

Scientific basics to develop functional meat pâtés

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Abstract. The problems of providing consumers with healthy nutrition in sufficient quantities are typical for the entire modern world, and specialists are working hard to solve them, trying to harmonize the priorities of nutritional value with the basics of thrifty use of food resources. In this regard, it is important to develop functional food products, the composition and production technology of which rationally correspond to the nutritional needs of certain categories of consumers. The purpose of the article is to substantiate the use of the indicated vegetable raw materials in functional pâté products and to determine the quantitative parameters of their inclusion in formulations. To study the swelling and hydration of the samples, conventional laboratory methods were used, the water-retaining and fat-retaining capacities were determined by the Schoch method, the amino acid composition – by using the High-Performance Liquid Chromatography. The research has confirmed the feasibility of using plant flour and oils as sources of protein and fat to impart functional properties to meat products and to save valuable meat raw materials. Studies of the physical, chemical and functional-technological properties of flaxseed, rice, corn, sunflower flour showed that flaxseed and rice flour are the most suitable for creating formulations of functional meat products. The determination of the amino acid composition of these two types of flour showed a higher content of essential amino acids, including lysine, in flaxseed flour, which is very valuable for ensuring the proper functioning of the child's brain. For the rational conduct of research, a generalized scheme for planning formulations of functional pâté products was proposed, based on the properties of the used plant materials and the desired functional properties of these products. The practical value of the studies performed is that they made it possible to determine the necessary ratios of vegetable raw materials in the formulations of meat pâtés, which determine their functional properties

Keywords: functional food products; nutrients; meat products; flaxseed flour; rice flour; amino acid composition

INTRODUCTION

The Declaration of the Food and Agriculture Organization of the United Nations (1996) contains a provision that food security is ensured when all persons at all

times have physical and economic access to safe and nutritious food, sufficient to satisfy their physiological needs and ensure an active and healthy life. An

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important role in this is played by functional foods, that is, foods, each of which is intended for systematic consumption as part of diets, and at the same time maintains and improves health, and also reduces the risk of developing nutrition-related diseases due to the presence of physiologically functional food ingredients in its formulation (Borsolyuk *et al.*, 2018).

The idea of producing foods with enhanced functionality by incorporating bioactive ingredients has prompted academia and the food industry to intensify research and development in functional foods. This suggests that dietary and lifestyle modification is a practical strategy to reduce the incidence of chronic diseases. Although there is no single definition worldwide, foods can only be considered functional if, in addition to their primary nutritional impact, they beneficially affect certain physiological functions in the human body, improving physical condition and / or reducing the risk of non-communicable diseases and chronic diseases (Ramírez Osorio *et al.*, 2021).

Some scholars have emphasized the importance of developing new biologically valuable ingredients from natural resources, as well as the positive therapeutic effect in the nutrition of patients with certain chronic diseases using functional foods and nutraceuticals their formulations including functional and biological substances. Biological ingredients (bioingredients) are substances that are used for food production or food preparation and are present (although possibly in a modified form) in the final product and have a pronounced biological activity in relation to the consumer's body. In the modern world, bioingredients play an important role in various areas of human life (Premkumar & Vasudevan, 2018).

The production of functional food products based on meat raw materials is developing in the direction of expanding the diversity of products, combining and optimizing their composition in order to achieve nutritional and biological value, preserve valuable components of raw materials, and compensate for the lack of a number of macro- and micronutrients by including functional ingredients in formulations. Regarding meat products, the efforts of specialists are mainly directed to their modification by changing the content of lipids and fatty acids and / or by adding a number of functional ingredients: fibers, vegetable proteins, monounsaturated or polyunsaturated fatty acids, vitamins, calcium, phytomaterials (Premkumar & Vasudevan, 2018). It is necessary that the combined meat products have a high biological value due to the combination of meat raw materials with food and protein supplements of animal and vegetable origin, characteristic for pronounced functional properties and the

proper content of essential nutrients. For this purpose, proteins of plant, animal, microbiological origin, are used in the form of isolates, concentrates or flour. Examples of such natural proteins are blood, bone and milk proteins, wheat gluten, legume proteins and sunflower (Acosta *et al.*, 2021; McClements & Grossmann, 2021).

