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The influence of lingonberry and sea buckthorn powder-aqua solutions on the nutritional value of sander roe

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ABSTRACT

Fish roe is a rich source of polyunsaturated fatty acids, essential amino acids and several vitamins. The paper presents the possibility of using fish caviar treatment with berry solutions instead of traditional preservatives. The purpose of this study is to determine the effect of berry solutions from lingonberry powder (Vaccinium vitis-idea) and buckthorn (*Hippophae rhamnoides*) on the nutritional, biological value and safety of walleye caviar through the use of wild plants as preservatives. Samples of the caviar of the common walleye Sander (*Sander lucioperca*) were selected as research objects. The results showed that experimental caviar samples treated with berry solutions showed differences ($p>0.05$) compared to the control sample with saline solution, this proves an increase in the nutritional value and safety of fish caviar. It is also shown that the use of berry solutions from cranberries (LS) and sea buckthorn (SBS) combined with salt is 35% more effective compared to the control sample containing only salt (S). This means that using berry solutions significantly improves the results compared to the traditional canning method. This effect may be due to the additional beneficial properties of berry extracts, such as antioxidant and antimicrobial activity, which contribute to better preservation of caviar quality and safety. It was found that using a berry solution from cranberry powder revealed the best result. Also, it was shown that the greatest value and composition was possessed by the LS sample, which more satisfied the daily requirement of vitamins A, E and B group in comparison with other samples ($p>0.05$), the content of vitamin A (0.016±0.014); vitamin B (0.24±0.16); vitamin E (2.89±0.04); vitamin PP (2.1±0.05). This is because treating pikeperch caviar with berry solutions increases the amount of water-soluble and fat-soluble vitamins.

Keywords: common lingonberry (*Vaccinium vitis-idaea*), pikeperch roe, sea buckthorn (*Hippophae rhamnoides*), food safety, amino acids, vitamins

INTRODUCTION

Caviar, a symbol of luxury today, has come a long way since it was mainly distributed in the regions around the Caspian Sea. In the early 1700s, caviar was popular in these parts, but during the 18th century, it became a subject of import to Europe. Here, caviar quickly gained popularity among elite society and became a symbol of status and sophistication. By the end of the 20th century, the increased demand for caviar on the international market led to serious environmental consequences. Producers began overfishing wild sturgeon to meet this demand and maximise profits, which led to a sharp decline in their population. The mass production of caviar for export threatened not only wild sturgeon populations but also the sustainability of the business itself. These events have led to stricter regulations and the development of alternative production methods, such as aquaculture, to conserve sturgeon and ensure sustainable caviar production **[1]**.

Caviar is a semi-canned fish product, and certain storage and packaging conditions are important to ensure its safety. Storing caviar at a low temperature, around 0 °C, slows the growth of microorganisms and preserves its freshness. Packaging caviar under anaerobic conditions, i.e., without access to air, is also critical, as it helps prevent oxidation and bacterial growth that can cause product spoilage. These measures preserve the quality of caviar and extend its shelf life while ensuring consumer safety **[2]**. Caviar is a valuable food product due to its unique chemical composition, which includes complete proteins, highly unsaturated fatty acids, vitamins, and macro- and microelements. Caviar products from various fish species, such as sturgeon, salmon, cod, herring, and sea urchins, have a high nutritional value.

Pikeperch caviar is especially popular. It combines valuable nutritional properties with a relatively low cost, making it available to a wide range of people with different levels of financial well-being. Pikeperch caviar is rich in easily digestible proteins, fats, and vitamins of groups A, D, E, and B.

Caviar has a low lipid content, but it contains all important water-soluble vitamins. Its chemical composition includes the following vitamins:

- Thiamine (vitamin B1): 50-95%
- Riboflavin (vitamin B2): 110-830%
- Folic acid (vitamin B9): 10-12%
- Cyanocobalamin (vitamin B12): 0,7-1,4%
- Niacin (vitamin B3): 1 000-3 200%
- Pantothenic acid (vitamin B5): 50-200%.

These vitamins play an important role in metabolism and maintaining the body's health, making caviar tasty and healthy food **[3]**.

One of the priority tasks in caviar production is ensuring the high quality of finished products, which includes controlling the permissible level of bacterial contamination. To achieve these goals, producers use preservatives. Preservatives help prevent the growth and multiplication of pathogenic microorganisms that can cause the product to spoil and threaten consumers' health.

Preservatives in caviar perform several important functions:

Stabilisation of the product, preventing its oxidation and change in taste.

Increasing the shelf life of caviar while preserving its nutritional value.

Reducing the risk of dangerous bacteria such as Clostridium botulinum, which can cause botulism.

Currently, in response to customers' increasing needs and requirements for the quality of food products, there is a steady tendency to expand the range of products. One key direction is the search and introduction of natural food additives, which can increase the nutritional value of products while having a preserving effect. This allows for the reduction of the dose or the elimination of the use of chemical preservatives.

Natural food additives such as herbal extracts, spices, essential oils, organic acids, and antioxidants are becoming increasingly popular in the food industry. They improve the taste and flavour of products and help extend shelf life by inhibiting the growth of pathogens.

This approach aligns with the current trends towards healthy eating and environmental safety and meets consumer demand for products with minimal artificial additives. As a result, natural preservatives and food additives are becoming an important element of innovation in the food industry, contributing to safer, healthier, and higher-quality food products.

However, to ensure the preservation of caviar quality without preservatives, it is necessary to increase its salinity, which leads to the deterioration of its organoleptic properties and reduces the product's usefulness. In recent years, products with a reduced sodium chloride content have been produced to prevent violations of salt metabolism in the human body and cardiovascular and other diseases. At the same time, preserving caviar only with sodium chloride and storing it at sub-zero temperatures does not provide the necessary microbiological level of safety during long-term storage.

Preservatives—sodium benzoic acid and potassium sorbate— traditionally preserve fish products. However, with modern tendencies to reduce chemical preservatives, natural preservatives and spice oil extracts from natural plant components are offered to replace them.

