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Biochemical composition and quality of herring preserves with addition of bio-protective cultures

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Abstract. Herrings rich in vitamins B12, A, D, minerals, including calcium, potassium, magnesium, iodine, possess high levels of lysine, tyrosine, phenylalanine and tryptophan, as well as omega-3 unsaturated fatty acids, namely eicosapentanoic, docosahexoenoic and docosapentoenoic. To suppress the microbiological spoilage of fish preserves, it is promising to use bio-protective cultures that have minimal impact on the production process and product properties. Bacterial strains are able to exert a static effect on the microflora, which causes biodeterioration of food products. Microorganisms as part of bio-protective cultures are included in the fermentation process, so they can be attributed to ordinary food ingredients, so there is no need to put separate information on the packaging. The chemical composition of the frozen Atlantic and Pacific herring fillet, the amino acid composition of proteins, and the fatty acid composition of lipids were studied. The difference between Atlantic and Pacific herrings was detected, which consists in a significantly higher content of docosahexaenoic acid. The difference in the fractional composition of triacylglycerols for the Atlantic and Pacific herring was established. The microflora of SafePro B-2 biological product (Chr. Hansen GmbH), containing multiple strains of *Lactobacillus sakei*, and the viability of the culture in preserves fillings were studied. The experimental development of canned food with SafePro B-2 additives was carried out. Microbiological, organoleptic and biochemical indicators of the preserves quality during cold storage were studied. The influence of introduced culture on the dynamics of preserves curing period and their shelf life was established.

Key words: frozen fillet of Atlantic and Pacific herrings, fatty acid composition, triglycerides, bio-protective cultures, preserves, fillings, buffering, curing period.

INTRODUCTION

Fish raw materials are characterized by diversity in size, mass composition, biochemical properties and nutritional value.

Herrings are important products of fishing industry as it counts about 20% of the global fish catch. Herring in Russia is captured in the northern Atlantic Ocean, the Black, Azov, Caspian, Barents Seas and in the Far East.

As a result of ripening the herring meat in a salty form acquires a pleasant taste and aroma, so the major volume of catch is salted, some part of which is then smoked cold and marinated. Another part of catch is used for production of canned food, a small amount of small herring is sent for hot smoking and is sold freshly frozen.

Herring is a popular component of traditional fish dishes in the Russian cuisine. It is rich in vitamins B12, A, D, minerals, including calcium, potassium, magnesium, iodine (Olsen, 2001). Herrings possess high levels of lysine, tyrosine, phenylalanine and tryptophan, as well as omega-3 unsaturated fatty acids, namely eicosapentanoic, docosahexoenoic and docosapentoenoic. The linoleic acid is the omega-6 fatty acid of herring (Olsen, 2001; Timberg et al., 2011). Atlantic herring (*Clupea harengus*) is widespread in the northern Atlantic Ocean, and also lives in the vast water area of the Greenland, Norwegian and Barents Seas (Gritsenko et al., 2006). Pacific herring (*Clupea pallasii*) is found in the Pacific Ocean from Korea to the Anadyr Gulf and from California to the Bering Strait. It is catched in the Bering, Okhotsk and Japan Seas (Laakkonen et al., 2013).

Analysis of modern technologies for herring processing shows an increase in the relative share of the natural fish preserves output (Bocharova-Leskina et al., 2015; Maksimova et al., 2018; Timoshenkova et al., 2019). However, statistics shows a weak saturation of this segment (Naujmin, 2017). The assortment of herring preserves is limited to products in oil and wine fillings possessing long shelf life.

To suppress the microbiological spoilage of fish preserves, it is promising to use bio-protective cultures that have minimal impact on the production process and product properties (Abdrakhmanova & Zaitseva, 2012). Bacterial strains with antagonistic activity against pathogens of microbiological food spoilage belong to the Lactobacillus genus and are able to exert a static effect on the microflora, which causes biodeterioration of food products (Axelsson, 2004; Bazarnova et al., 2018). Microorganisms as part of bio-protective cultures are included in the fermentation process, so they can be attributed to ordinary food ingredients, so there is no need to put separate information on the packaging.

