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Influence of organic acids on organoleptic and structural and mechanical properties of freshwater hydrobiont meat

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Abstract. Research on the use of organic acids in freshwater fish conservation in aquaculture farms is gaining importance due to the growing interest in the quality and safety of fish products. The purpose of the study was to create and substantiate a new technology for preserving freshwater fish with the addition of spicy root vegetables, and in pretreatment of raw materials with organic acids. During the study, carp were treated with salt and various concentrations of organic acids, stored under certain temperature conditions. Sensory assessment, pH, and shear boundary stress were used to evaluate the results, and chemical analysis was performed using a penetrometer and potentiometric method. Based on the findings, a scientifically based technology for preserving freshwater fish with the addition of spicy root vegetables with a fundamentally new method of treatment of raw materials with organic acids has been developed to expand the scope of application of fish products that will have a higher biological value. It was found that at the initial stages of processing, no noticeable organoleptic changes were observed in the samples under study. Comparative analysis of the results confirmed the positive effect of acetic acid at a concentration of 1.0%, for tartaric acid, the best effect was determined with the addition of 0.5-1.0%, and for citric acid, the study indicates that its use does not lead to softening of muscle tissue, indicating the feasibility of its use. Studies have confirmed the use of pretreatment of semi-finished products of salted carp treated with 1.0-1.5% malic acid for 60 minutes to obtain a tender, juicy, and soft consistency, which corresponds to 5 points in the sensory assessment. According to the results of the conducted studies, the positive effect of using organic acids to soften carp meat in the production of preserves from freshwater fish was established. The practical significance of the study is to improve the technologies of meat processing and food production, and to determine the optimal conditions for preserving the taste and texture qualities of meat products

Keywords: carp; shear limit stress; hydrobionts; organoleptic parameters; under-ripening fish

Introduction

Providing the population with high-quality food products of increased biological and nutritional value is quite relevant today. The reason lies in the violation of the diet, that is, the lack of many necessary food elements. In this regard, the concept of creating new, balanced food products rich in functional ingredients to ensure their sustainability and safety after processing and during storage is becoming increasingly relevant.

In Ukraine, the current state of human nutrition requires the development and implementation of technology for products that would be made from raw materials of natural origin and predictive composition. Currently, these products do not yet meet the human needs for basic food elements. Freshwater fish farming and fishing are developing in Ukraine, but the product range is limited to live and chilled fish. The sensory and nutritional value of freshwater fish is necessary to improve processing technology by combining it with vegetable raw materials. Changes in the structure of the raw material base of Ukraine towards increasing the catch of freshwater aquaculture species necessitate the expansion of the range of food products based on these hydrobionts. Unlike marine fish, freshwater fish has lower nutritional and biological value. In this regard, in recent years, much research has focused on the development of technologies for the production of aquatic products from freshwater fish with plant ingredients and materials of animal origin in order to increase the nutritional value, maintain and regulate functional properties (Gao *et al.*, 2023).

Carp is one of the most common fish in the water farms of Ukraine. This fish contains a lot of protein with a full set of essential amino acids, biologically effective fatty acids, but fish meat has a low percentage or does not contain fibre, some trace elements necessary for nutrition according to the needs of modern ideas about nutrition. In particular, freshwater fish do not have high taste properties, which requires their improvement. Spicy root vegetables are grown in Ukraine, which are little used in fish production. Previous studies have shown that the use of raw materials of plant origin, including root vegetables that are spicy-aromatic, in the technology of processing hydrobionts, contributes to the improvement of sensory indicators and the creation of food products containing functional ingredients (Holembovska *et al*., 2021).

N.V. Novikova *et al.* (2023) investigated the biological and nutritional value of newly developed preserves that were enriched with biologically valuable plant-based ingredients. A special feature of the newly developed preserves is that the fruit filling used is fresh juice obtained from cranberry and elderberry fruits. The use of natural preservatives that can increase the shelf life of fresh fish has been investigated by many researchers, in particular S. Pedrós-Garrido *et al*. (2020). Their studies identified 8 essential oils (lemon, lemongrass, lime, garlic, onion, oregano, thyme, and rosemary) and 3 organic acids (ascorbic, citric, and lactic).

M.A. Ezzat *et al.* (2023) developed traditional fermented foods from freshwater fish such as Mozambique tilapia (*Oreochromis mossambicus*) and carp with the addition of tamarind pulp (*Tamarindus indica*) and dried slices of *Garcinia atroviridis* to promote the fermentation process. N. Hananiah & A.A. Rahim (2022) were concerned with preserving food quality by eliminating or controlling the proliferation of pathogens, which could be achieved by adding natural ingredients such as lime juice (*Citrus aurantifolia*) to the main recipe of preserves. The presence of organic acids in lime acted as an acidifier that provides a low pH environment for microbes to slow their growth. However, no systematic studies have been conducted in the field of activating the maturation of freshwater fish when introduced into preserves. Therefore, the development of technology for preserving freshwater fish and spicy root vegetables is an urgent problem and the solution of which will contribute to the creation of high-quality, safe, affordable, and biologically valuable fish products from domestic raw materials.

The purpose of the study was to determine the patterns of change in indicator complexes of carp meat under the influence of various acid concentrations during cold storage at temperatures from 0 to 5°C within 90 minutes of treatment.

Literature Review

Analysis of current trends in the development of fish production technology allows identifying the following key areas related to the technology of multicomponent food products, improvement of canning technology from hydrobionts that have the ability to ripen slowly, enrichment of recipe ingredients, pretreatment of raw materials by various methods, using physico-chemical technologies, biotechnologies for the production of traditional fish products: canned food, preserves, pates, dry, salted, dried culinary products, and products made from washed minced meat for the production of surimi (Holembovska *et al*., 2021).

It is known that the addition of enzyme preparations when salting fish helps to obtain a good quality product from unripe fish species. In the production of fish preserves, expensive enzyme preparations from plant and microbial raw materials can be used, such as *H. Mediteranei* fermentation broth for softening pollock meat or the proteolytic enzyme preparation *Sal Intersor EC* for the production of fish fillet preserves (Rodak & Fil, 2016). These researchers demonstrated 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 own proteinases, which would not allow obtaining the necessary degree of maturity without the addition of proteolytic enzyme preparations to enhance the process.

