Design of the formulation composition and technology of finely ground fish semi-preserves with immunomodulatory properties

N Y Zarubin, E V Lavrukhina, L O Arkhipov, E N Kharenko and O V Bredikhina

Russian Federal Research Institute Of Fisheries and Oceanography, 17 V. Krasnoselskaya, Moscow, 107140, Russia

E-mail: zar.nickita@yandex.ru

Abstract. The paper presents research data substantiating the relevance of the development of ready-to-eat food products in the form of finely ground semi-canned fish containing components with immunomodulatory properties, namely fat-soluble vitamins A and D, polyunsaturated acids of the omega -3.6 group, copper (Cu) and the prebiotic inulin. Due to mathematical modeling, optimal recipe compositions have been designed and a technology for this type of product has been developed. Studies of quality indicators of the developed finished product made it possible to establish its high nutritional value, in particular, its biological value: semi-canned food contains fat-soluble vitamins A (from 386.50 to 443.31 μg/100 g) and D (from 10.39 to 12.96 μg/100 g), polyunsaturated fatty acids of the omega -3.6 group (ω-3/ω-6 - from 1.02/0.08 g to 1.35/0.23 g), an essential trace element copper (Cu - 0.86-1.21 mg/100 g), as well as dietary fiber, in In particular, inulin (3.12-3.49, the amount of which will satisfy the daily physiological need above 15%, which allows us to say about the enrichment of these minor macro- and micronutrients and recommend it as a natural functional food with immunomodulatory properties.

1. Introduction

Today, more and more new strains of viruses are constantly emerging in the world that pose an immediate danger to human life and health. Due to weakened immunity, many diseases are severe and can be fatal. Therefore, preventive health measures are needed that can reduce the risk of infection and progression of viral diseases.

One of the preventive measures is the development of products with immunomodulatory properties, which is one of the promising areas for strengthening human immunity and reducing the risk of contracting viral infections [1].

It is known that vitamin D has an antiviral effect, which can inhibit viral replication, and also has anti-inflammatory and immunomodulatory effects. Vitamin D deficiency, which occurs in 80% of Russians, is associated with impaired functioning of innate and acquired immunity and an increased risk of viral and bacterial diseases [1, 2]. Adequate supply of the body with vitamin D is one of the foundations of antiviral immunity, including against the influenza virus. According to the WHO, vitamin D deficiency is of a pandemic nature, affecting over 1 billion inhabitants of the planet [2]. Retinol, or vitamin A, is also important, as it enhances the synthesis of interleukin proteins, which, in turn, stimulates the division of T-lymphocytes. These cells are active participants in immune responses, they...
identify and destroy viruses and bacteria, and fight tumor cells. The use of vitamin A can increase resistance to infections, accelerate recovery and provide antioxidant protection [1,3].

Polyunsaturated fatty acids of the omega-3 (ω-3) and omega-6 (ω-6) class also participate in the formation of the immune defense of the human body. ω-3 and ω-6 fatty acids play a certain role in the phenotypic maturation of immune cells and the development of a functionally competent immune response, including the maturation of cytokine markers of T-lymphocytes [4, 5].

In addition, trace elements, in particular copper, play an important role in enhancing human immunity. Copper is present in the body's antioxidant defense system, being a cofactor of the enzyme superoxide dismutase, which is involved in the neutralization of oxygen free radicals. This bio element increases the body's resistance to certain infections, binds microbial toxins and enhances the effect of antibiotics. Copper has a pronounced anti-inflammatory property, softens the manifestations of autoimmune diseases, and promotes the absorption of iron. With a copper deficiency, hematopoiesis, iron absorption, impaired connective tissue structure suffer, there is a predisposition to bronchial asthma, cardiopathies, allergodermatosis, and weakens the body's immune mechanism as a whole [3, 6, 9].

