Specialized food products of increased biological value on a fish basis

Maria Tsibizova[1], *Olga* Bredikhina[2], *Vilen* Gizbrecht[2], *Nikita* Zarubin[2*], and *Elizaveta* Lavrukhina[2]

[1] Federal State Budgetary Educational Institution of Higher Education "Astrakhan State Technical University", 414056, Astrakhan region, Astrakhan city district, Astrakhan, Tatishcheva str., Russia
[2] Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 105187, Okruzhnoy proezd, Moscow, Russia

Abstract. According to the Strategy for Improving the Quality of Food Products in the Russian Federation until 2030, the priority area is the development of modern technologies for the production of food ingredients and food processing technologies, including biotechnologies to create conditions for the production of new generation food products with specified quality characteristics and promote the principles of healthy nutrition. Thus research in the field of creation, design of technologies and formulations of functional, enriched, specialized fish-based food products are developing. A special place is occupied by products for the nutrition of athletes, the diet and balance of which are determined by the rhythm of the training process. It is proposed to use fish pastes of increased biological value for nutrition of athletes. The main component of such products can be both aquatic biological resources and aquaculture objects. The possibility of expanding the assortment line of fish culinary products is considered. To increase the biological value of the pastes addition of Jerusalem artichoke is justified. The organoleptic and physico-chemical indicators of the quality of the resulting pastes were studied, which showed the possibility of including a phosphorus-calcium food supplement and Jerusalem artichoke in their recipe.

1 Introduction

A special place among the current areas is occupied by research in the field of creating, designing technologies and prescription compositions of functional, enriched, specialized food products, in particular, on a fish basis using biotechnology methods, which allows expanding the range of these types of products and using them for nutrition, enabling a person to maintain a healthy lifestyle.

At the same time athletes are an equally important group of the population that needs to create food products taking into account nutritional correction. Features of the diet of athletes and its balance are due to the rhythm of the training process. Sports, including professional sports, impose special requirements on the organization of specialized nutrition for athletes,

* Corresponding author: zar.nickita@yandex.ru

as they are associated with significant energy costs, which must be replenished through properly organized nutrition. It is well known that the diet, which, as a rule, provides for up to five meals, including snacks, should ensure the supply of the necessary substances for the normal course of metabolic processes, maintaining the functioning of the athlete's body and his increased physical performance. One of the problems in the nutrition of an athlete is a sufficient intake of vitamins and minerals from food, any deficiency of which adversely affects their performance [1, 2].

The most important factors that characterize a person's performance include the development of speed-strength qualities and neuromuscular coordination of movements, bioenergetic (aerobic and anaerobic) capabilities of the body. Among the biochemical factors that determine the speed-strength abilities of a person, the total content and enzymatic properties of contractile muscle proteins are noted [3]. It is well known that specific manifestations of physical performance in various sports are specific and depend on its type. Features of the manifestation and formation of physical performance factors depend on the correct organization of the athlete's nutrition.

It is customary to distinguish two main lines in sports nutrition. The first line includes basic nutrition, i.e. focused on the full satisfaction of all nutritional needs of active athletes and ensuring a high level of their health and performance. The second line is an ergogenic diet, where nutritional factors are used to target key metabolic reactions in the body to cause a significant improvement in human physical performance [4,5].

It is well known that when performing sports loads, the breakdown of proteins, mainly muscle proteins, increases, therefore, an increased supply of amino acids is necessary to restore. This necessitates the use of a high protein diet. In addition, the loss of minerals through sweat during exercise and during muscle recovery in the inter-workout period should also be compensated. Scientists have found that to a greater extent athletes need such macro- and microelements as calcium, magnesium, potassium and phosphorus. The iron requirements of athletes are approximately 70% higher than those of non-athletes (this is especially true for endurance sports), 2.5 times higher for phosphorus and calcium, 1.5 times higher for manganese, 1.5 times higher for copper and in magnesium, by 2 times; in chromium, by 3–5 times; in zinc, by 1.7 times; and in selenium, by an average of 3 times [4]. Thus, issues related to the additional intake of minerals with food are also relevant.

