CHAPTER 6

Improvement of technology of fish pastes with the addition of non-traditional raw materials

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Abstract

The growing interest of consumers in functional fish products has contributed to the development of innovative formulations enriched with biologically active and nutritionally valuable components. This study investigated the effect of including goji berries in the formulations of crucian carp-based fish sticks. Three experimental samples were developed: control – without herbal additives, sample 1 – with 2% goji berries, sample 2 – with 4% goji berries and sample 3 – with 6% goji berries. The physicochemical parameters of the products were studied, in particular, moisture, protein, fat, minerals and acidity, as well as technological characteristics – moisture retention capacity, color, texture and sensory characteristics. The inclusion of berries increased the mineral content, while the moisture content of the products decreased (from 78.0 to 68.0%). The samples with berries demonstrated improved sensory properties and increased structural density, which positively affected the textural characteristics.

When stored at 4°C for 4 days, the samples with goji berries maintained the stability of physicochemical parameters: changes in acidity and peroxide value were minimal, and sensory properties were high, indicating good oxidative and microbiological stability. The organoleptic evaluation showed improved taste characteristics and aroma harmony, which were most pronounced in sample 2.

The results of the study confirm the feasibility of using plant biologically active additives in fish pastes to increase nutritional value, functional properties and

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organoleptic appeal. Further studies are recommended to assess microbiological stability during long-term storage and study consumer preferences for introduction into production.

Keywords

Crucian carp, goji berries, biologically active additives, physicochemical properties, organoleptic properties, texture, oxidative stability, nutritional value.

6.1 Introduction

Recently, the range of fish culinary products in the world has expanded significantly. These trends are echoed by domestic producers. For example, the production of canned food, salted fish, and smoked products has decreased significantly due to rather subtle undesirable changes in the product as a result of the use of strict sterilization regimes, the high content of table salt in salty and spicy products, and the presence of harmful carcinogenic substances in smoke-smoked products [1].

The growing importance of fish products and plant foods can lead to a significant increase in the production of combined fish and plant products, and, consequently, to an expansion of the range of food products with increased balance [2].

In the last decade, the number of people using ready-made meals and semi-finished products in their diet has increased. In addition, a significant change in the traditional tastes of the population has resulted from increasing awareness of the impact of various products on human health and life expectancy [3, 4].

The development of fish culinary production is able to solve the problem of complex processing of raw materials with reduced market value, traditionally not used by the population for food, as well as secondary products of fish processing and the production of highly nutritious, biologically complete food products from them.

Fish semi-finished products and various culinary products do not require a labor-intensive process of fish processing and after simple processing can be quickly prepared for consumption [5–7].

This type of production is characterized by a large range of goods, which continues to expand constantly. However, the volume of culinary products is limited, since these are mainly perishable products with limited shelf life.

The production of fish pastes in industrial conditions in a wide range allows for a more rational use of fish raw materials compared to the sale of fish as a whole, uncut, chilled or frozen. For example, from large fish it is possible to produce semi-finished products and baked products, from small or mechanically damaged fish – minced and pasty products [8].

The demand for pâté products is steadily growing, with fish pâtés occupying one of the leading places among consumer preferences due to their ease of use, which is especially important in the conditions of the intensive pace of life of modern society. At the same time, the assortment of the Ukrainian market is mostly represented by pâtés made exclusively from fish raw materials without the use of combined ingredients [9]. In this regard, improving technological approaches to the production of pâtés from freshwater fish is a scientifically sound and relevant area of research.

Modern scientific research is actively aimed at optimizing the technology of fish pâtés with the involvement of non-traditional types of raw materials. The main attention is paid to increasing the nutritional and biological value of the product, ensuring its safety and increasing the shelf life.

V. Dorozhko's research [10] was devoted to improving the technology of fish pastes using non-traditional raw materials. The work substantiated the feasibility of combining freshwater fish with plant ingredients, in particular maca root, broccoli and beetroot. The results showed that the addition of these components positively affects the organoleptic characteristics of the product, in particular taste, color and consistency, and also contributes to increasing its biological value. It was established that the use of plant raw materials allows to expand the range of functional food products and improve the overall quality of fish pastes.

In the studies of N. Holembovska and A. Vlasenko [11], the effect of including quail eggs and plant ingredients in the composition of fish pastes on their chemical composition, organoleptic characteristics and physicochemical indicators was analyzed.

V. Sapsay [12] focused on the development of fish paste recipes using plant raw materials in order to increase the nutritional value of the product and improve its organoleptic properties.

In the study of C. Ballo and M. Enriquez, a fish paste was created, manufactured using mechanized equipment for the production of fish paste, and the results of an experimental study of its qualitative and sensory characteristics were presented, which is important for assessing the suitability of such a production technology for the food industry [13].

In the works of N. Holembovska and others [14], the effect of including cranberries and goji berries in the recipe of pâtés on their chemical composition, organoleptic and physicochemical characteristics, and the shelf life of the finished product was determined.

In the work of A. Menchynska et al., new types of fish pastes were developed based on combining fish raw materials with additional ingredients in order to increase their nutritional and consumer value. The authors found that the use of improved recipes contributes to the improvement of organoleptic indicators and overall acceptability of fish pastes compared to the control sample, which confirms the prospects for the use of non-traditional recipe solutions in the technology of fish products [15].

Other studies show the effect of protein-carbohydrate compositions of plant origin, in particular based on pea and soy proteins, on the quality indicators of fish pastes and found that a rationally selected ratio of plant protein components and fish raw materials contributes to improving the textural characteristics of the product, reducing moisture loss during heat treatment, and enriching the amino acid composition due to essential amino acids [16].

K. Bashir et al. [17] presented natural food additives and preservatives in the technology of fish pastes. The authors systematized modern scientific data on various ingredients used to improve the quality of fish pastes, including the use of various natural additives (for example, seaweed powders, shrimp powder and other components) and ways of their influence on the technological and organoleptic properties of the final products.

In the study of O. Selezneva [18] analyzed the feasibility of using wild animal meat in the technology of meat pâté production, which ensures an increase in their nutritional value and contributes to a decrease in the mass fraction of fat in the finished product.

According to the results of research by I. Bal [19], it was found that the use of pink salmon milt in the technology of fish pastes contributes to the preservation of high organoleptic quality indicators during storage, reduces peroxide value and microbiological contamination, and ensures product safety for up to 120 hours at a temperature of 0–4°C.

Thus, current trends in the development of the food industry indicate the feasibility of improving the production technologies of fish culinary products, in particular pâtés, as a promising direction of rational use of fish raw materials. Their production allows not only to expand the range of products of increased biological value, but also to ensure complex processing of raw materials, including unprofitable fish species and by-products of its processing.

At the same time, the issue of increasing the nutritional and functional value of such products by optimizing the recipe composition, reducing the salt content, using plant components and natural ingredients that meet modern requirements for healthy nutrition remains relevant.

Thus, scientific substantiation of technological solutions for the creation of competitive fish pâtés and other pasty products with specified indicators of quality, safety and balance is an important task of modern food science and practice.

6.2 Scientific substantiation of the functional properties of goji berries (*Lycium barbarum* L.)

Wild berries are widely used in various industries: they are used in the production of finished medicines, as well as in food, canning, confectionery, non-alcoholic and alcoholic, meat and dairy, bakery, perfume and cosmetic products for medical, preventive and health purposes.

Wild plants used as food raw materials are valuable sources of vitamins, minerals and other biologically active components. The creation of new food products using wild berries allows enriching the diet of the population of Ukraine with useful micronutrients. The development of products for medical and preventive nutrition is of particular importance. Adding wild raw materials to food products helps to solve many problems of dietary and health-improving direction. One of the promising ingredients for such purposes can be goji berries.

