Recipe modeling and the study of the chemical composition of functional fish culinary products

Olga Kutina[1],and *Irina* Korotkyh[2*]

[1]All-Russian Research Institute, Fisheries and Oceanography, Moscow, Russia
[2] Belgorod State National Research University, Belgorod, Russia

Abstract. The biochemical composition of the new fish culinary product is considered. The results make it possible to attribute the product to functional products. Compositions with a given set of nutritional value indicators were simulated by optimizing multicomponent formulations. Products are characterized by preset properties: functionality, balance of amino acid, mineral and vitamin compositions, high organoleptic characteristics due to the inclusion of original plant materials (spinach, green peas, cauliflower, eggplant, etc.) and individual methods for their preliminary preparation. The technology and the recipe are protected by a patent [1], technical standards [2], have been tested in production conditions. Product samples participated in the nomination "Innovative Product" at the international exhibition of food products, beverages and raw materials for their production PRODEXPO in 2015-2018. Development "Fish loaf" received a silver medal in 2015.

1 Introduction

"Fundamentals of state power of the Russian Federation for the period up to 2020" [3], "Fundamentals of state power of the Russian Federation in the field of healthy nutrition for the period up to 2020" [4], "Doctrine of food security of the Russian Federation" [5], "Strategy improving the quality of food products in the Russian Federation until 2030" (approved by Order of the Government of the Russian Federation of June 29, 2016 No. 1364-p) [7] and the Action Plan for the implementation of the Strategy for improving the quality of food in the Russian Federation until 2030 (approved by Order of the Government of the Russian Federation of April 19, 2017 No. 738 -p) [8]. All of these documents address issues related to the creation of conditions that ensure the satisfaction of the needs of various population groups for healthy nutrition in accordance with the requirements of medical science, as well as taking into account established traditions, habits and economic conditions.

Raw fish is the most important component of a healthy diet due to the uniqueness of the source of raw materials:
- balanced amino acid composition;
- the presence of essential polyunsaturated fatty acids of the omega-3 family.

But the development of products based on fish with desired properties is difficult, because the variability of the chemical composition of fish is approximately 40%, which is a fairly high indicator.

In order to expand the range of fish products, for the systematic use in the composition of food rations by all age groups of a healthy population, taking into account the rational use of fish raw materials and scientifically based nutritional standards, innovative products have

been developed. The chemical composition of this product, justified from the point of view of evidence-based medicine, allows us to attribute it to a functional product.

Modeling of compositions with a given set of nutritional value indicators was carried out by optimizing multicomponent formulations.

2 Experimental

The following research methods were used in the analysis of the developed products:
- for laboratory research of fish products, sampling and preparation of samples was carried out according to a single technique in accordance with the requirements of GOST 7636-85 [9], GOST 31339-2006 [10];
- determination of protein content - Kjeldahl method according to GOST 25011-2017 [11];
- the amino acid composition of the proteins was determined on an AAA-835 amino acid analyzer ("Hitachi", Japan) by liquid chromatography;
- tryptophan content was determined according to GOST 32201-2013 (ISO 13904: 2005) [12];
- the vitamin content was determined by gas-liquid chromatography on a device Crystalux-4000M (Russia) on the reverse phase;
- the potassium and magnesium content was determined by the photometric method according to GOST 26449.1-85 [13];
- determination of phosphorus - according to GOST 26657-97 [14].

To solve optimization problem, we applied the computer program of the Kuban State Technological University "Generik", intended for aided design and

*Corresponding author: korotkikh@bsu.edu.ru

calculation of multicomponent recipes of functional food products [15].

Statistical processing of individual indicators was carried out according to the Microsoft Excel-7.0 program with the determination of the average value, standard deviation and significance of differences by Student.

Experimental studies were carried out in 3-5 replicates.

3 Results and discussion

To obtain estimated information on the nutrient content in the composition of the modeled recipe, the material balance was used:

$$C_i = \frac{\sum\limits_{j=1}^{n} a_{i,j} \times x_j}{\sum\limits_{j=1}^{n} x_j}, \quad (1)$$

where C_i – is a mass fraction of a particular macro or microcating substance in the recipe;

a_{ij} – is the value of the mass fraction of the i-th nutrient in the j-th ingredient (component);

x_j – mass fraction of the j-th component in the recipe.

In the calculation process, the amino acid composition of prescription ingredients was used. From the obtained materials, data were selected that are characterized by the highest rates of desirability function (DF), which reflects the degree of balance of amino acids in product proteins.