It is also advisable to establish threshold values of biochemical markers of spoilage of frozen herring, which undergo a long-term storage process. These markers will make it possible to assess the content of protein and lipid decomposition products and establish a correlation with normalized physical-chemical quality indicators of frozen fish (Rehbein & Orlick, 1990).

Based on the aforesaid, chemical-technological and biochemical studies of Russian herring and development of technology of preserves using bio-protective cultures are relevant.

The aim of this work is to study the biochemical composition of Atlantic and Pacific herring fillets and the quality of herring preserves with addition of bio-protective cultures.

MATERIALS AND METHODS

Samples of frozen Atlantic herring *Clupea harengus* (Greenland, plant GL 5778) and Pacific herring *Clupea pallasii* (Murmansk Trawl Fleet, ship Vladimir Sibirtsev); samples of salted Atlantic and Pacific herring fillet ('Baltic coas' JSC) were used as objects of study.

Samples of apple and citrus pectin manufactured by Herbsreith & Fox KG Pektin-Fabriken (Germany) and B-2 SAFEPRO (CHR Hansen, Denmark) containing strain *Lactobacillus sakei* (1×10^9 CFU g^{-1}) strains were used for developing preserves fillings.

To obtain the composite sample, blocks of frozen herring fillet with a size range of frozen herring fillet from six to ten pieces per 1 kg were used. Samples were taken after defrosting in blocks, the fillet temperature on the block surface was 9 °C, inside the block it was –1 °C. Prior to testing samples were stored at -22 °C in transport packaging from the manufacturer. Samples were delivered to the laboratory in a vacuum bag without complete disruption.

The mass fractions of protein, fat, and moisture in the herring fillet, as well as the mass fraction of salt in salted fish and the filling of preserves were determined according to AOAC (Association of Official Analytical Chemists).

The composition of fatty acids in herring fillets was determined by gas-liquid chromatography of methyl esters according to the procedure for pharmacopoeia fish oil (Bazarnova et al., 2019).

When determining the composition of triglycerides (TAG), the lipid fraction was separated by the BUME method (Lofgren et al., 2012) by a 4-fold excess (volume: weight) of a mixture of n-butanol and methanol (3:1 by volume), followed by extraction with a mixture of n-heptane and ethyl acetate (3:1 by volume) in the presence of 1% acetic acid. Phospholipids were then precipitated by acetone in the cold, after which the content and distribution of triglycerides and free fatty acids were determined by short-column high-temperature gas-liquid chromatography (Hooper & Parrish, 2009). The analysis conditions were the following: Agilent DB-HT + SimDis column (5 m × 0.54 mm × 0.15 μm); the volume of the injected sample is 1 μl, the inlet temperature is 380 °C, the flow divider is 1:25; carrier gas is nitrogen, 20 cm s^{-1}; column temperature: 2 min. at 80 °C – 25 °C min^{-1}; 5 min. at 380 °C. The AOC20i automatic sample feeder ensured high reproducibility of results (within ± 5% of the peak area), which made it possible to use the method of external standards.

The degree of raw materials preservation by the content of biogenic amines was evaluated after extraction with 0.5 M of perchloric acid (4 °C, 16 h), with subsequent centrifugation at 3,000 rpm min^{-1} for 5 minutes to remove fat. The content of free biogenic amines in deproteinized muscle tissue extracts was determined by ion chromatography using mobile phase with strong acid and acetonitrile (Erupe et al., 2010). The analysis conditions were the following: Dionex CS10 column, 4×125 mm, 40 °C; conductometric detector; mobile phase is 5 mM perchloric acid + 6% acetonitrile, 0.6 mL min^{-1}.

Herring ageing during salting and in preserves was determined by the buffer value in grad. The solids content in preserves fillings during storage was according to (Tülsner & Koch, 2010).

Pilot production of salted herring fillet and preserves was carried out on the basis of ‘Baltic coast’ JSC (St. Petersburg). Analysis of sanitary-significant microflora of frozen herring fillet, experimental and control samples of ‘Spicy herring in jelly’ preserves during refrigerated storage for 25 days at 4 ± 2 °C was carried out according to methods recommended by AOAC (2015). In particular, we determined the amount of mould and yeasts (AOAC 997.02), *Escherichia coli* (AOAC 991.14), APC kfu g^{-1} (AOAC 986.32), *Staphylococcus aureus* (AOAC 975.55), Bacteria of the *Clostridium* genus (AOAC 974.38).