M. Pobedash developed the technology of enzymatic processing of zebra mussels with proteolytic action, the effect of using the proteolytic enzyme preparation "Protofermol" from bivalve zebra mussels without separating the leaf in advance to enhance the maturation process of preserves from dissected herring (Pobedash, 2013; Pobedash & Sydorenko, 2014). A.J. Reid *et al.* (2019) substantiated the mechanism of action of antibacterial drugs on microorganisms, their proteolytic and lipolytic enzymes, which reduces microbial contamination of semi-finished products and finished fish products. Considerable interest was aroused by the technology of production of preserves from non-fish aquatic products, in particular, squids and sea snails, which are under-ripening raw materials for the production of preservatives. The technology of preserves from these shellfish involves pretreatment of raw materials by blanching or using progressive peak wave processing to soften the consistency of meat. The effectiveness of treatment of fish preserves with orange juice, which promotes their maturation, has been proven. The use of orange juice as a food additive gives the product the following functional properties: saturates preserves with biologically active substances, vitamins C, PP, B vitamins, beta-carotene, and potassium, calcium, iron, and selenium (Bytiutskaia, 2010).

N.B. Rathod *et al.* (2021) considered technologies of fish ingredients that are promising for improving preservation technologies, since products in which the natural properties of raw materials are better preserved due to the absence of heat treatment. Therefore, changes in the structure of fisheries, general trends to reduce the volume of marine fish caught and the growth of freshwater fish used for aquaculture, leads to the need to improve raw material processing technologies and increase the scale of production of food products based on freshwater fish. The most promising way to solve these problems is to develop a technology for preserving freshwater fish, based on the principle of combining food products by enriching them with plant raw materials. The technology of preserves from under-ripening hydrobionts is associated with the use of factors that activate the own enzyme system of muscle tissue and contribute to the formation of a "bouquet" of food products. However, in the production of many products, including preserves, in order to increase the safety of products during storage, organic acids (acetic, tartaric, citric, malic, etc.) are more often used in the technology, the positive effect of which is proved by the researchers (Derkach *et al.*, 2022; Wang *et al.*, 2023).

However, in order to determine the pattern of exposure to different acid concentrations both to ensure safety and to stimulate maturation, it is necessary to conduct additional studies that are conditioned by the characteristics of the type of raw material. The concept of creating new food products that are balanced in chemical composition, enriching functional ingredients, ensuring their safety after and during processing, is becoming increasingly relevant. Based on the generalisation of theoretical literature, the study highlights the expediency of using organic acids in the technology of freshwater fish canning, which contribute to the maturation of semi-finished products with a salty taste and form food products with high sensory properties and increased biological value.

Materials and Methods

The research was conducted in 2022 at the laboratories of the National University of Life and Environmental Sciences of Ukraine, the Faculty of Food technologies and quality management of agricultural products at the Department of meat, fish, and seafood technology. Carp were cut into fillets, salted with brine to a salt concentration of 5% at room temperature for 24 hours. The fillets were then treated with organic acids of various concentrations. The control samples consisted of carp meat only, which was salted without the addition of organic acids. Canned samples were stored in plastic containers with a capacity of 200 cm^3 at a temperature of 0 to +4°C. The average sample was then taken from each unit, which was characterised by sensory assessment, pH, and shear limit stress after grinding.

The main raw materials used in the research were live fish (carp) according to DSTU 2284:2010 (2012), grown in the reservoirs of Cherkasy fish farms; table salt according to DSTU 3583:2015 (2017); table vinegar according to DSTU 2450:2006 (2006); apple cider vinegar according to DSTU 2450:2006 (2007), citric acid according to DSTU 908:2006 (2006), wine vinegar according to DSTU 2450:2006 (2007), and laboratory equipment: pH meter (LLC Chemlaborreactive, Ukraine) and penetrometer PCE-PTR 200N (LLC Chemlaborreactive, Ukraine). To determine the value of the ultimate shear stress (USS), a PCE-PTR 200n penetrometer was used using a room temperature exposure of 5 s, placing the pieces in identical metal measuring containers when using a measuring cone with a vertex angle of 2α=60°. For research, the muscle tissue of raw fish was crushed in an electric meat grinder with a grid hole diameter of 3 mm. After grinding, the water index (pH, active acidity) was determined in the obtained samples using the potentiometric method (Slobodianiuk *et al.,* 2018).

Evaluation of organoleptic characteristics included analysis of the appearance, taste, aroma, colour, and consistency of the product. An expert panel set up to assess the sensory quality of the fillets used a 5-point scale developed by the authors throughout the processing. Each of the parameters was evaluated according to a five – point system, where 5 points corresponded to an excellent level of quality, 4 points – good quality, 3 points – satisfactory, 2 points – unsatisfactory, and 1 point – low quality. The results of sensory evaluation were reflected in profile graphs that detail changes in fish consistency after acid exposure compared to the control group. 5 repetitions were performed for the study, and the analysis of experimental data was carried out using mathematical and statistical methods.

All data was processed using mathematical statistics methods, using Microsoft Excel and STATISTICA editors. The accuracy of the experimental results was determined using the Student's t-test with a confidence level of ≤0.05, provided that the number of parallel measurements was at least 5. To solve linear programming problems, the MS Excel table processor (Excel Solver) was used.

Results and Discussion

The technology of preserves made from under-ripening aquatic organisms is based on the use of factors that activate the muscle tissue's own enzyme system and contribute to the development of a pleasant taste inherent in this food product. Organic acids (acetic, tartaric, citric, malic, etc.) are increasingly used in the production of many products, especially preserves, to improve product safety during storage, as evidenced by the development of research papers. However, to determine the regularity of the effect of different acid concentrations both to ensure safety and to stimulate maturation, it is necessary to conduct additional studies due to the characteristics of the type of raw material. Sensory evaluation of carp meat under the influence of different concentrations of acetic acid showed a positive effect depending on the processing time (Fig. 1).

At the first stage of processing, no significant organoleptic changes were observed in the control and experimental samples. After 30 minutes of treatment, the sensory parameters of the prototypes improved compared to the control, especially at a concentration of 0.7-1.5%. Carp pieces after treatment with different concentrations of acetic acid differed from the control samples in the best shape indicators. After 30 minutes of acid exposure, there was an improvement in taste, smell, and colour. The consistency of all the tested variants was soft, very tender and juicy, and after 90 minutes of processing, it became less tender and softer with obvious signs of white coating.

