Innovative meat product technology: a new look at traditional nutrition

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Abstract. A promising direction in the development of new food products is the reduction of calories and partial replacement of ingredients of animal origin with vegetable ones to maximize the saturation of foods with nutrients that contribute to the maintenance of normal life. The aim of this work was to develop an optimized recipe for a meat product – pate, based on a traditional recipe, but including herbal ingredients of local origin. The proposed recipe for pate in traditional cuisine allows to reduce the calorie and fat content of the daily diet of a modern person while increasing the protein content, expands the range of finished meat products on the consumer market, and maximizes the provision of the organism with the necessary nutrients. The paper presents the results of a comparative analysis of the qualitative characteristics of the pate, made according to the traditional recipe, and experimental samples with different contents of the herbal ingredient, followed by the selection of a sample with an experimentally determined optimal composition. The plant components included in the new recipe – pumpkin-flaxseed complex and carrot dietary fiber – provide the maximum balance of nutrients.

1 Introduction

New trends of modern dietetics in recent years are aimed at the need to adjust the traditional diets of the population through the development of innovative food recipes. The widespread enthusiasm of the population for healthy eating, the maximum enrichment of food with nutrients with a parallel reduction in the caloric content of rations dictate the search for new technologies for the preparation of traditional products with biologically useful components. Currently, the development of functional and fortified meat food products and the reduction of their cost is a relevant direction in the food industry. Functional nutritional traditions first originated in Japan when the first lactic fermented milk oligopolysaccharide (YakultHonsa) was produced in 1955. Following Japan, the EU countries and the United States began to study the biological value of functional products in the 1990s [1]. Today, more than 100 thousand names of functional and fortified products are known, which, according to the international classification, are divided into 7 main groups according to the presence of specific ingredients, the main groups of which are presented in Figure 1. Nevertheless,

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biotechnology continues to develop and this list has recently expanded due to various combinations of functional ingredients in accordance with the growing needs of the food market. The modern food industry is moving towards expanding the supply of essential food products in accordance with the needs of society.

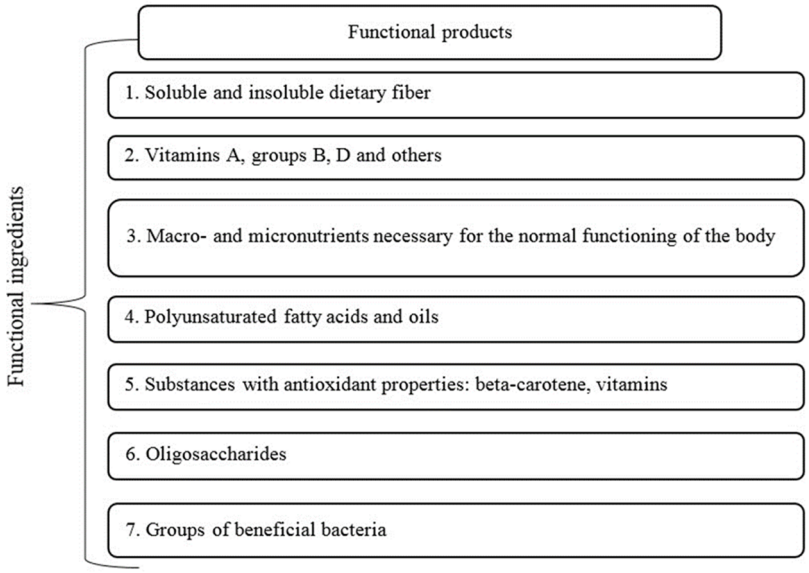

Fig. 1. Groups of functional products by the presence of functional ingredients.

Meat products refer to products regularly consumed by people, since the essential amino acids contained in various types of meat can enter the body only with its consumption [2]. Expanding the range of offered meat products in the modern world requires the search for new technological solutions that can reduce the cost of the produced product, its calorie content, and enrich it with useful vitamins and minerals.