Functional foods contain functional ingredients their addition being beneficial to the health of consumers, namely probiotic bacteria, prebiotics, dietary fiber, synbiotics, antioxidants, polyunsaturated (ω -3) fatty acids, plant sterols, biologically active peptides, minerals and vitamins. The addition of functional ingredients to meat products should not change the properties of the said products. New ingredients should be present in the formulations in such quantities that have a positive impact on the health of consumers (Borsolyuk *et al.*, 2018). Often the functional properties of meat products are achieved by changing the content of lipids and fatty acids or adding fiber, vegetable proteins, monounsaturated or polyunsaturated fatty acids, vitamins, calcium, phytomaterials, etc. (Abzhanova *et al.*, 2022). It is relevant that the trend of using functional bioactive compounds in meat production is becoming more pronounced. Undoubtedly, these components can significantly affect human health, but the qualitative and quantitative composition of these substances must be correctly selected. In particular, an important question is whether the product will be processed and, if so, what processing will be applied (Pogorzelska-Nowicka *et al.*, 2018). Of no small importance in the development of functional meat products is also taking into account the deficiency of certain substances in the diet of specific consumer groups. The process of creating new meat products with functional properties is complex and depends not only on the influence of functional ingredients on the nutritional value of the final product, but also on the quality of its production (Borsolyuk *et al.*, 2018).

The information given above lets it possible formulating the goal of the research the said goal consisting in the study of the functional meat pâtés intended for the children of preschool and school age, substantiating plant raw materials used for the purpose and rational formulations of these pâtés.

LITERATURE REVIEW

The ability to develop functional foods aims to use strategies that can condition the presence of certain compounds, either by limiting the content of those that have negative consequences (for example, allergens or irritants) for the health of consumers, or by increasing the proportion of those that show beneficial effects (for example, fiber, polyphenols, flavonoids, carotenoids, vitamins and minerals) (Jiménez-Colmenero, 2013). In this

context, food waste is an important source of bioactive components that can be used as ingredients or additives to develop functional foods (Kumar *et al.*, 2017).

In the scientific practice of Ukraine, the term “functional food products” refers to a wide range of food products: carriers of natural and organic substances, low-calorie and calorie-free products for weight control, foods enriched with vitamins and microelements, energy drinks, probiotic products, dairy products with specific properties. To maintain the health, performance and longevity of a person, it is very important to observe three basic principles of rational nutrition: balance of energy, meeting the needs of the body in the required quantity and ratio of nutrients and diet. Studies by medical scientists carried out in Ukraine have shown that recently there has been a decrease in protein in the diet of the population (Order of the Cabinet of Ministers of Ukraine No. 332-2004-r, 2020). At the same time, many people were found to be obese due to metabolic disorders. As of 2021, the average life expectancy of the population of Ukraine is 65.16 years for men and 74.36 years for women (State Statistics Service of Ukraine, 2022). For elderly category of consumers, the need to develop and produce special functional food products seems obvious. Another large group of consumers who need functional products are children and adolescents.

These are foods that contain biologically active components that have a nutritionally beneficial effect on one or more functions of the body, the purpose of which is to reduce the incidence of chronic non-communicable diseases. Among the specific elements or biologically active components in food systems, probiotics, biologically active peptides, carotenoids, vitamins, phenolic compounds, phytoestrogens, fatty acids or structured lipids are to be mentioned. According to statistics, globally, the production of these products is increasing by 48% annually because the addition of these components, either naturally or through modification, has been shown to provide great developmental health benefits every day, early growth, protection against oxidative stress, regulation of metabolic processes, physiology of the cardiovascular system and the gastrointestinal tract, mental, cognitive, physical and/or athletic performance (Fuentes *et al.*, 2015; Lamos *et al.*, 2018; Delgado Sánchez, 2019).

