmitic acid	16: 0	20.52	5.70	5.71	6.43	
stearic acid	18: 0	3.64	3.88	3.88	3.85	
arachic acid	20: 0	0.14	0.30	0.28	0.21	
nonadecanoic acid	19: 0	0.41	-	-	-	
myristic acid	14: 0	0.09	-	-	-	
Monounsaturated fatty acids, incl.		**33.14**	**22.37**	**22.13**	**22.18**	**30**
palmitooleic acid	16: 1	5.10	-	-	-	
ω_9 oleic acid	18: 1	15.85	22.37	22.13	22.18	
ω_9 elaidic acid	18: 1	12.14	-	-	-	
gadoleic acid	20: 1	0.06	-	-	-	
Polyunsaturated fatty acids, incl.		**12.83**	**67.33**	**67.51**	**66.76**	**11**
linolenoic acid ω_3	18: 2	6.09	59.97	60.09	59.58	
linoleic acid ω_6	18: 3	6.09	6.46	6.51	6.38	
linolenoic acid ω_6	18: 3	-	0.29	0.26	0.22	
eicosatetraenoic acid	20: 4	-	0.61	0.65	0.58	
eicosadienoic acid	20: 2	0.64	-	-	-	
Unidentified		**29.23**	**0.25**	**0.27**	**0.24**	

Table 4 Indicators of biological effectiveness of lipids of preserves made of carp and aromatic raw products with sunflower and linseed oil

Lipids	Ratio of FA types			
	SFA:MFA:PUFA	PUFA:SFA	C18:2:C18:1	ω_6:ω_3
Ideal lipid (Tsypriian, Manasar, Slobodkin, 2007)	1:1:1	0.2:0.4	> 0.25	10: 1
with sunflower oil				
Control sample	1: 1.34: 0.52	0.52: 1	1: 2.60	1: 1.00
Preserves with ginger	1: 1.27: 0.47	0.47: 1	1: 0.37	1: 1.14
Preserves with horseradish	1: 1.24: 0.43	0.43: 1	1: 0.36	1: 0.98
Preserves with parsley	1: 1.28: 0.47	0.47: 1	1: 0.37	1: 1.14
with sunflower and linseed oil				
Control sample	1: 1.34: 0.52	0.52: 1	1: 2.60	1: 1.00
Preserves with ginger	1: 2.23: 6.69	6.69: 1	1: 0.37	1: 9.28
Preserves with horseradish	1: 2.19: 6.69	6.69: 1	1: 0.36	1: 9.23
Preserves with parsley	1: 2.05: 6.17	6.17: 1	1: 0.37	1: 9.35

Table 5 Effect of added aromatic root vegetables on the mineral composition of freshwater carp preserves, mg/100 g

Mineral element	Preserves under study:				10% of the adequate daily consumption requirement (Onishchenko, 2004)
	control sample	with ginger	with horseradish	with parsley	
Potassium	83.51 ±2.11	93.89 ±2.02	108.87 ±3.09	97.21 ±2.43	250
Calcium	15.43 ±0.69	21.69 ±0.61	21.81 ±1.06	28.99 ±1.02	125
Sulfur	19.11 ±0.80	22.73 ±0.30	26.77 ±1.15	20.23 ±1.13	1.0
Iron	0.15 ±0.02	0.59 ±0.03	0.22 ±0.03	0.26 ±0.03	1.5
Manganese	—	0.17 ±0.02	0.01 ±0.005	0.03 ±0.006	0.2

Note: (n = 5, $p \leq 0.05$).

approaches the recommended amount. Among saturated acids, palmitic acid is dominant, the content of which in experimental samples with various aromatic root vegetables exceeds the control sample by 5%.

The fatty acid composition of preserves with sunflower and linseed oil is shown in Table 3.

Analyzing the data presented in Table 3, it was found that the content of saturated and monounsaturated FA compared to the recommended amount in the experimental samples is lower, but the enrichment of preserves takes place due to the high content of polyunsaturated FA, namely linoleic acid the linseed oil is rich in.

The results of indicators of biological effectiveness of lipids of preserves made of carp and aromatic raw products with sunflower oil and sunflower-and-linseed oil are shown in Table 4.