Promising technologies for the production of meat and vegetable products are one of the important tasks in the framework of the concept of state policy in the field of healthy nutrition of the population of Russia. As part of the work, the needs of the working-age population for nutrients were studied. Thus, beef was chosen as the raw meat, which has dietary properties and also contains a wide variety of easily digestible proteins [3, 4]. In addition, beef is the most popular and preferred meat among all segments of the population. As a plant ingredient, a pumpkin-flaxseed complex was chosen as a protein-vitamin-mineral component, a source of vegetable fiber and PUFAs, such as omega-3 and omega-6 [5].

The purpose of the study is to develop an innovative recipe for a meat product – pate, aimed at expanding the distribution area of enriched and functional nutrition among the adult population in national regions. A vegetable component – a pumpkin-flaxseed complex in different dosages – was introduced into the technology of the pate produced, and a number of indicators of the finished product were assessed. Based on the results obtained, a pate recipe with an effective rate of application of the pumpkin-flaxseed complex was selected.

2 Materials and methods

The object of the scientific research was the technology of manufacturing a meat product – beef pate «Kalmytsky-TL» with the addition of a vegetable complex based on pumpkin and flax. The traditional recipe for beef pate «Kalmytsky» was used as a control. The proposed innovative technology for the production of beef pate «Kalmytsky-TL» is aimed at enriching

the traditional meat pate with useful ingredients contained in the vegetable pumpkin-flaxseed complex. Also, a feature is the introduction of a pre-hydrated and prepared in the required proportion of pumpkin-flaxseed complex into the cutter. The ratio of plant components in the complex should be 80% pumpkin oilcake and 20% flaxseed flour for the new recipe for pate «Kalmytsky-TL».

Research of prototypes of the meat product was carried out on the basis of the Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production. In the course of laboratory research of the samples, the optimal ratios of ingredients were established.

Sampling and analysis of the properties of pumpkin-flaxseed oilcake were carried out according to the following methods: determination of moisture and volatile substances according to GOST R 54705-2011; determination of the mass fraction of fat and extractives in accordance with GOST 13979.2-94; determination of the total mass fraction of soluble proteins in accordance with GOST 13979.3-68; cellulose – GOST 32749-2014, determination of color and odor, the amount of dark inclusions and fine impurities in accordance with GOST 13979.4-68.

Meat pates were made according to the traditional technology: initially, raw meat was prepared using a hot method to obtain a greasy mass, then all the necessary ingredients were added to the control sample, and pumpkin-flaxseed complex was added to the Kalmytsky-TL pate, according to the developed recipe. The loaves were cooked in a heat chamber until the temperature inside the loaf reached 70-72°C. The finished pates were cooled, labeled and stored at 0-6°C for no more than 5 days.

The selection and preparation of samples of meat pates for laboratory research was carried out according to a unified methodology in accordance with the requirements of GOST R 51447-99 (ISO 3100-1-91). Determination of organoleptic indicators was carried out in accordance with the requirements of GOST 9959-2015, GOST R 53159-2008, GOST R 53161-2008. The mass fraction of fat was determined according to GOST 23042-2015; protein – GOST 25011-2017, carbohydrates – according to GOST 34134-2017; the mass fraction of moisture according to GOST 33319-2015, the content of dietary fiber – according to the method described in GOST R 54014-2010 [6].

The energy value of the samples (kcal / 100 g) was determined by a calculation method based on the fact that the caloric content of nutrients (1 g of fat – 9 kcal, 1 g of protein – 4 kcal, and 1 g of carbohydrates – 3.75 kcal) was multiplied by the percentage of the appropriate nutrients.

The balance of essential amino acids in the product was assessed by the utilitarian coefficient of the amino acid composition of the protein. The utilitarian coefficient was calculated using the formula 1:

$$U = \frac{\Sigma A_i * C_{min}/C_i}{\Sigma A_i}, \quad (1)$$

where Ai is the content of the i-th amino acid, g / 100 g of protein;

Cmin – minimum score of essential amino acid;

C – score i-th essential amino acid.