Goji berries (common dogwood, or Tibetan barberry) belong to the genus Lycium and are part of the nightshade family (*Solanaceae*). It is a perennial evergreen shrub with flexible, drooping branches that can reach about three meters in height. The shoots have thorns, and the leaves are elliptical and short-petiolate. The flowers are purple, bell-shaped, located in the axils of the leaves. The fruits are juicy, bright red, with a characteristic bittersweet or slightly sour taste, elliptical in shape, about 1–2 cm in diameter, and outwardly resemble a small ripe tomato. Each berry contains from 10 to 60 small yellow seeds with a curved embryo. The flowering period falls on September-October, and the fruits ripen in November [20].

Goji berries are found in Japan, Korea, and Eastern China, where they grow along roads, on dry slopes of foothills and mountainous areas. This plant is cultivated in China, Japan, the island of Java, Hawaii, the countries of Southeast Europe, and Asia in general, with the main industrial plantations concentrated in China.

The plant is also widespread in the Mediterranean region, as well as in Southwest and Central Asia. In North America and Australia, goji is often grown as an ornamental or for hedge formation.

The species *L. Chinense* is most characteristic of East Asia and is actively cultivated in South China, Korea and Japan. Industrial cultivation of *L. barbarum* is concentrated mainly in the Chinese region of Ningxia-Hui and in the Xinjiang Uygur Autonomous Region in the west of the country [21].

The genus *Lycium* L. from the nightshade family (*Solanaceae*) has more than 88 species, which are mainly found in non-tropical regions of the world, with the greatest diversity observed in South America. Chinese blackthorn is widespread in Korea, Japan and East China. In natural conditions, it grows in rocky gorges, along roads, on arid foothills and mountain slopes. This plant is cultivated in Japan and China, as well as on the island of Java, the Hawaiian Islands, in the countries of Central Asia and in Europe.

The high content of biologically active substances, vitamins and mineral components determines the expediency of using berries in the creation of products for medical and preventive and health purposes, especially in conditions of micronutrient deficiency in the diet of the population of Ukraine.

Goji berries, in particular representatives of the genus *Lycium*, are characterized by a valuable chemical composition, a wide distribution area and the possibility of cultivation, which makes them a promising ingredient for the development of new functional food products. At the same time, the insufficient level of scientifically substantiated approaches to the use of goji berries in domestic food production, as well as limited data on the technological aspects of their application, necessitate further research in this direction. This confirms the relevance of the chosen topic and determines the expediency of conducting comprehensive scientific work aimed at substantiating the use of goji berries in medical and preventive nutrition products.

Given the growing body of research supporting the health benefits of natural products [22], global fruit production has increased significantly over the past twenty years [23]. Similar trends are observed for goji berries, with their cultivation areas expanding rapidly in recent years. This is particularly evident in European countries (Italy, Romania, Bulgaria, Portugal, Greece, Serbia), as well as in North America and Australia. Romania currently leads the EU in terms of *L. barbarum* plantation area [24, 25].

According to P. Bora et al. [26], goji berries contain significant amounts of carbohydrates (46 g/100 g of fresh fruit) and dietary fiber (16 g/100 g of fresh weight). In a study by T. Ilić et al. [27], the chemical composition of *L. barbarum* was analyzed and the following indicators were determined: moisture content – 75.32 g/100 g of fresh weight, carbohydrates – 16.93 g/100 g of dry weight, dietary fiber – 3.63 g/100 g of fresh weight, protein – 1.98 g/100 g of dry weight, fat – 1.15 g/100 g of dry weight, and ash – 0.84 g/100 g of dry weight.

Similar data were obtained by T. Pires et al. during the analysis of dried goji berries and stems. The researchers found that their chemical composition includes 87 g/100 g of dry matter carbohydrates, 5.3 g/100 g of protein, 4.1 g/100 g of fat and 3.21 g/100 g of ash. In addition, a significant amount of soluble sugars (27.9 g/100 g of dry matter) was found in the samples, among which fructose (12.7 g/100 g), glucose (14.4 g/100 g) and sucrose (0.8 g/100 g) were identified [28].

In a study by T. Pires et al. [28] on the organic acids of goji berries, the presence of citric (1.29 g/100 g dry weight), succinic (0.77 g/100 g) and oxalic (0.010 g/100 g) acids was found. In addition, the authors identified tocopherols, among which

α-tocopherol (0.23 mg/100 g) and δ-tocopherol (0.09 mg/100 g) were determined. The samples were also analyzed for a fatty acid profile, the total content of which was 4.1 g/100 g dry weight. The researchers found the presence of sixteen types of fatty acids, among which polyunsaturated ones dominated – linoleic (53.4%), oleic (16.5%) and palmitic (12.77%).

According to the results of the study by T. Ilić et al. [27], among the fatty acids in goji berries, linoleic (52.1%), oleic (23.6%) and palmitic (17.6%) dominated, which together account for about 95% of their total content. Similar trends were also noted by P. Skenderidis et al. [29], who recorded the concentrations of linoleic, oleic and palmitic acids in the ranges of 37.89–43.96%, 16.71–20.07% and 15.08–21.79%, respectively.

Regarding the mineral composition, numerous scientific works indicate that the main minerals of goji berries include potassium, sodium and calcium. Thus, according to P. Bora et al. [26], 100 g of berries contain 434 mg of potassium, 60 mg of calcium, 5.4 mg of iron and 1.5 mg of zinc. In the work of E. Llorent-Martínez et al. [30], on the contrary, significantly higher values are given: potassium – 1460 mg/100 g, sodium – 550 mg/100 g and calcium – 50 mg/100 g. In turn, T. Ilić et al. [27], estimated the content of macronutrients in the dry matter of berries: potassium – 445.12 mg/100 g, phosphorus – 231.52 mg/100 g, sodium – 74.57 mg/100 g and calcium – 29.02 mg/100 g. Ascorbic acid (48.94 mg/100 g of fresh fruit) and tocopherols (0.33 mg/100 g of dry weight) were found in goji berries [27]. Vitamin E (α-tocopherol) is a key lipid-soluble antioxidant in cells, capable of inhibiting membrane lipid peroxidation [31, 32], while vitamin C (ascorbic acid) provides important antioxidant activity in goji berries [25].

In the work of M. Polat et al. [33], devoted to the assessment of the quality of goji berries (*Lycium barbarum* L.) depending on the fruiting period and seasonal conditions, it was shown that the physicochemical characteristics of the fruits change during the season. In particular, from the first to the last harvest, a decrease in the length, width and weight of the fruits by 21%, 18% and 33%, respectively, was observed. At the same time, the total anthocyanin content increased by 264%, phenolic compounds – by 48%, and antioxidant activity – by 105%.

The researchers also measured titratable acidity and soluble solids content, and found a positive relationship between the concentration of phenolic compounds and soluble solids and titratable acidity. The results indicate that late harvests provide higher phytochemical value, while early harvests provide better pomological characteristics. In a study by Y. Zhou et al. [34], which focused on the composition, characteristics and antifungal properties of the cutin layer of goji berries (*Lycium barbarum* L.) at different stages of development, it was found that 26 chemical components were identified in the cutin extracts, among which fatty acids, alkanes, aromatic acids and small molecular acids dominated. These compounds play a key role in the formation of the structure of the cutin layer and may be associated with antifungal activity.

In a study by D. Ağagündüz et al. [35] on the physicochemical and antioxidant profile of dried goji berries (*Lycium barbarum*), it was found that the berries contain high levels of bioactive compounds. Thus, the total phenolic content was 207.2 ± 1.51 mg/100 g dry weight, and the antioxidant activity was 32.6 ± 1.82 μmol/g. The content of L-ascorbic acid (vitamin C) was 31.0 ± 1.62 mg/100 g. In a review by I. Szot et al. [36] on the beneficial and functional properties of goji berries (*Lycium barbarum* and *Lycium chinense*), it was noted that these fruits are rich in various bioactive compounds that provide their antioxidant and functional activities. These include phenolic acids, flavonoids, proanthocyanidins, coumarins, tannins, carotenoids, and anthocyanins, making berries an important source of antioxidants and functional phytonutrients.