Similar technologies were obtained by T. Maevskaia *et al.* (2012), who used organic acids in the washing of minced meat to produce better surimi from freshwater fish, increasing the washing efficiency. The proposed methods improved some indicators of washed minced meat, while worsening others. The proteins of minced meat obtained during the washing process contained almost the same amount of non-replaceable amino acids, and the use of catholyte allowed obtaining a product whose proteins are richer in non-replaceable amino acids, helping to identify the effect of the type of washing liquid on some values of indicators.

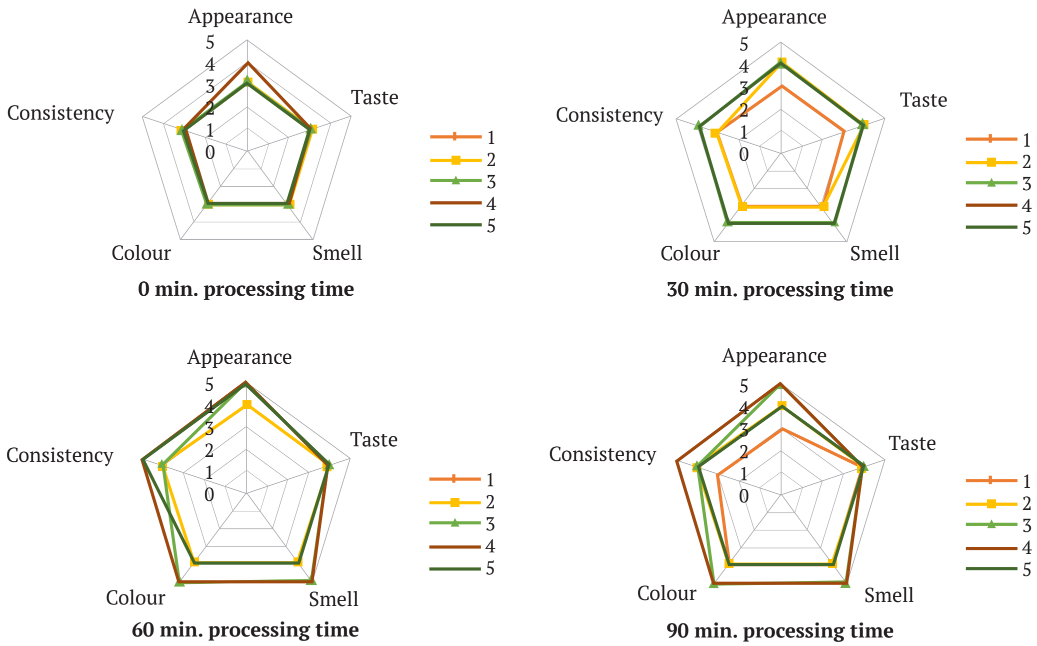

Figure 1. Changes in the organoleptic evaluation of carp meat under the influence of different concentrations of acetic acid and dependence on processing time

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

The best results in terms of softening consistency, taste, smell, and colour were observed for samples treated with 1.0% acetic acid during 60 minutes of treatment. They develop a soft consistency, the meat becomes very soft, excessively tender and juicy and corresponds to a 5-point scale. Therefore, according to the results of organoleptic evaluation, acetic acid in all experimental samples has a positive effect on carp meat, and a more pronounced effect is manifested in the variant with a concentration of 0.7-1.0%. The characteristics of the change in USS in the muscle tissue of carp treated with acetic acid are shown in Figure 2.

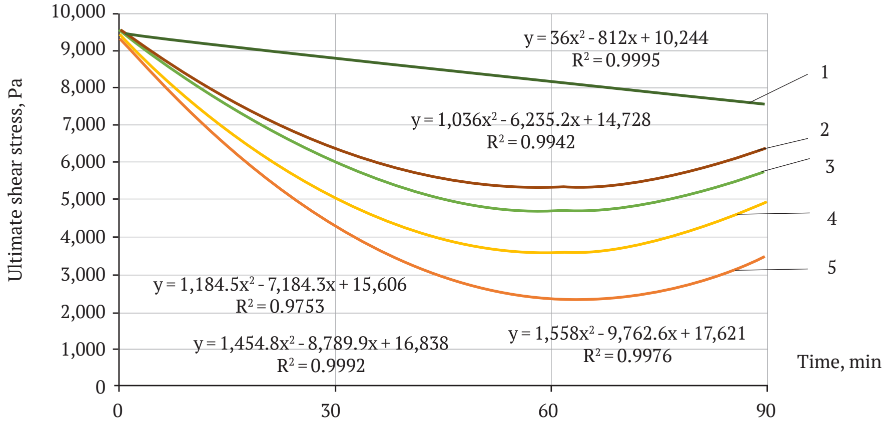

Figure 2. Dynamics of dependence of the USS of carp meat on the action of different concentrations of acetic acid for 90 minutes

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

Analysing the data, it was concluded that the effect of all acetic acid concentrations is accompanied by a more significant decrease in the USS index compared to the control sample, which indicates the effect of acid on carp meat, resulting in its softening. Gradual decrease in this indicator is observed up to 60 minutes, after which it begins to grow again. It is proved that the consistency of fish meat under the action of acids has the ability to soften, which is confirmed by the activation of cathepsin enzymes and a decrease in pH to the acidic side. The results of this study are consistent with these theories. A linear dependence of changes in the pH of carp meat during exposure to different concentrations of acetic acid was observed, characterised by a decrease in the acidic side from 6.8 to 4.3 (Fig. 3).