The Amino Acid Difference Ratio (AADR) shows the average excess of the amino acid score of essential amino acids compared to the lowest level of the rate of any essential amino acid. AADR shows an excess amount of essential amino acids that are not used for plastic needs, and is calculated according to formula 2:

$$AADR = \frac{\sum C_i - C_{min}}{n}, \quad (2)$$

where Ci is the amino acid score of the i-th amino acid;

Cmin – minimum amino acid rate;

n – the number of amino acids.

The biological value of protein (BV) is calculated using formula 3:

To carry out experimental studies, generally recognized methods for assessing the objects under study and recommendations were applied. On the basis of the experiment carried out for the selected sample of pate, technical conditions TU 10.13.15-022-70959595-2020 "Meat and meat-vegetable pates" and, accordingly, technological instructions were developed.

The research materials were processed by the method of variation statistics using the Microsoft Office software package on a PC.

3 Results and discussion

3.1 Justification for the choice of herbal ingredients for adding to the recipe of pate

Meat and meat products were and remain one of the most demanded and necessary products for the nutrition of the population. Their diversity gives the consumer more choice in a wide range of prices and quality. Nevertheless, when choosing a product, it is also important to rely on the characteristics of the organism and its needs for nutrients for the implementation of normal life and health preservation [7].

The plant ingredient in the production of the experimental meat product was a pumpkin-flaxseed complex, which includes 2 components – pumpkin oilcake and flaxseed flour; additionally, dietary carrot fiber was added to the recipe of the experimental sample. The need to develop this recipe with the involvement in the production of domestic plant raw materials is dictated by the Doctrine of Food Security of the Russian Federation (approved by the Decree of the President of the Russian Federation of January 30, 2010 No. 120), which considers the possibility of improving and developing new directions in biotechnology of food production based on the creation of new food products with the involvement of by-product domestic plant raw materials in the food industry. Here is a brief description of the selected herbal ingredients.

The first and main component of our herbal complex was pumpkin oilcake, which is a by-product of processing pumpkin seeds for oil. The pumpkin oilcake is a dark green powder with a pleasant smell. Produced in the LLC Research and Development Center «New Biotechnologies» in Volgograd according to the requirements of the technical specifications TU 9146-173-10514645-09. Laboratory studies have shown the presence of the following biologically active substances in the oilcake: carotenoids, tocopherols, phospholipids, which play an important role in the body. This ingredient goes well with raw meat and complements its composition with the specified substances [8].

Evaluation of the chemical composition of pumpkin revealed a high content of vitamins (beta-carotene, vitamins B1, B2, C, E, P and minerals (K, Ca, Mn, Zn, F, Cu, Co, Fe, Na). Heat treatment of pumpkin oilcake significantly changes its chemical composition (Table 1).

Table 1. The composition of proteins of pumpkin seeds and the resulting oilcake, %.

Solubility	**Seeds**	**Pumpkin protein-carbohydrate complex**	
		Temperature of warming up the oilcake	
		60°C	**80°C**
Soluble proteins	90.86±2.16	80.28±2.64	70.74±2.19
Insoluble proteins	9.14±2.03	19.72±2.37	29.26±2.04

According to the studies carried out, a higher heating temperature of the oilcake dramatically reduces the content of some amino acids. So, in the product, when heated to 80 °C, the content of the following amino acids decreases: lysine – by 6.6%; histidine – by 19.5

(P>0.999); arginine – by 5.4; threonine – by 28.8 (P>0.999); valine – by 5.1; isoleucine – by 12.4 (P>0.999); phenylalanine – by 35.1 (P>0.999); tryptophan – by 21.5% (P>0.999) compared to the control (60°C). In this case, this is a big loss, therefore, a softer technology for heating the cake is recommended – no higher than a temperature of 60°C.