The introduction of bio-protective cultures in preserves fillings was carried out as follows. The lyophilized B-2 SAFEPRO preparation was diluted in distilled water in a ratio of 1:15. The resulting suspension was evenly distributed over the surface of herring

cut and put into cans in a ratio of 0.02% to the fish weight, after which they were filled with fillings, hermetically sealed, and stored at 4 ± 2 °C for 25 days. Preservatives produced without addition of bio-protective cultures were used as control samples.

Statistical processing of research results was carried out using the Microsoft Office Excel software and the one-way analysis of variance Analysis of Variance (ANOVA). The obtained experimental data are presented with the reference to confidence interval calculated using the t-criteria. The confidence probability is 0.95 and statistical significance of the given results is $p < 0.05$. The samples were examined in 3-fold repeatability mode. The difference between Atlantic and Pacific herring fillets is statistically significant.

RESULTS AND DISCUSSION

The process of herring filleting can lead to damage accelerating unwanted changes during fish freezing and storage. Reduced herring cutting quality affects the fillet texture when stored in frozen state. The results of organoleptic assessment of quality and sanitary significant microflora of the studied samples of frozen Atlantic and Pacific herring fillets showed that all fillet samples comply with the requirements for quality and safety of fish (Bremner, 2002; Blackburn, 2006).

Fatty fish species are known to contain more than 5% of lipids localized in tissues as triglycerides. Seasonal fluctuations in the fat content of the Atlantic herring are significant and can vary from 1 to 25% of the total fat content. The tendency of frozen fish to rancid depends on the fatty acid composition and localization of adipose tissue (Rehbein & Orlick, 1990).

It was found that the fat content of Pacific herring, which is caught in the winter period, is higher than that of the Atlantic by 3.2%, and the moisture content is less by 5%. The protein content in both types of herring is approximately the same (Table 1).

Table 1. Total chemical composition of the studied herring fillets

Characteristics	Atlantic		Pacific	
	Winter catch	USFDA* data	Winter catch	USFDA* data
Protein, %	16.9 ± 0.2	17.7	16.3 ± 0.2	14.0
Fat, %	16.3 ± 0.3	12.5	19.5 ± 0.4	15.0
Moisture, %	68.3 ± 2.0	61.3	63.3 ± 1.8	69.5

* – USFDA – *Food and Drug Administration*is the federal agency of the United States Department of Health and Human Services.

It was found that saturated fatty acids in the studied fillet samples are represented by palmitic (C16:0) and myristic (C14:0) acids, the content of stearic (C18:0) acid is very small (Table 2).

Monounsaturated fatty acids are represented by the ω-9 family: oleic (C18:1), the sum of gadoleic (C20:1(n11) and gondoic (C20: (n9), eruca (cis-13-docosenoic) 22:1(n9) acids.

Polyunsaturated fatty acids are represented by acids of the ω-3 family: docosahexaenoic (C22:6(n3), eicosapentaenoic, stioric acid (C18:4(n3), alpha-linolenic (C18:3(n3), clupadonic (C22:5(n3) acids.

Table 2. Fatty acid composition of lipids for Atlantic and Pacific herring fillet