At the same time, one should monitor the microbiota of the gastrointestinal tract, the improvement of which is facilitated by the use of prebiotics obtained from plant materials, among which inulin play an important role. A feature of inulin is its ability to increase the absorption of vitamins and minerals in the body, such as calcium, magnesium, zinc, copper, iron, phosphorus and selenium. Inulin participates in the metabolism of lipids in the blood - cholesterol, triglycerides and phospholipids, thereby improving its effectiveness, thereby reducing the risk of cardiovascular diseases, mitigating their consequences and helps to strengthen the body's immune defense [7, 8, 9].

One of the main sources of vitamin A, D, ω-3.6 and copper is sea fish and its liver (in particular, Cod and Pollock liver), and inulin is a plant product - Jerusalem artichoke, which can be used to create natural functional food products [10] for the prevention of deficiency of minor macro- and microelements. The development of such food products, which provides for the rational use of raw materials, in particular fish, based on assortment and recipe optimization, selection of recipes for the chemical composition of recipe components and the introduction of new types of products balanced in terms of biological value using modeling methods, is relevant.

Considering the accelerated pace of life of a modern person and his employment, interest increases the demand not only for finished culinary products that require a minimum investment of time for their complete culinary processing, but also for products that do not require time consuming to bring them to full culinary readiness. This group of products includes finely ground food products - pates based on fish raw materials. A significant advantage of products based on a finely ground food system is the possibility of using practically any raw material of plant and animal origin for their production with various technological parameters and properties, including functional ones, which are important for increasing the biological value of a food product. Homogeneous food systems with a certain degree of grinding, ensuring the maximum functional, technological and rheological properties of the product, are obtained by using colloid mills, cutters, emulsifiers, homogenizers, which make it possible to achieve fine grinding of raw materials.

Since, when designing the recipe composition and technology of natural functional food products with immunomodulatory properties, it is important to maximize the preservation of minor nutrients and obtain them with a high degree of readiness, preference was given to the group of semi-canned food products. In accordance with GOST 28322-2014 “By-products of fruits, vegetables and mushrooms. Terms and definitions "semi-canned foods are food products that have been processed by physical and chemical methods that meet the established microbiological parameters with a shelf life of less than 6 months under specified storage conditions".

This choice is justified by the fact that semi-canned food is made in a sealed container without oxygen access, which reduces the oxidation of fats and may not be sterilized at temperatures above 100 °C, leading to the loss of polyunsaturated fatty acids and vitamins A and D [3, 4], and pasteurization at a temperature of 60-100 °C in accordance with the Technical Regulations of the Eurasian Economic Union "On the safety of fish and fish products (TR EAEU 040/2016)". The temperature regime of
pasteurization in a closed system, in contrast to heat treatment above 100 °C in an open system (cooking, frying and baking), contributes to the maximum preservation of minor nutrients, in particular, fat-soluble vitamins A, D and polyunsaturated fatty acids of the ω-3:6 group, which are sensitive to high temperatures, and are also actively oxidized in the presence of oxygen [1, 2, 3, 4, 5].

In this regard, the main purpose of the research was the design of the recipe composition and the development of technology for finely ground semi-canned fish with immunomodulatory properties using fish raw materials containing vitamins A and D, polyunsaturated acids of the ω-3, 6 group, copper, as well as functional plant components.

2. Objects and methods of research
Macrourus (Macrourus), Pollock (Theragra chalcogramma), mackerel (Scomber), which are sources of complete protein (13.0–19.0%) and polyunsaturated fatty acids omega-3, 6 (in particular, mackerel). As a source of vitamin A and D, to model the recipe composition, cod and Pollock liver was chosen, in which their content varies from 3500 to 4600 μg/100 g and from 100 to 250 μg/100 g, respectively [5, 11, 12].