Among the fatty acids contained in the human diet, there are two groups, some of which are necessary for the body, while others are not. It is difficult for a person to produce the necessary substances on their own, so they come from food, being a good source of energy in case of deficiency – the examples are α -linolenic (ω -3) and linoleic (ω -6) acids (Lemahieu *et al.*, 2017). However, saturated or trans acids may pose a health

risk to the consumer (Moghadasian & Shahidi, 2016). Therefore, polyunsaturated fatty acids (PUFAs) or volatile fatty acids have received a lot of interest lately, as they are found in varying amounts in mammalian cell membranes, among the most important being: docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), from the ω -3 family where seafood is the richest source of these components, while α -linoleic acid is found in vegetables such as seed oils, green leaves and legumes (Colussi *et al.*, 2016). These compounds contribute to a reduction in the number of people with cardiovascular disease and death from this cause, according to epidemiological studies (Baker *et al.*, 2016). Commercial blends of fats have been replaced by vegetable oils or oilseeds, fish oils, or combinations thereof, increasing the functional value of foods. On the other hand, in the poultry industry, interest has increased in enriching the diet of birds with fish, flaxseed or rapeseed oil due to the increase in the content of polyunsaturated fatty acids formed in meat. Studies have shown that levels of this type of acid increase, thus revealing higher levels of EPA and DHA in breast and thighs, as well as levels of linolenic acid where 100g of breast or thigh meat provides the body on average 33% and 15.5%, respectively, of the recommended human daily intake of EPA and DHA (Konieczka *et al.*, 2017).

Thus the numerous examples of scientific works including those mentioned in the above literature review confirm the beneficial effect of different plant raw materials in the course of supplying human organism with nutritionally valuable substances and compounds.

MATERIALS AND METHODS

The determination of the physical and chemical characteristics of the functional pâtés was carried out using a set of research methods. The following parameters of the functional pâtés were determined using the methods specified below:

- protein content (by mass) was determined according to the content of total nitrogen according to Kjeldahl with subsequent distillation of ammonia;
- water content (by mass) was determined by the thermogravimetric method using electronic moisture balance ADS-50 (AXIS) by drying the sample to constant weight at a temperature of 105°C;
- fat content (by mass) was determined using the Soxhlet method – extraction of samples with dichloroethane and drying to constant weight after evaporation of the solvent;
- carbohydrates content (by mass) was determined using the formula [100 - (protein + water + fat + ash)];
- moisture-binding capacity was determined by pressing according to E. Okuskhanova *et al.* (2017).

The swelling capacity of flour samples was determined by keeping a 1% aqueous suspension in a measuring cylinder for a day at a temperature of 18-20°C. Swelling was evaluated as the maximum amount of water that an object can absorb and retain until dynamic equilibrium, related to the weight of the sample. The level of hydration of flour samples was determined by the amount of bound water (product: water ratio). The water-retaining and fat-retaining capacity of flour samples was determined by the Schoch method with the addition of water (for WRC) or fat (for FRC), holding in a water bath and subsequent centrifugation for 15 minutes at 6000 rpm. The amino acid composition of flour proteins was studied according to the International Standard ISO 13903:2005 (2005). Amino acids were separated by ion-exchange chromatography, reacted with ninhydrin, and the content of amino acids was determined by the photometric method (wavelength 570 nm). The results of the studies were also statistically processed using the Microsoft® Office Excel 2003 software package. The experiments were repeated three times. The results were considered significant at a confidence level of P 0.05. Graphical processing of the results was carried out using the Microsoft® Office Excel 2003 software package.