It should be particularly noted that the high content of fatty acids of the ω_3 family in the lipids of preserves, which we have found, speaks for their high biological efficiency **(Mushtruk et al., 2020a; Barboza et al., 2020; Golembovskaya, 2020)**.

The characteristics of the effect of aromatic root vegetables on the mineral composition of preserves made of freshwater carp fish are shown in Table 5.

Based on these results, the level of all mineral elements is significantly increased in preserves with aromatic root vegetables, compared to the control sample and studies by other authors **(Dementeva and Bogdanov, 2017; Petrik, 2016; Abramova and Goferber, 2017)**, which speaks for the expediency of adding aromatic root vegetables to this product to enrich it with essential mineral elements and obtain a healthy food product of high value.

Taking into account the different needs of a human body for minerals, we have calculated the level of macro- and microelements to meet daily needs provided that 200 grams of preserves are consumed (Figure 2).

The control sample was characterized by a lower degree of meeting the daily requirement for most trace elements, which can be explained by a less balanced mineral composition of fish raw products.

These data speak for the fact that the degree of manganese supply provided that the preserve with ginger is consumed is the highest and makes up 85% of its daily requirement, respectively. Preserves with horseradish and parsley meet the need for this element by 5% and 15%, while in the control sample it is absent.

Preserves with ginger are also rich in ferrum and potassium – 39% and 38%, respectively. Comparing them with other samples, we can conclude that they are most enriched with minerals due to the addition of ginger.

Determination of the content of toxic elements in the composition of preserves is one of the essential characteristics of their health safety (Table 6).

According to the results of Table 6, it was found that the addition of aromatic root vegetables to the composition of preserves is not accompanied by an increase in the level of toxic elements, which guarantees their health safety and suitability for consumption.

The obtained results for determining the chemical composition of preserves made of carp and aromatic root vegetables (Table 1) speak for the fact that the protein content in test samples of preserves ranges from 11.68% to 11.93 %. The lowest protein content was observed in the control sample.

The fat content in the finished preserves ranged from 9.36% to 11.99%, which has a positive effect on the product's taste properties.

Determination of the moisture content in the finished preserves has shown that there is a certain fluctuation in this indicator in the range from 65.61 (preserves with

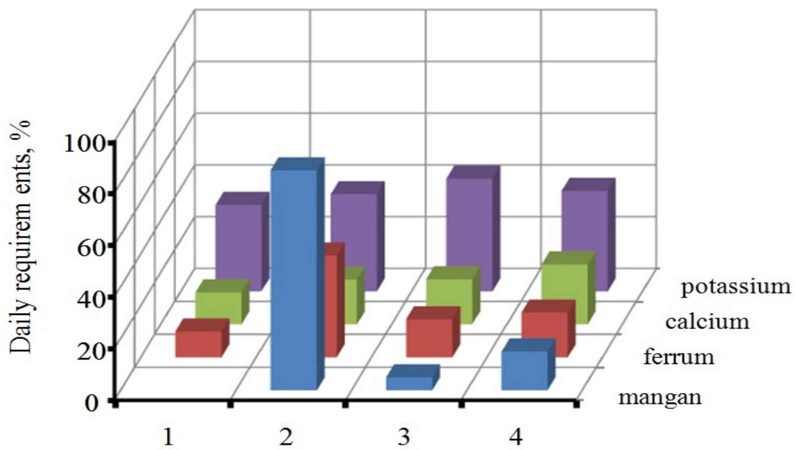

Figure 2 The degree of meeting a person's daily need for minerals provided that 200 g of fish preserves are consumed, %. Note: 1 – control sample; 2 – preserves with ginger; 3 – preserves with horseradish; 4 – preserves with parsley.

Table 6 Mass fraction of toxic elements in preserves with aromatic root vegetables, mg.100g^{-1}.

