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EFFECT OF NON-TRADITIONAL RAW MATERIAL ON QUALITY AND NUTRITIONAL VALUE OF LIVER PÂTÉ

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Abstract: *The goal of the research was to study the applicability of ground cakes in the production of liver pâté with increased nutritional characteristics. The studies revealed that the substitution of beef liver in the amount of 3.0 % with the same amount of ground cake of black cumin seed in the formula of liver pâté contributed to: the change in color from «brown» to «gray with brown shade», the appearance of light spiciness in the taste; an increase in the content of protein (by 7.8 %) and ash (by 20.6 %), in the content of calcium (by 5.7 times), iron (by 3.4 times), magnesium (by 2.3 times), copper (by 2.2 times), manganese (by 63 %), zinc (by 25 %), and a decrease in the content of vitamin A by 11.7 % with the stabilization of the number of mesophilic microorganisms. The substitution of 10.0 % of beef liver with the same amount of the ground cake of pine nut kernels contributed to: the formation of slightly sweet taste and tenderer consistency; an increase in the content of protein (by 38.3 %) and ash (by 24.5 %), minerals – manganese (by 6.1 times), calcium (by 4.3 times), magnesium (by 3.9 times), iron and copper (by 2.3 times), phosphorus (by 2.2 times), zinc (by 27%), and a decrease in the content of vitamin A by 27.5%.*

Key words: *liver pâté, black cumin seed, pine nut kernel, mineral content, quality.*

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1. Introduction

Liver pâtés are popular all over the world, but as a rule, they contain a large amount of saturated animal fats and cholesterol, which is unfavourable from the perspective of modern nutritional science. The use of plant raw materials, rich in essential nutrients, makes it possible to obtain combined functional products complying with physiological norms of nutrition [7], [10-11], [15], [18], [25], [28].

There have been developed formulas of pork liver pâté with the addition of hemp seed, flaxseed and their combinations, which enriches the product with polyunsaturated fatty acids, as well as with plant fibber, protein and mineral elements [31]. The technology of pâté production using non-traditional plant material, such as selenium wheat flour, pumpkin, sprouted soybean seeds, insulin with wheat bran and laminaria, honey extract of walnuts, black cumin oil, green tea, chestnut and grape extract, is widely known [5, 15-16, 19, 23, 28, 30].

Well-known black cumin (*Nigella sativa* L.) or black caraway is a promising raw component in dietary modifications; it is used in daily ration or added as a functional ingredient [2], [4]. Black cumin seeds contain: protein (26 %), carbohydrates (25 %), fibber (8.4 %), as well as alkaloids, saponins, flavonoids, pigments, resins, waxes, tannins, coumarins, ascorbic acid. The seeds are rich in minerals, such as Cu, P, Zn and Fe [1], [20].

The characteristic feature of the chemical composition of pine nut kernels is a significant content of essential amino acids, polyunsaturated fatty acids, B vitamins, tocopherols, dietary fibber, protein fractions, microelements, which indicates its potential as a high-value additive in food products [6], [8], [13], [17], [24], [29].

The goal of the research was to study the applicability of ground cakes of black cumin seed and pine nut kernels in the production of liver pâté with increased nutritional characteristics.

2. Material and Methods

2.1. Materials

The pâté prepared according to a traditional recipe (composition, net weight: beef liver – 857 g, pork fat – 150 g, butter – 100 g, onion – 100 g, carrots – 74 g, meat broth – 50 g, food salt – 17 g, spices – 8 g) [12] was used as a control sample. The yield of the obtained pâté was 1000 g. When cooking the pâté, chopped onions and carrots were fried with fat until half done. Then chopped liver and spices were added, simmered until done and passed through the cutter with fine grating twice. After that, softened butter, broth ant salt were added and mixed thoroughly. The pâté was moulded into bars of 100 g net weight.

Experimental samples were obtained by adding plant raw materials, substituting the same amount of beef liver in the formula: sample No.1 – adding ground cake of black cumin seed («Sibirskiy» trademark) in the amount of 1.5; 3.0; 5.0 % (supplier – VELA Kedrovy Rai, Moscow, Russia); sample No.2 – adding ground cedar kernels («Siberian Product» trademark) in the amount of 5.0; 7.0; 10.0 % (supplier – Dar Altaya, Altai Territory, Barnaul, Russia). The quantative range of cake dosage was experimental.