Pumpkin belongs to dietary products, it is recommended for various diseases of the gastrointestinal tract. The dietary fiber contained in pumpkin is beneficial, contains symbiont bacteria that affect the digestive function of the intestines and suppress the development of pathogenic microorganisms in the intestines, which promote the absorption of vitamins and amino acids. In addition, it is known that pumpkin cake is a natural enterosorbent and antioxidant that binds and neutralizes toxic substances and participates in redox processes. Due to the high content of pectin polysaccharide in the oilcake, heavy metal ions are bound and removed from the body. [9, 10].

The second component of our herbal complex is flaxseed flour. This is a fairly valuable product of flax seed processing. Flax is widespread in Central European part of Russia. In recent years, flax has been widely cultivated in the southern chernozems of the Volgograd region, so there are no difficulties with its supply. Flaxseed flour is produced at Borodinskoye LLC in the Uryupinsky District and is sold ready-made, which greatly facilitates its processing and inclusion in the complex.

Evaluation of the chemical composition of flaxseed flour showed a high content of dietary fiber in it (about 30%), which binds fat molecules and removes them from the body, normalizes the digestive tract and lowers cholesterol levels. Flaxseed flour is a source of Omega-3 and Omega-6 fatty acids, vegetable protein (36% in flour), amino acids, vitamins, macro- and microelements necessary for humans. Regular consumption of flaxseed flour activates metabolism, improves blood formation, prevents the development of atherosclerosis, restores skin elasticity. Selenium, potassium and magnesium, contained in flaxseed flour in significant quantities, helps to maintain normal blood pressure and the activity of the cardiovascular system in general, to resist stress. Vitamin E, which is rich in flaxseed flour, supports antioxidant processes throughout the body.

As mentioned above, the main component of the experimental herbal ingredient was pumpkin oilcake, which constituted 80% of the complex, flaxseed flour was introduced in a volume of 20%.

The complex was introduced into the product in the form of a hydrated powder: thanks to the technology of cold pressing and the production of powders, all useful biological components will be preserved in them. For hydration, a part of the beef broth used in the formulations of the «Kalmytsky» and «Kalmytsky-TL» pates was used, the ratio was 1: 1. The assessment of the chemical composition of the complex is presented in Table 2.

Table 2. Chemical composition of the pumpkin-flaxseed complex.

№	Indicators	Content in %, based on 100 g pumpkin-flaxseed complex
1	Water	6.30
2	Protein	28.80
3	Fat	14.0
4	Carbohydrates	39.0
5	Alimentary fiber	11.90
6	Calorie content, kcal	374.0

In the developed formulation, ready-made carrot dietary fibers were additionally introduced, which make it possible to maximize the enrichment of the developed meat and vegetable product with ballast substances, which will have a stimulating and prophylactic effect on the metabolic and digestive processes of the body. We took Russian-made LP carrot fiber. The chemical composition is represented by: soluble fibers – 22.7% and insoluble

fibers – 67.0%, ash – 4.5%, moisture – 10.0%, proteins – 3.2%, fat – 0.8%. World studies have shown that the body's daily need for dietary fiber varies between 30-50 g.

3.2 Research of quality indicators of pates

During the development of the formulation, three different samples of pate were produced – one control and two experimental with different levels of herbal component application. The composition of the formulations is shown in Table 3. In experimental sample No. 2, the ratio of the plant complex and beef broth used for hydration was 1 : 0.85.

Table 3. Production data and recipe compositions of samples.