Indicator	Preserves under study: control sample	with ginger	with horseradish	with parsley	Permissible levels, max **(Tsypriian, Manasar, Slobodkin, 2007)**
Copper	0.03 ±0.005	0.05 ±0.007	0.03 ±0.001	0.06 ±0.010	1.0
Zinc	0.20 ±0.010	0.59 ±0.020	0.19 ±0.020	0.25 ±0.020	4.0
Rubidium	0.09 ±0.005	0.25 ±0.009	0.01 ±0.003	0.01 ±0.006	undefined
Strontium	0.39 ±0.010	0.39 ±0.010	0.64 ±0.020	0.82 ±0.020	undefined
Nickel	0.02 ±0.004	0.009 ±0.0002	0.02 ±0.001	0.01 ±0.005	undefined

Note: (n = 5, $p \leq 0.05$).

horseradish) to 70.49 (control sample preserves).

In terms of mineral content, the test samples differ in comparison with the control sample. In our opinion, this is because vegetable supplements contain a wide range of minerals, which in combination with minerals contained in fish raw products enrich ready-made preserves **(Lebskaya, Pavluchenko and Moisiienko, 2017; Slobodyanyuk et al., 2019)**.

The sum of individual groups of carp lipid fatty acids corresponds to or exceeds the recommended amount of daily need **(Tsypriian, Manasar, Slobodkin, 2007)**.

Fatty acids play an essential part in human metabolic processes.

Therefore, the composition of fatty acids in food products is vital for ensuring normal metabolism and its correction in various disorders. Accordingly, the composition of fatty acids of the final form of a food product hinges on the characteristics of the ingredients that are used in its production. Among the results of the fatty acid composition of preserve lipids with the use of sunflower oil, MUFAs dominate (33.14 – 38.17%), with the use of sunflower and linseed oil in combination, PUFAs dominate (12.83 – 67.51%).

Changes in the fatty acid composition of preserves (Tables 2, 3) are mainly associated with an increase in the amount of polyunsaturated fatty acids that were introduced with the addition of linseed oil, which is a positive factor.

Among PUFAs, linolenic acid makes up the largest amount (59.58 – 60.09%). The record shows that this acid is vital for humans, it serves mainly as an energy supplier but plays an essential part in the treatment and prevention of cardiovascular diseases, such as coronary heart disease, hypertension, hyperlipoproteinemia, thanks to its lipid-lowering, antiplatelet and hypotensive effects **(Loizzo et al., 2016)**.

The degree of lipid fatty acids absorption hinges on the ratio of individual fatty acids and characterizes their biological effectiveness. It does not diverge from practical data. The ratio of individual classes of lipids does not correspond to the recommendations proposed by nutrition specialists. However, data on the ratio of fatty acids ω_6:ω_3 in all types of preserves speak for their high biological efficiency. The record shows that the recommended ratio of PUFAs of ω_6 family/PUFAs of the $\omega_3$family in the diet of a healthy person is 10:1, and in cases of lipid metabolism pathology, it is 5:1 and even 3:1 **(Shulgina, et al., 2017; Zheplinska et al., 2019)**. However, the greatest deficiency in the diet is noted for fatty acids of the ω_3 family. Therefore, the high content of ω_3 family acids in preserve lipids that we have found speaks for their high biological efficiency.

The mineral composition of preserves is characterized by a fairly high content of potassium (93.89 – 108.87 mg.100g^{-1}), calcium (21.69 – 28.99 mg.100g^{-1}), sulfur (20.23 – 26.77 mg.100g^{-1}) compared to the control sample. Based on the study of the mineral composition of fish raw products, the need to optimize it due to the insignificant amount or absence of some essential elements, in particular potassium, manganese, iodine, bromine, selenium, has been proven.

Conducting corresponding research would be very appropriate, as it would make it possible to enrich the recipes of preserves based on freshwater fish with a wide range of vegetable additives, increasing their nutritional value and allowing to get a product rich in such vital nutrients as carbohydrates, calcium, potassium, phosphorus, sulfur, sodium, magnesium, manganese and iron.

CONCLUSION

Studies on the chemical composition of preserves gave positive results and proved that the addition of aromatic root vegetables increases the mineral content compared to the control sample.

The biological effectiveness of the fatty acid composition of carp preserves is due to an increase in the amount of polyunsaturated fatty acids, namely linoleic acid ω_6, which was introduced with the addition of linseed oil to fish flesh, and compared with the daily requirement exceeds the recommended content.