In addition to polyphenols, berries contain macro- and micronutrients, including proteins, fats, carbohydrates, and minerals (particularly potassium, magnesium, iron, and zinc), as well as vitamin C. These components play an important role in maintaining health and increasing the nutritional value of berries as a functional product.

Researchers have identified polysaccharides in the amount of 5–8% of the dry weight, which are the main functional components of berries, as well as total phenolic compounds that provide antioxidant activity of fruits.

The fatty acid profile showed the presence of oleic (21.7%), palmitic (8.2%), stearic (2.9%) and myristic (0.1%) acids, among which mono- and polyunsaturated fatty acids dominate [37].

In the study of I. Taneva and Z. Zlatev [38], the mineral composition of berries was analyzed and it was found that 100 g of dried fruits contain: calcium – 49.0 mg, phosphorus – 370.0 mg, sodium – 1.32 mg, potassium – 193.0 mg, magnesium – 120.0 mg, iron – 0.04 mg, copper – 0.01 mg and manganese – 0.008 mg of dry weight.

In the study of M. Spano et al. [39] analyzed the metabolic profile of fresh goji berries (*Lycium barbarum* L.) from two cultivars, Big Lifeberry and Sweet Lifeberry, grown in Central Italy, using an integrated analytical approach combining nuclear magnetic resonance (NMR) and electrospray FT ICR mass spectrometry for the precise detection and quantification of molecules in the fruits. The study showed that the berries contain a wide range of metabolites, including sugars (glucose, fructose, sucrose), amino acids (including glycine, betaine, proline), organic acids, fatty acids, polyphenols, and terpenes, indicating a rich chemical composition and potentially high bioactivity of the fruits. The chemical composition of goji berries includes betaine, rutin, ascorbic acid, and daucosterol. An essential oil rich in cinnamic acid and phenolic compounds was found in the bark of the plant. In addition, the bark contains leucine, choline, about 2.2% fatty oil, protein substances, daucosterol, and alkaloid compounds characteristic of the Solanaceae family, in particular physalin [40].

Both the fruits and Cortex Lycii have numerous pharmacological properties, including antiglaucoma, immunomodulatory, antitumor, antioxidant, anti-aging, neuroprotective activity, and the ability to lower blood sugar levels. For many centuries, goji berries have been used in Asia as a medicinal plant raw material due to their high nutritional value, health-promoting properties, and a wide range of biological activities [26, 41]. Several scientific studies confirm their usefulness, including antioxidant activity [24, 42, 43], antitumor effect [24, 44, 45], antimicrobial properties [44, 46], the ability to lower blood glucose [25] and lipid levels [25], as well as antimutagenic [45], prebiotic [25, 26, 46], immunomodulatory [47], antifatigue [44], antiaging and neuroprotective effects [43].

Approximately 75–85% of fresh goji berries after harvest undergo a dehydration process, most often carried out using traditional heat drying, freeze-drying or vacuum-pulsation methods, before they are sold [48–50]. In addition to dried fruits, other goji products are widely available on the market, including juices, wines and various primary processed products.

Among the berry beverages, pulp juice, clear juice, dry instant drinks, as well as dairy and sour-milk products made by fermentation with lactic acid bacteria are offered [51–54]. Wine products include blended wines obtained by infusing berries and other bioactive or medicinal components in strong alcoholic beverages, as well as fermented wines, where goji berries are fermented together with dates (*Ziziphus jujuba Mill.*), honey and other nutritional additives [55].

Wild berry crops are considered as a promising source of raw materials for the production of health and medical and prophylactic food products, which is explained by the high content of biologically active substances and a wide range of their use in various industries. Of particular interest among such plants are goji berries (*Lycium spp.*), which have been used in traditional Asian medicine for centuries and are increasingly being included in modern food technologies.

Analysis of scientific data shows that goji berries are characterized by high nutritional value and complex biochemical composition. They contain carbohydrates, dietary fiber, proteins and lipids, organic acids, antioxidant vitamins (ascorbic acid and tocopherols), as well as macro- and microelements. The predominance of polyunsaturated fatty acids, in particular linoleic, enhances their biological potential. Taken together, these components provide antioxidant, immunomodulatory, metabolic-corrective, neuroprotective and geroprotective properties of goji berries.

Therefore, goji berries can be considered as a promising functional ingredient for the creation of new food products with increased biological value. Further scientific research aimed at improving processing technologies in order to preserve bioactive components and develop innovative products from wild plant raw materials remains relevant and has significant practical importance for the development of the food industry of Ukraine.

6.3 Characteristics of the nutritional and biological value of fish and vegetable raw materials

Fish fillets must meet certain organoleptic and physicochemical characteristics, which ensures the quality of the final product. Analysis of organoleptic indicators of goji berries allows to assess their taste, color and consistency properties, and the chemical composition allows to determine the content of macro- and microelements, proteins, pectin substances and fiber, which justifies their functional value in nutrition.

The obtained data on the organoleptic and chemical characteristics of fish and berry components allow to plan the technological process of producing fish pastes with high nutritional and biological value, which makes them promising as a functional food product.

According to organoleptic indicators, frozen fillets must meet the requirements and standards specified in **Table 6.1**.

The primary raw materials for cooking fish pastes are minced crucian and crushed goji berries.

The dimensional composition of the fish is given in the **Table 6.2**.

The length of the carcass is 25.2 cm, the height of the fish body is 6 cm, and the width of the fish body is 4 cm (average size of the fish). The mass composition of crucian is presented in **Table 6.3**.

The output of fish meat is 25.9 g, waste – 66.1 g, losses – 7.9 g. The chemical composition of fish raw materials was determined during the study, as shown in **Table 6.4**.

The results of studies of organoleptic indicators of cranberries and goji berries are presented in **Table 6.5**.

The chemical composition of goji berries is presented in the **Table 6.6**.

Analyzing the presented data, it is possible to conclude that goji berries are characterized by low moisture content (12.3%), which contributes to their longer shelf life. The content of pectin substances (2.5%) and fiber (3.6%) indicates the ability of the berries to support digestion and normalize intestinal function.

Table 6.1 Organoleptic characteristics of frozen fish fillets

Indicator name	Characteristic and standard
Appearance: blocks individually frozen fillets	Clean, dense, with a flat surface without significant differences in block height. Clean, even, whole, without significant deformation. May exhibit: slight loosening of the muscle tissue along the edge of the fillet block; presence of scale residues on the surface of the fillet with skin without scales; skin damage in horse mackerel and sturgeon fillets at the sites where scutes have been removed
Placement procedure	The fillets are placed into molds in uniform layers: in the bottom layer with the skin or subcutaneous side facing downward, and in the top layer with the skin or subcutaneous side facing upward
Flesh consistency: after defrosting	Firm, typical of this type of fish
After boiling	Tender, juicy, brittle, typical of this type of fish. It may be slightly dry, fibrous, but not hard, rubbery, jelly-like
Flesh color	Typical of this type of fish
Odor (after defrosting)	Typical of fresh fish, without any foreign odor
Taste and smell after cooking	Typical for this type of fish, without any foreign taste or smell

Table 6.2 Dimensional composition of crucian

L_a, cm	L_i, cm	L_h, cm	L_t, cm	L_m, cm	*h*, cm	*b*, cm
23	18.5	4.5	5	14	7	2

Note: initial weight of gutted carcass – 356 g

Table 6.3 Mass composition of crucian

Weight, kg	Content to the total weight of fish, %				
	fillet	skin	bones	fins	scales
0.177	25.9 ± 0.5	3.9 ± 0.3	12.7 ± 0.9	4.6 ± 0.2	7.9 ± 0.2

Note: initial weight of gutted carcass – 177 g, results are in %, ($n = 5$, $p \leq 0.05$)