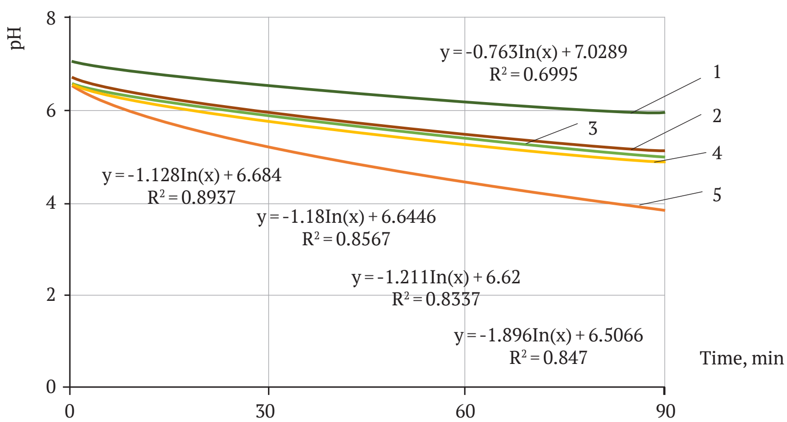

Figure 3. Dynamics of changes in the pH of carp meat under the influence of acetic acid of different concentrations depending on the processing time

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

The indicator of changes in the consistency of meat – USS – indicates that after 60 minutes of acid treatment, the consistency is compacted against the background of a gradual change in pH to the acidic side and the organoleptic evaluation of softening of the consistency (Fig. 4).

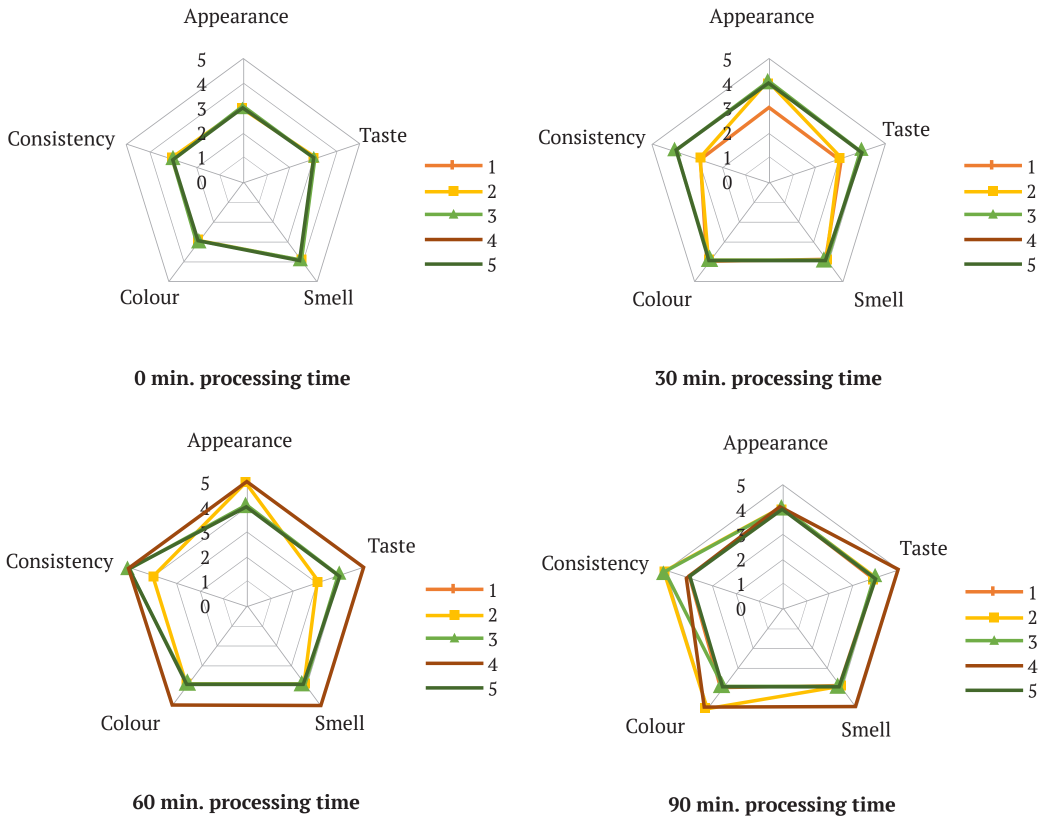

Figure 4. Changes in the organoleptic evaluation of carp meat under the influence of different concentrations of malic acid and dependence on the processing time

Notes: (n=5, p≤0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

These inconsistencies can be explained by the fact that when the period of processing carp meat with acids is extended, both protein hydrolysis and denaturation changes occur simultaneously. An organoleptic evaluation of carp meat treated with malic acid at different concentrations is shown in Fig. 4. After 30 minutes of treatment, the organoleptic characteristics of the experimental samples improved compared to the control, after 60 minutes of processing at a concentration of 0.5%, the appearance improved significantly; at 0.7; 1.5% – the consistency reached high quality, the meat became soft, extra tender and juicy; at 1.0% these samples correspond to a 5-point score. During 90 minutes of processing, the samples lose their quality in terms of such indicators as consistency, which becomes more rigid, and appearance of minor signs of white plaque on the surface. The results of the study of USS of carp meat treated with malic acid are shown in Fig. 5.

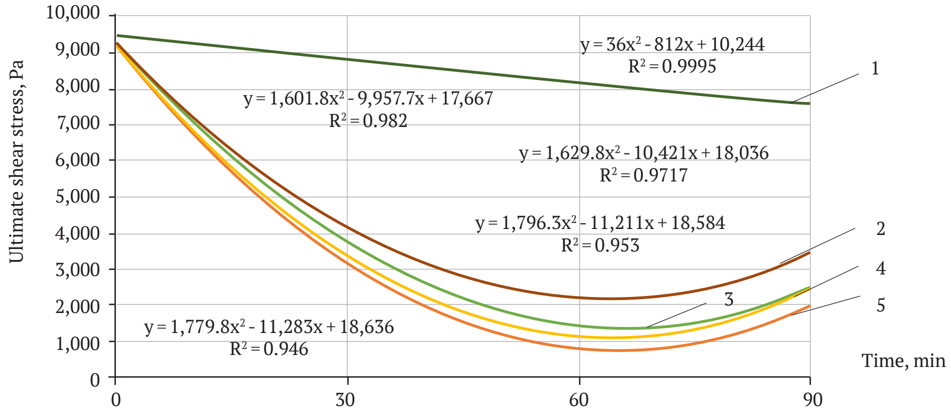

Figure 5. Dependence of the ultimate shear stress of carp meat on exposure to various concentrations of malic acid for 90 minutes

Notes: (n=5, p≤0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

The nature of exposure to different concentrations of malic acid is identical to that of acetic acid, but during its use, the greatest decrease in the USS index during the same time was noted. Changes in the pH value of carp meat are consistent with the results of a study of changes in this indicator after treatment with acetic acid, showing that in this case, cathepsin activation occurs after 45 minutes (Fig. 6) and is characterised by a gradual decrease from 6.8 to 4.2 in the acidic side. S. You *et al.* (2022) proved that a decrease in the value of active acidity negatively affects fish proteins due to the destruction of some essential amino acids, primarily lysine and sulphur-containing ones.