The authors consider that protein products, which include fish culinary products, play a key role in the diet of athletes. The most popular for athletes are pates, which are quite convenient to use and can be included in their diet as a snack. Therefore, it remains relevant to conduct research to expand the range of fish culinary products using the example of the production of pâtés. Both aquatic biological resources and aquaculture objects can be used as the main component of pâtés.

Carp is considered the most promising product among aquaculture objects for processing using the principles of deep fractionation, the production volumes of which are at the level of 35% of the total production of commercial aquaculture products in the Astrakhan region and Russia. Therefore, minced fish from carp obtained by traditional technology was used as the main object of study. Our studies of the chemical composition of minced fish showed that it contains more than 17% protein and up to 4.5% fat, which confirms its use as the main component of pies intended for nutrition of athletes [6].

In our opinion a phosphate-calcium mineral supplement obtained from fish bone tissue can be a source of natural calcium and phosphorus. As a mineral component of the pastes, we propose to use a phosphorus-calcium food supplement obtained by us using a previously developed technology. According to the developed technology, it is necessary to clean fish bones from muscle tissue by boiling bone tissue in the anolyte of the ECA solution, which allows not only to achieve maximum extraction of nitrogenous extractives into the broth, but also to separate muscle tissue from bone tissue. The broth formed during the cooking process

is usually used in the technology of the gelling component for various fish spread products. The fish bones formed after cleaning from muscle tissue are dried for 20-30 minutes, and then fired at a temperature of 700 ° C for 8-9 hours until a dried dark-beige bone mass with slight gray inclusions is obtained. Then it is additionally crushed to obtain a powder without large inclusions [7]. The resulting powder can be included in the composition of the pastes in an amount of up to 3% in order to increase the content of calcium and phosphorus in them in the form digestible by the human body.

To enrich pates with dietary fiber and improve their consistency and juiciness, it is proposed to include vegetable components in their composition. Among the vegetable crops that a person consumes in his diet, Jerusalem artichoke tubers, which are a source of biologically active substances, can be noted. A feature of Jerusalem artichoke is its representation as a carbohydrate complex based on fructose and its polymers: inulin and fructooligosaccharides. They also contain sugars, proteins, organic acids, pectins and inulin polysaccharide (up to 17%). They contain a fairly large amount of mineral salts: salts of potassium, iron, silicon, zinc. An equally important feature is the development of fish food products also with a low content of table salt, which is in line with modern principles of healthy nutrition, which provide for a reduction in the share of its consumption.

Thus, the purpose of the conducted research is to substantiate and develop the formulation of specialized food products of increased biological value based on fish in the form of pastes intended for inclusion in the diet of athletes.

2 Objects and methods of research

The objects of research were such aquaculture object as carp, which is widely used for the production of molded culinary products, carp cutting waste - bone tissue, including the backbone, head, fins, phosphorus-calcium food supplement obtained from bone tissue, vegetable components, experimental samples of pates.

The recipe compositions of fish-based pates with plant components proposed for testing in the experiment are presented in Table 1.

Table 1. Model recipes for carp pates, tested in the experiment.

Components	**Component consumption**			
	Control Recipe		**Recipe No 1**	
	kg/tube	**%**	**kg/tube**	**%**
Minced fish from carp	275.6	75.0	174.6	47.5
Egg	1.0	0.3	1.0	0.3
Salt	1.45	0.4	1.45	0.4
Ground black pepper	0.02	0.01	0.02	0.01
Ground allspice	0.02	0.01	0.02	0.01
Jerusalem artichoke	-	-	91.8	25.0
Carrot	36.7	10.0	36.7	10.0
Phosphorus-calcium food supplement	-	-	11.0	3.0
Water	52.55	14.3	50.91	13.8
Product yield, taking into account losses due to mixing, grinding and packaging	367.5	100	367.5	100.0

2.1 Sampling

When setting up the experiment, sampling was carried out in accordance with GOST 31339-2006 [8].

2.2 Determination of the chemical composition

The mass fraction of water was determined by drying at a temperature of 103 ± 5 °C to constant weight [9].