The model samples were stored at a temperature of 4±2 °C for 24 hours.

2.2. Methods

Physicochemical and microbiological studies were carried out by classical methods [22].

2.3. Methods of Testing Plant Raw Material

The cakes were tested for organoleptic properties. The appearance and colour was determined visually, the smell and taste – by tasting [9]. The mass fraction of moisture was determined by distilling water from the cake slurry in a solvent forming an azeotropic mixture with water, followed by measuring the volume of the distilled water. The content of phosphorus was determined using its ability combining with ammonium molybdenum to form phosphomolybdic acid, which is reduced by the amidol reagent and gives a blue colour. The content of vitamins was determined by high-performance liquid chromatography. The presence of Salmonella bacteria was determined by sowing the product into a selective liquid, and then into a selective agarized nutrient medium, incubating the crops at a temperature of 37 ± 1 °C for 24 ± 3 hours, followed by identification of all the visible colonies that grew, using biochemical and serological tests. The presence of *S. aureus* was determined by sowing the product on the surface of a dense nutrient medium, incubating the crops at a temperature of 37 ± 1 °C for 24-48 hours, and counting typical colonies with subsequent confirmation of their belonging to *S. aureus* according to their plasma-coagulating ability.

2.4. Testing Methods for Model Samples of Liver Pâté

A scale from one to nine was used during the tasting evaluation of the liver pâté in order to determine the compliance of organoleptic properties with the requirements of regulatory documents [3]. The mass fraction of sodium chloride was determined by titrating the chloride ion extracted from the product with a silver ion in a neutral medium in the presence of potassium chromate; the mass fraction of phosphorus – by mineralization of the sample with nitric and sulphuric acids, precipitation of phosphorus in the form of quinoline phosphomolybdate and determination of the precipitate mass.

The content of calcium, manganese, magnesium, iron, copper and zinc in the plant raw material and in the combined products was determined by the method of flame atomic absorption; the mass fraction of protein was determined using the Kjeldahl method which consists in mineralization of the sample and photometric measurement of the intensity of indophenol blue, which is proportional to the amount of ammonia in the mineralized substance; the mass fraction of fat was determined by the extraction method in the Soxhlet apparatus; the mass fraction of ash – by complete combustion of the organic part of the sample of the raw material with the subsequent gravimetric determination of the test item. The quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM) was determined by inoculating a sample of the product into the meat-peptone agar, incubating the crops at 30 ± 1 °C for 72 hours, and then calculating all the grown

visible colonies. The presence of bacteria of the *E. coli* group was determined by sowing the product into a selectively diagnostic nutrient medium, incubating the crops at a temperature of 37 ± 1 °C for 24 ± 3 hours, then counting typical and atypical colonies and determining the possibility of bacteria from these colonies to ferment lactose to form gas. The quantity of sulphite-reducing clostridia was determined by inoculating a sample of the product into a nutrient medium with the presence of iron sulphite agar, incubating the crops at a temperature of 37 ± 1 °C for 24-48 hours, and then counting the colonies of different intensity of black colour.

The daily norm of consumption of mineral components for an adult was taken from the existing standards [26].

2.5. Statistical Analysis

All measurements were repeated three times. Statistical analysis was performed using Microsoft Excel XP and Statistica 8.0. Statistical error did not exceed 5% (with a 95% confidence level).

3. Results and Discussion

3.1. Testing Cakes Quality and Safety

At the first stage of the experiment, much attention was paid to the study of organoleptic, certain physical, chemical and microbiological properties and mineral value of the cakes to establish the applicability of the non-traditional plant raw material as a component increasing the nutritional value of the combined product. The results are given in Table 1.

The organoleptic evaluation revealed the following characteristic smell and taste properties of the cakes (without any foreign smell or aftertaste): black cumin seed cake demonstrated typical neutral smell and moderately bitter taste with no flavour; the one of pine nut kernels demonstrated typical slightly sweet taste. According to the colour scheme (cream-white colour), the cake from pine nut kernels turned out to be more technological for liver pâté production, which allowed using it in larger dosages.