To those mentioned above, the development of caviar preparation technology with vegetable additives that have a positive effect not only on the organoleptic characteristics of products but also on the storability, providing the realisation of the direction of expanding the range of caviar products, is relevant. One of the main tasks of caviar product technologies is to produce products safe for consumers, have pleasant organoleptic characteristics without adding preservatives that inhibit bacterial spoilage of the product, and have a long shelf life **[4]**.

Based on the above, natural substances that will ensure finished products' microbiological and food safety must be searched for. Wild fruits can be an alternative to existing preservatives. Two of the most popular wild fruits are cowberries and sea buckthorn.

Lingonberries (*Vaccinium vitis-idaea*) grow in the north of Kazakhstan. Lingonberries contain many biologically important substances - sugars from 8 to 10% (glucose - up to 3.6%, fructose - up to 4.6%, sucrose - up to 0.6%), organic acids (2.0-3.5 %), vitamins B - 0.03 mg %, E - 1.0 mg %, provitamin A (carotene) - 0.05-0.10 mg%, minerals (0.26-0.35 %), tannins (100-400 mg). The organic acids in cranberries contain citric, malic, tartaric, salicylic, boric and benzoic acids. Benzoic acid is an antiseptic and a strong natural antioxidant which significantly affects the strengthening of cell membranes in the body **[5]**, **[6]**, **[7]**.

Figure 1 Common lingonberry (*Vaccinium vitis-idaea*).

Sea buckthorn (*Hippophae rhamnoides*) belongs to the genus sea buckthorn (*Hippophaë*), family Elaeagnaceae. Sea buckthorn fruits contain carbohydrates (8.0-8.5%), including pectin substances (0.4-0.5%), organic acids (2.0-2.5%), tannins, vitamins C (200 mg%), E (5 mg%), group B (2.32 mg%), various macro- and microelements (0.3-0.7%), and sea buckthorn oil (1.7-8.0%), rich in unsaturated fatty acids (linoleic and linolenic) **[8]**, **[9]**, **[10]**.

Figure 2 Buckthorn (*Hippophae rhamnoides*).

The purpose of this study is to determine the influence of berry solutions of lingonberry (*Vaccinium vitis-idaea*) and sea buckthorn (*Hippophae rhamnoides*) powder on the nutritional, biological value, and safety of pikeperch caviar due to the use of wild fruits as preservatives.

We selected samples of fresh pikeperch roe aged in berry solutions as objects of study. Fresh caviar – Lightly salted, requires refrigeration, short shelf life To prepare the berry solution, we used powders of common cowberry and sea buckthorn.

Scientific Hypothesis

This paper presents the results of a study of pikeperch (*Sander lucioperca*) caviar using berry solutions prepared from lingonberry (*Vaccinium vitis-idaea*) and sea buckthorn (*Hippophae rhamnoides*) powder. Treatment of caviar with lingonberry powder solution has a positive effect on its nutritional value, microbiological safety and organoleptic properties due to the antimicrobial and antioxidant properties of lingonberries, which improves the quality of the product and increases its shelf life compared to traditional methods of preservation.

MATERIAL AND METHODOLOGY

Samples

Pikeperch roe *Sander lucioperca*, belonging to the perch family (Percidae), was obtained from Bolashak Bastau Company, Republic of Kazakhstan. Fruit of lingonberry (*Vaccinium vitis-idaea*) and sea buckthorn (*Hippophae rhamnoides*) were received from Synthite Industries (Almaty, Kazakhstan).

Chemicals

Barium hydroxide $Ba(OH)_2$, sulfuric acid H_2SO_4, barium sulfate $BaSO_4$, hexane C_6H_{14} were purchased from Sigma-Aldrich, Inc. (Merck KGaA, Darmstadt, Germany), which guarantees high quality and reliability of the chemicals used in the experiments.

Instruments

Capillary electrophoresis: "Droplet 105A" (Agilent Technologies (USA)).

Gas chromatograph: "Crystallux 4000M" (Meta-Chrome, Russia)

Laboratory Methods

The study of the chemical composition of caviar consisted in determining the content of protein, fat, moisture, ash, vitamins, and minerals according to ISO 12875:2011, Traceability of finfish products — Specification on the information to be recorded in captured finfish distribution chains.

Toxic metals were determined according to GOST 30178-96 **[11]**.

The out mass fraction of amino acids was measured by capillary electrophoresis using the capillary electrophoresis system "Kapel 105 A" **[12]**. A 0.1000 g weight of the product under study was placed in a glass vial, 5 cm^3 of barium hydroxide solution was added. The vial is placed in the desiccator, which is placed in a desiccator for 14 - 16 hours at a temperature of 110 °C. At the end of hydrolysis, hot hydrolysate from the vial was quantitatively transferred to a measuring flask with a capacity of 100 cm^3, in which previously placed 40 - 50 cm^3 of distilled water was, add 1 - 3 drops of methyl red indicator and neutralise the solution by first adding 3.5 cm^3 of the sulfuric acid solution, and then add sulfuric acid solution drop by drop until the colour changes from yellow to pink. Then, bring the volume of the solution to the mark with distilled water, stir, and leave for 10 - 15 minutes until the solution is clear above the barium sulfate precipitate. 1.0 cm^3 of the obtained solution is placed in an Eppendorf tube and centrifuged for 2-3 min at 6000 vol/min, after which 0.5 cm^3 of the solution is transferred into a dry Eppendorf tube and used for analysis.

The study of fatty acids was carried out on the gas chromatograph "Crystallux 4000 M". It is equipped with a flame ionisation detector and quartz capillary column SP – 2560 100 m×0.25 mm ID, 0.2 µm fixed phase F. The Supelco ® 37 FAME Mix standard was used as an identification mix. The following chromatographic separation parameters were used: nitrogen was used as a gas carrier, T1 temperature for column 65-70 °C (retention period 5 min), T2 at a speed of 4G/min 240 °C, evaporator temperature 230 °C, detector 260 °C, volume of the introduced sample 1 µL. To control the modes of analysis and to process the chromatogram and the data obtained, the program "NetChrom 2" was used. We showed the latest results in percentages obtained from total fatty acids. The fatty phase was separated for the preparation of methyl esters. A sample of oil taken for the test was thoroughly mixed. Then, the oil (2-3 drops) was taken with a glass test tube and dissolved in 1.9 cm^3 of hexane. After stirring the reaction mixture vigorously (2 min), it was allowed to stand for 5 min and filtered. Then, the mixture ready for analysis was sent to the gas chromatograph **[13]**.