The use of this raw material in the composition of the product will contribute to its enrichment with fat-soluble vitamins. Also, the liver of cod and Pollock is a full-fledged source of copper (immunomodulatory component), its content reaches 125000 μg/100 g with a daily rate of 1000 μg [9, 10, 12]. The use of inulin will improve the stability of the food system and the texture of the product due to its emulsifying and stabilizing properties and enrich it with prebiotics, which will have a positive effect on the motility of the gastrointestinal tract of the human body [7, 13, 14]. To reduce the bitterness of the liver of cod and Pollock and increase the saturation of the fish taste, a mixture of herbs for fish dishes, pickled cucumbers and low-fat soft cottage cheese were used.

2.1. Mathematical data processing
Experimental data processing and recipe optimization were carried out using mathematical statistics using Microsoft Excel 365 programs [15, 16, 17].

2.2. Technological process
To obtain finely ground semi-canned food, a technology has been developed based on such technological processes as homogenization and pasteurization. Homogenization allows you to obtain a homogeneous, delicate, smearing consistency of the food system for semi-canned fish, which are pates, which are finely ground homogeneous products. It was taken into account that fat-soluble vitamins are resistant to high temperatures, but not higher than 120 °C for vitamin A and 100 °C for vitamin D [3, 4]. In this regard, in order to preserve their chemical structure and biological activity, pasteurization under vacuum at a temperature of 95 °C was chosen as a heat treatment, which allows ensuring the greatest preservation of the lipid component of fish raw materials in hermetically sealed cans without oxygen access.

This is due to the fact that heat treatment of a product in a closed system eliminates the loss of nutrients that occur during heat treatment in an open system with oxygen access (cooking, frying, baking). The absence of oxygen in the product and inactivation of tissue and microbial enzymes during pasteurization exclude the process of lipid oxidation and hydrolysis, thereby preserving minor micronutrients [18].

At the first stage, fish raw materials (grenadier, Pollock, mackerel) were defrosting in running or periodically changed water at a temperature not exceeding 15 °C at a fish to water weight ratio of 1:2, followed by washing and cutting to fillets. The resulting fish fillet was ground through a top with a hole diameter of 3 mm. Frozen livers of cod and Pollock were thawed and cut into pieces 3–5 cm in diameter. Grinding cod and Pollock livers on a top is not rational, as it leads to high losses of the fat fraction. Further, to prepare for the homogenization process, the food system of the product was formed. For this, depending on the example of the recipe composition, chopped fish fillets, liver, fat-free cottage cheese,
pickled cucumbers, water, inulin and food additives (salt, a mixture of herbs for fish dishes, alginate, carrageenan) were mixed in a container.

At the second stage, the formed food system for semi-canned fish was homogenized at 7000 - 9000 rpm for 4–6 minutes, which made it possible to obtain a finely ground homogeneous mass. Then they were packed in sterilized glass jars with a volume of 100 ml. To do this, parchment circles soaked in boiled fresh water are placed on the bottom of the can and under the lid (the diameter of the parchment circles should be 3–4 mm less than the inner diameter of the can) and the homogeneous mass was packed, followed by sealing.

At the third stage, the product was pasteurized under vacuum at a temperature of 95 °C for 30 minutes until fully cooked. The duration of pasteurization of the product is justified experimentally. With the selected modes, a ready-to-eat product is obtained, which is confirmed by a temperature in the center of the product of 72 °C. After the completion of pasteurization, the jars with product samples were cooled to a temperature of 12–15 °C, washed and dried.

2.3. Determination of the chemical composition
The mass fraction of water was determined by drying at a temperature of 103±5 °C to constant mass [19].

The mass fraction of ash was determined by burning a dried sample in a muffle furnace at t=500–700 °C to constant weight [19].

The mass fraction of protein was determined by the Kjeldahl method using an autoanalyzer of the Swedish company FOSS Analitical AB, model FOSS 2300, calculated from the total nitrogen content using a coefficient of 6.25 [20].

The mass fraction of fat was determined by the extraction method using a Soxhlet apparatus [19].