RESULTS AND DISCUSSION

Regarding meat products, the efforts of specialists are mainly aimed at modifying them by changing the content of lipids and fatty acids and / or by adding a number of functional ingredients: fibers, vegetable proteins, monounsaturated or polyunsaturated fatty acids, vitamins, calcium, phytomaterials. The following basic requirements for the creation of specialized meat-based products are rational:

- the protein component of functional meat products must combine protein of animal and vegetable origin – this provides a more pronounced physiological effect;
- sources of animal protein in the product can be beef, pork, chicken and turkey meat;
- it is recommended to use chickpeas, soybean products, cereals and cereals as a source of vegetable protein;

➤ products should be enriched with vitamins, macro- and microelements at their optimal ratio, polyunsaturated fatty acids, dietary fiber, which reduce the risk of developing cardiovascular diseases;

➤ the fat component can be formed by the fat of meat raw materials and vegetable oils: sunflower, corn, flaxseed, soybean and others, as a source of polyunsaturated fatty acids;

➤ the source of carbohydrates should be vegetable products - cereals, vegetables containing sufficient dietary fiber and fiber;

➤ the energy value of 100 g of the product should be in the range of 150-200 kcal. Some researchers suggest using rice and corn flour or cereals for the production of meat products, which allows for a more rational use of protein resources (Bashtova, 2015).

Therefore, the partial replacement of meat in meat products with protein raw materials of plant origin is justified in the economic and technological sense, and is also useful in terms of improving the nutritional value of these products. Of the various forms of adding vegetable protein raw materials to the formulations of meat products, there are isolates that are inferior to flour in terms of their effect on the sensorial properties and suitability of products for storage. Raw meat is rich in ω -3 and ω -6 fatty acids, but a certain balance is needed between them, which determines the functionality of the product. To achieve good results in the balance of the fatty acid composition of meat products, the use of vegetable raw materials in their formulations, primarily vegetable oils, as well as flour (Borsolyuk *et al.*, 2017), makes it possible. As part of the research, an assessment was made of the nutritional, physical, chemical and technological properties of different types of flour used in the composition of functional pâté products intended for feeding children of preschool and school age. The flow of technological processes is mainly determined by the functional and technological properties of the components, therefore, in order to rationally use various types of flour or their mixture in pâté formulations, a study of the functional and technological properties of the specified raw materials was carried out, the results of which are shown in Table 1.

Table 1. Physical, chemical and technological parameters of flour samples

Parameter	Flaxseed flour	Rice flour	Maize flour	Sunflower flour	Flour mix *
Water, %	6.93	9.80	7.85	5.69	8.57
Protein, %	26.11	6.50	7.27	31.97	19.15
Fat, %	14.62	2.17	2.38	9.89	8.19
Ash, %	5.86	81.02	0.26	6.83	3.12
Carbohydrates, %	46.48	0.51	82.24	45.62	61.0

Table 1, Continued

Parameter	Flaxseed flour	Rice flour	Maize flour	Sunflower flour	Flour mix *
Swelling, cm ³ /g	12.2	3.6	0.54	1.0	7.4
Hydration level	1:6	1:7	1:6	1:3	1:7
Water retaining capacity, %	622.5	575	220.0	300.0	220.0
Fat retaining capacity, %	192.5	245	137.0	170.0	132.5

Notes: * - mix of maize and flaxseed oils in the ratio of 1:1

Source: L. Borsolyuk et al. (2017)

It is known that the amino acid composition indicates the quality of food protein. Essential amino acids are especially important, which are not synthesized in

the human body and enter it with food. At this stage of the research, the amino acid composition of flaxseed and rice flour was analyzed, the results are shown in Table 2.