The methods of sampling and sample preparation for microbiological analyses were determined according to ISO 6579-1:2017/Amd 1:2020. Meat-peptone agar was used for all microbiological analyses (BioMedia, Russia).

Description of the Experiment

Sample preparation:

The berries were distributed evenly on mesh baking trays and dried convectively in cabinet-type dryers at 30 - 60 °C to a residual humidity of 5 - 8.5 %, obtaining dried berries. Then, they were cooled and ground to a particle size of no more than 50 µm, obtaining berry powder.

The whole 200-400 grams oyster was carefully immersed and kept in different solutions: in salt solution at the rate of 3% salt per 100 ml of water; in berry solution (with lingonberries) at the rate of 3% salt, 1% lingonberry powder per 100 ml of water; in berry solution (with sea buckthorn) at the rate of 3% sea buckthorn powder per 100 ml of water, 1% salt, at the temperature of 10-15 °C, for 20 min.

The research was conducted at the «Research Laboratory for Assessing the Quality and Safety of Food Products», Almaty Technological University.

Number of samples analyzed: we analysed 24 samples.

Number of repeated analyses: 3

Number of experiment replication: 3

Design of the experiment: The physicochemical parameters of caviar were carried out according to standard methods. These methods include assessing caviar appearance, colour, consistency, taste, and aroma. Standard methods ensure accuracy and comparability of results, which allows objective assessment of the quality of caviar and its compliance with regulatory requirements.

Statistical Analysis

The statistical analysis was done using the SPSS program (IBM SPSS STATISTICS 20, SPS Tc.). The Tukey HSD test was selected to compare the roe's quality parameters. The analysis of the methods was carried out using a single-factor analysis of variance (ANOVA). This means that the comparison was performed at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

Changes in the physicochemical composition of experimental samples aged in solutions are presented in Table 1.

The analysis of Table 1 showed that the protein content of the samples did not differ significantly from each other. The amount of protein are samples S (18.34±0.21), LS (18.35±0.21) and SBS (18.35±0.33), respectively. There was a slight decrease in fat in the experimental sample LS (0.19±0.2). In sample S (79.04±1.05), the moisture content is higher; this rather depends on the characteristics of the fish, the stage of maturity of the eggs and the method of processing. The sample S (1.51±0.03) shows an increase in ash content, while the LS (1.52±0.01) and SBS (1.58±0.01) samples show a decrease.

Table 1 Physicochemical parameters of the roe of Sander fish of the studied samples

Component	S	LS	SBS
Protein, %	18.34±0.21[a]	18.35±0.21[a]	18.35±0.33[a]
Fat, %	0.20±0.1[a]	0.21±0.1[a]	1.21±0.2[b]
Water, %	78.14±1.87[a]	76.94±1.62[a]	76.48±2.62[a]
Ash, %	1.45±0.03[a]	1.52±0.01[b]	1.58±0.01[c]

The study of vitamin composition showed (Table 2) that LS and SBS significantly increased in the experimental samples. The LS sample has the highest value and composition, which more satisfied the daily requirement of vitamins A, E and B group compared to other samples, ($p>0.05$), the content of vitamin A (0.016±0.014); vitamin B (0.24±0.16); vitamin E (2.89±0.04); vitamin PP (2.1±0.05). This is because treatment of pikeperch caviar with berry solutions increases the amount of water-soluble and fat-soluble vitamins.

Table 2 Results of studies on vitamin content in tested specimens.

Specimens/Vitamins, mg/100 g	S	LS	SBS
Vitamin A	0.014±0.01[a]	0.016±0.014[a]	0.015±0.010[a]
Vitamin B	0.20±0.12[a]	0.24±0.16[a]	0.21±0.11[a]
Vitamin E	2.84±0.01[a]	2.89±0.02[6]	2.89±0.03[6]
Vitamin PP	2.07±0.06[a]	2.3±0.05[c]	2.18±0.04[b]

A comparison of the results obtained from the mineral composition of the samples (Table 3) indicates that an increase in the content of macro- and microelements is observed in experimental samples of LS and SBS. In the sample LS, potassium (294.36±0.93), calcium (44.51±0.50), sodium (42.524±0.12), iron (1.25±0.05), phosphorus (240.14±0.14), higher than in other samples, in the sample SBS, potassium (283.36±0.65), calcium (44.64±0.35), sodium (41.84±0.34), magnesium (25.45±0.31), iron (1.17±0.04), phosphorus (236.71±0.12), which indicates that caviar extract in berry solutions significantly increases the mineral content.

Table 3 The content of minerals compositions in the studied roe samples.

Mineral elements, mg/g	KS	LS	SBS
Potassium	271.21±0.22[a]	294.36±0.93[c]	283.36±0.65[b]
Calcium	40.75±0.21[a]	44.51±0.50[b]	44.64±0.35[b]
Sodium	38.50±0.18[a]	42.524±0.12[c]	41.84±0.34[b]
Magnesium	24.01±0.15[a]	25.44±0.55[b]	25.45±0.31[b]
Iron	1.11±0.02[a]	1.25±0.05[a]	1.17±0.04[a]
Phosphorus	233.12±0.93[a]	240.14±0.14[c]	236.71±0.12[b]

Table 4 summarises the results of the samples for toxic elements. As can be seen from the data, in sample KS, arsenic (< 0.25) was detected; in sample LS and SBS, cadmium (< 0.25),) in sample SBS, lead (< 1.0), while no toxic elements were detected in sample LS.

Table 4 The content of toxic elements in the studied roe samples.

Toxic elements, mg/g	KS	LS	SBS
Pb	not found	not found	< 1.0
Cd	< 0.25	not found	< 0.25
As	not found	not found	not found

In samples KS, LS and SBS studied comparison of the amino acid composition of caviar aged in different solutions (Table 5), showing the presence of all essential amino acids, the content of which is from 0.18 to 1.90 g, which is more than 46.9 % of the total amount of essential amino acids. The analysis revealed a rather high content of leucine (0.94-0.96 %), valine (0.88-1.05 %), lysine (0.62-1.63 %), phenylalanine (0.18-0.23 %), threonine (0.76-0.85 %) and tryptophan (1.86-1.90 %).