Name of raw materials	**Quantity, kg / 100 kg during production:**		
	control sample	**sample No. 1 15%**	**sample No. 2 20%**
Main raw material			
Beef	50	40	35
Beef liver	20	15	15
Pasteurized cow's milk	17	–	–
Beef broth	–	17	17
Unsalted cow's butter	5	4	4
Pumpkin-linen complex	–	15	20
Carrot fiber LP	–	4	4
Spices and materials			
Edible table salt	1.5	1.5	1.5
Bulb onions	3	3	3
Potato food starch	3	–	–
Ground white pepper	0.2	0.2	0.2
Ground black pepper	0.3	0.3	0.3
Total, kg	100	100	100
Product yield, %	98	100	102

Next, an organoleptic analysis of finished samples of meat products was carried out. The group of experts used a rating assessment of various gustatory and external parameters of the finished product on a 5-point scale.

The results of the analysis are presented in the profilogram (Figure 2) and in Table 4. The developed sample was assessed in comparison with the control one by interviewing a group of experts on organoleptic indicators. Experts conducted tasting of the control and experimental samples and gave them marks on a 5-point scale.

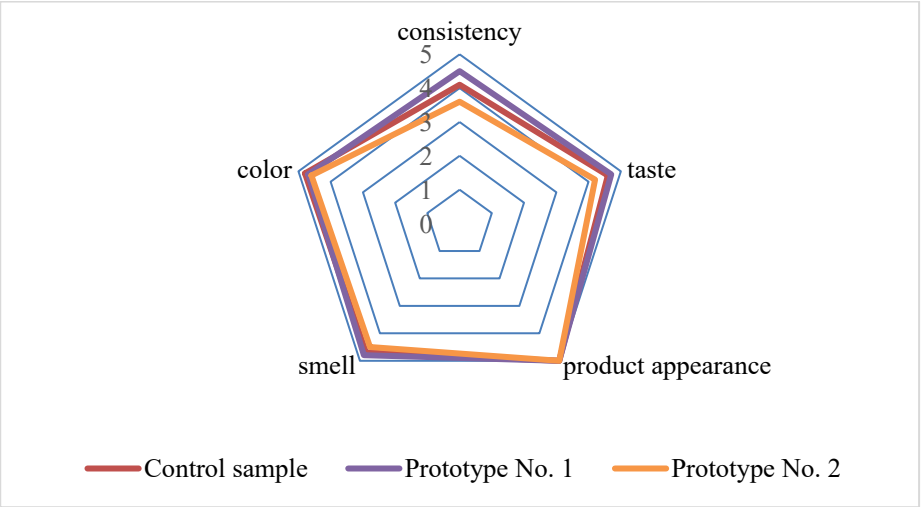

Fig. 2. Organoleptic evaluation of produced samples.

As we can see from the profilogram, during the survey it was noted that the experimental sample No. 1 compared to the control one had a higher score in terms of consistency, taste and smell. Sample No. 2 received the lowest score in terms of consistency and taste.

Table 4. Organoleptic characteristics of the pate.

Indicator	**Samples with different containing of pumpkin-flaxseed complex**		
	control sample	**sample No. 1 15%**	**sample No. 2 20%**
Product appearance	loaves with a clean, dry surface, no damage to the shell, stains and slips	loaves with a clean, dry surface, no damage to the shell, stains and slips	loaves with a clean, dry surface, no damage to the shell, stains and slips
Score:	5.0	5.0	5.0
Color	from gray to light gray	from gray to light gray, containing inclusions of herbal ingredients	from gray to light gray, the concentration of herbal ingredients is noticeably higher
Score:	4.8	4.7	4.6
Consistency	a homogeneous, evenly mixed mass in the section; consistency is viscous, crumbly	a homogeneous, evenly mixed mass in the section; viscous consistency, smearing	a homogeneous, evenly mixed mass in the section; the consistency is friable, dry, there is an increase in crumbling
Score:	4.1	4.5	3.6
Smell	pronounced meaty aroma	pronounced meaty aroma with a slight hint of pumpkin and spices	meaty aroma is less pronounced, there is an aroma of pumpkin-flaxseed oilcake
Score:	4.7	4.8	4.5
Taste	characteristic of this type of product, moderately salty, without foreign aftertaste, pronounced	pronounced meaty taste, moderately salty, with a slight hint of pumpkin seeds and spices	meaty taste is less pronounced, moderately salty, there is a characteristic

	meat taste with a milky aftertaste		aftertaste of pumpkin seeds and flax
Score:	4.6	4.7	4.2
Total:	23.2	23.7	21.9