In comparison with the control sample, in the preserves under study, the level of all mineral elements is significantly increased, which speaks for the expediency of adding aromatic root vegetables to this product to enrich it with these essential elements to obtain high-value and healthy food product. As for the content of toxic elements, preserves with aromatic root vegetables are good for health.

The chemical composition of the experimental formulations differed from the control sample with a higher protein content: 15% vs. 11%, fat: 10 – 12% vs. 9%, and minerals: 9 – 10% vs. 8%, but the energy value of the experimental preserves was higher 144 – 172 in compared with control: 131.

Studies of changes in the quality and safety of preserves during storage have determined the allowable shelf life of preserves no more than 28 days at temperatures from 0 to +4 °C.

REFERENCES

Abramova, L., Goferber, E. 2017. Objective measurement of the biochemical maturation processes of slightly salted herring fillet. *Scientific journal "Izvestia KSTU"*, vol. 47, p. 73-79.

Alekseeva, L. 2019. On the issue of improving the technological scheme for the production of preservers with additives. *Eurasian Union of Scientists*, vol. 3, no. 60, p. 33-36.

Barboza, L., Lopes, C., Oliveira, P., Bessa, F., Otero, V., Henriques, B., Guilhermino, L. 2020. Microplastics in wild fish from North East Atlantic Ocean and its potential for causing neurotoxic effects, lipid oxidative damage, and human health risks associated with ingestion exposure. *Science of the Total Environment*, vol. 717, p. 134625. https://doi.org/10.1016/j.scitotenv.2019.134625

Brazhnaya, I. 2016. Effect of enzyme preparation on quality of preserves in flavored oil from poorly maturing fish of the 3orth Basin. *Bulletin of the Murmansk State Technical University*, vol. 19, no. 4, p. 854-860. https://doi.org/10.21443/1560-9278-2016-4-854-860

Bùi, S. D. 2011. *Development of technology for the production of preserves made of aquaculture objects based on biotechnological techniques* : dissertation theses – 'Biotechnology of food products and biologically active substances', p. 23.

Chernyavskaya, S., Esina, L., Krivonos, O., Bogomolova, V. 2019 Producing enzymatic hydrolyzate from freshwater mollusc dreissena polymorpha *Vestnik of astrakhan state technical university. Series: Fishing industry*, vol. 2, p. 101-111. https://doi.org/10.21443/1560-9278-2016-4-854-860

da Silva, P., Miranda, L., Makrakis, S., de Assumpção, L., Dias, J., Makrakis, M. 2019. Tributaries as biodiversity preserves: An ichthyoplankton perspective from the severely impounded Upper Paraná River. *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 29, no. 2, p. 258-269. https://doi.org/10.1002/aqc.3037

Davletshina, T., Shulgina, L., Pavlovsky, A., Solodova, E., Pavel, K. 2019. Composition of lipids and fatty acids in muscle tissue of chub mackerel scomber japonicus. *Izvestiya TINRO*. vol. 196, p. 203 https://doi.org/10.26428/1606-9919-2019-196-193-203

Dementeva, N., Bogdanov, V. 2017. The quality and technology of preserves from herring Pacific. Food and processing technologies *Agroindustrial complex-healthy food products*, vol. 1, p. 67-73.

DSTU 2284. 2010. *Live fish. General specifications. Quality management systems – Requirements.*

DSTU 2450. 2006. *Vinegars made of raw products. General specifications. Quality management systems – Requirements.*

DSTU 294. 1991. *Fresh horseradish root. General specifications. Quality management systems – Requirements.*

DSTU 3583. 2015. *Table salt. General technical conditions. Quality management systems – Requirements.*

DSTU 4492. 2017. *Sunflower oil. General specifications. Quality management systems – Requirements.*

DSTU 6010. 2008. *Fresh parsley root. General specifications. Quality management systems – Requirements.*

DSTU 8029. 2015. *Fish and fish products. Moisture determination methods General specifications. Quality management systems – Requirements.*

DSTU 8030. 2015. *Fish and fish products. Methods for determining protein substances. General specifications. Quality management systems – Requirements.*