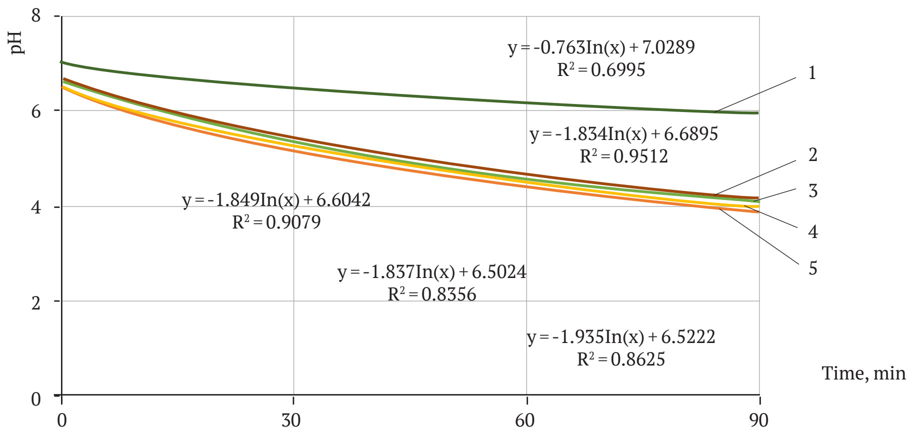

Figure 6. Dynamics of changes in the pH of carp meat under the influence of different concentrations of malic acid depending on the processing time

Notes: (n=5, p≤0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

M.M. Pobedash & O.V. Sydorenko (2014) investigated pH changes in fish preserves with the addition of sea buckthorn and cranberries, which were used as preservative components that are natural and with the assistance of which the pH stabilisation of the environment of preserves is achieved due to organic acids in their composition. In addition, their action affected the buffering indicators, it remained stable due to the action of plant components, also extended the shelf life and improved consumer properties. Researchers also explained the effect of organic acids (namely benzoic acid), natural antioxidants and pectin substances, which are found in plant additives, on the state of consistency of fish meat, which becomes softer and more tender. The organoleptic evaluation of carp meat treated with different concentrations of citric acid is not entirely consistent with the indicators of USS changes (Fig. 7).

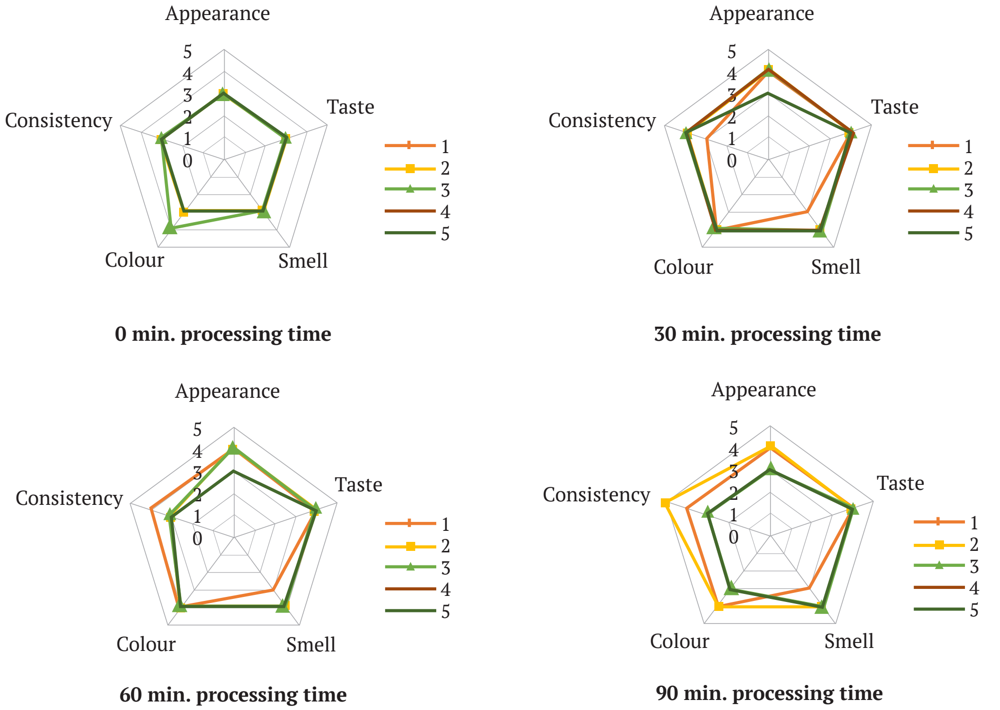

Figure 7. Changes in the indicators of organoleptic evaluation of carp meat under the influence of different effects of citric acid concentration

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

These acid concentrations do not soften the consistency and according to organoleptic indicators, the higher the acidity, the larger the white layer and dense consistency. After 30-60 minutes of treatment, no significant organoleptic changes were observed in the control and experimental samples. In the study samples, organoleptic parameters improved compared to the control, and the consistency, on the contrary, was tougher than in the control with the first sign of white plaque. After 90 minutes, samples treated with citric acid at a concentration of 0.5% showed better organoleptic characteristics than other samples, and the consistency corresponded to 5 points.

The nature of exposure to different concentrations of citric acid is identical to that of acetic and malic acids, but the USS indicators decrease quite slightly (Fig. 8), which is not accompanied by softening of the consistency of carp meat. When measured after 45 minutes using all citric acid concentrations, the pH of carp meat changed to a degree indicating activation of its own cathepsin enzyme (Fig. 9) and is characterised by a gradual shift to the acidic side from 4.2-3.9.

The organoleptic evaluation of carp meat treated with tartaric acid at different concentrations is shown in Figure 10.