In the control sample, the formulation excluded vegetable raw materials, as a result of which the pate had a loose, crumbly consistency. In addition, it had a pronounced meaty aroma and milky taste: the presence of pasteurized whole milk in the recipe excluded its use for people with non-digestibility of milk protein. In addition, the introduction of milk into the recipe significantly reduced the shelf life of the pate.

In the experimental sample No. 1 of the pate, 15% of the pumpkin-flaxseed complex was introduced into the recipes, which did not so much affect the taste and appearance of the product. This sample had a less crumbly consistency compared to the control sample. The resulting pate had a pleasant meaty taste with a slight hint of pumpkin and spices, the consistency was homogeneous and smeared.

Despite the positive organoleptic picture in sample No. 1, in sample No. 2 the addition of pumpkin-flaxseed complex in the amount of 20% of the total mass of minced meat led to an increase in dryness and crumbling of the finished pate, the pate had a characteristic flavor of pumpkin-flaxseed oilcake.

Further, laboratory studies of the finished samples were carried out: the mass fraction of protein, the mass fraction of fat, moisture and sodium chloride were determined according to generally accepted methods (Table 5).

Table 5. Laboratory research data of finished samples.

Indicator	**Samples**		
	control sample	**sample No. 1 15%**	**sample No. 2 20%**
Manufacturer	LLC Research and Development Center «New Biotechnologies»	LLC Research and Development Center «New Biotechnologies»	LLC Research and Development Center «New Biotechnologies»
Sample weight, g	2.015	2.015	2.015
Mass fraction of protein, %	16.33±0.1	17.01±0.2	18.25±0.05
Mass fraction of fat, %	12.2±0.1	11.8±0.3	10.25±0.05
Mass fraction of carbohydrates, %	4.53±0.05	4.25±0.05	5.22±0.05
Moisture content, %	65.20±0.05	66.23±0.06	68.25±0.05
Mass fraction of sodium chloride, %	1.2±0.1	1.1±0.1	1.17±0.10
Cellulose, %	0.09±0.01	1.14±0.01	1.44±0.01
Energy value, kcal	192.1±1.5	190.2±3.7	184.8±0.9

According to the table, it can be seen that the content in the investigated experimental sample No. 1 of the protein is higher than in the control. This is achieved mainly due to the inclusion in the formulation of the pumpkin-linseed complex, which has a high protein content – 28.8 g / 100 g of raw material. In terms of fat content, the control sample turned out to be more nutritious, and experimental sample No. 2 was more dietary, and experimental sample No. 1 took an intermediate position. This ratio was achieved by replacing part of the animal products in the formulation with plant materials and dietary fiber. In the control sample there are more carbohydrates than in the experimental sample No. 1 due to the introduction of pasteurized cow's milk, the main carbohydrate of which is lactose, which does not participate in the binding of free moisture. Despite the presence of a plant component in the composition of samples No. 1 and No. 2, the value of the mass fraction of moisture for

the experimental and control samples differs slightly. According to these indicators, one can judge the relative resistance of the product to microbial spoilage. The experimental value of the mass fraction of sodium chloride of the experimental and control samples differ by 0.07-0.1. The indicators do not exceed the permissible norms for the content of sodium chloride in meat products. By all criteria, the most preferable is sample No. 1 of the «Kalmytsky-TL» pate with a content of no more than 15% of the plant complex. Experimental sample No. 2 has the lowest fat content and, accordingly, energy value, but loses in taste characteristics. Thus, the control and experimental sample No. 1 took part in further studies.