The content of the lipid fraction, rich in polyunsaturated fatty acids, in pine nut kernel cake 5 times exceeded this content in black cumin seed cake. The protein content in black cumin seed cake (40.60 ± 1.40 %) as well as ash content (6.46 ± 0.03 %) twice exceeded the same indices in pine nut kernel cake. The relatively high ash content in the raw material is explained by the high concentration of mineral elements in the cumin seeds, in particular iron (6.8 times more), calcium (5.4 times), magnesium (1.6 times). However, the content of phosphorus and manganese in black cumin seeds is 14.4 and 1.8 times less than in kernels of pine nuts, respectively.

During the study of microbiological parameters of the cake quality, there was no presence of bacteria of the *E. coli* group, *Salmonella*, *Staphylococcus aureus* and *Sulphite-reducing clostridia* in the tested plant material. The content of mesophilic microflora in pine nut kernels cake was 1.5 times lower.

3.2. Testing the Effect of Cakes on Quality of Model Samples of Liver Pâté

The second stage of the research was dedicated to the effect of the cakes in different dosages on the quality of model samples of pâté. The results of the

research of organoleptic properties are given in the Figures 1 and 2.

Quality parameters and mineral composition of cakes Table 1

Test item	Test results	
	black cumin seed cake	*pine nut kernel cake*
Organoleptic Parameters		
Appearance and consistency	Homogeneous, free-flowing powder, particle size less than 0.3 mm	
Colour	Black-brown, uniform throughout the mass	Cream-white, uniform throughout the mass
Smell	Typical, neutral. No musty, mouldy, rancid or any other foreign smell	
Taste	Typical, moderately bitter taste with no flavour. No musty, mouldy, rancid or any other foreign aftertaste	Typical, slightly sweet taste with no flavour. No musty, mouldy, rancid or any other foreign aftertaste
Physical and Chemical Parameters		
Mass fraction of moisture [%]	7.20 ± 0.70	3.20 ± 0.30
Mass fraction of protein [%]	40.6 ± 1.4	20.8 ± 0.6
Mass fraction of fat [%]	10.2 ± 0.5	54.2 ± 1.3
Mass fraction of ash [%]	6.46 ± 0.03	3.07 ± 0.02
Phosphorus content [mg/kg]	781.00 ± 166.00	11256.00 ± 3144.70
Calcium content [mg/kg]	3869.70 ± 1393.09	717.34 ± 258.24
Copper content [mg/kg]	19.59 ± 1.96	11.92 ± 1.19
Iron content [mg/kg]	411.28 ± 41.13	60.37 ± 6.04
Magnesium content [mg/kg]	3720.5 ± 1004.5	2286.3 ± 617.3
Manganese content [mg/kg]	41.80 ± 13.79	75.43 ± 24.89
Zinc content [mg/kg]	51.60 ± 5.16	51.80 ± 5.18
Microbiological Parameters		
QMAFAnM [CFU/g]	3.2×10^2	2.1×10^2
Pathogens, including salmonella in 25 g	not detected	
S. aureus in 0.1 g	not detected	
E. coli (coliforms) in 1 g	not detected	
Sulphite-reducing clostridia in 0.1 g	not detected	

The results of organoleptic evaluation of the model samples illustrate the degree of changes in consumer properties of the products with an increase in the dosage of black cumin seed cake. Thus, the seed cake in the amount of 1.5 % only slightly changed the appearance of the pâté, introducing a grayish hue in the brown colour of the product. On average, the experimental samples scored 8.7 ± 0.3 points, which corresponds to the category of «very good» quality. The cake in the amount of 3% caused a greater change in the colour (the colour of samples changed from «brown» to «gray with a brown shade») and taste of the finished product

(the taste became a little spicier), but consistency and juiciness remained acceptable. During the tasting evaluation, the test samples on average scored 8.2 ± 0.3 points, which corresponds to the category of «very good» quality. The increase in the amount of plant raw material to 5% worsened the taste of the pâté samples, causing an unpleasant herbaceous aftertaste and somewhat dry juiciness. As a result, the product's quality decreased to the «below average» category. The consistency of the combined samples during chewing was satisfactory, however somewhat dry. The average score of the experimental samples (5.6 ± 0.3 points) made it possible to identify the quality as «average».