Table 5 The amino acid composition in the studied roe samples.

Amino acid	KS	LS	SBS
Valine	0.98±0.25[a]	1.05±0.54[a]	0.98±0.35[a]
Leucine + Isoleucine	0.94±0.38[a]	0.96±0.42[a]	0.95±0.29[a]
Lysine	1.63±0.26[b]	1.65±0.59[b]	1.63±0.21[a]
Methionine	0.54±0.22[a]	0.55±0.25[a]	0.55±0.14[a]
Threonine	0.80±0.31[a]	0.85±0.38[a]	0.81±0.25[a]
Tryptophan	1.86±0.16[a]	1.90±0.12[a]	1.87±0.08[a]
Phenylalanine	0.18±0.01[a]	0.23±0.02[b]	0.22±0.02[b]
Arginine	1.04±0.36[a]	1.08±0.31[a]	1.05±0.51[a]
Tyrosine	0.50±0.42[a]	0.52±0.41[a]	0.50±0.15[a]
Histidine	0.40±0.14[a]	0.50±0.37[a]	0.48±0.24[a]
Proline	1.13±0.26[a]	1.14±0.70[a]	1.15±0.31[a]
Serine	0.57±0.39[a]	0.59±0.35[a]	0.58±0.25[a]
Alanine	1.31±0.41[a]	1.33±0.25[a]	1.32±0.21[a]
Glycine	1.02±0.72[a]	1.04±0.14[a]	1.03±0.28[a]

The microbiological index of caviar aged in different solutions was compared in CW, LC and SBS samples (Table 6). The analysis showed that in the experimental sample LS, SBS, there was a slight decrease in the number of mesophilic aerobic and facultatively anaerobic microorganisms. The obtained results indicate that using sea buckthorn and lingonberry hulls not only increases the nutritional value of finished products, but also extends the shelf life of finished products. After treating the cans with a solution of lingonberry and sea buckthorn powder, the shelf life is up to 6 months.

Table 6 Results of microbiological parameters in the studied caviar samples.

Indicators	S	LS	SBS
Number of mesophilic aerobic and facultatively anaerobic microorganisms	$8 \cdot 10^3$	$2 \cdot 10^3$	$5 \cdot 10^3$
Coliforms	undetected	undetected	undetected
Sulphite-reducing clostridia	undetected	undetected	undetected
Staphylococcus aureus S.aureus	undetected	undetected	undetected
Salmonella	undetected	undetected	undetected
Moulds	undetected	undetected	2
Yeasts	15	9	12

The fatty acid composition shows (Figure 1) that the sum of saturated fatty acids in sample KS is 10.97%, in sample LS 15.16%, in sample SBS 15.52% and is mainly represented by palmitic and stearic acids. The proportion of monounsaturated fatty acids in LS and SBS samples is 33.10% and 34.66%, respectively, 1.62% and 3.18% more than in sample KS. Among the monounsaturated acids, oleic acid dominates with 21.48% (S), 21.96% (LS) and 22.94% (SBS), followed by palmitoleic acid with 6.75% (SBS), 6.95% (S) and 8.12% (LS), respectively. High polyunsaturated acid content (49.80-66.32%) was observed in LS and SBS samples, of which docosahexaenoic acid (22:6 wt.%) dominated with 30.20% and eicosapentaenoic acid (20:5 wt.%) with 6.01%. While sample S was dominated by linolenic acid (18:2 om6) -12.67%.

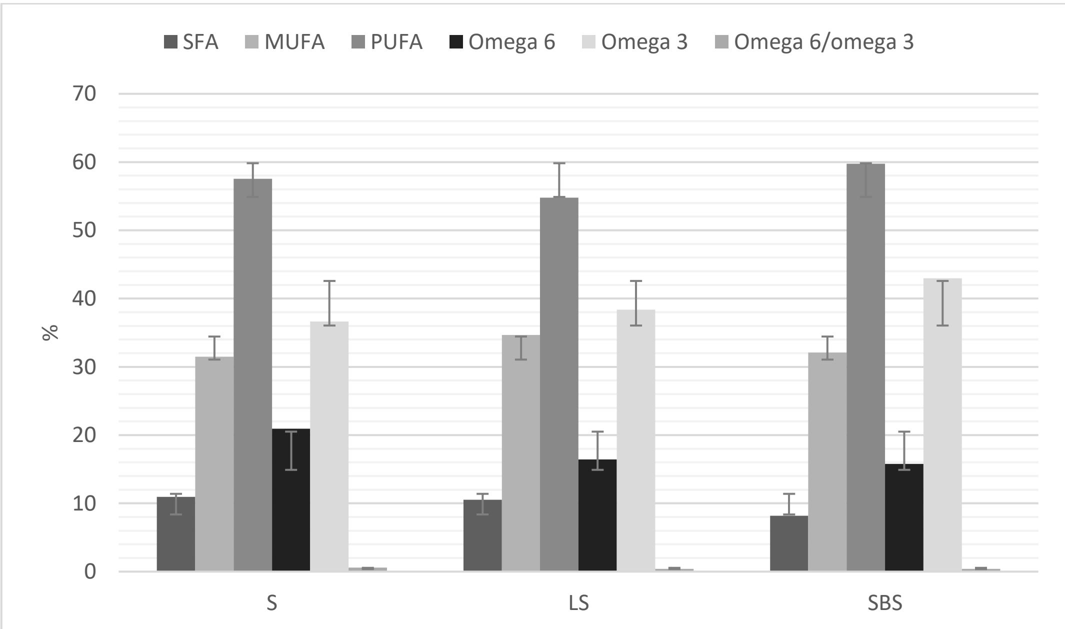

Figure 3 Comparison of fatty acid amounts in roes fat.

Studies show that using sea buckthorn in feed products improves the quality of end products, including poultry, pork, and fish **[14]**. Thus, using sea buckthorn in feed products can improve the nutritional value and quality of end products such as poultry, pork, and fish **[15]**.