Table 6.4 Chemical composition of hake

Indicator	Content
Protein content	16.5 ± 0.5
Fat content	3.9 ± 0.1
Moisture content	78.5 ± 1.3
Mineral content	1.1 ± 0.15

Note: results are in %, ($n = 5$, $p \leq 0.05$)

Table 6.5 Organoleptic characteristics of goji berries

Indicators	Goji berries
Appearance and consistency	The berry is dark red, spherical or ellipsoidal in shape, up to 12 mm in diameter, without visible inclusions or impurities
Taste and smell	Pleasant juicy, sour taste with a slightly bitter aftertaste
Color	Dark red, uniform throughout the mass

Table 6.6 Chemical composition of goji berries

Indicator name	Goji berries
Mass fraction of moisture, %	12.3 ± 0.2
Pectic substances, %	2.5 ± 0.1
Fiber, %	3.6 ± 0.2
Essential macronutrients, mg/kg	
K	2265 ± 23.22
Ca	888.1 ± 8.88
Mg	1357 ± 13.6
Zn	10.33 ± 0.8
Essential micronutrients, mg/kg	
Fe	91.58 ± 0.92
Mn	9.82 ± 0.2

Among the macronutrients, the most abundant are potassium (2265 mg/kg), magnesium (1357 mg/kg) and calcium (888.1 mg/kg), which makes the berries useful for the cardiovascular system and bones. The content of zinc (10.33 mg/kg) also supports immunity.

Among the micronutrients, the most significant is iron (91.58 mg/kg), which helps prevent anemia, and manganese (9.82 mg/kg) supports antioxidant processes in the body.

Thus, goji berries are a valuable source of both macro- and micronutrients, as well as dietary fiber, which justifies their use as a functional food product.

6.4 Technological aspects of the production of fish pastes with the addition of goji berries

The following materials were used to make minced meat and ready-made pastes: crucian carp grown in the Kyiv region, Goji berries produced by LLC "NVO FitoBio-Technology", Organic Herbs.

The crucian carp were stored in a refrigerator at a temperature of +4°C for one day until the experiment.

At the initial stage, all the necessary ingredients were prepared, including crucian carp, Goji berries, carrots, onions, oil, salt and ground black pepper.

The prepared fish carcasses are cleaned, disassembled, while removing inedible parts of the fish: caudal, dorsal and anal fins, gill covers, eyes, intestines and gall bladder. All edible parts of the fish are used to obtain the product. Then the disassembled fish is washed in running water, small fish are whole, and large fish are cut into pieces.

The disassembled fish is submitted for blanching, the purpose of which is to destroy enzymes, increase the permeability of cell protoplasm, which is necessary to improve the taste, reduce the amount of microflora, partially remove air from the raw materials, and oxygen. After blanching, cooling was carried out to a temperature in the thickness of the product of 20–30°C.

The chopped vegetables are submitted to a perforated vibrating roller, where the product is dehydrated for 3–4 minutes, then the vegetables are sent to a bath with oil heated to 95–100°C, where the vegetables are saturated with oil, then the vegetables are submitted to a vibrating tray, on which the vegetables are fried at an oil temperature in the range of 95–100°C.

Then the blanched crucian carp, onions and carrots are chopped into a shredder with a grate diameter of $\varnothing = 4$ mm, which ensures uniform grinding of the raw materials. To conduct the experiment, 2, 4, 6% of Goji berries were added to the recipes of the test samples. Dried Goji berries before use in the production of pâtés are subject to preliminary preparation in order to restore their structure, reduce stiffness, ensure microbiological safety and uniform distribution in the product.

At the first stage, the berries are sorted to remove foreign impurities and damaged berries. Then the berries are washed in running drinking water to remove surface contaminants.

The next stage is hydration (soaking) of dried berries when they are poured with warm water at a temperature of 40–60°C in a ratio of 1:5 and kept for 30 minutes until the pulp is fully elastic.

After hydration, a short-term heat treatment is carried out, blanching for 1–2 minutes, in order to reduce the microbiological load and stabilize the color of the raw materials. Then the berries were ground to the required degree of dispersion using a laboratory mill grinder SM-3C for the desired consistency of the pate.

Prepared Goji berries are introduced into the pate mass at the cutting stage. The mass fraction of Goji berries is 2, 4, 6% of the total mass of the pate, taking into account the recipe features.

All ingredients were weighed and homogenized until a uniform consistency was achieved, packed into containers and subjected to heat treatment in boiling water (100°C) for 60 minutes.

6.5 Fish paste recipes

Modern consumers are increasingly paying attention to food products not only in terms of taste, but also taking into account their functional and biological value. The growing demand for healthy eating stimulates the development of the market for fish culinary products, in particular, pâtés and paste-like products, which combine high nutritional value with ease of consumption.

Solving these problems is possible by including plant components in the recipe, which not only improve the organoleptic properties of the product, but also increase its functional value. Among the promising ingredients are carrots, onions and goji berries, which are characterized by a high content of biologically active compounds, minerals and dietary fiber. Goji berries in particular are distinguished by their antioxidant activity, richness in trace elements (potassium, magnesium, calcium, iron, zinc) and the ability to increase the shelf life of products.

The aim of the study is to assess the impact of introducing plant components, in particular goji berries, on the physicochemical, organoleptic and functional properties of fish pastes, as well as to develop a product formulation with an optimal ratio of fish and plant raw materials. The implementation of such approaches allows creating a competitive food product that meets modern requirements for healthy nutrition and consumer needs.

Taking into account the standards of need recommended by FAO/WHO, formulations of new pastes were developed. Samples of pastes were selected taking into account the content of the main components in them: experiment 1 – with the addition of 2% berries; experiment 2 – with the addition of 4% berries, experiment 3 – with the addition of 6% berries, the control sample – without additives, based only on crucian carp meat.

The developed formulation of the control sample is presented in **Table 6.7**.

Combining freshwater fish raw materials with vegetable raw materials allows to optimize the taste properties of the finished product, biological value and extend the shelf life.

The recipes for new crucian carp-based pastes are given in **Table 6.8**.

Analysis of the formulation composition showed that the introduction of plant raw materials (carrots, onions and goji berries) allows to partially reduce the share of fish raw materials without significantly disrupting the structure of the product, while increasing its functional value. Goji berries are a source of biologically active substances, antioxidants, vitamins and minerals, which contributes to increasing the nutritional and biological value of pâtés.

Table 6.7 Recipe of the control sample of pate

Component names	Formulation composition, kg per 100 kg of product
	Natural pate (Control)
Stuffed crucian carp	88
Salt	1.5
Ground black pepper	0.5
Sunflower oil	10

Table 6.8 Recipes for pâtés with vegetable additives

Component names	Formulation composition, kg per 100 kg of product		
	Sample 1	Sample 2	Sample 3
Stuffed crucian carp	69	67	65
Salt	1.5	1.5	1.5
Ground black pepper	0.5	0.5	0.5
Sunflower oil	10	10	10
Carrot	8	8	8
Onion	9	9	9
Goji berries	2	4	6

Combining freshwater fish raw materials with plant components provides: improvement of organoleptic indicators (taste, aroma, color); enrichment of the product with dietary fiber and antioxidant compounds; potential increase in resistance to oxidative processes and expansion of the range of functional fish products.

Thus, the developed formulations are promising in terms of increasing nutritional value, forming new taste characteristics and creating a competitive functional product based on freshwater fish. It is advisable to determine the optimal percentage of berries added based on the results of further organoleptic, physicochemical, and microbiological studies.

6.6 Chemical composition of fish pastes

In modern food production, special attention is paid not only to the taste properties of products, but also to their nutritional and functional value. One of the directions for increasing the nutritional value of finished products is the introduction of plant components, in particular berries and vegetables, which enrich products with biologically active substances and minerals.

The study of the chemical composition of fish pastes with the addition of goji berries was carried out in order to assess the influence of plant ingredients on the main nutritional indicators of the product: protein, fat, moisture and mineral content. The analysis allows to determine how changing the ratio of minced fish and additives affects the nutritional value and technological properties of products, and also allows to choose optimal recipe solutions for the production of functional food products.