The mass fraction of carbohydrates was determined by extraction of soluble carbohydrates (sugars) from the product with distilled water at a temperature of 50-60 °C, subsequent hydrolysis of easily hydrolyzable carbohydrates (starch) with 1% sulfuric acid solution in the residue, dehydration of sugars from the extract and hydrolyzate, staining the solutions with an anthrone reagent and photometric determination optical density of solutions [19].

The mass fraction of inulin was determined spectrophotometrically based on the ability of sugars, such as fructose and sucrose, to form products with maximum absorption at a wavelength of 200–380 nm when heated with concentrated acids [13].

The mass fraction of copper was determined by dry mineralization (ashing) of the sample using nitric acid as an auxiliary agent and subsequent quantitative determination of copper by polarography in alternating current mode [19].

The recommended daily intake of nutrients was calculated in accordance with the norms of consumption established in the territory of the Russian Federation [8, 9, 10, 16, 17, 21].

2.4. Determination of energy value
The energy value was determined by a calculation method using data on the chemical composition and conversion factors for protein: fat: carbohydrates 4: 9: 4 [17, 19].

2.5. Determination of amino acid and fatty acid composition
The amino acid and fatty acid composition of the product was determined by gas-liquid chromatography. Amino acid rate was determined by a calculation method using an amino acid scale and daily requirement for essential amino acids [19].

2.6. Determination of the content of fat-soluble vitamins
The content of fat-soluble vitamins was determined by high performance liquid chromatography. The method is based on alkaline hydrolysis of a product sample and extraction of fat-soluble vitamins with diethyl ether. The analysis of the obtained extracts is carried out by the method of high performance liquid chromatography in the ultraviolet (UV) region of the spectrum with a given wavelength. The
results obtained in the form of peaks on the chromatogram are compared with the peaks of standard solutions of samples of vitamins of known mass concentrations [19].

2.7. Determination of organoleptic characteristics
Organoleptic indicators were determined by visual, olfactory and gustatory methods using verbal characteristics of properties and a point scale [16, 19].

3. Results and their discussion
The calculation of the mass fractions of the components included in the recipe composition of finely ground semi-canned fish with immunomodulatory properties was carried out using the methods of mathematical modeling [15, 16, 17, 22, 23, 24]. Table 1 shows the main criteria for calculating one of the recipe compositions of finely ground fish semi-canned food. Based on the information matrix of the data (table 1), a system of linear balance equations was compiled, which made it possible to calculate the projected recipe compositions.

Table 1. Example data matrix for designing the recipe composition of finely ground fish semi-canned food with immunomodulatory properties.

| Ingredients                  | X  | Content                        | g/100g | g/100g | g/100g | μg  | mcg  | g/100g  |
|------------------------------|----|--------------------------------|--------|--------|--------|-----|------|---------|
| Grenadier mince              | X0 | protein, fat, Prebiotics, vitamins D, copper, ω-3/ω-6 | 12.70  | 0.50   | 0      | 0   | 60.00| 0.04/0.0004 |
| Mackerel mince              | X1 |                                | 16.90  | 18.50  | 0      | 16.10/50.00| 100.00| 0.41/0.03 |
| Cod liver                   | X2 |                                | 11.0   | 47.00  | 0      | 100.00/4400| 12500.00| 0.40/0.02 |
| Water                       | X3 |                                | 0      | 0      | 0      | 0   | 0    | 0       |
| Salt                        | X6 |                                | 0      | 0      | 0      | 0   | 0    | 0       |
| Mix of herbs for fish dishes| X7 |                                | 0      | 0      | 0      | 0   | 0    | 0       |
| Pickles                     | X8 |                                | 0.33   | 0.20   | 2.26   | 0   | 28.00| 0       |
| Inulin                      | X9 |                                | 0      | 0      | 100.00 | 0   | 0    | 0       |
| Alginate + carrageenan      | X10|                                | 0      | 0      | 100.00 | 0   | 0    | 0       |
| Balance equation            |    |                                | 10.85  | 9.39   | 3.91   | 13.88/452.05 | 1302.26| 0.85/0.04 |

Thus, on the basis of mathematical modeling for the experimental studies, 15 formulations of finely ground semi-canned fish with immunomodulatory properties were designed. Based on the calculated quantitative content of vitamins A, D, ω-3.6, copper and prebiotics, daily consumption rates, as well as organoleptic analysis, a sample of 4 optimal formulations of products was made for further research (table 2).