DSTU 8717. 2017. *Fish and fish products. Methods for determining fat. General specifications. Quality management systems – Requirements.*

DSTU 8718. 2017. *Fish and fish products. Methods for determination of ash and mineral impurities General specifications. Quality management systems – Requirements.*

DSTU 8844. 2019 *Feed, mixed feed, mixed feed raw products. Method for determining the crude fiber. General specifications. Quality management systems – Requirements.*

DSTU EN ISO 11885. 2019. *Water quality. Determination of the content of 33 elements by atomic emission spectrometry using an inductively coupled plasma. General specifications. Quality management systems – Requirements.*

DSTU ISO 1003. 2018. *Spices and seasonings. Ginger roots, in pieces or ground. General specifications. Quality management systems – Requirements.*

DSTU ISO 2254. 2008. *Whole and ground cloves (powdered). General specifications. Quality management systems – Requirements.*

DSTU ISO 959-1. 2008. *Spices. Black and white pepper. General specifications. Quality management systems – Requirements.*

Dvoryaninova, O., Alyokhina, A., Storublyovtsev, S. 2010. Obtaining and research of the freshwater carp flesh's enzyme complex properties. *News of Higher Educational Institutions, Food Technology*, vol. 4, p. 13-15.

Eveleva, V., Cherpalova, T. 2019. Innovative decisions to improve food quality and safety. *Food systems*, vol. 2, no. 4, p. 14-17. https://doi.org/10.21323/2618-9771-2019-2-4-14-17

Fedorova, D., Kuzmenko, Y. 2015. Technological aspects of complex use of azov frozen goby in production of fish and vegetable semi-products. *Scientific Works of NUFT*, vol. 21, no. 6, p. 167-181.

Fedorova, T., Dasheev, B. 2017. About the possibility of using thistle spot in the production of fish prests. Food industry and public catering. *Current state and development prospects*. vol. 23, p. 33-35.

Fernandez, C., Mascolo, D., Monaghan, S. J., Baily, J. L., Chalmers, L., Paladini, G., Fridman, S. 2019. Methacarn preserves mucus integrity and improves visualization of amoebae in gills of Atlantic salmon (Salmo salar L.). Journal of fish diseases, vol. 42, no. 6, p. 883-894. https://doi.org/10.1111/jfd.12988

Golembovskaya, N. 2020. Improvement of technology of preserves from freshwater fish species. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Food Technologies*, vol. 22, no. 94, p. 27-31. https://doi.org/10.32718/nvlvet-f9406

Golembovskaya, N., Lebskaya, T. 2015 Application of gamma-radiation treatment to control maturation and to increase safety of the preserves from carp meat. *Vestnik of astrakhan state technical university. series: fishing industry,* vol. 2, p. 116-122.

GOST 17594, 1981. *Dry bay leaves. General specifications. Quality management systems – Requirements.*

GOST ISO 973, 2016. *All spice [Pimenta dioica (L.) Merr.], grains or ground. General specifications. Quality management systems – Requirements.*

GOST ISO 17764-1. 2015. *Feeds, compound feeds. Determination of the content of fatty acids. Part 1. Preparation of methyl esters*.

Lansing, M., Sauvé, Y., Dimopoulos, I., Field, C. J., Suh, M., Wizzard, P.,Turner, J. 2018. Parenteral lipid dose restriction with soy oil, not fish oil, preserves retinal function in neonatal piglets. *Journal of Parenteral and Enteral Nutrition*, vol. 42, no. 7, p. 1177-1184. https://doi.org/10.1002/jpen.1145

Lebskaya, T., Pavluchenko, Yu., Moisiienko, O. 2017. Quality and safety of preserves from the Black Sea rapana meat. *Goods and markets*, vol. 2, no. 1, p. 66-77.