The mass fraction of ash was determined by burning a dried sample in a muffle furnace at t = 500–700°C to constant weight [9].

The mass fraction of protein was determined by the Kjeldahl method using an autoanalyzer from the Swedish company FOSS Analitical AB, model FOSS 2300, calculated from the content of total nitrogen using a coefficient of 6.25 [9].

The mass fraction of fat was determined by the extraction method using the Soxhlet apparatus [9].

The content of carbohydrates was determined by the calculation method, using data on the content of protein, fat, ash and water in the objects of study.

2.3 Determination of energy value

The energy value was determined by the calculation method, using data on the chemical composition and conversion factors protein: fat: carbohydrates 4:9:4.

2.4 Determination of organoleptic indicators

The organoleptic quality indicators of the objects of study were studied in accordance with the requirements of GOST 7631-2008 [10], GOST 32790-2014 [11] and the recommendations of scientists [12] using a verbal description of properties.

2.5 Determination of the mineral composition

The mineral composition was determined by inductively coupled plasma mass spectrometry on a Nexion 300D quadrupole mass spectrometer (PerkinElmer, USA).

3 Results and discussion

As a result of the research the chemical composition of carp bone tissue before and after cooking and their energy value were studied (Table 2).

Table 2. The chemical composition of carp bone tissue before and after cooking and their energy value.

Research objects	Contents, %				Energy value, kcal
	Fat	Protein	Moisture	Ash	
Bone tissue of carp before cooking	4.1±0.1	17.6±0.8	69.6±2.8	8.7±0.5	107.3±5.9
Bone tissue of carp after separation of muscle tissue	3.8±0.1	16.8±1.1	61.5±3.1	17.9±0.4	101.4±6.2

After cooking the bone tissue (Table 2), the content of mineral substances significantly increases, thereby confirming that the bone tissue is a good source of macro- and microelements. It has also been established that cooking bones with subsequent separation of muscle tissue leads to a decrease in the mass fraction of fat, on average by 7%, which affects the energy value. The high-water content in the bone tissue requires a drying process, so after drying, the moisture content in them was no more than 8%. The resulting phosphorus-calcium dietary supplement was a finely ground dark beige powder without foreign taste and smell, which confirms the possibility of its inclusion in the composition of fish pastes to increase their biological value. In addition, it was found that in 1 g of a phosphorus-calcium food supplement obtained from carp bone tissue, the calcium content was 42 mg, phosphorus - 33 mg.

Based on the recipe composition of pates proposed for testing, prototypes were obtained. It has been established that the obtained test samples of pates have an attractive appearance, have a pronounced taste and aroma characteristic of a fish product. The inclusion of Jerusalem artichoke pates in the recipe gives them a certain tenderness and increased juiciness, despite the inclusion of a phosphorus-calcium food supplement in the pates of recipe No. 1. The color of the pates is uniform, and dark beige in the sample of the recipe No. 1 and gray-beige in the control sample due to the inclusion of carrots in their recipe. Thus, the inclusion of a phosphorus-calcium food supplement in the amount of 3% of pate No. 1 in the recipe did not have a negative effect on their organoleptic characteristics.

The chemical composition and energy value of pies of prototypes tested in the experiment are presented in Table 3.

Table 3. The chemical composition and energy value of pies of prototypes tested in the experiment.

Pates	Contents, %					Energy value, kcal
	Protein	Fat	Carbohydrates	Ash	Water	
Control Recipe	17.1±0.4	3.3±0.2	1.8±0,1	1.5±0.1	76.3±1.4	105.3±2.2
Recipe No 1	15.9±0.3	2.8±0.2	2.2±0,2	2.8±0.1	76.3±1.2	104.6±2.1

The calculation of the chemical composition of pates based on minced carp meat showed (Table 3) that the introduction of new components affects the chemical composition of these products. Thus, the introduction of Jerusalem artichoke into recipe No. 1 reduced the proportion of protein in it compared to the control by an average of 7%, as well as the fat content by 15%, but increased the proportion of carbohydrates by an average of 18%. The content of mineral substances is maximum in formulation No. 1 due to the introduction of phosphorus-calcium food supplements into the composition of the pastes. Calculations of the energy value of pates showed that the decrease in the share of the fish component and the increase in the share of the vegetable component had practically no significant effect. But the biological value of the pâtés obtained according to recipe No. 1 is certainly higher, which is due to the introduction of a mineral food additive into their composition.