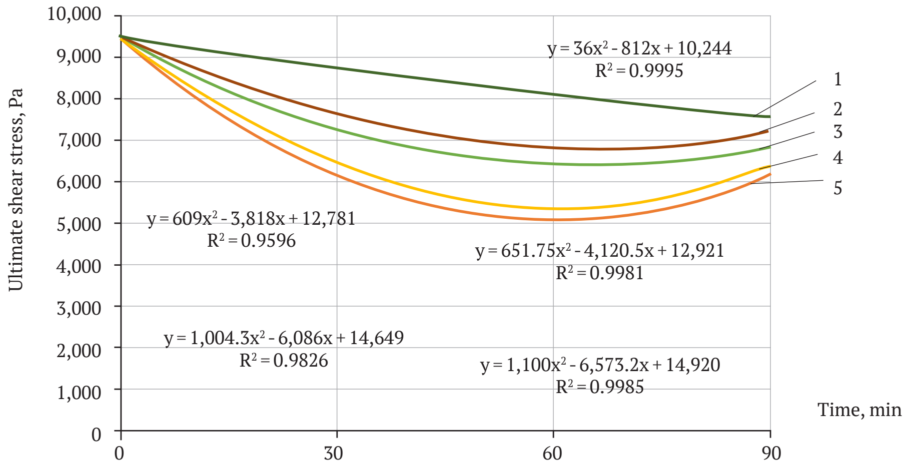

Figure 8. Dynamics of changes in the ultimate shear stress in carp meat under the influence of various concentrations of citric acid for 90 minutes

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

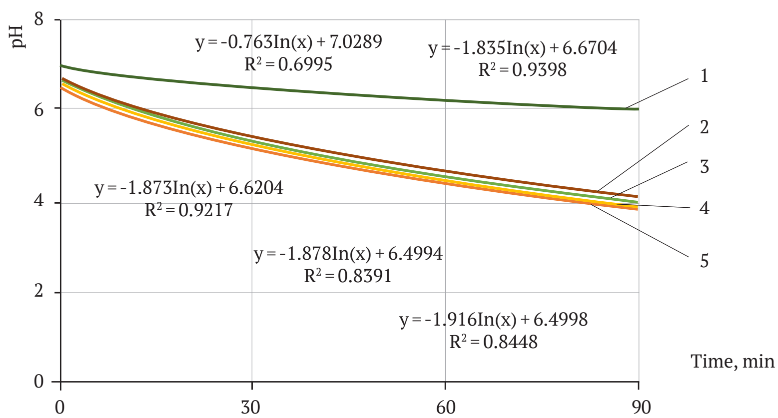

Figure 9. Dynamics of changes in the level of acidity in carp meat when interacting with different concentrations of citric acid, depending on the processing time

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

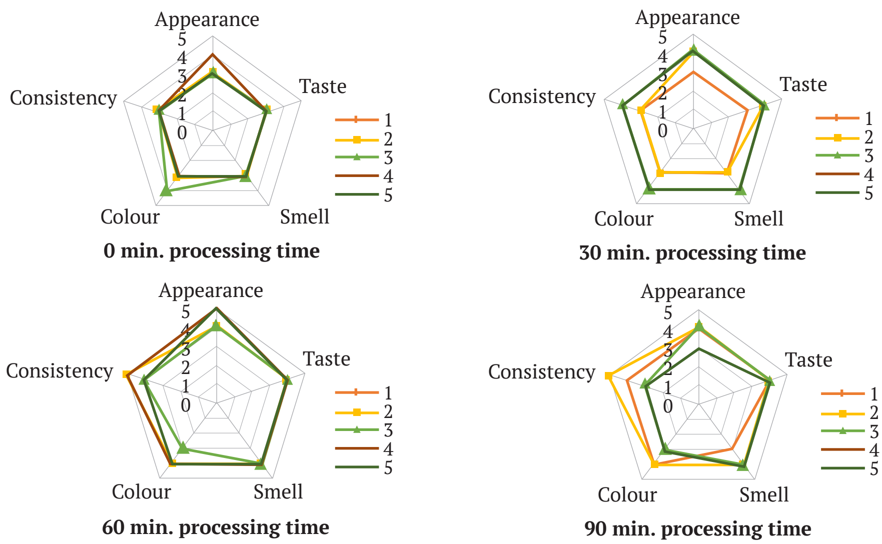

Figure 10. Dynamics of assessment of organoleptic characteristics of carp meat under the influence of different concentrations of tartaric acid during different processing periods

Notes: (n=5, p≤0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

After 60-90 minutes of treatment, there were no significant sensory changes, the samples did not reach 5 points on the sensory score, the consistency was not too soft or juicy. After 90 minutes, samples treated with tartaric acid with a concentration of 0.5-1% showed better organoleptic characteristics than other samples, and the consistency was 5 points. The nature of the effect of different concentrations of tartaric acid on USS indicators differed from the effect of acetic, malic, and citric acids. On the control sample, with an increase in the processing time, this indicator gradually decreased and the changes had a linear relationship. Exposure to 0.5% tartaric acid was accompanied by a gradual increase in the USS index. Tartaric acid concentrations such as 0.7, 1.0, and 1.5% softened the consistency of carp meat and the best results were obtained when using 1.5% concentration for 60 minutes (Fig. 11).

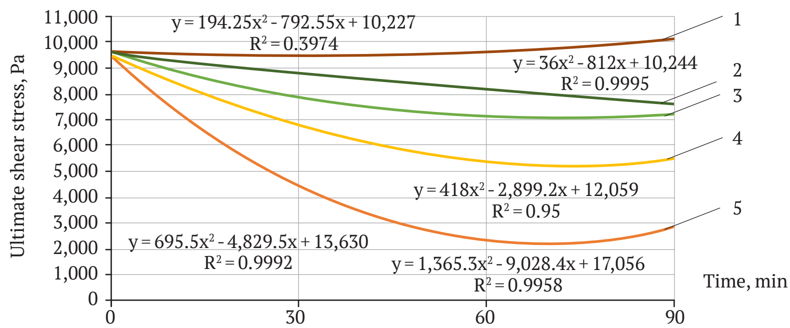

Figure 11. Relationship of changes in the acidity of carp meat under the influence of different concentrations of tartaric acid for 90 minutes

Notes: (n=5, p≤0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

Under the influence of all tartaric acid concentrations, the dynamics of changes in the pH of carp meat had a linear relationship, which was characterised by a gradual shift from 6.8 to the acidic side to 5.1, which contributed to partial activation of cathepsins (Fig. 12).