Preservatives are used to obtain safe finished products in producing salted caviar from different fish species. The production method greatly influences the quality of ready-salted caviar **[16]**.

It should be noted that the technology for processing fish eggs and caviar is quite labour-intensive and has many stages. Therefore, strict observance of all parameters of the technological process, processing, and preservation of caviar grains is required. Kopylenko L.R. conducted scientific substantiation and developed technology for preserving sturgeon and salmon fish caviar **[17]**.

The results of the sample study showed significant differences ($p<0.05$) in terms of humidity: S, LS and SBS samples; ash: LS and SBS samples; fats: s and LS samples; proteins: LS and SBS samples, which indicates that different treatments affected the original composition of caviar, which draws attention to the high ash content for the S sample due to the use of NaCl without berry powder. Compared to raw materials, the humidity indicator decreased for all samples due to the immersion of caviar in brine and the use in the NaCl recipe. The Tuki test showed that all medium samples had significant differences in humidity ($p <0.05$); S and LS samples for Ash, LS and SBS for oils. In this study, NaCl and Berry solution's content slightly changed the amount of proteins and moisture in the samples. The use of fruit powders and NaCl may have contributed to the reduction of moisture, which led to the highest concentration and energy intensity of S-Type ash.

The mineral element content in the samples indicates the presence and effect of berry solutions on caviar. Lingonberries and sea buckthorn berries have high concentrations of trace elements, making them potential sources of significant minerals that play an important role in nutrition and maintaining human health. Compared to sample S, the LS and SBS samples had an increase in K, Ca, Na, Mg, Fe, and P content.

The main subject of the article is pikeperch caviar. Pikeperch (*Sander lucioperca*) is the largest freshwater predator of the Perch family, including perches and ruffs. This species inhabits warm and exceptionally clean water bodies, which affects its extract and organoleptic properties of caviar.

Caviar is a food product derived from the ovaries of fish, which undergoes a complex technological process to process caviar grains. The female pikeperch lays caviar in the form of long (up to 1 m) reticulated ribbons of gelatinous substance, and accompanying males fertilise it. Pikeperch spawn is characterised by strong watering. Its water content is up to 56% or more. The diameter is 1.0-2.0 mm (sometimes 1 mm). Caviar of particulate and other fish is sold in cans and barrels, i.e., free of connective tissue of caviar eggs and caviar balls.

It should be noted that few studies of pikeperch caviar exist, both among Russian-speaking authors and in English-language sources **[18]**. In recent decades, perch fish, particularly pikeperch, have become a subject of increased interest in the fishing industry on a global scale **[19]**.

In several research papers, scientists have investigated the use of chasteberry extract in meat pates **[20]** and other meat products **[21]**, as well as the effect of sea buckthorn powder on meat products **[22]**, **[23]**, **[24]**. These studies have shown that:

1. Cranberry extract, due to its antioxidant and antimicrobial properties, can improve the flavour, shelf life, and nutritional value of meat products.
2. Sea buckthorn powder has also been studied as an additive to meat products, providing benefits in the form of increased antioxidant activity, improved organoleptic properties, and enrichment of the product with vitamins and minerals.

These results highlight the potential of using natural berry additives to improve food quality and safety, which may also apply to the caviar considered in your paper.

Researchers **[25]** used sea buckthorn extract to produce freeze-dried carp roe substitutes as an antioxidant and antimicrobial agent. Due to its natural antioxidant and antimicrobial properties, sea buckthorn extract effectively improved the product's stability and safety **[25]**. These studies highlight the potential of using plant extracts to improve fish products' quality and shelf life, which may also be useful for developing similar solutions in producing pikeperch caviar.

Other scientists have also investigated the effect of sea buckthorn and lingonberry extract on the nutritional value of fish products **[26]**. These studies have shown that berry extracts can significantly improve the nutritional value and organoleptic properties of fish products due to the following factors:

- Antioxidant properties: Sea buckthorn and cranberry extracts contain active antioxidants that help prevent fat oxidation and maintain product freshness.
- Improved vitaminization: Berries are rich in vitamins (such as vitamins C and E) that can enrich fish products, making them more nutritious.

Antimicrobial properties: These extracts can inhibit the growth and development of microbes, which helps increase the shelf life of foods.

Using sea buckthorn and cranberry extracts may help create healthier and more spoilage-resistant fish products, which is of interest for further research and application in caviar production **[27]**. Scientists have also investigated the fact that sea buckthorn has various biological properties such as anti-inflammatory, antioxidant, and anti-cancer activities. These properties can significantly contribute to the nutritional value of fish products. **[28]**.

It has been shown that fruit and berry pomace can be effectively used in pickled fish products **[29]**. Thus, using fruit and berry extracts in marinated fish products effectively improves their safety, quality, and organoleptic properties.

Studies show that adding vegetable powders, including berry powders, can increase the moisture-holding capacity of minced fish products **[30]**.

A study of vitamin composition showed that treating Sander roes with berry solutions increases the amount of fat-soluble and water-soluble vitamins and significantly increases the mineral content.

The study of vitamin composition showed that treating pikeperch eggs with berry solutions increases the amount of fat-soluble and water-soluble vitamins and significantly increases the mineral content **[31]**. Studies have shown **[32]** that fish oil can be partially replaced by vegetable oils in the diet of young pikeperch without a negative effect on growth parameters **[33]**. However, increased lipid content in liver tissues and decreased lipid utilisation may be observed, indicating changes in metabolic processes related to lipid metabolism.

The results of toxic substance content tests determined the absence of lead and arsenic in samples S, LS and SBS, which allowed us to conclude that in the process of soaking in a solution with the addition of berry powders, toxic substances from caviar pass into solution, because under the influence of sodium chloride ions, hydration and solubility of proteins with which toxic substances are associated increases. As a result, toxic substances can pass from the roes into solution **[34]**. If the solution contains chitin or chitosan, which are sorbents, the toxic metals are not absorbed and are desorbed in the caviar grains **[35]**. This ensures that the toxic substances are removed from the caviar, thus increasing its safety and significantly improving the quality of roes products **[36]**. Also, it has been shown that coriander leaf extract can reduce heavy metal contamination in shellfish by reducing Pb, Hg, and Cu **[37]**.