The results are presented in **Tables 6.9**, **6.10** and demonstrate changes in the main components and mineral composition of fish pastes under the influence of the introduction of goji berries, which allows to draw conclusions about their effectiveness as a functional ingredient.

Table 6.9 General chemical composition of semi-finished products, % ($n = 5$, $p \leq 0.05$)

Name of indicators	Fish pâté			
	Control	Sample 1	Sample 2	Sample 3
Moisture content	70.38 ± 1.5	68.86 ± 0.24	68.72 ± 0.3	68.69 ± 0.33
Protein content	15.84 ± 0.65	14.83 ± 0.88	14.71 ± 0.71	14.59 ± 0.43
Fat content	12.52 ± 0.05	13.39 ± 0.07	13.42 ± 0.05	13.47 ± 0.05
Mineral content	1.26 ± 0.04	2.92 ± 0.04	3.15 ± 0.05	3.25 ± 0.06

The analysis of the chemical composition of the control sample and three samples of fish pastes with the addition of vegetables and goji berries showed that the introduction of plant components affects the nutritional properties of the product. Reducing the proportion of minced fish led to a slight decrease in protein content (from 15.84% in the control to 14.59% in the sample with 6% goji) and a simultaneous increase in fat content (from 12.52% to 13.47%). Humidity remained practically stable, indicating the preservation of consistency and optimal technological properties of the pastes. At the same time, increasing the proportion of goji berries contributed to an increase in the content of minerals (up to 3.25%), which increases the functional value of the product. The results obtained allow to recommend the sample with

6% goji berries as optimal in terms of the combination of nutritional value, mineral composition and technological characteristics.

6.7 Research on organoleptic indicators of fish pastes

In order to determine the taste properties of fish pastes, an organoleptic assessment of the quality of the test samples was carried out during all stages of production and storage. The assessment was carried out using a self-developed 5-point scale.

To assess the sensory properties of products, the flavor profiling method is used, which belongs to the basic descriptive methods of sensory analysis [56]. This approach is widely recommended for the development of new and improvement of existing food products [57]. The use of the flavor profiling method allows for a detailed description of the set of descriptors that determine the overall sensory impression of the product. The advantage of sensory analysis compared to instrumental methods is the possibility of simultaneous human assessment of a wide range of organoleptic indicators and their integrated interpretation.

The method described in DSTU ISO 6564:2005 "Sensory research. Methodology. Methods for creating a flavor spectrum" [58, 59] was used to create the flavor profiles. The sensory evaluation was carried out by 20 permanent members, including teachers, staff and postgraduate students. The evaluators tasted and rated the pâtés for appearance, aroma, color, taste, viscosity and overall acceptability. The rating scales were provided in the evaluation sheet to all evaluators. Regarding taste and mouthfeel, the evaluation was carried out by analyzing the harmony of taste, aftertaste, tenderness and juiciness of the product. Regarding aroma, appearance and viscosity, the fish pâté was placed in a saucer, smelled and observed visually. It was allowed to smell and taste again. The procedure was repeated three times with an interval of 5 minutes. Participants of the experiment rinse their mouths in preparation for the next test.

For the sensory assessment of fish pastes, the survey participants were offered a scale of ten descriptors, ordered in descending order of their significance. Based on the analysis of the descriptors, their weight significance in the formation of an integral assessment of the quality of the samples was determined, taking into account the consumer importance of each indicator. The tasting assessment was carried out on a scale of desirability and intensity of the taste and aromatic characteristics of the product, where 0 points corresponded to the absence of a sign, 1 point – barely noticeable intensity, 2 points – weak manifestation, 3 points – medium level, 4 points – strong and 5 points – very strong manifestation of the indicator [60].

Laboratory results data were presented as the mean standard deviation and statically analyzed using one-way analysis of variance to determine significant differences between groups. All statistical analyses were performed using statistical analysis programs in Excel.

Based on the results of consumer preference studies that were conducted, a set of 10 descriptors was defined for flavor characterization (**Table 6.10**).

Table 6.10 Sensory evaluation of fish pastes using the flavor profile method ($n = 5, p \leq 0.05$)

Descriptors	Intensity of characteristics, score				
	Fish pâté				
	Standard	Control	Sample 1	Sample 2	Sample 3
Aroma and taste characteristics					
harmonious	5.0	4.0 ± 0.10	5.0 ± 0.10	5,0 ± 0.20	5.0 ± 0.20
typical	4.5	3.0 ± 0.01	4.0 ± 0.01	4.0 ± 0.02	4.0 ± 0.02
fishy	4.5	3.5 ± 0.10	4.5 ± 0.10	4.5 ± 0.10	4.8 ± 0.30
slightly pronounced	3.5	1.0 ± 0.20	3.0 ± 0.10	4.1 ± 0.20	3.5 ± 0.10
sweet	3.0	1.0 ± 0.01	2.5 ± 0.20	2.8 ± 0.30	3.0 ± 0.03
salty	3.0	3.0 ± 0.01	2.5 ± 0.01	2.5 ± 0.10	2.5 ± 0.02
Consistency characteristics					
tender	3.0	3.0 ± 0.10	2.0 ± 0.20	2.5 ± 0.20	2.5 ± 0.10
juicy	3.5	3.0 ± 0.10	3.5 ± 0.20	3.5 ± 0.10	3.0 ± 0.10
spreadable	1.0	2.0 ± 0.02	2.5 ± 0.02	3.0 ± 0.02	2.9 ± 0.02
Overall impression	5.0	4.4 ± 0.10	5.0 ± 0.20	5.0 ± 0.10	4.0 ± 0.10
Total points	36.0	27.9	34.5	36.9	35.2

Analyzing this table, it is possible to observe that the control sample is characterized by reduced indicators of harmony of aroma and taste (4.0 points), a weakly expressed fishy taste (3.5 points) and insufficient intensity of sweet and salty notes (1.0–3.0 points each). The consistency is juicy and plastic (3.0 points each), but the density slightly exceeds the reference value (2.0 points versus 1.0). The overall impression of the control sample is 4.4 points, and the total score is only 27.9 points, indicating lower consumer properties than the reference.

In experimental sample 1, there is a significant improvement in sensory characteristics. The indicators of harmony and fishy taste have reached the reference level (5.0 and 4.5 points, respectively). Also, moderate flavor intensity (3.0 points) was noted, with sweet and salty notes balanced (2.5 points), and optimal plasticity indicators (3.5 points). The overall impression was 5.0 points, and the total score was 34.5 points, which significantly exceeded the control.

Experimental sample 2 is characterized by the most harmonious combination of aroma, taste, and consistency. High scores were given to harmony (5.0 points), moderately pronounced taste (4.1 points) and optimal density (3.0 points). Juiciness and plasticity indicators corresponded to the reference values or close to them. The total number of points for this sample is the highest – 36.9 points, which even exceeds the reference (36.0 points), and the overall impression is 5.0 points.

Experimental sample 3 is also characterized by high sensory indicators, in particular, an intense fishy taste (4.8 points) and harmony (5.0 points). At the same time, a slightly lower overall impression score (4.0 points) and reduced juiciness (2.5 points) caused a slight decrease in the total score to 35.2 points compared to experimental sample 2.

The results obtained indicate that the use of improved recipes and technological parameters in the experimental samples allowed to significantly improve the organoleptic properties of fish pastes. The most optimal in terms of the set of sensory indicators is experimental sample 3, which is characterized by high harmony of taste and aroma, balanced consistency and the highest sum of points. This confirms the feasibility of the selected technological solutions for the production of fish pastes of increased biological value.

The control sample of fish pastes was distinguished by a light gray color, a sweet-salty taste, as well as a plastic and uniformly dense consistency. Such indicators indicate the need to improve the recipe in order to achieve the desired sensory characteristics (**Fig. 6.1**).