Designation	Fatty acid composition of herring fillet		*USFDA* data***	
	Atlantic	Pacific	Atlantic	Pacific
Saturated Fatty Acids (SFAs)				
8:0	- *	-	-	-
10:0	0.24 ± 0.02	0.32 ± 0.03	0.06	-
12:0	-	-	0.15	-
14:0	- *	4.73 ± 0.25	7.04	7.34
16:0	12.07 ± 0.60	12.50 ± 0.65	17.20	16.27
18:0	0.87 ± 0.04	1.13 ± 0.05	1.39	2.07
20:0	0.14 ± 0.01	0.16 ± 0.01	-	-
22:0	0.03 ± 0.01	0.04 ± 0.01	-	-
Monounsaturated fatty acids (MUFAs)				
16:1	4.82 ± 0.25	6.51 ± 0.30	7.91	8.50
18:1n9	8.12 ± 0.40	12.91 ± 0.65	19.28**	23.42**
18:1n11	1.07 ± 0.05	3.12 ± 0.16	-	-
20:1**	10.87 ± 0.50	12.76 ± 0.65	9.17	10.93
22:1n9	16.44 ± 0.80	19.54 ± 0.95	10.68	12.00
Polyunsaturated fatty acids (PUFA)				
18:2n6	1.60 ± 0.08	0.57 ± 0.03	1.65	1.54
18:3n3	1.55 ± 0.08	0.18 ± 0.01	1.31	0.46
18:4n3	4.45 ± 0.20	0.82 ± 0.04	2.72	1.99
20:2n6	0.22 ± 0.01	0.08 ± 0.01	-	-
20:3n3	0.36 ± 0.02	0.20 ± 0.01	-	-
20:4n3	0.70 ± 0.03	0.23 ± 0.01	0.76**	0.77**
20:4n6	0.17 ± 0.01	0.04 ± 0.01	-	-
20:5n3	7.26 ± 0.40	6.51 ± 0.30	9.01	10.93
22:5n3	0.70 ± 0.03	0.53 ± 0.03	0.70	1.38
22:6n3	9.32 ± 0.50	5.25 ± 0.30	10.96	5.54

* – The content of fatty acid is less than 0.1%; ** – I someresum; *** – USFDA – *Food and Drug Administration*is thefederal agency of the United States Department of Health and Human Services.

It was proved that polyunsaturated fatty acids have antioxidant properties, preventing premature aging, participate in the synthesis of prostaglandins, remove excess cholesterol in the form of unsaturated esters from the human body, thus contributing to the prevention of cardiovascular diseases, joint inflammation, and vision improvement (Hooper et al., 2019).

A characteristic statistically significant difference between the fatty acid composition of the Atlantic herring fillet sample and the Pacific herring consists in a significantly higher content of docosahexaenoic acid: about 10% and 5–5.5%, respectively. This difference is observed for the studied samples.

Fig. 1 shows the TAG composition for samples of Atlantic and Pacific herring fillets. The number after the letter T denotes the total number of carbon atoms in the acyl chains of TAG. For example, T48 corresponds not only to tripalmitin with three residues with a chain length of 16 carbon atoms, but also to all isomers containing saturated and unsaturated acid residues with a total chain length of 48 carbon atoms - lauryl distearin, oleyl palmityl myristine, etc.

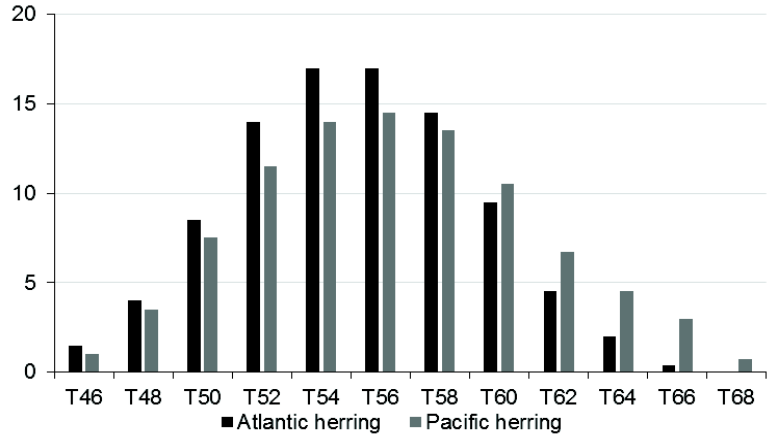

Figure 1. Distribution of triacylglycerols (TAG) in herring samples, %. T is the total number of carbon atoms in acyl chains of TAG.

The fillet samples were found to have different fractional composition of triacylglycerols. For the Atlantic herring fillet sample, the maximum in the T54–T56 region is characterized by a sharper decline to the high molecular weight region, while noticeable amounts of triglycerides with a total length of acyl chains T66 and T68 are present in fat of Pacific herring fillet.