Taking into account the restrictions imposed on the quantitative content of components set during the development of food products (their sum is accepted as a unit) and permissible deviations from the values of the mass fractions of nutrients from reference ones, it was proposed to use the Lagrange function and the equation system in the form of conditions of the Kuhn-Tucker theorem for the convex programming problem to model recipes. Its solution allows us to obtain the vector x mass fractions of the recipe, the most balanced nutrient composition.

Modeling of the most balanced recipe does not always determine the highest quality of the finished food product, therefore, in most cases, not one, but a sufficiently wide range of options for the composition of the prescription composition is required for its development. For this purpose, it is proposed to divide the process of its optimization into two stages. The first is the modeling of the recipe as the definition of all possible options for the quantitative ratio of the ingredients included in it. The second is a qualitative assessment and selection of several of its most optimal options.

Harrington's desirability function was used as a generalized criterion for assessing the quality of the modeled recipe, which ensures the independence of the properties of particular indicators with different dimensions and a range of variable values, and at the same time it allows you to combine relative complex and simple unit quality criteria into one formula:

$$Y = \sqrt[k]{\prod_{i=1}^{k} \times p_i}, \quad (2)$$

where Y – is a comprehensive quality criterion;
p_i – particular criteria (functions) of quality.

When optimizing food recipes, it is usually advisable to use the desirability function using a two-way restriction:

$$p_i = \exp(-\left| y_i^` \right|^{n_c}, \quad (3)$$

$$y_i^` = \frac{2 \times C_i - (L_{i\max} + L_{i\min})}{L_{i\max} - L_{i\min}}, \quad (4)$$

where C_i – is the mass fraction of the i-th nutrient (food substance) in the studied recipe;

$L_{i\min}$, $L_{i\max}$ – the limits of the standard value of the i-th food substance.

The parameter n_i determines the characteristic of the curve, with $n_i \to \infty$ the curve takes a rectangular shape.

As a result of the research, a range of fish culinary products for a healthy nutrition was developed, including the "Fish Loaf", the recipe of which is presented in Table 1.

Table 1. Formatting sections, subsections and subsubsections

Name of the prescription component	Content, %
Cod fish fillet	30.0-40.0
Salmon fillet	15.0-25.0
Onion	5.0-8.0
Spinach	10.0-20.0
or eggplant	
or green peas	
or cauliflower	
Egg	3.5-4.5
Vegetable oil	4.0-6.0
Potato starch	2.0-3.0
Table salt	0.5-1.0
Spice mix	0.4-0.8
Water	12.0-30.0

Features:
- functionality;
-balance of amino acid, mineral and vitamin formulations;
- high quality of organoleptic indicators.

A culinary product has been developed for systematic use in order to increase the biological value and therapeutic value of diet food. It is part of dirts built on the principle of adapting the chemical composition and energy value of the diet to individual clinical and pathogenetic features of the disease.

We compared indicators of the chemical composition of the developed culinary product with the daily requirement of an adult for food substances according to the balanced nutrition formula by A. A. Pokrovsky (Table 2).

Table 2. Comparative indicators of the chemical composition of fish culinary products "fish loaf" with a daily requirement for them.

Food substances	Daily requirement	Contents per 100 g of fish culinary product	Contents per 100 g of fish culinary product, % of daily requirement
1	2	3	4
Protein, g	60-100	15.800±0.600	20.0
Essential amino acids, g			
tryptophan	1	0.234±0.039	23.0
leucine	4-6	1.660±0.042	41.0
isoleucine	3-4	0,644±0.056	21.0
valine	3-4	1.061±0.090	30.0
threonine	2-3	0.929±0.060	46.0
lysine	3-5	2.039±0.080	70.0
methionine	2-4	0.388±0.035	20.0
phenylalanine	2-4	0.771±0.059	38.0
Nonessential amino acids, g			
histidine	1,5-2	1.133±0.075	73.0
arginine	5-6	1.104±0.088	22.0
cysteine	2-3	0.190±0.022	10.0
tyrosine	3-4	0.712±0.062	22.0
alanine	3	1.013±0.098	30.0
serine	3	0.896±0.078	30.0
glutamic acid	16	3.353±0.020	21.0
asparagic acid	6	1.985±0.130	33.0
proline	5	0.907±0.070	18.0
Minerals, mg			
phosphorus	1200-1500	225.000±0.001	16. 7
potassium	2500-5000	750.000±0.001	30.0
magnesium	400-450	67.500±0.001	16.9
Vitamins and vitamin-like substances, mg			
thiamine (vitamin B_1)	1.1-2.0	0.290±0.001	19.3
riboflavin (vitamin B_2)	1.3-2.4	0.310±0.001	23.8
pyridoxine (vitamin B_6)	1.8-2.0	0.280±0.001	15.6
cobalamin (vitamin B_{12})	0.003	0.00045+0.00001	15.0

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