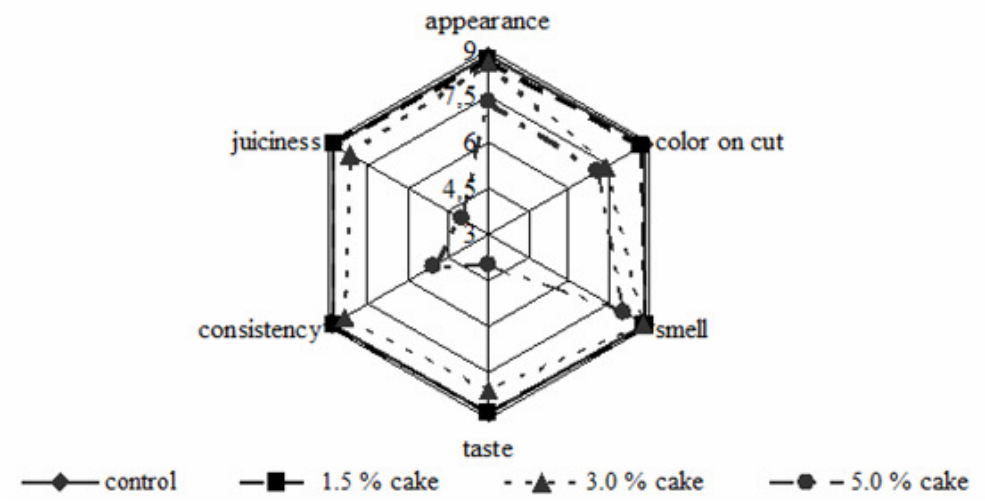

Fig. 1. P*rofile diagram of organoleptic evaluation of liver pâté model samples with added black cumin seed cake*

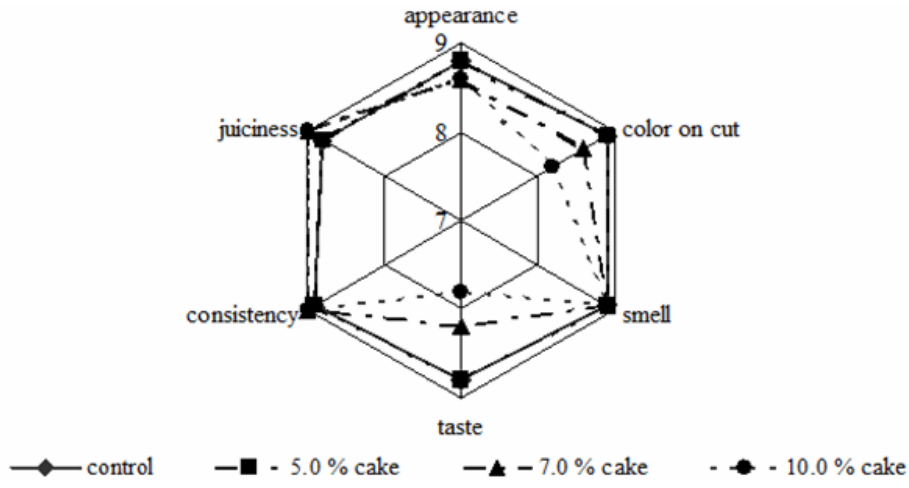

Fig. 2. *Profile diagram of organoleptic evaluation of liver pâté model samples with added pine nut kernel cake*

The pine nut kernel cake in the amount of 5.0% did not have any effect on the consumer properties of the liver pâté, that is, the organoleptic characteristics of the experimental samples did not differ from the control ones. The average score of the samples was 8.8 ± 0.2, which corresponded to the category of «very good» quality. The introduction of pine nut kernel cake of cream-white colour in the amount of 7.0 and 10.0% did not significantly change the brown colour of the pâté. The difference with the control sample in the score for colour during the tasting assessment was 0.3 and 0.7 points, respectively. However, the taste of the pâté with 10.0 % of pine nut kernels turned out to be slightly sweet, but it remained quite tasty (scored 7.8 points and corresponded to «good» quality), which gave the product some piquancy while having a more tender consistency.