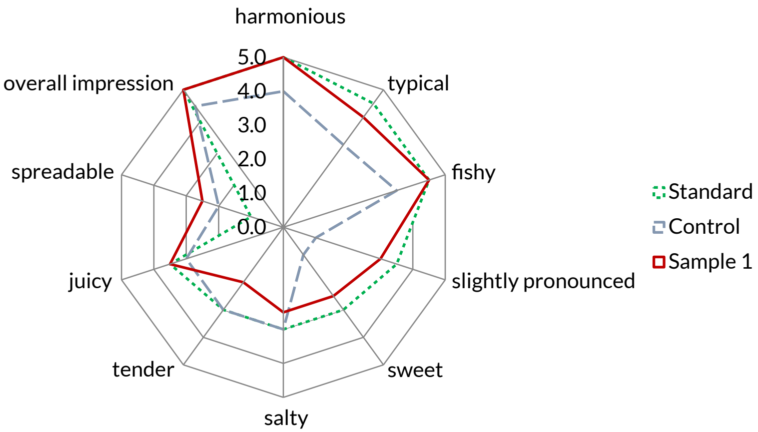

Fig. 6.1 Flavor profile of fish pâté with the addition of Goji berries (sample 1)

The figure shows the results of the organoleptic evaluation of the samples, presented in the form of a petal diagram. This method of visualization allows to clearly trace the differences between the reference, control and experimental samples according to the main sensory indicators. The evaluation was carried out taking into account the harmony of taste, typicality of aroma, pronounced fishy aftertaste, intensity of taste, sweetness, saltiness, juiciness, plasticity, density of consistency and overall impression.

As can be seen from the diagram, the reference sample has the most balanced profile and received the highest scores for the indicators "harmonious", "characteristic" and "overall impression". This indicates its good sensory quality and compliance with the expected characteristics of the product. The control sample is close to the reference in most indicators, but is somewhat inferior in individual taste and textural properties.

The experimental sample is characterized by certain differences in the profile. In terms of individual taste indicators, it approaches the reference, but in terms of consistency characteristics, in particular density and plasticity, there is a decrease in the ratings. At the same time, the overall impression of the sample remains at a sufficient level, which indicates its potential consumer appeal.

When comparing the calculated overall score in points, the experimental sample exceeds the reference with the addition of goji berries in the amount of 4% – with a score of 36.9 (**Fig. 6.2**).

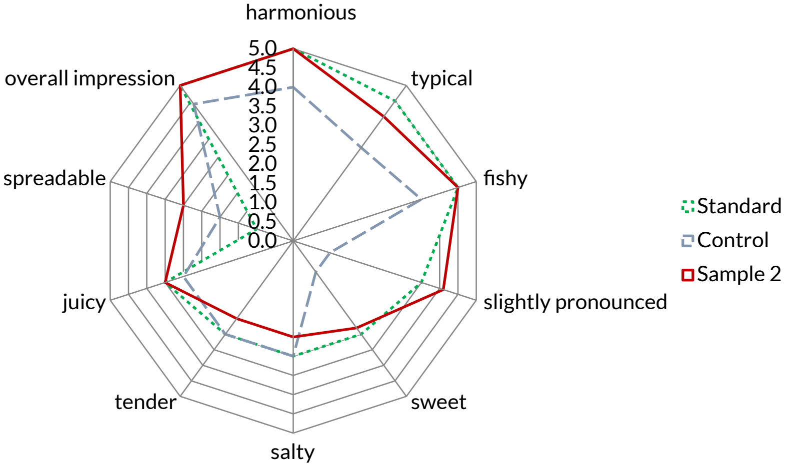

Fig. 6.2 Flavor profile of fish pâté with the addition of goji berries (sample 2)

Experimental sample 2 generally demonstrates positive dynamics compared to the control. In particular, sufficient harmony of taste, a well-pronounced fishy aftertaste and better plasticity indicators were noted. At the same time, its density indicator score is lower than that of the reference sample, which may indicate a softer product structure. Sweetness and saltiness are moderate and do not disrupt the overall taste balance.

Thus, the results obtained indicate that experimental sample 2 exceeds the reference and control indicators in most characteristics. This confirms that the product, according to this recipe, is the most balanced.

The flavor profile of the fish pate of experimental sample 3 is shown in **Fig. 6.3**.

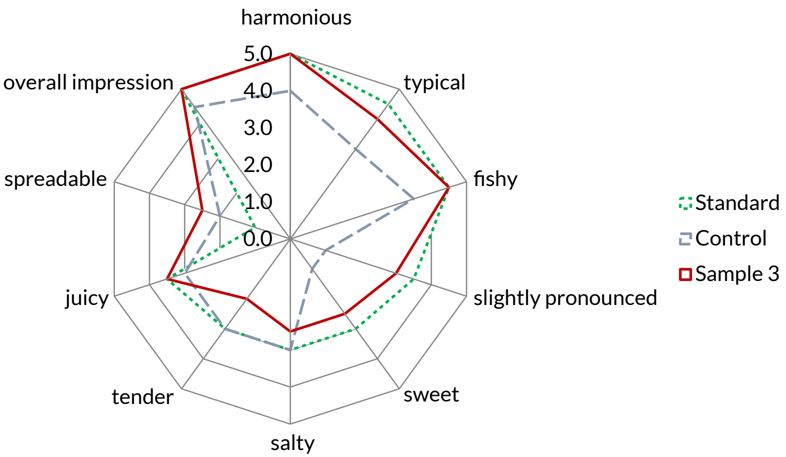

Fig. 6.3 Flavor profile of fish pâté with the addition of goji berries (sample 3)

Experimental sample 3 shows a tendency to improve individual indicators compared to the control, particularly in taste harmony, fishy flavor, and plasticity. At the same time, its values for the "density" parameter remain lower, suggesting a less dense, softer product consistency. The indicators of sweetness and saltiness are within moderate values and do not create a taste imbalance.

Thus, the results obtained indicate that experimental sample 3 approaches the reference in most sensory characteristics and exceeds the control in individual indicators. This confirms the positive impact of the technological changes introduced and the feasibility of further optimizing them to improve the product's structural and mechanical properties.

6.8 Dynamics of organoleptic, physicochemical quality indicators of fish pastes during storage

Organoleptic evaluation is one of the key methods for determining the quality of food products, since sensory indicators directly shape consumer preferences and product competitiveness. For fish pastes, appearance, color, aroma, taste, and consistency are particularly important and can change during storage due to physicochemical and microbiological processes.

The introduction of plant raw materials, in particular goji berries, can not only increase the biological value of the product, but also affect its sensory characteristics and stability during storage. In this regard, it is relevant to study the dynamics of organoleptic indicators of fish pastes with different contents of plant additives during the established storage period.

The aim of this study was to determine the effect of goji berries on the organoleptic properties of fish pastes and establish the optimal storage period based on the results of tasting evaluation.

Studies of organoleptic quality indicators of experimental samples of fish pastes during the storage period are given in **Table 6.11**.

