NON-TRADITIONAL PLANT-BASED RAW MATERIALS FOR THE INNOVATIVE TECHNOLOGY OF A HEALTHY PATE

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Nowadays, there is growing interest in the development of healthy foods that can supply the human diet with essential nutrients. One of the most promising areas is the improvement of meat pate technology. The main limitations of conventional pates include the low content or complete absence of dietary fibre, the limited amount of biologically active compounds and the high content of fat and food additives, which reduces their nutritional value.

To solve this problem, it is proposed to use bioactivated lentils and green buckwheat as enriching components in the pate recipe. The bioactivation was carried out by germinating the grains. Germination increases the nutritional value, promotes the bioavailability of nutrients, reduces the content of antialimentary compounds and improves the functional composition of proteins. For meat and vegetable pates, it is important to maintain a high protein content while enriching the product with natural sorbents. It was found that germinated lentils contain 32.2 % protein and 2.9 % fibre, while germinated buckwheat contains 12.8 % protein and 9.3 % fibre. Based on this data, a flour composition mixture was developed with an optimal ratio of 60% germinated buckwheat and 40 % germinated lentils.

Formulations for pate with the addition of this mixture in the amount of 5 to 20 % were created. It was confirmed that the optimum content of the mixture of germinated lentils and buckwheat in the formulation is 15%, at which the product retains the correct organoleptic and physicochemical properties.

The obtained pate fulfils the requirements of the normative documentation and belongs to the category of functional food products. It has been proven that consumption in the amount of 100 g of this pate covers 10 to 50% of an adult's daily requirement for a series of essential nutrients.

Keywords: pate, lentils, buckwheat, germinated grains, fiber content, nutritional value

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Introduction

The development of innovative technologies in the food industry is of particular importance. Through the targeted search, formation and implementation of new ideas, the food industry can create new products that meet the changing needs of consumers. Such products are in line with the principles of healthy diet and have a positive impact on consumer health by enabling an active and creative longevity (Simakhina, 2022). In the current phase, it is imperative that innovation in the food industry is prioritised, especially in the production of nutritious and healthy foods, which have an increasing share in the global market (Abuajah et al., 2015; Simakhina et al., 2021).

It is undeniable that the current global prevalence of diseases is related to lifestyle, especially diet (Akseer et al., 2020; Bashta et al., 2023). Both experimental and epidemiological studies provide convincing evidence that the current dietary and lifestyle habits of the majority of people contribute significantly to the pathogenesis of chronic, non-infectious diseases. These include, for example, cardiovascular disease, various forms of diet-related cancer, diabetes and obesity (Bennett et al., 2018; Chaput et al., 2011). Consequently, the lack of biologically active nutrients in the diet, which significantly influence metabolic processes in the human body, necessitates the exploration of unconventional food sources with high biological value. It is necessary to develop new food production technologies and improve existing ones in order to expand the range of healthy foods in terms of their composition and nutritional value.

At the same time, an increasing consumer demand for ready-to-eat products can be observed worldwide (Contini et al., 2016). These products include pates, which are popular among consumers because of their versatility. They can be used in regular meals, are convenient for tourism and are becoming increasingly popular in restaurants.

Among the various pates available for purchase, a common feature is the predominance of meat and fish products, often accompanied by a considerable number of technological additives and a relatively homogeneous chemical composition (Decker & Park, 2010; Kambarova et al., 2021).

Nevertheless, the analysis of the pate segment shows a consistent growth trend. Pates are a universal and delicious food that appeals to a wide range of consumers. They offer a wide range of flavours and textures and satisfy different consumer preferences (Olmedilla-Alonso et al., 2014). The market is expected to expand further in the near future, driven by an increasing demand for innovative and high-quality products, especially functional and plant-based pates (Kotlyar et al., 2021; Yevlash et al., 2018). This trend is in line with the current challenge of developing innovative food technologies for health and preventive diet products.