The latter, apparently, can be explained by the fatty acid composition of the pine nut lipids rich in polyunsaturated fatty acids, which form the plastic properties of the structure of food products [9]. The average score of the test samples with 10.0% of the pine kernel cake was 8.5 ± 0.2, which corresponds to the category of «very good» product quality.

Based on the results, the test samples with the addition of 3.0 % black cumin seed cake and 10.0 % pine nut kernel cake were chosen for further research, since at the indicated concentrations of the non-traditional plant raw materials, model samples of the liver pâté still retain acceptable consumer characteristics.

The results of the studies of physical, chemical and microbiological quality parameters of the pâté model samples in a comparative aspect are given in Table 2.

While testing the liver pâté samples, it was found that the mass fractions of moisture, protein, fat and sodium chloride were in the same quantitative range both in the control and test samples. However, the protein content in the test samples tended to increase: by 7.8 % when adding black cumin seed cake and by 38.3 % when adding pine nut kernel cake. The ash content in the test samples with the plant material was also higher than in the control sample by 20.6 and 24.5 %, respectively, which complies with the results of testing the mineral value of the model pâté samples.

The bacteria of the E. coli group and the sulphite-reducing clostridia were not detected in a given mass of the control and test samples throughout the entire experiment period. The results of bacterial contamination studies of the model samples of the pâté show that QMAFAnM was within normal limits (not more than 1.0×10^3) in the control and test samples even at the end of the shelf life (24 hours). However, the quantity of mesophilic aerobic and facultative anaerobic microorganisms after 24 hours of storage increased by 23 % in the samples with black cumin seed cake, while in the control and in the test samples with pine nut cake it increased by 32-33 %. The stabilization of the QMAFAnM can be explained by the well-known ability of black cumin seed in various dosages to inhibit the growth of *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Listeria innocua*, *staphylococci*, as well as *Aspergillus flavus, Fusarium graminearum, Fusarium moniliforme, Penicillium viridicatum* etc. [14], [21], [27].

Quality parameters of liver pâté model samples Table 2

Test item	Test results		
	control	*3.0 % black cumin seed cake*	*10.0 % Pinenut kerne lcake*
Freshly made samples			
Mass fraction of moisture [%]	43.1 ± 0.7	43.0 ± 0.7	44.2 ± 0.6
Mass fraction of protein [%]	14.10 ± 0.88	15.20 ± 0.88	19.50 ± 0.90
Mass fraction of fat [%]	29.1 ± 2.9	28.2 ± 2.8	29.7 ± 2.3
Mass fraction of sodium chloride [%]	0.60 ± 0.07	0.60 ± 0.07	0.60 ± 0.07
Mass fraction of ash [%]	1.55 ± 0.03	1.87 ± 0.03	1.93 ± 0.03
QMAFAnM [CFU/g]	7.5×10^2	7.7×10^2	6.9×10^2
E. coli (coliforms) in 1 g	not detected		
Sulphite-reducing clostridia in 0.1 g	not detected		
Samples after 24 hours of storage			
Mass fraction of moisture [%]	42.7 ± 0.7	42.9 ± 0.7	44.0 ± 0.7
QMAFAnM [CFU/g]	9.9×10^2	9.5×10^2	9.2×10^2
E. coli (coliforms) in 1 g	not detected		
Sulphite-reducing clostridia in 0.1 g	not detected		

3.3. Testing the Effect of Plant Raw Material on Nutritional Value of Liver Pâté Model Samples

Mineral substances along with proteins, fats and carbohydrates are vital components of human nutrition, necessary for forming the structures of living tissues and for carrying out the biochemical and physiological processes underlying the vital activity of the organism. Unlike other essential nutrients (polyunsaturated fatty acids, essential amino acids), vitamins are not a building material or source of energy. Fat-soluble vitamins perform the signal functions of exogenous prohormones and hormones (hormone vitamins). In this connection, the last stage of the research was dedicated to the study of the content of certain mineral components and vitamins in the model samples of the liver pâté. The results of the studies are given in Table 3.