The study of the composition of amino acids revealed the known changes in LS and SBS samples. This, perhaps, made it possible to obtain roe with high nutritional value when keeping roe in berry solutions, when the proteins penetrate the roe and accumulate. Since the roe did not undergo heat treatment, all biologically valuable nutrients were preserved in the product, which improved its quality.

Processing roe in berry solutions with the addition of salt will increase the shelf life of the product, as well as enrich the product with valuable nutrients **[38]**. Salt concentrations (2, 4 and 8%) affect rainbow trout caviar's physicochemical and microbiological quality parameters during 21-day storage at 4°C **[39]**. The results of the studies varied depending on the type of berry solution. Statistical analysis showed that the treatment with lingonberry solution was significantly more effective than the treatment with sea buckthorn and salt solution **[40]**.

Figure 4 Pike-perch roe pike-perch caviar before processing.

Figure 5 Pikeperch caviar pike-perch after treatment with lingonberry powder solution.

CONCLUSION

The results obtained in this study indicate differences between roe samples treated with different preservatives. The differences were particularly noticeable when all measured parameters (physical, chemical and microbiological) were combined.

The results of the sample study showed significant differences ($p<0.05$) in terms of humidity: S, LS and SBS samples; ash: LS and SBS samples; fats: s and LS samples; proteins: LS and SBS samples, which indicates that different treatments affected the original composition of caviar, which draws attention to the high ash content for the S sample due to the use of NaCl without berry powder. Compared to raw materials, the humidity indicator decreased for all samples due to the immersion of caviar in brine and the NaCl recipe. All medium samples showed significant differences in humidity ($p <0.05$); S and LS samples for Ash, LS and SBS for oils.

Also, it is shown that the sum of saturated fatty acids in sample KS is 10.97%, in sample LS is 15.16%, in sample SBS is 15.52% and is mainly represented by palmitic and stearic acids. The proportion of monounsaturated fatty acids in LS and SBS samples is 33.10% and 34.66%, respectively, which is 1.62% and 3.18% more than in sample KS. Among the monounsaturated acids, oleic acid dominates with 21.48% (S), 21.96% (LS) and 22.94% (SBS), followed by palmitoleic acid with 6.75% (SBS), 6.95% (S) and 8.12% (LS), respectively. High polyunsaturated acid content (49.80-66.32%) was observed in LS and SBS samples, of which docosahexaenoic acid (22:6 wt.%) dominated with 30.20% and eicosapentaenoic acid (20:5 wt.%) with 6.01%. While sample S was dominated by linolenic acid (18:2 om6) -12.67%.

The study found that berry solutions from lingonberry and sea buckthorn powder enrich food products with biologically active substances. Experimental work established that berry solutions improve the taste and aroma of aged roe and will exclude the addition of chemical preservatives in roe processing.

REFERENCES

1. Holembovska, N., Tyshchenko, L., Slobodyanyuk, N., Israelian, V., Kryzhova, Y., Ivaniuta, A., Pylypchuk, O., Menchynska, A., Shtonda, O., & Nosevych, D. (2021). Use of aromatic root vegetables in the technology of freshwater fish preserves. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 15, pp. 296–305). HACCP Consulting. https://doi.org/10.5219/1581
2. Lopez, A., Bellagamba, F., Tirloni, E., Vasconi, M., Stella, S., Bernardi, C., Pazzaglia, M., & Moretti, V. M. (2021). Evolution of Food Safety Features and Volatile Profile in White Sturgeon Caviar Treated with Different Formulations of Salt and Preservatives during a Long-Term Storage Time. In Foods (Vol. 10, Issue 4, p. 850). MDPI AG. https://doi.org/10.3390/foods10040850
3. Oeleker, K., Alter, T., Kleer, J., Pund, R.-P., Gölz, G., Hildebrandt, G., & Huehn, S. (2015). Microbiological and chemical investigation of caviar at retail. In Journal für Verbraucherschutz und Lebensmittelsicherheit (Vol. 10, Issue S1, pp. 35–37). Springer Science and Business Media LLC. https://doi.org/10.1007/s00003-015-1002-4
4. Huang, L., Song, Y., Kamal, T., Li, Y., Xia, K., Lin, Z., Qi, L., Cheng, S., Zhu, B.-W., & Tan, M. (2017). A non-invasive method based on low-field NMR to analyze the quality changes in caviar from hybrid sturgeon (Huso dauricus, Acipenser schrenckiid). In Journal of Food Processing and Preservation (Vol. 41, Issue 6, p. e13256). Hindawi Limited. https://doi.org/10.1111/jfpp.13256
5. Kowalska, K. (2021). Lingonberry (Vaccinium vitis-idaea L.) Fruit as a Source of Bioactive Compounds with Health-Promoting Effects—A Review. In International Journal of Molecular Sciences (Vol. 22, Issue 10, p. 5126). MDPI AG. https://doi.org/10.3390/ijms22105126
6. Dróżdż, P., Šėžienė, V., Wójcik, J., & Pyrzyńska, K. (2017). Evaluation of Bioactive Compounds, Minerals and Antioxidant Activity of Lingonberry (Vaccinium vitis-idaea L.) Fruits. In Molecules (Vol. 23, Issue 1, p. 53). MDPI AG. https://doi.org/10.3390/molecules23010053
7. Amundsen, M., Hykkerud, A. L., Kelanne, N., Tuominen, S., Schmidt, G., Laaksonen, O., Yang, B., Martinussen, I., Jaakola, L., & Aaby, K. (2023). Composition of Sugars, Organic Acids, Phenolic Compounds, and Volatile Organic Compounds in Lingonberries (Vaccinium vitis-idaea L.) at Five Ripening Stages. In Foods (Vol. 12, Issue 11, p. 2154). MDPI AG. https://doi.org/10.3390/foods12112154
8. Chen, Y., Cai, Y., Wang, K., & Wang, Y. (2023). Bioactive Compounds in Sea Buckthorn and their Efficacy in Preventing and Treating Metabolic Syndrome. In Foods (Vol. 12, Issue 10, p. 1985). MDPI AG. https://doi.org/10.3390/foods12101985
9. Dong, K., Binosha Fernando, W. M. A. D., Durham, R., Stockmann, R., & Jayasena, V. (2021). Nutritional Value, Health-promoting Benefits and Food Application of Sea Buckthorn. In Food Reviews International (Vol. 39, Issue 4, pp. 2122–2137). Informa UK Limited. https://doi.org/10.1080/87559129.2021.1943429