Geographically, Europe represents the largest market for pates, mainly due to its strong culinary traditions and high consumption of meat products (Holm et al., 2000). However, the market is also expanding in other regions, including North America and the Asia-Pacific region. This is due to the increasing interest in international cuisine and the expansion of the range of vegetable pates.

The production of meat products based on a combination of high-quality protein-rich animal and vegetable raw materials can be seen as a possible way of expanding the range of healthy pates. It solves the problem of balanced nutrition and optimises the biological value of the final product (Antonini et al., 2020). Most scientists agree that the combination of meat and plant-based ingredients is the most promising way to solve the problem of healthy nutrition (Haschuk et al., 2022; Pogorzelska-Nowicka et al., 2018). The combination of ingredients enables the production of a diverse range of high-quality products, expands the product assortment, and allows the development of optimal customised recipes to ensure the best consistency and biological value of the final product (Galanakis & Charis, 2021).

A review of literary sources shows that the use of plant-based raw materials in the production of meat products not only provides an opportunity to enrich them with functional ingredients and increase their digestibility, but also to obtain products that meet basic physiological standards (Gadimova Natavan Safar et al., 2021). It is advisable to use vegetables, cereals and legumes, their by-products, etc. (Rocchetti et al., 2023). The inclusion of these relatively inexpensive raw materials in the composition of meat products reduces their overall cost and also gives them a healthy orientation (Das et al., 2016; Sarwar et al., 2013).

Meat-plant-based pates are produced by combining different protein sources (Felisberto et al., 2015; Drachuk et al., 2018). In addition, biologically active substances are added to the plant-based raw materials (Keenan et al., 2014; Bibiana Alves dos Santo et al., 2012). Currently, unconventional raw materials with a high content of micronutrients, proteins, and dietary fiber are not fully utilized for food purposes (Abdul Haque et al., 2024; Pezhuk et al., 2023). This problem needs to be addressed by developing a new generation of recipes and creating original technologies for the production of mixed meat and plant-based products. The aim is to achieve an optimal content of proteins, fats, vitamins, macro- and micronutrients and other important components (Drachuk et al., 2018).

The sources of these nutrients are plant raw materials, in particular cereals and legumes, which are increasingly attracting the attention of researchers. They are a valuable source of vitamins, minerals, cellulose and a considerable amount of biologically active compounds, including phenols, carotenoids, lignans, starch, sterols and phytates. These compounds exhibit additive and synergistic effects as they serve as absorbents of free radicals, cofactors for antioxidant enzymes or indirectly as antioxidants and have a positive impact on human health by reducing the risk of chronic diseases (Hassan et al., 2020; Topping, 2007).

It is possible to increase the content of biologically active substances in cereals and legumes and reduce the content of antinutritive substances by bioactivating the selected raw materials (Gupta et al., 2015). Bioactivation by germination of grains, beans and seeds is used to soften the kernel or cotyledons, increase nutritional value, reduce antinutritive substances and improve the functional composition of proteins (Bazhay-Zhezherun et al., 2022).

The process of germination is a natural technology for the biological activation of cereals to improve the nutritional and functional properties of cereals (Hefni & Witthöft, 2011). The main objective of this process is to increase the concentration of key nutrients, including vitamins, minerals and antioxidants, soluble dietary fiber and phytochemicals, as well as other substances useful to the consumer (Van Hung et al., 2015).

It is important to monitor and control the process of germination to ensure that it is short and carried out at low temperatures to prevent the degradation of β-glucans. This is because they significantly influence the reduction of cholesterol and glucose levels in the blood, the functioning of the cardiovascular system and have antimicrobial, anti-cancer and radioprotective effects. It has been shown that the content of β-glucans in oat grains decreases by 40–45% during a 72-hour germination period (Havrlentová et al., 2011).

The process of germination improves the bioavailability of nutrients in food by partially hydrolysing them and whole grain minerals such as iron (Fe) and zinc (Zn), which are more difficult to absorb due to the presence of natural inhibitors, and by reducing the activity of existing antialimentary substances such as enzyme inhibitors, haemagglutinins, etc. (Gupta et al., 2015; Bashta et al., 2019).