Table 2. Recipe composition of finely ground semi-canned fish with immunomodulatory properties.

| Formulation components | Recipe № 1 | Recipe № 2 | Recipe № 3 | Recipe № 4 |
|------------------------|------------|------------|------------|------------|
| Grenadier mince        | 44.60      | 47.00      | -          | -          |
| Mackerel mince         | 24.40      | 22.80      | 24.50      | 21.40      |
| Minced pollock         | -          | -          | 39.50      | 42.60      |
| Cod liver              | 10.00      | -          | 10.00      | -          |
| Pollock liver          | -          | 10.00      | -          | 10.00      |
| Water                  | 10.60      | 10.80      | 9.80       | 10.80      |
| Salt                   | 0.50       | 0.50       | 0.50       | 0.50       |
The development of technology for finely ground food products with functional properties consists not only in modeling recipe compositions (varying the type and ratio of the main components), but also in optimizing the parameters of the main technological operations: homogenization and pasteurization. These operations made it possible to disperse the components of the recipe composition with different strengths [22, 23].

Based on simulated recipe compositions and established rational parameters of homogenization processes (process duration - 4 minutes at a speed of 7000 rpm for recipes № 1 and № 2; process duration - 6 minutes at a speed of 9000 rpm for recipes № 3 and № 4) and pasteurization (processing time - 30 minutes at a temperature of 95 °C), a technology has been developed for the process of obtaining semi-canned fish with immunomodulatory properties.

It has been substantiated that for fine grinding and obtaining a smearing consistency, the particle diameter of finely ground muscle tissue should be in the range from 0.1 to 1.4 mm [25]. Selected experimentally, based on the particle diameter during grinding and rheological properties, the homogenization parameters made it possible to obtain a finely ground product such as pate, the diameter of the muscle tissue particles, which were included in the set chapel. Differences in the parameters of homogenization for recipes № 1 and № 2 and recipes № 3 and № 4 are due to the fact that the muscle tissue of grenadier is looser and watered than the muscle tissue of Pollock, which is more fibrous and dense, requiring more time and speed for grinding [26, 27, 28].

Experimental production of samples of the developed products and its study to determine quality indicators, including fatty acid composition, the content of fat-soluble vitamins A and D, copper and inulin (tables 3–5) were carried out.

**Table 3.** Chemical composition and energy value of finely ground semi-canned fish with immunomodulatory properties.

| Indicators                  | Recipe № 1       | Recipe № 2       | Recipe № 3       | Recipe № 4       | Recommanded daily allowance [8, 9, 10] | The share of the daily allowance, % |
|-----------------------------|-------------------|-------------------|-------------------|-------------------|---------------------------------------|-----------------------------------|
| mass fraction of water,%    | 72.25±0.79        | 73.12±0.83        | 70.50±0.51        | 72.57±0.79        | -                                     | -                                 |
| mass fraction of protein,%  | 8.66±0.05         | 9.56±0.09         | 10.62±0.11        | 11.51±0.05        | 70 g                                  | 12.37-16.44                       |
| mass fraction of fat,%      | 12.98±0.13        | 11.92±0.10        | 12.19±0.12        | 8.90±0.13         | 70 g                                  | 12.71-18.54                       |
| mass fraction of carbohydrates,% | 4.21±0.02      | 3.59±0.04         | 4.95±0.05         | 3.99±0.26         | 257 g                                 | 1.43-1.92                         |
| mass fraction of ash,%      | 1.90±0.02         | 1.81±0.01         | 1.74±0.01         | 2.03±0.02         | -                                     | -                                 |
| energy value, kcal          | 164.30±2.12       | 169.82±2.34       | 171.99±3.21       | 142.10±1.98       | 2500 kcal                             | 5.68-6.87                         |
After analyzing the chemical composition of the samples of the developed semi-canned fish, it can be concluded that in 4 formulations of the product, the protein content varied from 8.66 to 11.51%, which is 12.37–16.44% of the daily protein intake. The fat content in all product formulations is more than 8.9%, which will affect the calorie content in general. Protein and fat in product samples of all recipe compositions satisfy the physiological daily intake by more than 10%, in accordance with this fact, this fact allows us to attribute it to foods with a high content of nutrients [9, 10]. The mass fraction of carbohydrates and minerals in the semi-canned samples ranged from 3.59–4.95 and 1.74–2.03%, respectively. The amount of total carbohydrates was mainly influenced by the introduction of inulin in an amount of 3 to 4 g per 100 g of product.