The estimates suggest (Figure 3) that including into the diet 100 g of liver pâté with seed cakes in the formula allows to meet an adult person's need for mineral elements to a significantly higher degree, namely:

- Products with black cumin seed cake cover the following physiological need: 176.2% of iron for men and 97.9% for women, 19.3% of copper, 6-7% of zinc, manganese and calcium, 4.7% of magnesium;
- Products with pine nut kernel cake cover: 98.5% of iron for men and 54.8% for women, 58.9% of manganese, 20.7% of copper, 11.3% of magnesium, 5-6% of calcium and zinc.

Mineral and vitamin value of liver pâté model samples Table 3

Test item	Test results		
	control	*3. 0% black cumin seed cake*	*10.0 % pine nut kernel cake*
Mass fraction of phosphorus [%]	0.290±0.018	0.300±0.018	0.631±0.018
Calcium content [mg/kg]	144.50±56.36	821.16±295.62	627.44±225.88
Copper content [mg/kg]	1.60±0.16	3.53±0.35	3.67±0.36
Iron content [mg/kg]	73.19±7.32	249.38±24.94	171.73±7.17
Magnesium content [mg/kg]	151.32±56.75	342.64±128.49	603.75±163.01
Manganese content [mg/kg]	2.29±0.92	3.74±1.50	14.06±5.62
Zinc content [mg/kg]	27.50±2.75	34.47±3.45	35.00±3.80
Vitamin A content (retinol) [mg/kg]	1.71±0.34	1.51±0.25	1.24±0.25
Vitamin E content (Alpha tocopherol) [mg/kg]	< 25.0		
Vitamin D_3 content (cholecalciferol) [mg/kg]	< 0.5		

This allows optimizing the diet in relation to certain micronutrients and preventing a number of alimentary-dependent diseases.

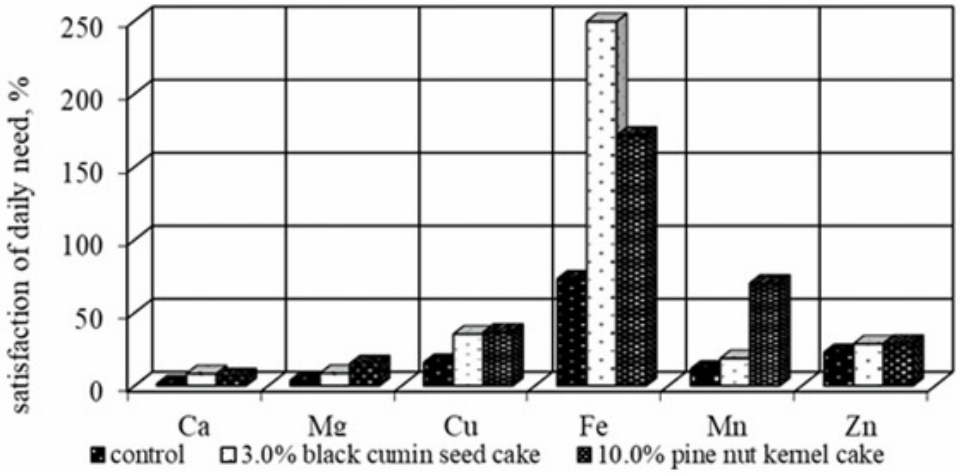

Fig. 3. *Satisfaction of physiological need for minerals with 100 g pâté*

4. Conclusions

The positive effect, which the cakes under research in the studied concentration have on the replenishment of the liver pâté mineral value, was established for the first time. As for macronutrients, the test samples with 3.0 % black cumin seed cake contain more calcium (5.7 times), magnesium (2.3 times), as for microelements – iron (3.4 times), copper (2.2 times), manganese (by 63 %), zinc (by 25 %). The content of zinc in the model samples was within one quantitative range.

The addition of 10.0 % pine nut kernel

cake in the liver pâté promotes an increase of manganese (6.1 times), calcium (4.3 times), magnesium (3.9 times), iron and copper (2.3 times), phosphorus 2.2 times), and zinc (by 27 %) in the finished product.

However, it was revealed that substitution of beef liver with black cumin seed cake caused a decrease in the content of vitamin A in the pâté by 11.7 %, with pine nut kernel cake - by 27.5 %, while the content of vitamin E and D_3 remained stable.

Acknowledgments

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