It was revealed that the level of lipid decomposition products (free fatty acids) in herring fillet is 3–5% of neutral fat (Table 3). The total content of free fatty acids (FFA) in the Pacific herring fillet is 1.5 times higher than that in the Atlantic herring fillet.

Table 3. The content of lipid hydrolysis products (FFA) in herring, g kg^{-1}

Herring	Amount of carbon atoms in FFA						
type	C12	C14	C16	C18	C20	C22	Total
Atlantic	0.11 ± 0.01	1.61 ± 0.08	7.09 ± 0.35	5.36 ± 0.30	8.06 ± 0.40	11.31 ± 0.60	33.54
Pacific	0.24 ± 0.01	1.44 ± 0.07	11.80 ± 0.60	8.32 ± 0.40	12.22 ± 0.60	16.25 ± 0.80	50.27

The amino acid composition of the Atlantic herring is presented in Table 4. It was found that the content of indispensable amino acids (AA) in the herring fillet of winter catch is about 5 mg g^{-1} higher than that in the fillet of autumn catch, but their percentage in the total composition of amino acids does not depend on the catch season. The differences between the obtained values and the data provided by USFDA (The federal agency of the United States Department of Health and Human Services) are attributed to environmental factors in the habitat of Russian herring.

Table 5 presents the content of biogenic amines in samples of Atlantic and Pacific herring fillets. It was revealed that reduction and demethylation of TMAO is almost limiting (methylamine predominates, TMA and TMAO are absent).

Table 4. The amino acid composition of the Atlantic herring fillet

Designation by nomenclature	Season of catch				*USFDA* data	
	Autumn		Winter			
	mg g^{-1}	%	mg g^{-1}	%	mg g^{-1}	%
Asp	13.4 ± 0.7	10.8 ± 0.6	14.2 ± 0.7	10.8 ± 0.6	18.39	11.3
Glu	22.3 ± 1.0	17.9 ± 0.9	24.2 ± 1.1	18.4 ± 0.9	26.81	16.5
Ser	5.2 ± 0.3	4.1 ± 0.2	4.8 ± 0.3	3.6 ± 0.2	7.33	4.5
His	3.0 ± 0.2	2.4 ± 0.1	4.1 ± 0.2	3.1 ± 0.2	5.29	3.2
Gly	6.7 ± 0.3	5.4 ± 0.3	7.8 ± 0.4	6.0 ± 0.3	8.62	5.3
Thr*	6.4 ± 0.3	5.1 ± 0.3	6.1 ± 0.3	4.6 ± 0.2	7.87	4.8
Ala	9.0 ± 0.5	7.2 ± 0.3	9.6 ± 0.5	7.3 ± 0.3	10.90	6.7
Arg	8.3 ± 0.4	6.7 ± 0.3	8.4 ± 0.4	6.4 ± 0.3	10.80	6.6
Tyr*	3.8 ± 0.2	3.1 ± 0.2	4.6 ± 0.2	3.5 ± 0.2	6.06	3.7
Val*	7.3 ± 0.4	5.8 ± 0.3	7.0 ± 0.4	5.3 ± 0.3	9.25	5.7
Met*	4.4 ± 0.2	3.5 ± 0.2	4.4 ± 0.2	3.4 ± 0.2	5.32	3.3
Phe*	4.9 ± 0.3	3.9 ± 0.2	5.5 ± 0.3	4.2 ± 0.2	7.01	4.3
Ile*	5.5 ± 0.3	4.4 ± 0.2	7.3 ± 0.4	5.6 ± 0.3	8.28	5.1
Leu*	11.0 ± 0.6	8.9 ± 0.5	12.2 ± 0.6	9.3 ± 0.5	14.60	9.0
Lys*	13.1 ± 0.7	10.5 ± 0.5	14.1 ± 0.7	10.7 ± 0.6	16.50	10.1
The sum of indispensable amino acids	56.4	45.2	61.2	46.6	74.9	46.0

* – indispensable amino acids.

Thus, we can conclude that, despite the microbiological and organoleptic characteristics of frozen herring fillet meet the regulatory requirements, the studied samples of Atlantic and Pacific herring fillets contain a significant amount of hydrolytic decomposition products of proteins and lipids.