The energy value of the obtained product samples was at the level of 142.10–171.99 kcal and satisfies the physiological energy requirement for an adult by 5.68–6.87%. Based on the data on energy value, the developed semi-canned food can be classified as medium-calorie, providing the human body with energy from 100 to 200 kcal from every 100 g [8, 9, 10, 22, 24].

| Indicators                  | Recipe № 1 | Recipe № 2 | Recipe № 3 | Recipe № 4 | Recommended daily allowance [8, 9, 10] | The share of the daily allowance,% |
|-----------------------------|------------|------------|------------|------------|---------------------------------------|-----------------------------------|
| Vitamin A content, μg/100g | 432.05±1.28| 405.12±1.05| 443.31±1.42| 386.50±0.92| 900 mcg / day - for an adult           | 42.83–49.27                      |
|                             |            |            |            |            | 3,000 mcg/day – acceptable level      | for an adult                      |
|                             |            |            |            |            |                                       | 12.88-14.78 from the acceptable level |
| Vitamin D content, μg/100g  | 12.45±0.09 | 11.76±0.06 | 12.96±0.09 | 10.39±0.06 | 10 mcg/day - for an adult              | 103.90–129.60                     |
|                             |            |            |            |            | 15 mcg/day - for those 60 years old    | - for an adult                    |
|                             |            |            |            |            | 50 mcg/day - acceptable level         | 69.27–86.40                       |
|                             |            |            |            |            |                                       | from people who are 60 years old  |
| Copper content, mg/100g     | 1.13±0.02  | 1.06±0.01  | 1.21±0.02  | 0.89±0.01 | 1.0 mg/day - for an adult              | 103.90–129.60                     |
|                             |            |            |            |            | 5 mg/day - acceptable level           | - for an adult                    |
|                             |            |            |            |            |                                       | 69.27–86.40                       |
|                             |            |            |            |            |                                       | from people who are 60 years old  |
| Inulin content,%            | 3.89±0.03  | 3.05±0.05  | 3.96±0.05  | 3.12±0.03 | 20 g/day - for an adult               | 15.25–19.80                      |

When studying the content of vitamins A and D in products, it was found that their mass content varied from 386.50 to 443.31 μg/100 g for vitamin A and from 10.39 to 12.96 μg/100 g for vitamin D. It was determined that the content of vitamin D exceeded the daily rate for an adult is 3.90–29.60%, and
the daily rate for people over 60 years old is on average 77.84%. The daily vitamin A satisfaction rate was 42.83–49.27%, depending on the formulation. It should be noted that the upper permissible level for vitamin A is 300 µg/day, and for vitamin D – 50 µg/day [8, 9]. The percentage of which from the upper permissible level of consumption was in the range from 12.88 to 14.78% (vitamin A) and from 20.78 to 25.92% (vitamin D). In accordance with this, the developed products can be attributed to the source of these vitamins, and used to prevent their deficiency, which, in turn, contributes to a positive effect on the immune defense of the human body.