10. Vilas-Franquesa, A., Saldo, J., & Juan, B. (2020). Potential of sea buckthorn-based ingredients for the food and feed industry – a review. In Food Production, Processing and Nutrition (Vol. 2, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1186/s43014-020-00032-y
11. Delgado-Andrade, C., Navarro, M., López, H., & López, M. C. (2003). Determination of total arsenic levels by hydride generation atomic absorption spectrometry in foods from south-east Spain: estimation of daily dietary intake. In Food Additives and Contaminants (Vol. 20, Issue 10, pp. 923–932). Informa UK Limited. https://doi.org/10.1080/02652030310001594450
12. Komarova N. V., Kamensev Ya. S. (2006). Prakticheskoe rukovodstvo po ispolzovaniu system kapillyarnogo elektroforeza. [A Practical Guide to Using Capillary Electrophoresis Systems], Veda, p. 212
13. Fodor-Csorba, K. (1992). Chromatographic methods for the determination of pesticides in foods. In Journal of Chromatography A (Vol. 624, Issues 1–2, pp. 353–367). Elsevier BV. https://doi.org/10.1016/0021-9673(92)85688-p
14. Vilas-Franquesa, A., Saldo, J., & Juan, B. (2020). Potential of sea buckthorn-based ingredients for the food and feed industry – a review. In Food Production, Processing and Nutrition (Vol. 2, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1186/s43014-020-00032-y
15. Saracila, M., Untea, A. E., Panaite, T. D., Varzaru, I., Oancea, A.-G., Turcu, R. P., & Vlaicu, P. A. (2022). Effects of Supplementing Sea Buckthorn Leaves (Hippophae rhamnoides L.) and Chromium (III) in Broiler Diet on the Nutritional Quality and Lipid Oxidative Stability of Meat. In Antioxidants (Vol. 11, Issue 11, p. 2220). MDPI AG. https://doi.org/10.3390/antiox11112220
16. Panjaitan, F. C. A., Yeh, N., & Chai, H. (2020). Effect of different processing on quality changes of barramundi (Lates calcarifer) caviar during chilled storage (4°C). In Journal of Food Processing and Preservation (Vol. 44, Issue 10). Hindawi Limited. https://doi.org/10.1111/jfpp.14790
17. Kopylenko, L. R., & Rubtsova, T. E. (2004). Effect of Pasteurization on the Activity of Proteinases in Salmon Roe. In Applied Biochemistry and Microbiology (Vol. 40, Issue 5, pp. 441–444). Springer Science and Business Media LLC. https://doi.org/10.1023/b:abim.0000040664.96905.d9
18. Staroszczyk, H., Kusznierewicz, B., Malinowska-Pańczyk, E., Sinkiewicz, I., Gottfried, K., & Kołodziejska, I. (2020). Fish gelatin films containing aqueous extracts from phenolic-rich fruit pomace. In LWT (Vol. 117, p. 108613). Elsevier BV. https://doi.org/10.1016/j.lwt.2019.108613
19. Jurevičiūtė, I., Keršienė, M., Bašinskienė, L., Leskauskaitė, D., & Jasutienė, I. (2022). Characterization of Berry Pomace Powders as Dietary Fiber-Rich Food Ingredients with Functional Properties. In Foods (Vol. 11, Issue 5, p. 716). MDPI AG. https://doi.org/10.3390/foods11050716
20. Bazhenova, B., Zhamsaranova, S., Zabalueva, Y., Gerasimov, A., & Zambulaeva, N. (2020). Effects of lingonberry extract on the antioxidant capacity of meat paste. In Foods and Raw Materials (Vol. 8, Issue 2, pp. 250–258). Kemerovo State University. https://doi.org/10.21603/2308-4057-2020-2-250-258
21. Bazhenova, B. A., Zhamsaranova, S. D., Zambulaeva, N. D., Zabalueva, Yu. Y., Gerasimov, A. V., & Syngeeva, E. V. (2020). Methods for improving the preservation of natural antioxidants in meat products. In Proceedings of Universities. Applied Chemistry and Biotechnology (Vol. 10, Issue 1, pp. 84–94). Irkutsk National Research Technical University. https://doi.org/10.21285/2227-2925-2020-10-1-84-94
22. Saracila, M., Untea, A. E., Panaite, T. D., Varzaru, I., Oancea, A.-G., Turcu, R. P., & Vlaicu, P. A. (2022). Effects of Supplementing Sea Buckthorn Leaves (Hippophae rhamnoides L.) and Chromium (III) in Broiler Diet on the Nutritional Quality and Lipid Oxidative Stability of Meat. In Antioxidants (Vol. 11, Issue 11, p. 2220). MDPI AG. https://doi.org/10.3390/antiox11112220
23. Qin, X., Zhang, T., Cao, Y., Deng, B., Zhang, J., & Zhao, J. (2020). Effects of dietary sea buckthorn pomace supplementation on skeletal muscle mass and meat quality in lambs. In Meat Science (Vol. 166, p. 108141). Elsevier BV. https://doi.org/10.1016/j.meatsci.2020.108141
24. Momani Shaker, M., Al-Beitawi, N. A., Bláha, J., & Mahmoud, Z. (2017). The effect of sea buckthorn (Hippophae rhamnoides L.) fruit residues on performance and egg quality of laying hens. In Journal of Applied Animal Research (Vol. 46, Issue 1, pp. 422–426). Informa UK Limited. https://doi.org/10.1080/09712119.2017.1324456
25. Binsi, P. K., Nayak, N., Sarkar, P. C., Sahu, U., Lalitha, K. V., Ninan, G., & Ravishankar, C. N. (2019). Conversion of carp roe mass to caviar substitutes: Stabilization with oregano extract. In LWT (Vol. 108, pp. 446–455). Elsevier BV. https://doi.org/10.1016/j.lwt.2019.03.001
26. Alakomi, H.-L., Maukonen, J., Honkapää, K., Storgårds, E., Quirin, K.-W., Yang, B., & Saarela, M. (2017). Effect of Plant Antimicrobial Agents Containing Marinades on Storage Stability and Microbiological Quality of Broiler Chicken Cuts Packed with Modified Atmosphere Packaging. In Journal of Food Protection (Vol. 80, Issue 10, pp. 1689–1696). Elsevier BV. https://doi.org/10.4315/0362-028x.jfp-17-076