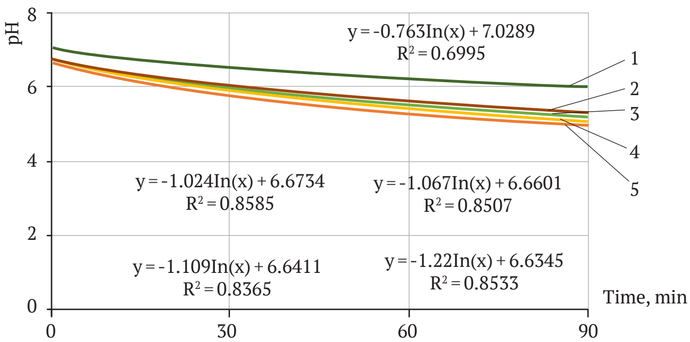

Figure 12. Changes in the level of acidity in carp meat depending on the processing time and different concentrations of tartaric acid

Notes: (n=5, p⩽0.05): 1 – control; 2 – C=0.5%; 3 – C=0.7%; 4 – C=1.0%; 5 – C=1.5%

Source: developed by the authors

The difference in the effect of organic acids on softening fish meat can be explained by the fact that acetic, malic, citric acids are carboxylic, which are widely used in the food industry as flavourings, acidity regulators, and preservatives. Acetic acid is monobasic, malic acid is dibasic, and citric acid is tribasic. In water, these acids easily dissociate and the degree of their dissociation due to the different number of bases is not the same, which probably determines such differences in the effect on the muscle tissue of fish. The oxygen-hydrogen bond of the carboxyl group (-COOH) in acetic acid is highly polar, so these compounds can easily dissociate and exhibit acidic properties, which can promote cathepsin activation and soften the consistency of muscle tissue. N.V. Novikova *et al.* (2023) also used acetic acid with a concentration of 9% in their research in the manufacture of preserves. A significant effect on the consistency of fish was influenced by the addition of elderberry and cranberry plant raw materials, due to which the fish became softened, and preserves were enriched with ascorbic acid, rutin and folacin, which took part in the metabolic processes, protecting the molecules from damage by reactive oxygen species. Organoleptic studies, USS, and pH confirmed the positive results of using organic acids of various concentrations in the treatment of freshwater fish both to ensure safety and to stimulate maturation.

Notably, organic acids such as lactic, malic, citric, etc. are known for their antibacterial, preservative, and antioxidant properties. Therefore, a number of studies are known that confirm this fact. The organoleptic properties of meat, such as colour, smell, taste, and texture, may be important for consumers. Research by X. Liu *et al.* (2019) confirm that adding organic acids to processed meat can improve its taste, reduce adverse odours, and preserve its natural colour, although the study does not specify the shelf life of such products, which is consistent with the results in the context of the current study. Structural and mechanical properties are also affected. Thus, the structural and mechanical properties of meat that were studied by M. Nikoo *et al.* (2021) indicate a possible positive effect of organic acids. For example, they can promote the breakdown of collagen.

O.A. Olopade *et al.* (2023) investigated the mechanisms of the effect of organic acids on meat, in particular, their interaction with proteins. The researchers claim that different types of acids cause different processes of breakdown of meat proteins and affect the preservation of moisture in meat, which is confirmed by an objective analysis of the results, which include a wide range of factors that affect the properties of meat during interaction with organic acids. In addition, some researchers note that optimal conditions and concentrations of organic acids may vary depending on the type of hydrobionts and processed meat. The research presented by S. Rahayu *et al.* (2022) provides specific guidance on this hypothesis.

Prospects for the use of organic acids in industrial conditions to improve the quality of meat and its shelf life are described by K. Rahmanifarah *et al.* (2023). In industrial settings, the use of organic acids to optimise the processing and conservation processes of freshwater fish can be an important strategy for improving the quality and duration of product storage. An analysis of the study by the above-mentioned researchers may indicate possible advantages of implementing these approaches in industrial production. In the context of the current study, it is worth noting that organic acids can interact with fish meat, promoting protein breakdown and improving the texture and organoleptic characteristics of the product. Their antimicrobial activity can also provide an additional level of safety and shelf life, reducing the risk of micro-organisms and fish spoilage. However, the introduction of these technologies in industry requires additional research and process optimisation. It is important to consider different production conditions, types of freshwater fish, and compliance with regulatory standards for product safety and quality.

The study by N. Sadeghinejad *et al.* (2019) highlighted the safety issues and possible risks associated with the use of organic acids in food. The researchers provide a detailed comparative analysis of canned meat and fish, in particular, considering the influence of organic acids on their quality and safety. The study focuses on determining the interaction between organic acids and meat or fish during the conservation process. The possible effects of these acids on the organoleptic and chemical properties of products are analysed, and their impact on the safety of consumption is evaluated. One of the key aspects is to identify possible risks associated with the use of organic acids in food that may arise as a result of chemical interactions and potentially affect the quality and safety of products. This study opens up space for discussing the possible benefits and limitations of using organic acids in canned food, emphasising the importance of balancing improving the technical characteristics of products and ensuring their safety for the consumer. In particular, the results of the comparative analysis of meat and fish preserves carried out within the framework of the study can play an important role in shaping scientific approaches to the use of organic acids in the food industry and determining their optimal application in the context of ensuring food safety and quality. In general, these sources can serve as a basis for discussing the effect of organic acids on the meat of freshwater hydrobionts, and for determining the prospects for their use in the food industry.

N. Slobodyanyuk *et al.* (2018), O.B. Tkachenko *et al.* (2020) analysed scientific sources and studies on indicators of the biological value of freshwater fish in Ukrainian and foreign reservoirs. The prospects of using this raw material resource to expand the range of high-quality food products are indicated. The paper presents the results of the analysis of the chemical, fatty acid, amino acid, and mineral composition of carp, silver carp, and bream meat. A comparative analysis of the nutritional value of these fish species, which are promising for industrial processing, was carried out, revealing certain differences in the studied indicators. The presented results of the analysis of the total chemical composition show that fish from the

Ukrainian reservoir is characterised by a high protein content and moderate fat content, while protein contains all the necessary amino acids. The study of the mass fraction of toxic elements confirms that the level of heavy metals in fish is lower than acceptable standards, in particular in silver carp, carp, and bream.