The aim of this study is to develop the compositional profile of a nutritionally enhanced meat and plant-based pate, utilizing germinated lentil and green buckwheat grains and to investigate its quality indicators.

Materials and Methods

In developing the recipe for a nutritious pate, the following ingredients were selected: pork meat and pork liver, pork lard, germinated lentil and green buckwheat grains, onions, carrots, salt and spices.

During the study of the composition and physicochemical properties of the raw materials, semi-finished products and finished products analyses were conducted using generally accepted methods. The dry matter (DM) content was determined by drying a sample of the raw material to a constant weight at a temperature of 105°C, protein content by the Kjeldahl method, and the measurement of fat content by the accelerated extraction-weight method,the iodometric method to measure the carbohydrate content and the acid hydrolysis method to determine the fibre content (Escarpa et al., 2015; Haschuk et al., 2022).

The organoleptic parameters were quantified by sensory analysis using a scale developed by our research team and the flavour profile method (Stone et al., 2020; Prasol et al., 2017; Stone, 2018).

The physical and chemical properties as well as the organoleptic characteristics of the developed pate samples were evaluated in accordance with the requirements of the DSTU 4432:2005 Meat pates.

Excel spreadsheet editor to evaluate the nutritional and biological values of the product used in the study. The nutritional and biological values of the products were evaluated using the nutrient integral score calculating method.

Results and Discussion

The value of a meat pate and the selection of its ingredients are determined by its nutritional value, functional characteristics and technological properties. Before selecting a food environment, the following types of meat were analysed: beef muscle, first category beef, second category beef, pork liver, pork heart, pork muscle, pork lard, pork loin, pork fat, first category veal and second category veal. It is obvious that different combinations of raw meat products must be used to fulfil the body's need for amino acids and other biologically active substances.

The choice of pork liver and other ingredients in the recipe, including pork, lard, carrots and onions, was made with the intention of maximising the various beneficial properties of the pate. A review of the scientific and patent literature revealed that pork liver is the most important raw material for pate products. It is a valuable and easily digestible product that is widely available on the raw material market. The composition of liver includes a considerable amount of proteins containing iron, nitrogenous extractive substances, minerals (potassium, calcium, zinc, copper, selenium, etc.) and vitamins (B group and especially a high content of vitamin A in liver) (Pasichnyi et al, 2015; Shubina et al, 2016).

Pork meat and lard contain a considerable amount of proteins and fats, which are important for building cells and producing energy. Carrots and onions provide the body with vitamins, minerals and antioxidants that support health and immunity. In addition, all these ingredients add flavour and aroma to the pate, enhancing its appeal to the consumer.

To enrich the given pate, it was decided to use germinated lentil and buckwheat grains. The choice of unconventional ingredients for the production of a new pate was justified by their chemical composition. In particular, the protein content of lentils is not inferior to that of soya beans, beans and peas, ranging from 24% to 35%. It is a source of B-complex vitamins, including β-carotene, as well as minerals (Orekhivskyi et al, 2017). In addition, green buckwheat contains all essential amino acids, dietary fiber, polyunsaturated fatty acids, powerful antioxidants and a wide range of vitamins and minerals (Tanveer Bilal Pirzadah & Bisma Malik, 2020).

Thus, germination of selected grains has been used to increase nutritional value, bioavailability of nutritional components, reduction of antinutritive substances and improvement of functional composition of proteins. In addition, the content of B-complex vitamins, tocopherols and vitamin C in grains increases during germination, which is related to active synthesis processes in the germinating cotyledons. The synthesis of vitamins occurs through the action of enzymes using reserve substances and hydrolysis components, including sugars (Bashta et al., 2019).

The technological process of germination of the selected grain included the following steps: inspection of raw material, washing, cleaning, sanitising and soaking. The process was carried out with a combination of steam and water at a temperature of 20-22 °C for a period of 12 hours, then the excess water was removed, rinsed and germinated for 20-24 hours. The temperature of the germination process is maintained at 20-22 °C. The subsequent steps include washing, drying, milling and storage.