27. Guo, Z., Han, L., Yu, Q., & Lin, L. (2020). Effect of a sea buckthorn pomace extract-esterified potato starch film on the quality and spoilage bacteria of beef jerky sold in supermarket. In Food Chemistry (Vol. 326, p. 127001). Elsevier BV. https://doi.org/10.1016/j.foodchem.2020.127001

28. Ren, R., Li, N., Su, C., Wang, Y., Zhao, X., Yang, L., Li, Y., Zhang, B., Chen, J., & Ma, X. (2020). The bioactive components as well as the nutritional and health effects of sea buckthorn. In RSC Advances (Vol. 10, Issue 73, pp. 44654–44671). Royal Society of Chemistry (RSC). https://doi.org/10.1039/d0ra06488b

29. Roasto, M., Mäesaar, M., Püssa, T., Anton, D., Rätsep, R., Elias, T., Jortikka, S., Pärna, M., Kapp, K., Tepper, M., Kerner, K., & Meremäe, K. (2023). The Effect of Fruit and Berry Pomaces on the Growth Dynamics of Microorganisms and Sensory Properties of Marinated Rainbow Trout. In Microorganisms (Vol. 11, Issue 12, p. 2960). MDPI AG. https://doi.org/10.3390/microorganisms11122960

30. Mosharova, M. E., & Titova, I. M. (2022). Influence of vegetable powders obtained from products of processing fruit and vegetable raw materials on technological properties of minced fish. In Vestnik of Astrakhan State Technical University. Series: Fishing industry (Vol. 2022, Issue 2, pp. 115–120). Astrakhan State Technical University. https://doi.org/10.24143/2073-5529-2022-2-115-120

31. SCHULZ, C., KNAUS, U., WIRTH, M., & RENNERT, B. (2005). Effects of varying dietary fatty acid profile on growth performance, fatty acid, body and tissue composition of juvenile pike perch (Sander lucioperca). In Aquaculture Nutrition (Vol. 11, Issue 6, pp. 403–413). Hindawi Limited. https://doi.org/10.1111/j.1365-2095.2005.00369.x

32. Tsibizova, M. E., Ibragimova, A. R., & Kotelnikov, A. V. (2023). Fish culinary products for preschool children. In Vestnik of Astrakhan State Technical University. Series: Fishing industry (Vol. 2023, Issue 2, pp. 91–102). Astrakhan State Technical University. https://doi.org/10.24143/2073-5529-2023-2-91-102

33. İnanlı, A. G., Çoban, Ö. E., Yılmaz, Ö., Özpolat, E., & Kuzgun, N. K. (2019). Assessment of vitamin compositions and cholesterol levels of carp (Cyprinus carpio carpio) and rainbow trout (Oncorhynchus mykiss) caviars. In Ege Journal of Fisheries and Aquatic Sciences (Vol. 36, Issue 3, pp. 293–299). Ege University Faculty of Fisheries. https://doi.org/10.12714/egejfas.2019.36.3.10

34. Winarti, S., Pertiwi, C. N., Hanani, A. Z., Mujamil, S. I., Putra, K. A., & Herlambang, K. C. (2018). Beneficial of Coriander Leaves (Coriandrum sativumL.) to Reduce Heavy Metals Contamination in Rod Shellfish. In Journal of Physics: Conference Series (Vol. 953, p. 012237). IOP Publishing. https://doi.org/10.1088/1742-6596/953/1/012237

35. Tamagno, W. A., Alves, C., Tessaro, D., Sutorillo, N. T., Santin, W., & Barcellos, L. J. G. (2022). Deferoxamine Supplementation Abolished Iron-Related Toxicity of Ilex paraguariensis Extract: Behavioral and Biochemical Evaluation in Adult Zebrafish (Danio rerio). In Antioxidants (Vol. 11, Issue 8, p. 1507). MDPI AG. https://doi.org/10.3390/antiox11081507

36. Abdel Rahman, A. N., ElHady, M., Hassanin, M. E., & Mohamed, A. A.-R. (2019). Alleviative effects of dietary Indian lotus leaves on heavy metals-induced hepato-renal toxicity, oxidative stress, and histopathological alterations in Nile tilapia, Oreochromis niloticus (L.). In Aquaculture (Vol. 509, pp. 198–208). Elsevier BV. https://doi.org/10.1016/j.aquaculture.2019.05.030

37. Jamil Emon, F., Rohani, M. F., Sumaiya, N., Tuj Jannat, M. F., Akter, Y., Shahjahan, M., Abdul Kari, Z., Tahiluddin, A. B., & Goh, K. W. (2023). Bioaccumulation and Bioremediation of Heavy Metals in Fishes—A Review. In Toxics (Vol. 11, Issue 6, p. 510). MDPI AG. https://doi.org/10.3390/toxics11060510

38. Alak, G., Kaynar, Ö., & Atamanalp, M. (2021). The impact of salt concentrations on the physicochemical and microbiological changes of rainbow trout caviar. In Food Bioscience (Vol. 41, p. 100976). Elsevier BV. https://doi.org/10.1016/j.fbio.2021.100976

39. Gürel İnanli, A., Emir Coban, Ö., & Dartay, M. (2010). The chemical and sensorial changes in rainbow trout caviar salted in different ratios during storage. In Fisheries Science (Vol. 76, Issue 5, pp. 879–883). Springer Science and Business Media LLC. https://doi.org/10.1007/s12562-010-0279-6

40. Liato, V., Hammami, R., & Aïder, M. (2017). Influence of electro-activated solutions of weak organic acid salts on microbial quality and overall appearance of blueberries during storage. In Food Microbiology (Vol. 64, pp. 56–64). Elsevier BV. https://doi.org/10.1016/j.fm.2016.12.010

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