Based on the results obtained by R.R. Veloso *et al.* (2019), H.P. Vieira *et al.* (2019), changes in rheological characteristics, microbiological and toxicological parameters were found during the storage of minced meat from freshwater hydrobionts with plant components, in particular ginkgo biloba powder in the amount of 1%, 3%, and 5%. During the experiment, the moisture retention capacity of the developed minced meat was investigated. Changes in the effective viscosity of minced meat from hydrobionts after freezing and during storage were also determined. The organoleptic properties of minced meat were analysed after freezing and during 6 months of storage. The values of fat constants, such as acid, peroxide, and iodine numbers, were obtained. The results show that minced meat from hydrobionts with plant components retains its high consumer properties for 6 months of storage.

After conducting a comparative analysis of the results obtained by the above-mentioned researchers, it is possible to predict possible areas and prospects for further research:

1. *Study of the effects of various organic acids:* investigation of various types of organic acids (for example, lactic, malic) and their concentrations to determine optimal conditions for improving the quality of hydrobiont meat.

2. *Investigation of organoleptic properties*: study of the effect of organic acids on the taste, aroma, colour, and texture of meat and the possibility of using organic acids to improve the organoleptic characteristics of finished products.

3. *Study* of *structural and mechanical properties*: effect of organic acids on meat structure and other mechanical properties, to determine optimal po concentrations for best results.

4. *Mechanisms of action of organic acids:* investigation of molecular and biochemical processes that occur when organic acids interact with meat components, which will help to better understand the mechanisms of improving meat quality.

5. *Study of long-term exposure:* investigation of the effect of organic acid use on the quality of freshwater hydrobiont meat, including storage and transportation of products.

6. *Innovative processing methods:* study of new methods for introducing organic acids into meat, such as marinating, impregnating, or using nanoparticles to improve the effectiveness of exposure.

7. *Safety and health aspects:* research on safety aspects and the impact of organic acid administration on consumer health.

Research in these areas can help identify the potential benefits of using organic acids to improve the quality of freshwater hydrobiont meat, which, in turn, can lead to the development of new production technologies and improve the competitiveness of products in the market.

Conclusions

The study was carried out to determine changes in a set of indicators of carp meat under the influence of acids of different concentrations during storage in a refrigerator at a temperature of 0 to 5°C for 90 minutes of processing. At the first stages of treatment, there were no noticeable organoleptic changes in the control and experimental samples. After 30 minutes of treatment, organoleptic parameters improved in the experimental samples compared to the control, namely at a concentration of 0.7-1.5%. Pieces of carp meat after treatment with different acid concentrations differed from the control sample in the best indicators of taste, smell, and colour.

Comparison of the results of studies on the dependence of organoleptic evaluation on USS revealed the following patterns: the positive effect of acetic acid on carp meat occurs at a concentration of 0.7-1.0% for 60 minutes providing the appearance of a soft consistency; softening of the consistency of carp meat, which corresponds to high organoleptic indicators, occurs when treated with 1.0 and 1.5% malic acid for 60 minutes; for tartaric acid, the best result is determined by adding 0.5-1.0% acid for 60 minutes; analysis of the results of the study of the effect of citric acid on the consistency indicators of carp meat indicates that we have studied concentrations do not lead to softening of carp muscle tissue and show the inexpediency of its use. Thus, to soften carp meat, it is recommended to use 1.0 and 1.5% malic acid during 60 minutes of processing. Pretreatment of salty semi-finished products with 1.0-1.5% malic acid for 60 minutes to achieve a soft, tender, and juicy consistency is theoretically justified and experimentally confirmed.

Prospects for future research are to conduct comprehensive analyses of the effect of organic acids in the production of preserves with spicy-aromatic root vegetables and their impact on plant raw materials. This developed technology can be applied in the food industry in the production of fish preserves using freshwater fish, which will expand the range of fish products. However, to determine the regularity of the effect of different acid concentrations on both safety and maturation stimulation, it is necessary to conduct additional studies due to the specific features of the type of raw material. Therefore, this topic requires improvement and further investigation.

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Conflict of Interest

None.

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Вплив органічних кислот на органолептичні та структурно-механічні властивості м'яса прісноводних гідробіонтів

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Анотація. Дослідження використання органічних кислот у консервуванні прісноводної риби в аквакультурних господарствах набуває важливості через ростучий інтерес до якості та безпеки рибної продукції. Мета дослідження полягала у створенні та обґрунтуванні нової технології консервування прісноводної риби з додаванням пряних коренеплодів, а також у попередній обробці сировини органічними кислотами. Під час дослідження коропа обробляли за допомогою солі та різних концентрацій органічних кислот, зберігали при певних температурних умовах. Для оцінки результатів використовували сенсорну оцінку, pH і граничне напруження зсуву, а також проводили хімічний аналіз з використанням пенетрометра та потенціометричного методу. За результатами досліджень розроблено науково-обґрунтовану технологію консервування прісноводної риби з додаванням пряних коренеплодів з принципово новим способом обробки сировини органічними кислотами для розширення сфери застосування рибопродуктів, які матимуть більш високу біологічну цінність. Виявлено, що на початкових етапах обробки в досліджуваних зразках не спостерігалося відчутних органолептичних змін. Порівняльний аналіз результатів досліджень підтвердив позитивний вплив оцтової кислоти при концентрації 1,0 %, для винної кислоти найкращий ефект визначено при додаванні 0,5-1,0 %, а щодо лимонної кислоти дослідження вказує на те, що її використання не призводить до розм'якшення м'язової тканини, свідчачи про доцільність її використання. Дослідженнями підтверджено використання попередньої обробки напівфабрикатів солоного коропа обробленого 1,0-1,5 % яблучною кислотою протягом 60 хвилин для отримання ніжної, соковитої та м'якої консистенції, що відповідає 5 балам за сенсорною оцінкою. За результатами проведених досліджень встановлено позитивний вплив застосування органічних кислот для розм'якшення м'яса коропа при виробництві пресервів з прісноводних риб. Практичне значення дослідження полягає в удосконаленні технологій обробки м'яса та виробництва продуктів харчування, а також визначити оптимальні умови для збереження смакових та текстурних якостей м'ясних продуктів

Ключові слова: короп; гранична напруга зсуву; гідробіонти; органолептичні показники; слабодозріваюча риба