According to the data in Table 4, the copper content, depending on the formulation, was 0.86–1.21 mg/100 g, which satisfied the daily requirement by 86.00–121.00% for a group of adults. The high content of copper is associated with the use of cod and Pollock liver in recipes, which are rich in this microelement. In this connection, the use of semi-canned fish will contribute to the intake of copper in the human body, which will increase its antioxidant protection [3, 6, 9].

The content of inulin was in the amount of 3.12–3.49%, which was 15.25–19.80% of the daily intake of dietary fiber and, accordingly, confirmed the fact of product enrichment with this component [10, 22, 23, 24].

Table 5. Total fatty acid composition of finely ground semi-canned fish with immunomodulatory properties.

| Name of fatty acids | Recipe № 1 | Recipe № 2 | Recipe № 3 | Recipe № 4 | Recommended daily allowance [8, 9, 10] | Share of the daily value, % |
|---------------------|------------|------------|------------|------------|--------------------------------------|----------------------------|
| Σ Saturated         | 3.39       | 3.21       | 3.33       | 2.43       | 15 g/day                             | 16.20–22.60                |
| Σ Monounsaturated   | 5.11       | 4.81       | 4.97       | 4.16       | 15 g/day                             | 27.73–34.06                |
| Σ Polyunsaturated   | 4.19       | 3.84       | 3.89       | 2.31       | 12 g/day                             | 19.25–34.91                |
| Σ PUFA ω-3          | 1.35       | 1.19       | 1.23       | 1.02       | 2 g/day                              | 51.00–67.50                |
| Σ PUFA ω-6          | 0.23       | 0.11       | 0.18       | 0.08       | 10 g/day                             | 0.80–2.30                  |

After analyzing the fatty acid composition of the obtained samples of semi-canned fish, we can conclude that there is some difference in the content of saturated and unsaturated acids. Moreover, the total content of monounsaturated and polyunsaturated fatty acids prevails over the total content of saturated acids. Polyunsaturated fatty acids of the group ω-3/ω-6 (PUFA ω-3/ω-6) were contained in an amount from 1.02/0.08 g to 1.35/0.23 g, respectively. From this it follows that in terms of the content of omega-3 fatty acids, the products correspond to the daily intake of 51.00% to 67.50%. These groups of acids will participate in the immunomodulation of the human body, a role due to the phenotypic maturation of immune cells and cytokine markers of T-lymphocytes [4, 5].

In terms of organoleptic indicators, the product samples had a light beige color, a homogeneous, delicate, smearing consistency, with dark pinpoint inclusions of spices and pieces of cucumbers, the taste and smell were pleasant, with a slight fishy tint. It should be noted that the product samples according to recipes No. 1 and No. 2 have a more delicate consistency due to the use of grenadier, which has a watered consistency [22, 26, 27, 28]. Samples of products according to recipes No. 3 and No. 4 had a more fibrous structure, as a result of the fact that Pollock was used in these recipes, which had an increased fiber content in comparison with grenadier [22, 26, 27, 28].

4. Conclusion
The designed recipe compositions of semi-canned fish using mathematical modeling make it possible to obtain products that are sources of vitamins A and D, copper, ω-3,6, and at the same time contain the prebiotic inulin.

In accordance with studies of the mass fraction of functional food ingredients (protein, fat, inulin, vitamins A and D, copper, ω-3,6), the developed finely ground semi-canned fish can be attributed not only to products with a high content of nutrients [10], but and natural functional food products,
characterized by the content of functional food ingredients of animal and plant origin in an amount of at least 15% of the daily physiological requirement in one serving of the product [8, 9, 10]. Their use will reduce the deficiency of these micronutrients and have a positive effect on the body's immune defenses. At the same time, inulin will help to improve the microbiota of the gastrointestinal tract, which, accordingly, will strengthen the immune system as a whole.

The development of recipes and rational technologies that ensure a fuller use of all valuable components of raw materials, as well as the high quality of finished products with given taste and biological characteristics are of great social importance.

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