Experimental data were collected on the protein and fibre content of germinated grains, as it is important to maintain a high protein content and to enrich it with natural sorbents for meat and plant-based pate. This is because a major disadvantage of meat products is a low proportion or complete absence of dietary fiber, which is an essential part of the human diet.

The protein content of the test samples of germinated lentils was 32.2%, while the fibre content was 2.9%. In the test samples of green buckwheat grains, the protein content was 12.8%, while the fibre content was 9.3%.

Three different recipes of the composite mixture were developed, each with a different ratio of germinated grains. The first sample contained 40% germinated buckwheat grains and 60% germinated lentil grains, the second sample contained 50% germinated buckwheat and 50 sprouted lentil grains, and the third sample contained 60% germinated buckwheat grains and 40% germinated lentil grains. The primary physical and chemical characteristics as well as the organoleptic properties of the samples were evaluated. These included protein and fibre content, which are critical components of the developed pate (Table 1).

The determination of organoleptic indicators was carried out using a 30-point scale, where different parameters and their characteristics were evaluated according to specific criteria (each parameter with a maximum of 5 points): external appearance, cereal flavour, consistency, taste, texture, aftertaste.

The highest rating (29 points) was given to the sample of germinated cereal flour No. 3, based on its general organoleptic properties, satisfactory physical and chemical properties, and at the same time a high protein content (21.3%) and maximum fibre content (7.0%). The ratio, in which green buckwheat accounted for 60% and lentils 40%, was used in subsequent studies to determine the optimal amount of germinated grain in a new pate recipe.

A series of experimental pate samples were prepared containing pork liver, pork meat, lard, flour from germinated lentil and buckwheat grains, onions, carrots, salt and spices. The content of germinated lentils and buckwheat grains in predetermined proportions in the pate recipes varied from 5 to 20% (Table 2).

The organoleptic evaluation was carried out, the physicochemical parameters were determined and the nutritional value and biological value were calculated.

The pate samples with different proportions of germinated cereal flour, e.g. 5, 10, 15 and 20%, were analysed for organoleptic properties such as appearance, taste, smell, texture and aftertaste. Each of these factors was rated by the experts on a scale of one to five. The ratings are as follows: 5 points – "excellent" (highly desirable), 4 points – "good" (desirable), 3 points – "satisfactory" (moderately desirable), 2 points – "unsatisfactory" (undesirable), 1 point – very poor (highly undesirable).

Table 1. Results of the determination of the most important indicators of flour from germinated lentils and green buckwheat grains (n=3; p>0.95)

Parameter	Flour sample		
	№1	№2	№3
Protein content, %	24.2	22.4	21.3
Mass fraction of fibres, %	5.4	6.1	7.0
Humidity, %	13.2	13.1	13.0
Appearance	The flour has a creamy color, uniform and attractive	The flour has a beige color, uniform and attractive	The flour has a beige-green color, uniform and attractive
Grain flavor	The aroma is pleasant, characteristic for germinated grains with a more pronounced aroma of characteristic lentil grains	The aroma is pleasant, characteristic for germinated lentil and green buckwheat grains	The aroma is pleasant, characteristic for germinated lentil and green buckwheat grains
Consistency	The flour has a fine powder state, without the presence of coarse grains	The flour has a fine powder state, without the presence of coarse grains	The flour has a fine powder state, without the presence of coarse grains
Taste	The taste is rich, with notes of lentils and characteristic for germinated grains	The taste is rich and characteristic for germinated grains	The flavor is rich, buckwheat-like, characteristic for germinated grains
Texture	Fine-grained, homogeneous texture that crumbles easily	Fine-grained, homogeneous texture that crumbles easily	Fine-grained, homogeneous texture that crumbles easily
Aftertaste	The aftertaste is long and pleasant, with no unpleasant aftertaste	The aftertaste is long and pleasant, with no unpleasant aftertaste	The aftertaste is long and pleasant, with no unpleasant aftertaste
Overall rating of the organoleptic indicators	27 / 30	28 / 30	29 / 30