The Atlantic and Pacific herring fillet salting was carried out for 5 days at a temperature of 0 ± 2 °C. Salt and moisture content in the herring fillet and brine were measured with a frequency of 0.5 days.

Table 5. The content of free amines in extracts of herring fillet samples, g kg^{-1} (relative inaccuracy is 10%)

Herring fillet	Methylamine	Dimethylamine	Trimethylamineoxide	Trimethylamine
Atlantic	2.59	0.12	Less than0.01	Less than 0.01
Pacific	1.56	1.41	Less than0.01	Less than0.01

Salted semi-finished product of the Atlantic herring with a salt content of 4% and Pacific herring with a salt content of 4.5% are used for preparation of preserves. It was found that the salting duration of Atlantic herring fillets to the required salt content in fish is about 72 hours, and the duration of salting of Pacific herring fillets is about 120 hours.

It was revealed that the moisture-holding capacity of herring fillets during salting increases, which is explained by salt action on the muscle proteins of fish. The total percentage of bound moisture in slightly salted herring fillets increases by 3–4% by weight (Ozerova et al., 2017).

The studies of herring fillet buffering shows an increase in this indicator during salting to 70 degrees.

For the preparation of preserves, filling mixtures containing gelling components based on apple (0.85–1.40%) and citrus (0.87–1.33%) pectin, apple (3.0–3.5%) and wine (3.0–3.47%) vinegar with sugar and flavoring compositions from dry spices were developed.

Table 6 presents the nutritional and energy value of preserves from herring fillet in jelly. It was found that 100 g of 'Spicy herring in jelly' preserves allows one to fully cover the daily needs for polyunsaturated fatty acids of the omega-3 group.

Table 6. Nutritional and energy value for 100 g of 'Spicy herring in jelly' preserves

Protein, g	Fat, g	Carbohydrates, g	Calorific value, kcal
9.5	5.0	4.5	100
PUFAs content			
Name	g $100g^{-1}$	% of daily needs per day	
ω 3	1.05	105	
ω 6	0.07	2.75	

Table 7 presents the results of study of sanitary-indicative microflora of experimental and control samples of fish preserves 'Spicy herring in jelly' before and after refrigerated storage.

The results were compared with the standards established by the Commission Regulation (EC) on microbiological criteria for foodstuffs (2005). It was found that samples with addition of bio-protective cultures had a safe level of microbiological parameters, in contrast to control samples without addition of bio-protective cultures.

Table 7. Microbiological indicators of preserves 'Spicy herring in jelly' during storage at 4 ± 2 ºC for 25 days

Indicator	Control sample of the 'Spicy herring in jelly'		Experimental sample of the 'Spicy herring in jelly'		Standards
	Before storage	After storage	Before storage	After storage	
APC kfu·g^{-1}	1.0×10^2	1.2×10^3	1.0×10^2	2.0×10^2	1.0×10^5
Escherichia coli in 0.001 g	Not detected	Not detected	Not detected	Not detected	Are not allowed
Staphylococcus aureus in 0.01g	Not detected	Not detected	Not detected	Not detected	Are not allowed
Bacteria of the *Clostridium* genus in 0.01 g	Not detected	Not detected	Not detected	Not detected	Are not allowed
Mould, CFU·g^{-1}	Less than 10	10	Less than 10	Less than 10	Not more than 10
Yeasts, CFU·g^{-1}	Less than 10	11	Less than 10	Less than 10	Not more than 100

The microflora of preserves is represented by a significant number of rod-shaped bacterial cells, cocciform and diplobacteria are less observed (Ozerova et al., 2018). After 25 days of storage, a slight stratification of herring meat was observed in the control sample of preserves. One to two rods and diplobacteria were present in smears

from muscle deep layers within the field of view, and decomposed fibers of muscle tissue were visible on the glass slide. Extraneous microflora was absent in the experimental samples of preserves.

It was found that addition of *Lactobacillus sakei* to the fillings helps to soften the fish, which is associated with the acceleration of its maturation, which is confirmed by data shown in Fig. 2.