Loizzo, M., Pugliese, A., Bonesi, M., Tenuta, M., Menichini, F., Xiao, J., Tundis, R. 2016. Edible flowers: a rich source of phytochemicals with antioxidant and hypoglycemic properties. *Journal of agricultural and food chemistry*, vol. 64, no. 12, p. 2467-2474. https://doi.org/10.1021/acs.jafc.5b03092

Mushtruk, M., Gudzenko, M., Palamarchuk, I., Vasyliv, V., Slobodyanyuk, N., Kuts, A., Nychyk, O., Salavor, O., Bober, A. 2020b. Mathematical modeling of the oil extrusion process with pre-grinding of raw materials in a twin-screw extruder. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 14, p. 937-944. https://doi.org/10.5219/1436

Mushtruk, M., Vasyliv, V., Slobodaniuk, N., Mukoid, R., Deviatko, O. 2020a. Improvement of the Production Technology of Liquid Biofuel from Technical Fats and Oils. In Ivanov, V., Trojanowska, J., Machado, J., Liaposhchenko, O., Zajac, J., Pavlenko, I., Edl, M., Perakovic, D. *Advances in Design, Simulation and Manufacturing III*. Switzerland: Springer International Publishing, p. 377-386. ISBN 21954364-21954356. https://doi.org/10.1007/978-3-030-50491-5_36

Onishchenko, G. G. 2004 *Nutritive foods. Recommended levels of food and biologically active substances consumption*. Available at: https://files.stroyinf.ru/Data2/1/4293846/42 93846547.htm

Park, T. J., Lee, S. H., Lee, M. S., Lee, J. K., Lee, S. H., Zoh, K. D. 2020. Occurrence of microplastics in the Han River and riverine fish in South Korea. *Science of The Total Environment*, vol. *708*, 134535. https://doi.org/10.1016/j.scitotenv.2019.134535

Paska, M., Radzimovska, O., Burak, M. 2020 Development of new types of delicatessen products for special purposes. *Scientific works of the National University of Food Technologies*, vol. 26, no 5. p. 150-155. https://doi.org/10.24263/2225-2924-2020-26-5-19

Petrik, A. 2016. Technology of preserves from Pacific herring caviar in sauces and dressings. *Scientific works of Dalrybvtuz*, vol 39. p. 116-116.

Pobedash, M. 2020. Optimization of the term of storage of fish reserves on the basis of small herring fish. *Commodity Bulletin,* vol. 1, no. 9, p. 150-156.

Rodak, O., Fil, M. 2016. Development of fish preserves high biological value. *Scientific Messenger LNUVMBT named after S.Z. Gzhytskyj*, vol. 18, no. 2, p. 79-82. https://doi.org/10.15421/nvlvet6815

Saltanova, N., Malinovskaya, U. 2012. Impact of vegetable components included in the pickle solution on the quality of preserves during storage. *Petropavlovsk-Kamchatsky: Bulletin of the Kamchatsky State Technical University*, vol. 21, p. 53-59.

Shanina, O., Galyasnyj, I., Gavrysh, T., Dugina, K., Sukhenko, Y., Sukhenko, V., Miedviedieva, N., Mushtruk, M., Rozbytska, T., Slobodyanyuk, N. 2019. Development of gluten-free non-yeasted dough structure as factor of bread quality formation. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 13, no. 1, p. 971-983. https://doi.org/10.5219/1201

Shanina, O., Minchenko, S., Gavrysh, T., Sukhenko, Y., Sukhenko, V., Vasyliv, V., Miedviedieva, N., Mushtruk, M., Stechyshyn, M., Rozbytska, T. 2020. Substantiation of basic stages of gluten-free steamed bread production and its influence on quality of finished product. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 14, no. 1, p. 189-201. https://doi.org/10.5219/1200

Shubina, L., Ivanova, E., Kosenko, O., Zaporozhskaya, S., Belousova, S. 2019. The use of non-traditional types of raw materials and biologically active additives for the formation of technological and consumer properties of functional and fortified food products. *Izvestiya vuzov, Food technology*, vol. 2-3. p. 9-12.

Shubina, L., Strizhenko A., Kosenko O. 2017. Technology of preparation of semi-finished products for difficult fish and vegetable products. *Scientific works of KubGTU*, vol. 5. p. 133-141.