Table 2. Recipes for the developed pates with different proportions of flour from germinated lentils and buckwheat grains in a specific optimal ratio (1:1.5)

Raw materials	Pate recipes			
	№1	№2	№3	№4
Ratio of recipe ingredients, %				
Pork liver	50.5	50.5	45.5	44.5
Pork meat	12.5	11	10.5	9
Pork backfat	12	8	8.5	6.5
Carrot	10	10.5	10.5	10
Onion	7.4	7.4	7.4	7.4
Germinated grains of green buckwheat	3	6	9	12
Germinated lentil grains	2	4	6	8
Spice mix	1.3	1.3	1.3	1.3
Table salt	1.3	1.3	1.3	1.3
Total	100	100	100	100

The profile diagrams of the prepared pate samples with different amounts of germinated cereal flour are shown in Figure 1.

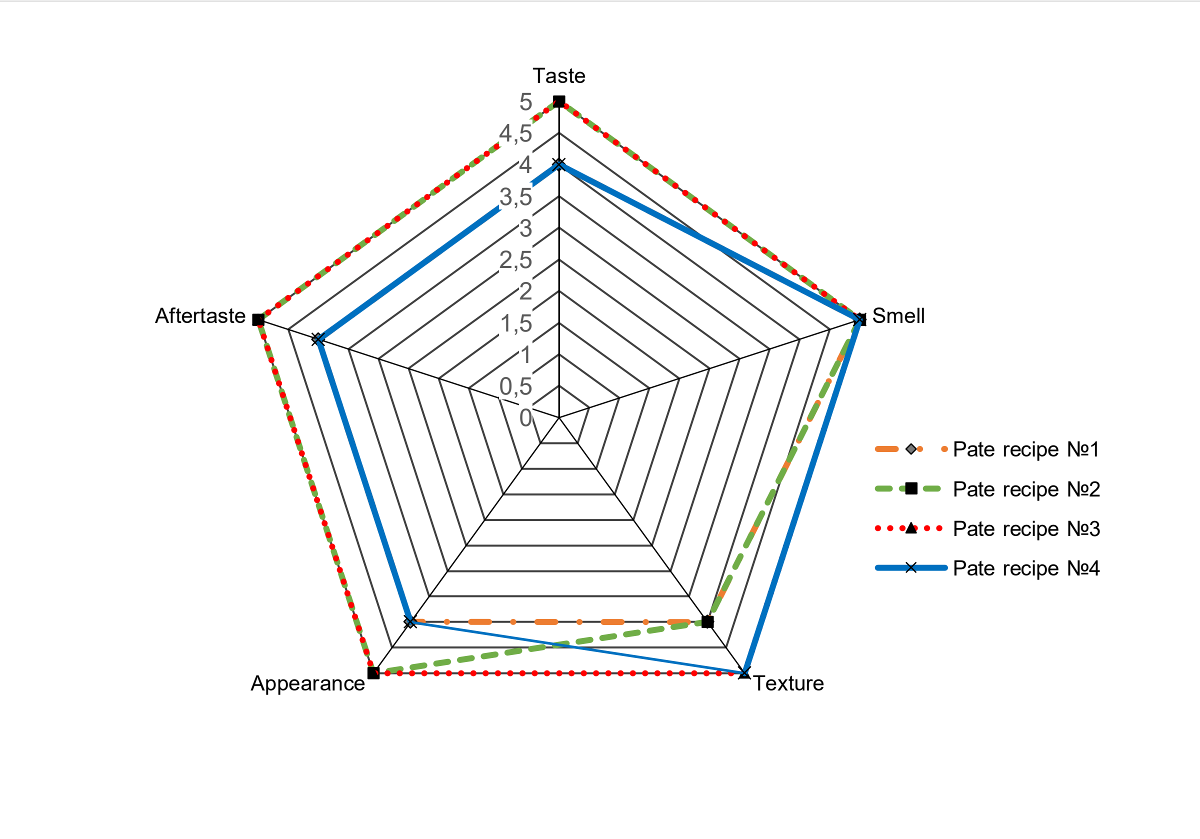

Figure 1. Profile diagrams of the prepared pate samples

The best maximum score was obtained by the sample of pate No. 3 with the addition of germinated lentil and buckwheat flour in the amount of 15%. As the profilograms show, the addition of 15% of flour from germinated grains improves the texture of the pate without oversaturating the finished product.