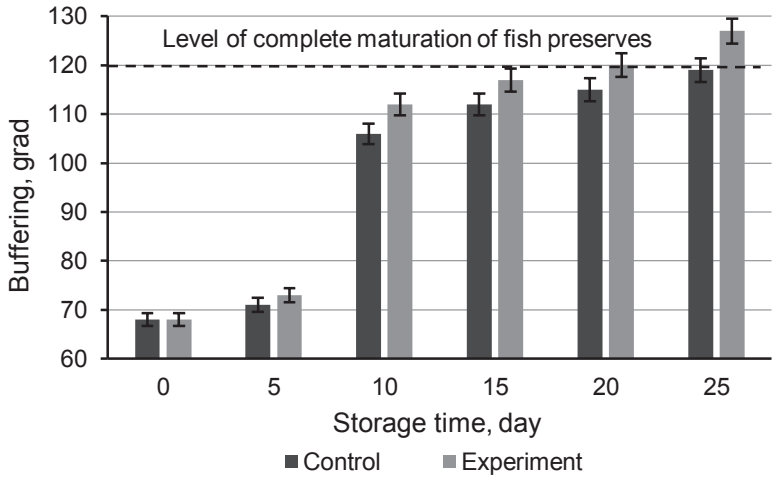

Figure 2. The influence of bio-protective cultures on maturation of 'Spicy herring in jelly' preserves during refrigerated storage. 4 ± 2 ºC, 25 days. The storage relevance between the control and experimental samples are statistically significant ($p < 0.05$).

It was also established that the sanitary-indicative microflora of 'Spicy herring in jelly' preserves during the entire storage period met the requirements of the Regulation standards.

It was found that the shelf life of preserves at a storage temperature of 4 ± 2 °C is 20 days taking into account the reserve ratio.

CONCLUSIONS

The studies of biochemical composition of the frozen fillet of Pacific and Atlantic herring showed that the fat content in the fillet during the winter period of catch in the Pacific herring is 3.2% higher than that of the Atlantic; the moisture content is 5% less, and the protein content is practically the same.

The PUFA content in the Atlantic herring fillet is 26.3%, and in the Pacific herring fillet it is 33.4% of the total fatty acid composition. Omega-3 fatty acids are represented by eicosatrienic (20:3n3), eicosapentanoic (20:5n3), docosa-pentaenoic (22: 5n3) and docosahexaenoic (22: 6n3) acids, and omega-6-fatty acids are linoleic (18:2n6), eicosadiene (20:2n6) and arachidonic (20:4n6) acids. A statistically significant difference between the fatty acid composition of the Atlantic herring fillet sample and the Pacific herring was revealed, which consists in a significantly higher content of docosahexaenoic acid: about 10% versus 5–5.5%, respectively.

It was established that the total content of PUFAs does not depend on the herring catch season and is somewhat different from the Food and Drug Administration data, which states for the influence of the herring habitat region on the ratio of fatty acids in herring lipids.

The difference between the samples of Atlantic and Pacific herring fillets by the fractional composition of TAG was established. For Atlantic *C. harengus* herring samples, the maximum in the T54–T56 region is characterized by a sharper decline to the high molecular weight region, while noticeable amounts of triglycerides with total acyl chain length of T66 and T68 are present in the Pacific herring fat.

The total content of free fatty acids in the Pacific herring fillet is 1.5 times higher than that in the Atlantic herring fillet, which indicates a more intensive process of lipid hydrolytic decomposition.

The studies of biogenic amines in frozen herring fillet showed almost complete reduction and demethylation of trimethylamino oxide, which is proved by predominance of methylamine.

The study of quality indicators of 'Spicy herring in jelly' preserves during refrigerated storage for 25 days revealed a slight decrease of solids content in fillings (by 0.4%). The indicator of buffering of preserves during storage increased to 127 grad, which indicates the completion of the ripening process of preserves. It was found that addition of bio-protective cultures containing the *Lactobacillus sakei* strain contribute to the acceleration of maturation of preserves and suppression of the process of microbiological damage during refrigerated storage.

Recipes and technology of cold appetizers from herring fillet in jelly preserves were introduced at 'Baltic coast' JSC (St. Petersburg).

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