When carrying out microstructural studies of raw minced meat, particles of muscle tissue were identified, consisting of loosely located multidirectional beams in relation to each other and a pronounced striation of muscle fibers. In addition to components of animal origin, the minced meat contains vegetable raw materials. As can be seen from Figure 3, the particles of the plant component of the experimental sample of the «Kalmytsky-TL» pate are diffusely distributed on the cut of the product samples.

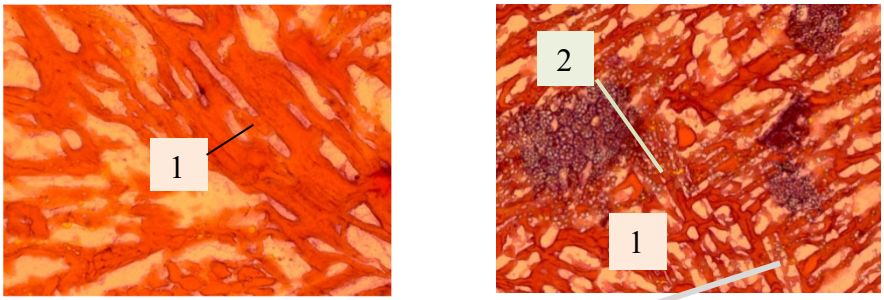

Fig. 3. Microstructure of raw minced meat of pates. a – control sample; b – a prototype with a pumpkin-flaxseed complex (15%), 1 – muscle fibers; 2 – plant inclusions

A microstructural study of the Kalmytsky-TL pate mince system (prototype No. 1) showed that the consistency of the minced meat system is rather dense and homogeneous, the mass includes muscle fibers and plant fibers in fragmentary separate inclusions. Small particles of muscle and connective tissue and plant inclusions can be observed in the system. Minced meat is distinguished by blurred boundaries between meat and vegetable complexes, the size of inclusions is no more than 200-300 microns.

3.3 Analysis of the amino acid composition of the «Kalmytsky-TL» pate

To assess the nutritional value of proteins, the content of amino acids in the product was analyzed, as well as the proportion of the daily intake that they constitute. The analysis was carried out according to the method of measuring the mass fraction of amino acids by capillary electrophoresis on the «Kapel-105M» system. The calculation results are presented in Table 6.

Table 6. The content of amino acids in the product, mg / 100 g of the product.

Amino acid	Amino acid content in pate, mg / 100 g	Consumption rate, mg / day	Share of daily consumption, %
Valine	666	2500	26.64
Leucine + Isoleucine	1764	6600	26.72
Lysine	847	4100	20.66

Methionine	380	1800	21.11
Threonine	551	2400	23.0
Tryptophan	155	800	19.4
Phenylalanine	652	4400	14.81
Alanin	658	3000	21.93
Arginine	1101	6000	18.35
Histidine	348	2000	17.4
Glycine	691	300	230.3
Proline	659	5000	13.2
Serine	519	3000	17.3
Tyrosine	555	3000	18.5

Based on the results of the research, a graph was drawn up for comparing the content of essential amino acids in 100 g of the product to the norm of their daily consumption for the population. According to Figure 4, it can be seen that the smallest share of the daily requirement is phenylalanine, the largest is valine.