The physicochemical parameters of the developed pates (Table 3) with different levels of germinated grains according to the developed recipes in Table 2 were determined.

Table 3. Physicochemical parameters of pate samples with different levels of germinated grain flour (n=3; p>0.95)

Name of the parameter	Test result				Control according to DSTU 4432:2005
	Sample №1	Sample №2	Sample №3	Sample №4	
Moisture content, %	63.7	63.0	62.6	62.2	65
Fat-holding capacity, %	75.4	77.7	82.3	83.4	75
Plasticity, $cm^2 \cdot g/kg$	7.2	8.3	9.2	9.7	7
pH	6.5	6.5	6.4	6.4	6.5

From the data obtained (Table 3), it can be concluded that the content of flour from the germinated lentil and buckwheat grains in the pate affects the physicochemical properties of the final product:

- with an increase in the proportion of flour from germinated lentil and buckwheat grains in the pate, the moisture content decreased slightly;
- the addition of more germinated lentil and buckwheat flour in the recipe leads to a higher density, which in turn improves the ability of the pate to retain fat;
- the plasticity index increases with the increase in the amount of flour, even more so with the addition of germinated grains in an amount of up to 15%.

Taking into account the physicochemical and organoleptic properties, the optimum dose of germinated lentil and buckwheat grains was selected at 15% in a ratio of 60% germinated buckwheat and 40% germinated lentil grains. The pate, with this amount of sprouted grains has a pleasant flavour and aroma, a good consistency and fully meets the specified standards in terms of physical and chemical parameters.

The nutritional value of the pate with the optimal dose of germinated grains of 15% was calculated. The macronutrient content of the pate is: protein – 14.9%, carbohydrates – 12.2% (including 1.25% fibre), fats – 13.2%, energy value – 223 kcal. It was found that the degree of meeting the daily requirement of macro and micronutrients for the adult population of the first labor intensity group by consuming 100 g of pate with the addition of 15% germinated lentil and buckwheat grains is as follows: %: proteins – 24.78, carbohydrates – 5.1 (dietary fibre – 5.2), fats – 22.6, vitamins (B_1 – 13.2, B_2 – 13.9, B_6 – 17.5, E – 16.5); minerals (P – 14.9, Fe – 21.8, Cu – 26.7, Zn – 19). The developed pate refers to the category of functional foods, as the consumption of 100 g per day covers 10...50% of the requirements of an adult organism for most nutrients.

Conclusions

The combination of animal and plant ingredients is a perspective area for adapting the composition of foods to modern nutritional requirements. The development of new or the improvement of existing recipes and technologies for meat pates using plant-based raw materials makes it possible to achieve an interesting flavour and texture, many variations in serving and a high nutritional value of the final product.

In this work, lentil and buckwheat grains were selected as additional sources of plant material rich in functional ingredients. The grains were germinated to increase the nutritional value of the selected fortifications, increase the bioavailability of nutritional components, reduce antinutritive substances and improve the functional composition of the proteins.

A series of recipes for meat and vegetable pates were developed, containing pork liver, pork, bacon, sprouted lentils and buckwheat grains, onions, carrots, salt, and spices.

According to the physicochemical and organoleptic properties determined, as well as the protein and fibre content, the optimum dose of germinated lentil and buckwheat grains in the pate recipe was 15 % in a ratio of 60 % germinated buckwheat grains and 40 % germinated lentil grains. The pate with this proportion of germinated grains has a pleasant taste and smell, a good consistency and fully complies with the specified standards in terms of physical and chemical parameters. It allows the final product to be enriched with dietary fibres, minerals, vitamins and other biologically active substances contained in sprouted lentil and buckwheat grains.

Conflict of interest

The authors state no conflict of interest.

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