Table 2. Amino acid content of flour samples

Amino acid	Flaxseed flour		Rice flour		
	g/100 g of flour	g/100 g of protein	g/100 g of flour	g/100 g of protein	
Protein content, %	26.11		6.5		
Essential:					
Arginine	Arg	2.539	9.77	0.516	7.94
Valin	Val	1.487	5.72	0.348	5.35
Histidine	His	0.802	3.10	0.149	2.29
Isoleucine	Ile	1.320	5.08	0.244	3.75
Leucine	Leu	1.580	6.08	0.488	7.51
Methionine	Met	0.587	2.26	0.144	2.22
Threonine	Thr	0.473	1.82	0.210	3.23
Phenylalanine	Phe	1.348	5.18	0.317	4.88
Lysine	Lys	1.259	4.84	0.207	3.18
Total essential:			43.83		40.35
Non-essential:					
Alanine	Ala	1.286	4.95	0.332	5.11
Aspartic acid	Asp.ac	2.052	7.89	0.549	8.45
Cysteine	Cys	0.473	1.82	0.107	1.65
Glycine	Gly	1.228	4.72	0.267	4.11
Glutamic acid	Glu.ac	3.123	12.01	1.097	16.88
Proline	Pro	1.179	4.53	0.278	4.28
Serene	Ser	1.148	4.42	0.310	4.77
Tyrosine	Tyr	0.737	2.83	0.314	4.83
Total non-essential:			43.18		50.06
Total:			83.64		90.42

Source: L. Borsolyuk et al. (2017)

As can be seen from the Table 2, the content of essential amino acids is higher in flaxseed flour. In particular, there is an advantage in the quantitative content of amino acids such as arginine, isoleucine, phenylalanine and lysine. In terms of the importance of ensuring the functional properties of the finished product, the most valuable amino acid is lysine, since this substance

contributes to brain function, which is very important for children of primary school age.

To formulate a pâté intended for preschool and school children, a general approach was used to develop formulations of emulsion products with the necessary modifications. To draw up a generalized scheme (Fig. 1) for formulating a functional pâté product for

these categories of consumers, the priority condition was precisely the proper functionality due to the chemical composition, bioavailability, proportions of components, processing method, degree of comminuting together with other physical and chemical parameters of the product (Borsolyuk *et al.*, 2018). In particular, vegetable oils were used in the composition,

which have a pronounced antioxidant effect. They also effectively inhibit the growth of tumors, inactivate toxic substances and bacteria, and have anti-inflammatory and immunoprotective traits. To improve the fatty acid composition of meat products, it is advisable to add vegetable oils in the form of emulsions (Bal-Prylypko & Leonova, 2020).