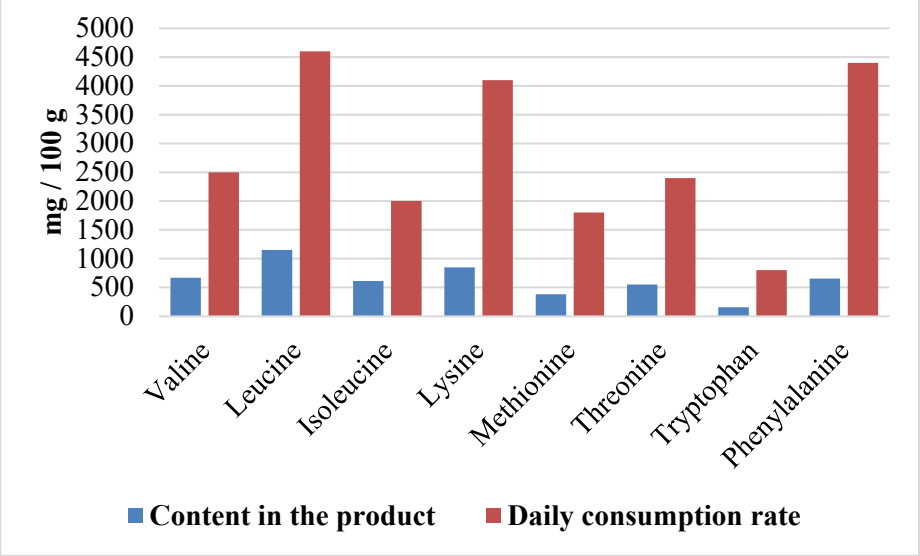

Fig. 4. Content of essential amino acids in the product, mg / 100 g of the product.

Comparison with the standard proposed by FAO WHO was carried out and the amino acid rate of essential amino acids was calculated. The calculation results are presented in Table 7. Thus, the limiting amino acid is methionine, the amino acid rate of which was 60.2%.

Table 7. Amino acid rate.

Amino acid	**Amino acid content in pate, mg / 100 g of product protein**	**The content of amino acids in the reference protein, mg / 100 g**	**Amino acid rate, %**
Valine	3694	2500	147.8
Leucine + Isoleucine	9784	11000	88.9
Lysine	4698	5500	85.4
Methionine	2108	3500	60.2
Threonine	3056	4000	76.4
Tryptophan	860	1000	86.0
Phenylalanine	3616	6000	60.3

The utilitarian coefficient of the amino acid composition of the protein was 0.73. AADR of pate is 15.4%, and its biological value is 84.6%. These indicators show a fairly high biological value of the protein of the product.

4 Conclusion

In the course of the work, the analysis of the main topic of the set goal was carried out, the choice of meat and vegetable raw materials, selected for adding pate to the recipe for traditional nutrition, was substantiated, and the characteristics of the finished product were also given. The prototype with the content of the vegetable complex in the amount of 15% of the mass of raw materials, spices and materials has improved organoleptic and physicochemical properties of the product, the cost of the recipe is reduced in comparison with the traditional pate due to the partial replacement of meat raw materials with a vegetable component. In the course of the organoleptic evaluation it was found that the «Kalmytsky-TL» pate (prototype No. 1) differs from the control sample in a more viscous and delicate consistency, an original, slightly spicy meaty pleasant aroma.

As a result of the analysis of the physicochemical parameters of the samples, it was found that the «Kalmytsky-TL» pate in comparison with the control sample contains a greater amount of protein (17.01% versus 16.33%), which was obtained due to the introduction of a protein-carbohydrate filler (oilcake pumpkin seeds and flax). The mass fraction of fat in the experimental sample No. 1, on the contrary, turned out to be less than in the control – 11.8% versus 12.2%, which was obtained due to the partial replacement of meat ingredients with vegetable ingredients and replacement of milk with beef broth. Enrichment of the pate with carrot dietary fiber allowed saturating the product with plant fiber and maximizing the property of the product to retain moisture, due to which a more moist structure of the pate was obtained in comparison with the control. Sample No. 2 had an improved chemical composition in comparison with the experimental sample No. 1, but lost in organoleptic characteristics.

Thus, through the experiment, the recipe of the pate was optimized and a decision was made to study the recipe of an experimental sample, which includes a pumpkin-flax complex in a volume of 15% and carrot dietary fiber. An enriched meat product with a protein-carbohydrate complex and dietary fiber has been developed for traditional nutrition using plant materials of local origin. The product has the best organoleptic qualities, as well as more preferable compared to the control sample, physicochemical indicators, finished product yield and more economical production.

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