Table 6.11 Organoleptic evaluation of fish pastes based on vegetable raw materials, scores ($n = 7$, $p \leq 0.05$)

Sample name	Shelf life, days	Indicators					Total score
		Appearance	Taste	Scent	Color	Consistence	
Control	1	4.1 ± 0.3	3.8 ± 0.2	4.0 ± 0.3	4.3 ± 0.3	4.1 ± 0.3	20.3
	2	4.2 ± 0.3	4.0 ± 0.3	4.1 ± 0.3	4.3 ± 0.3	4.1 ± 0.3	20.7
	3	4.2 ± 0.3	4.1 ± 0.3	4.1 ± 0.3	4.3 ± 0.3	4.1 ± 0.3	20.8
	4	4.2 ± 0.3	3.3 ± 0.3	4.0 ± 0.3	3.4 ± 0.3	4.2 ± 0.3	19.1
Sample 1	1	4.7 ± 0.4	4.3 ± 0.3	4.4 ± 0.3	4.4 ± 0.3	4.5 ± 0.4	22.3
	2	4.7 ± 0.4	4.5 ± 0.4	4.5 ± 0.4	4.7 ± 0.4	4.7 ± 0.4	23.1
	3	4.7 ± 0.4	4.6 ± 0.4	4.5 ± 0.4	4.7 ± 0.4	4.7 ± 0.4	23.2
	4	4.8 ± 0.4	4.4 ± 0.4	4.4 ± 0.4	4.6 ± 0.4	4.7 ± 0.4	22.9
Sample 2	1	4.7 ± 0.4	4.5 ± 0.4	4.5 ± 0.4	4.7 ± 0.4	4.3 ± 0.4	22.7
	2	4.8 ± 0.4	4.6 ± 0.4	4.6 ± 0.3	4.8 ± 0.4	4.4 ± 0.3	23.2
	3	4.8 ± 0.4	4.6 ± 0.4	4.6 ± 0.3	4.8 ± 0.4	4.5 ± 0.3	23.3
	4	4.8 ± 0.4	4.6 ± 0.3	4.5 ± 0.4	4.8 ± 0.4	4.4 ± 0.3	23.1
Sample 3	1	4.7 ± 0.4	4.5 ± 0.4	4.5 ± 0.4	4.9 ± 0.4	4.3 ± 0.4	22.9
	2	4.3 ± 0.3	4.6 ± 0.4	4.6 ± 0.3	4.7 ± 0.4	4.4 ± 0.3	22.6
	3	4.3 ± 0.3	4.6 ± 0.4	4.6 ± 0.3	4.7 ± 0.4	4.5 ± 0.3	22.7
	4	4.3 ± 0.3	4.6 ± 0.3	4.5 ± 0.4	4.6 ± 0.4	4.4 ± 0.3	22.4

As shown in **Table 6.11**, the best organoleptic indicators are those of fish pastes stored for 3 days. It is during this period that consumer properties form. The product acquires the best aroma, a delicate consistency, and a pleasant taste. After the tasting evaluation, it was found that all fish paste samples during this period had an attractive appearance, a pleasant taste and smell, and a fairly delicate, juicy consistency. According to the organoleptic evaluation, the best results were obtained with fish pastes containing goji berries. The control sample received the lowest score.

After 3 days of storage, the product's taste deteriorated, and an unpleasant odor developed.

During storage, a gradual increase in the acid and peroxide numbers was observed in all test samples, indicating the progression of hydrolytic and oxidative processes in the product's lipid fraction. An increase in the acid number characterizes the accumulation of free fatty acids due to the hydrolysis of triglycerides. In contrast, an increase in the peroxide number reflects the initial stages of lipid oxidation with the formation of peroxides and hydroperoxides.

The physicochemical parameters of the samples were studied during the storage period at a temperature of 0°C to 5°C in comparison with the control samples.

The depth of oxidative and hydrolytic changes in lipid substances of frozen semi-finished products during storage was estimated by the acid and peroxide numbers (**Fig. 6.4**, **6.5**).

The figure shows the change in the acid number (mg KOH) of the experimental fish paste samples during storage. All variants exhibit an exponential trend in the indicator's growth, as confirmed by high values of the coefficient of determination.

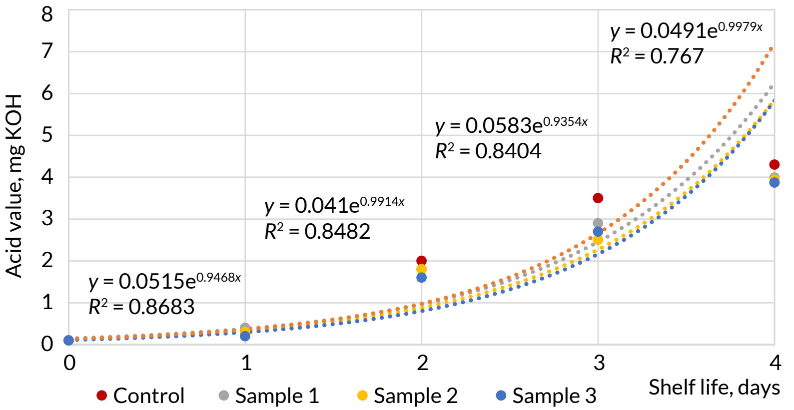

Fig. 6.4 Dynamics of changes in the acid value of fat in fish pastes during storage at 4°C

In the first 0–1 day of storage, the acid number remained at a minimum level and did not differ significantly between the samples. Starting from the second day, a gradual acceleration of its growth was observed, while on the 3–4th day a more intensive increase in the indicator was noted.

Throughout the entire period, the highest values of the acid number were established in the control sample. In contrast, samples with the addition of plant raw materials were characterized by a slower accumulation of free fatty acids. The smallest increase in the indicator was recorded in the variant with a higher proportion of functional additive.

The data obtained indicate that during storage, hydrolytic cleavage of lipids occurs, as evidenced by the exponential growth of the acid number. At the same time, the introduction of goji berries slows down the course of these processes, which is probably due to the presence of natural antioxidants in their composition. Thus, the use of plant raw materials contributes to increasing the stability of the lipid fraction of pates and can ensure the extension of their shelf life. The most pronounced stabilizing effect was observed in the sample with a larger amount of goji berries.

From the data presented in **Fig. 6.5**, it was established that changes in the peroxide value of lipids of semi-finished products during storage have a linear tendency to increase, which indicates the accumulation of primary oxidation products – peroxides. In the control cutlet samples, fat hydrolysis products accumulated more intensively than in the experimental samples.

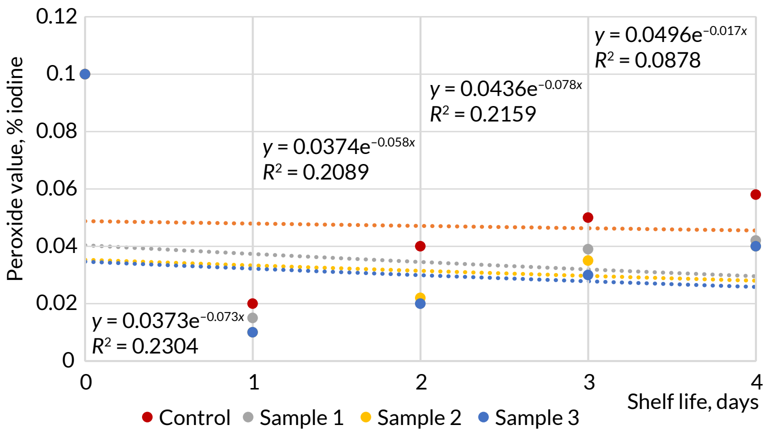

Fig. 6.5 Dynamics of changes in the peroxide value of fat in fish pastes during storage at 4°C

Analysis of the dynamics of the peroxide value in fish pastes with the addition of goji berries over 4 days of storage indicates a gradual increase in the indicator in all experimental samples, a natural consequence of lipid oxidation.

The lowest values of the peroxide value throughout the entire storage period were observed in samples 2 and 3, which indicates a pronounced antioxidant effect of goji berries.

In order to extend the shelf life, the paté samples were placed in plastic containers, which were hermetically sealed to avoid drying and oxidation of the fat. After that, they were stored at a temperature of –12°C and the determination of the chylo and peroxide value was carried out throughout the entire shelf life (**Fig. 6.6**, **6.7**).