Shulgina, L., Yakush, E., Davletshina, T., Pavlovskyi, A., Pavel', K., Kas'janov, S. 2017. Polyunsaturated fatty acids of omega-3 in foods from far eastern fish Health. *Medical ecology. Science,* vol. 5, no. 72, p. 42-45.

Slobodyanyuk, N., Menchynska, A., Manoli, T., Barysheva, Y. 2019. Influence of natural honey on safety indicators of fish preserves and pastes. *Animal Science and food technology*, vol. 1, no. 10. p. 40-46. https://doi.org/10.31548/animal2019.01.040

Sukhenko, Y., Sukhenko, V., Mushtruk, M., Vasuliv, V., Boyko, Y. 2017. Changing the quality of ground meat for sausage products in the process of grinding. *Eastern European Journal of Enterprise Technologies*, vol. 4, no. 11, p. 56-63.

TU U 15.4-14235416-001, 2010. *Linseed oil. Technical specifications. State Standard of Ukraine, p.6*

Tsypriian, V. I., Manasar, S. T., Slobodkin, V. S. 2007. *Food hygiene and the nutritionology basics. Textbook*, p. 544.

Zheplinska, M., Mushtruk, M., Vasyliv, V., Deviatko, O. 2019. Investigation of the process of production of crafted beer with spicy and aromatic raw materials. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 13, no. 1, p. 806-814. https://doi.org/10.5219/1183

Funds:

This research received no external funding.

Acknowledgments:

We would like to thank you to Dr. for Tatiana Lebskaya.

Conflict of Interest:

The authors declare no conflict of interest.

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

Contact Address:

*Nataliia Holembovska, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnika Potekhina, str. 16, Kyiv, 02163, Ukraine, Tel.: +38(096)206-62-76,
E-mail: natashagolembovska@gmail.com
ORCID: https://orcid.org/0000-0001-8159-4020

Liudmyla Tyshchenko, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnika Potekhina, str. 16, Kyiv, 03040, Ukraine, Tel.: +38(097)103-00-73,
E-mail: ltishchenko@ukr.net
ORCID: https://orcid.org/0000-0002-3609-0920

Natalia Slobodyanyuk, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products Department of technology of meat, fish and marine products, Polkovnyka Potekhina, str. 16, Kyiv, 03040, Ukraine, Tel.: +38(098)2768508,
E-mail: slob2210@ukr.net
ORCID: https://orcid.org/0000-0002-7724-2919

Valentyna Israelian, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnyka Potiekhina Str., 16, Kyiv, 03040, Ukraine, Tel.: +38(096)7240399,
E-mail: vs88@ukr.net
ORCID: https://orcid.org/0000-0002-7242-3227

Yuliya Kryzhova, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnika Potekhina, Str. 16, Kyiv, 03041, Ukraine, Tel.: +38(093)0370077,
E-mail: yuliya.kryzhova@ukr.net
ORCID: https://orcid.org/0000-0003-1165-8898

Anastasia Ivaniuta, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnyka Potiekhina Str., 16, Kyiv, 03040, Ukraine, Tel.: +38(096)879-07-22,
E-mail: ivanyta07@gmail.com
ORCID: https://orcid.org/0000-0002-1770-5774

Oksana Pylypchuk, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnyka Potiekhina Str., 16, Kyiv, 03040, Ukraine, Tel.: +38(096)9612083,
E-mail: pilipchuk_os@ukr.net
ORCID: https://orcid.org/0000-0002-2757-6232

Alina Menchynska, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnyka Potiekhina Str., 16, 03040, Kyiv, Ukraine, Tel.: +38(097)6583888,
E-mail: menchynska@ukr.net
ORCID: https://orcid.org/0000-0001-8593-3325

Oksana Shtonda, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnika Potekhina, str. 16, Kyiv, 02163, Ukraine, Tel.: +38(050)140-66-57,
E-mail: oasht@ukr.net
ORCID: https://orcid.org/0000-0002-7085-6133

Dmytro Nosevych, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Milk and Meat Production Technologies department, Polkovnika Potekhina, str. 16, Kyiv, 03040, Ukraine, Tel.: +38(097)2698151,
E-mail: dknocevich@i.ua
ORCID: https://orcid.org/0000-0003-2495-2084

Corresponding author: *