To confirm the increase in the biological value of pies due to the introduction of Jerusalem artichoke and phosphorus-calcium food supplements into their composition, a comparative analysis of the content of minerals in the main components of the pies was carried out (Table 4).

Table 4. Comparative analysis of the content of mineral substances in the main components of the pastes.

Macro- and microelements	Contents, mg			
	Minced carp	Jerusalem artichoke	Carrots	Egg
Sodium	55.13±0.08	3.18±0.01	21.24±0.07	134.16±2.12
Potassium	265.24±1.21	200.0±2.26	200.40±1.45	140.44±1.22
Phosphorus	210.22±0.45	78.21±0.07	55.24±0.05	192.88±3.24
Magnesium	25.21±0.05	12.08±0.05	38.21±0.04	12.45±0.05
Calcium	35.37±0.03	20.17±0.03	5.21±0.02	55.23±0.05
Copper	0.13±0.01	2.0±0.05	0.08±0.01	0.083±0.008
Manganese	0.15±0.01	0.21±0.01	0.23±0.01	0.029±0.001
Zinc	2.08±0.01	0.29±0.01	0.47±.01	1.14±0.04
Iron	0.8±0.1	0.45±.02	0.72±0.12	2.55±0.01

A comparative analysis of the content of mineral substances in the main components of the pastes showed (Table 4) that minced carp has a higher content of potassium and phosphorus. Minced fish contains the most zinc. Jerusalem artichoke is a source of copper, an egg is a source of sodium, iron, calcium. Of course, each component of the pate enriches this product with mineral macro- and microelements and has its own biological value, therefore, only a combination of plant and animal raw materials will make it possible to obtain a product that will have a high biological value and can be recommended for athletes as a snack.

Table 5 shows the established content of minerals in the pates of the formulations under consideration.

Table 5. The content of mineral substances in pâtés of recommended recipes.

Macro- and microelements	Contents, mg	
	Control Recipe	Control Recipe
Sodium	43.83±0.8	29.45±0.9
Potassium	399.2±1.8	371.3±2.5
Phosphorus	163.6±2.1	183.6±1.7
Magnesium	22.61±0.23	20.77±0.32
Calcium	31.53±0.41	37.42±0.33
Copper	10.65±0.08	33.86±0.24
Manganese	0.133±0.08	0.144±0.09
Zinc	1.57±0.09	1.19±0.08
Iron	0.68±0.08	0.56±0.08

According to the data presented (Table 5), the introduction of Jerusalem artichoke pates and phosphorus-calcium food supplements (recipe No. 1) into the formulation of pates had an impact on the content of macro- and microelements. It was found that the content of copper increased by an average of 3.3 times, calcium and phosphorus - by 16 and 11%, respectively, manganese - by 8%. At the same time, in the proposed for practical use in the diet of athletes, the content of potassium and magnesium significantly decreased (by 7% on average), zinc and iron - by an average of 26 and 18%, respectively, sodium - by 30%. Thus, the introduction of a phosphorus-calcium food supplement into the pate recipe increases their biological value.

4 Conclusion

The possibility of expanding the range of fish pastes, the main component of which is fish raw materials, both marine, oceanic, and objects of commercial aquaculture, is substantiated. The practical use of a phosphorus-calcium food supplement obtained from bone tissue formed after cutting fish helps to increase the biological value of the proposed product by increasing the content of such minerals as phosphorus, calcium, manganese, copper. Studies have been carried out to study the possibility of expanding the range of fish pastes by introducing an additional vegetable component into their composition, which acts as a source of inulin and fructooligosaccharides. The quality indicators of pates, their chemical composition, energy value, the content of individual macro- and microelements were studied, which showed a sufficiently high nutritional value, which makes it possible to recommend them for inclusion in the diet of athletes as a snack.

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