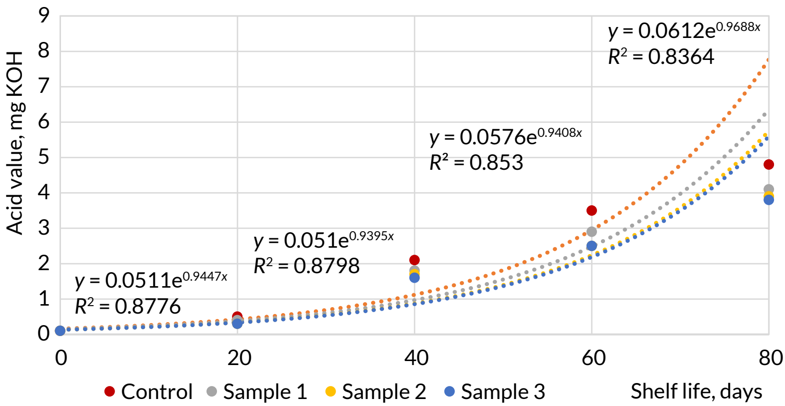

Fig. 6.6 Dynamics of changes in the acid value of fat in fish pastes during storage at –12°C

According to the results of the study, during storage, there is a gradual increase in the acid number in all the studied samples, which indicates the course of the processes of hydrolytic cleavage of lipids and the accumulation of free fatty acids.

Therefore, in the control sample, the accumulation of free fatty acids occurs most rapidly, while in the experimental samples a slower rate of increase in acid number is observed.

During storage, an exponential increase in the peroxide value is observed, which is due to the development of lipid oxidation processes. At the same time, in the experimental samples, the intensity of accumulation of primary oxidation products is lower compared to the control, which indicates an increase in the oxidative stability of the product and an extension of its shelf life.

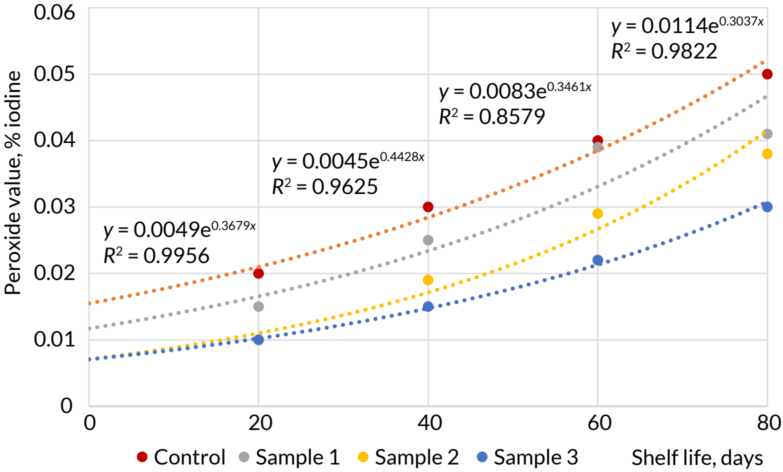

Fig. 6.7 Dynamics of changes in the peroxide value of fat in fish pastes during storage at 12°C

Based on the conducted studies, it was found that the storage temperature significantly affects the intensity of hydrolytic and oxidative processes in fish pastes. During storage at a temperature of 4°C, a faster increase in the acid and peroxide numbers is observed, which indicates a more intense accumulation of free fatty acids and primary lipid oxidation products.

In contrast, storage at a temperature of −12°C provides a much slower increase in the studied indicators. This is explained by the slowdown of biochemical and oxidative processes in the fat fraction of the product at a lower temperature.

The results obtained are consistent with data on the antioxidant properties of *Lycium barbarum*, which fruits contain polyphenols, carotenoids, and ascorbic acid, which are capable of inhibiting lipid peroxidation.

Thus, the addition of goji berries to the formulation of fish pastes increases their oxidative stability and slows the accumulation of primary fat oxidation products during storage, thereby positively affecting the product's quality and potential shelf life.

6.9 Microbiological indicators of fish pastes

To establish the microbiological safety of a new type of minced meat with vegetable raw materials, the total number of mesophilic aerobic and facultative anaerobic microorganisms in 1 g of the product, the presence of *Escherichia coli* bacteria, and pathogenic organisms were experimentally determined (**Table 6.12**). Pate samples were selected for analysis after 3 days of storage.

Table 6.12 Microbiological quality indicators of fish pastes

Naming indicators	Permissible level	Shelf life, days	Samples of fish pastes			
			Control	Sample 1	Sample 2	Sample 3
MAFAnM, CFU in 1 g	No more 2×10^4	3	1.0×10^5	1.2×10^4	1.3×10^4	1.3×10^4
BECG (coliforms), in 0.1 g	Not allowed	3	No	No	No	No
Golden Staphylococcus, in 0.1 g	Not allowed	3	No	No	No	No
Pathogenic microorganisms, including *Salmonella*, in 25 g	Not allowed	3	No	No	No	No

In the control samples after storage of fish pastes, an increase in KMAFAnM was noted compared to the experimental samples, which indicates the influence of algae on the extension of the shelf life of semi-finished products.

Microbiological indicators of the control and experimental samples throughout the entire storage period meet regulatory requirements, indicating the epidemiological safety of the produced fish pastes.

6.10 Conclusion

Analysis of current trends in the market of fish culinary products indicates a growing need for products with increased nutritional and biological value. Traditional types of products, such as canned, salted, and smoked fish, are limited due to the high content of table salt, carcinogenic substances from smoking, and imperceptible undesirable changes during sterilization. At the same time, the development of fish culinary production enables the comprehensive processing of fish with reduced commercial value, secondary products, and small fish, creating pâtés and pasty products that do not require complex processing and meet modern consumer requirements.

Studies have shown that the introduction of plant raw materials, in particular carrots, onions, and goji berries, into the recipe of fish pâtés allows for an increase in their nutritional, biological, and functional value, enriching the product with antioxidants, vitamins, macro- and microelements. Goji berries support the digestive system, improve mineral balance, and contribute to antioxidant and immunomodulatory effects, making them a promising ingredient for the creation of functional food products.

The inclusion of plant components, in particular carrots (8%), onions (9%), and goji berries (2–6%), allows to partially reduce the share of fish raw materials without deteriorating organoleptic properties. Goji berries are characterized by low moisture content (12.3%), the presence of pectin substances (2.5%) and fiber (3.6%), high content of potassium (2265 mg/kg), magnesium (1357 mg/kg), calcium (888.1 mg/kg), iron (91.58 mg/kg) and zinc (10.33 mg/kg), which increases the nutritional and functional value of the product.

Experiments have shown that the introduction of 2–6% goji berries ensures uniform distribution of raw materials in the pate, improves taste, aroma, and color characteristics, increases antioxidant potential, and helps extend shelf life. Combining fish raw materials with plant components also allows to increase the content of dietary fiber and biologically active compounds, increase the product's resistance to oxidative processes and create a functional food product that meets modern standards of healthy nutrition.

The introduction of goji berries into fish pâté formulations not only improves the nutritional and functional characteristics of the product but also positively affects its storage stability. The results of physicochemical studies showed that samples containing 2–6% goji berries were characterized by a slower increase in peroxide and acid values during storage compared to the control sample. Due to the presence of natural antioxidants in goji berries, oxidative processes in lipid components were inhibited, which contributed to improved product stability.

Thus, the scientifically substantiated use of goji berries in fish pate recipes allows to obtain a competitive product with high nutritional and biological value, optimal texture and taste characteristics, which confirms the prospects for the introduction of such technologies into the domestic food industry.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

Financing

The study was performed without financial support.

Data availability

The data that support the findings of this study will be made available by the authors on reasonable request.

Use of artificial intelligence statement

The authors confirm that no artificial intelligence technologies were used in the preparation of this work.

Authors' contributions

Nataliia Holembovska: Writing – editing, Conducting research.
Valentyna Israelian: Conducting research.
Natalia Slobodyanyuk: Conceptualisation, Review and Editing.
Anastasiia Ivaniuta: Project administration.
Inna Stetsyuk: Conceptualisation and Project administration.
Inna Kurbatova: Conceptualisation, Review and Editing.
Vasyl Shynkaruk: Conceptualisation, Writing – original draft.
Yaroslav Rudyk: Writing – original draft.

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