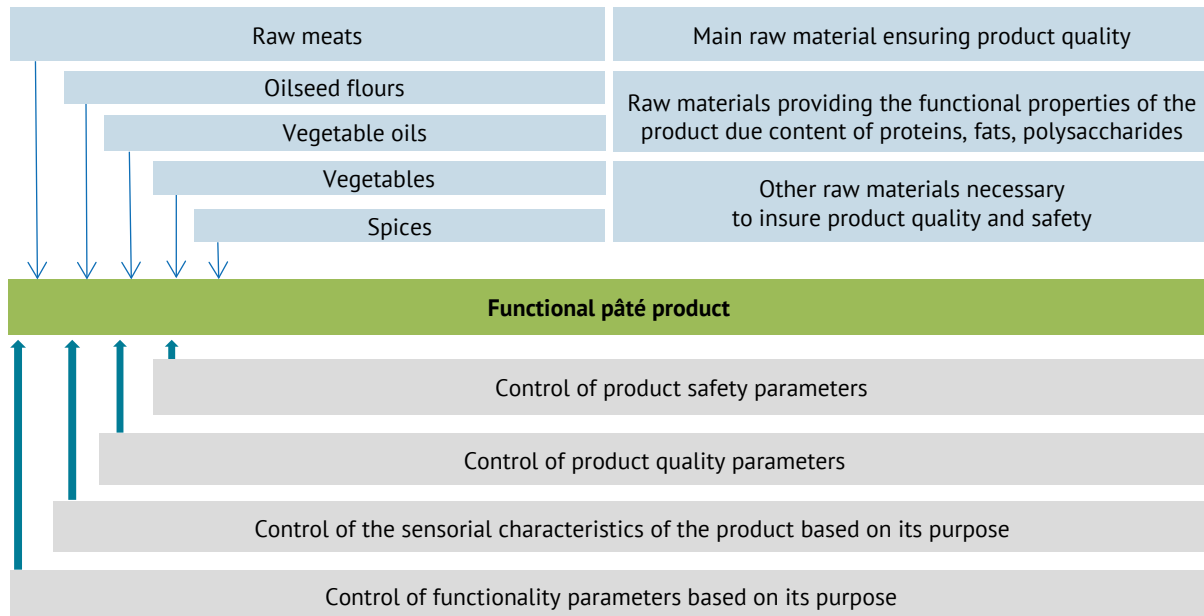


Figure 1. Chart of formation of a functional pâté formulation

Source: authors' own development

For the products of children nutrition, animal protein should make up 55% of the total amount of protein, vegetable fat – up to 30 % of the fat component of the product (Borsolyuk *et al.*, 2017). The ratio of polyunsaturated and monounsaturated fatty acids should be 1 : 1, the ratio of protein: fat should be 1.00 : 0.87. The liver is one of the best dietary sources of iron. It contains much more iron compounds such as hemoglobin and myoglobin than meat. Also, the liver is rich in vitamins of group B, PP, folic acid, contains minerals – potassium phosphorus, iron, manganese, copper, zinc (Gorneț, 2016). Iron from the liver is well absorbed by the body, since it is in the form of heme. To enrich formulations of pâtés with ω -3 and ω -6 fatty acids, blends of vegetable oils: sunflower and flaxseed (90 : 10) and corn and flaxseed (85 : 15) were used. Corn flour, sunflower and flour mixture were included in the formulations of meat pâtés in order to enrich them with vegetable protein, carbohydrate component and create the desired consistency grade, to prevent separation of the liquid phase (broth). Carrots were used as a source of pectin substances, fiber, vitamins A, B, E, K, carotenoids, macro- and microelements.

There are also other possible solutions to provide the sufficient functionality of meat products. Thus scholars consider it rational adding flaxseed flour to the formulations in different forms – not additionally treated, fried, partially defatted and defatted. Experiments showed that fried not defatted flour was the best for the fat absorption capacity of the product, while the best water absorption capacity was characteristic for non-fried partially defatted flour (Hussain *et al.*, 2008). The flax flour the formulation of a minced lamb product promoted raising water-retaining capacity, sensorial acceptability, texture and shelf life of the product (Sharma *et al.*, 2014). The flaxseed flour as a functional ingredient to ground beef cutlets added in the amount of 3, 6, 9, 12 and 15% caused a decrease in moisture and protein content and increase in alpha-linolenic acid content. Experiments showed the ratio of ω -6 to ω -3 to decrease from 5.76 for the product with 10% fat to 0.36 for that with 15% flax flour. The addition of 3 or 6% flaxseed flour improved the sensorial characteristics of the product studied (Bilek & Turhan, 2009).

There is information that the fat component of the daily diet should provide no more than 30% of the

energy requirement, including in equal amounts separate fractions of fatty acids, that is, saturated fatty acids : polyunsaturated fatty acids : monounsaturated fatty acids = 1 : 1 : 1 (Peshuk *et al.*, 2011). Such a composition of “ideal” fat is the basis for the development of norms for the physiological needs of for the basic nutrients and energy. Thus, the use of meat in the composition of pâtés for preschool and school children is necessary, since the meat contains biologically active substances that determine its functional properties: complete animal protein, bioactive peptides, minerals, vitamins, fatty acids, and for the enrichment of pâtés with fatty acids it is advisable to use vegetable oils, as well as corn and sunflower flour for enriching pâtés with vegetable protein and carbohydrates (Borsolyuk *et al.*, 2018).

To improve the content and lipid profile of meat pâtés, their formulation was changed, which reduced the total content of fat, cholesterol and improved the lipid profile by replacing part of the animal fat with more healthy lipids, the characteristics of which are more in line with scientific dietary recommendations. Vegetable oils belong to such substances (Freitas *et al.*, 2012). They contain sterols, which have an expressive antioxidant effect, inhibit the growth of tumors, inactivate toxic substances and bacteria, and have anti-inflammatory and immunoprotective properties.

It can be stated that the results obtained are sufficient in the terms of reaching the goal of this article. Somewhat different conclusions made by other authors do not contradict the said results but confirm the existence of numerous ways to improve functional and other important properties of the meat products studied.

CONCLUSIONS

For the manufacture of functional pâté products, a number of ingredients of plant origin are used, in particular, flour from the seeds of various crops and mixtures of various types of flour. The purpose of using flour in formulations of functional pâté products is, in particular, to enrich these products with proteins and polysaccharides. Comprehensive comparative studies of physical, chemical and technological properties of rice and flax flour showed significant advantages of

the latter in terms of ensuring the proper functional properties of the finished product. Flaxseed flour, as a functional component, normalizes the work of the gastrointestinal tract, as a technological component, it helps to increase the moisture-binding capacity of the meat system. It is rational to replace up to 15% of meat raw materials with flax flour in the composition of functional pâtés. The use of sunflower flour allows you to get a product that is balanced in chemical composition and enriched with proteins necessary for the normal functioning of the body. Corn flour can be considered a promising raw material in the production of functional pâtés, useful in diseases of the liver, cardiovascular system, and gout. The inclusion of corn flour in the composition of functional pâtés helps to remove fat accumulations from the body, and the presence of such a microelement as silicon helps to increase the elasticity of blood vessels and strengthen teeth. Studies have shown that corn flour is significantly inferior to flaxseed and sunflower in terms of protein and fat content, but contains more carbohydrates – mainly due to the higher content of starch. So, a promising direction for creating formulations of functional pâté products is a combination of corn and flax flour. This allows to increase the protein content in the mixture due to flaxseed flour and enrich the mixture with polysaccharides due to corn flour. It is advisable to focus further research on the development of specific formulations of functional pies intended for various special categories of consumers – preschool and school-age children, the elderly people, as well as those suffering from certain diseases, military personnel and other consumers in extreme conditions.

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CONFLICT OF INTEREST

None.

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Наукові основи розробки функціональних м'ясних паштетів

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Анотація. Проблеми забезпечення споживачів здоровим харчуванням у достатній кількості характерні для всього сучасного світу, і фахівці наполегливо працюють над їх вирішенням, намагаючись гармонізувати пріоритети харчової цінності з основами ощадливого використання продовольчих ресурсів. У зв'язку з цим важливого значення набуває розробка функціональних харчових продуктів, склад і технологія виробництва яких раціонально відповідають харчовим потребам окремих категорій споживачів. Мета статті – обґрунтувати використання рослинної сировини у функціональних паштетних виробках та визначити кількісні параметри її долучення до рецептур. Для дослідження набухання та гідратації зразків було використано загальноприйняті лабораторні методи, водоутримуючу та жирутримуючу здатність було визначено за методом Шоха, амінокислотний склад – за допомогою вискоєфективної рідинної хроматографії. Проведені дослідження підтвердили доцільність використання рослинного борошна та олій як джерел білка та жиру для надання функціональних властивостей м'ясним виробам та економії цінної м'ясної сировини. Дослідження фізико-хімічних та функціонально-технологічних властивостей лляного, рисового, кукурудзяного, соняшникового борошна показали, що лляне та рисове борошно є найбільш придатними для створення рецептур функціональних м'ясних продуктів. Визначення амінокислотного складу цих двох видів борошна показало вищий вміст незамінних амінокислот, зокрема лізину, у лляному борошні, що є дуже цінним для забезпечення належного функціонування дитячого мозку. Для раціонального проведення досліджень запропоновано узагальнену схему планування рецептур функціональних паштетних виробів, виходячи з властивостей використаної рослинної сировини та бажаних функціональних властивостей цих виробів. Практична цінність проведених досліджень полягає в тому, що вони дозволили визначити раціональні співвідношення рослинної сировини в рецептурах м'ясних паштетів, які визначають їх функціональні властивості

Ключові слова: функціональні харчові продукти; поживні речовини; м'ясні продукти; лляне борошно; рисове борошно; амінокислотний склад