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RESEARCH OF COMPOSITIONS OF AMINO ACIDS, FATTY ACIDS AND MINERALS IN MEAT PATE WITH ADDITION OF MEAT-AND-BONE PASTE

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Abstract
This article analyses the nutritional value of meat pate produced with the addition of meat-and-bone paste obtained from chicken bones. In the test samples of the pate, 20% of the poultry meat was replaced with the meat-and-bone paste. The comparative characteristic of the chemical, amino acid, fatty acid and mineral compositions of meat pate is given in the article. The comparative analysis of the nutritional value of meat pate showed that the addition of meat-and-bone paste decreases the moisture content by 0.23%, fat content by 1.22%, and increased the protein content (by 0.52%). In the test sample of the product the proportion of minerals increased significantly from 1.3% to 2.23% compared to the control sample. In terms of amino acid composition, the addition of meat-and-bone paste up to 20% instead of poultry meat significantly increases the content of amino acids like isoleucine (from 196 mg/100 g to 661 mg/100 g), leucine (from 807 mg/100 g to 1083 mg/100 g), threonine (from 454 mg/100 g to 610 mg/100 g). The test samples of pate, compared with the control samples, contain a higher amount of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids, including oleic (39.698%) and linoleic (21.546%) acids. The content of the saturated fatty acids (SFA) in the control sample are 37.8%, in the test sample it accounts to 32.9%. According to the mineral composition: the content of calcium is significantly increased in the test sample, (from 268.0 mg/100 g to 480.0 mg/100 g). In general, the addition of meat-and-bone paste made of chicken bones allows fortification the pate with the essential amino acids, mono- and polyunsaturated fatty acids and calcium.

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Introduction

Pate is a homogenized food product with a predominant content of meat or liver. The principle of pate manufacturing is based on combining of various types of products, as well as methods of their processing (boiling, blanching, sauteing, frying, homogenization, etc.) depending on the recipe [1]. The composition of meat pates can provide a significant impact on their nutritional characteristics. The specialized literature describes a wide variety of meat pate recipes where chicken offal is added. These types of pate are sold on the world market.

In the market of meat pate kinds, chicken pates are becoming more and more popular due to the increase in the global production of poultry meat. Along with the increase in consumption of poultry meat, the production of by-products obtained after the poultry slaughter is increasing simultaneously. The range of by-products include feathers, blood, bones, skin, viscera, offal, glands, limbs and various fatty tissues [2]. From chicken meat, in the production of pate, chicken breasts, chicken meat are used [3.4.5.6.7.8.9.10], secondary products obtained during slaughter and primary processing of poultry — muscular stomachs, liver, heart, heads, legs (up to 30%) [11,12,13,14,15,16,17,18,19]. However, the meat-and-bone offal obtained from the slaughter of poultry still remains unclaimed. The main barriers to the use of bone raw materials for food purposes in production is the lack of a proven technology for processing bone raw materials and lack of special equipment.

Nevertheless, in terms of nutritional value, first of all raw bone is a rich source of minerals. The main components of bone tissue are mineral substances, which make up to ¼ of the volume, or ½ of the tissue mass, which mineral substances are mainly represented by calcium salts of carbonic and phosphoric acids, magnesium salts of phosphoric acid and even less calcium fluoride are found in a smaller amount [20]. About 99% of all calcium is found in the skeleton. The elemental composition of the ash elements of the bone tissue is characterized by the following data (in %): CaO — 52; MgO — 1.2; P_2O_5 — 40.3; Na_2O — 1.1, K_2O — 0.2; Cl — 0.1; F — 0.1; CO_2–5.0 [21]. In addition, food bone is high in fat, protein and phosphorus-calcium compounds. The chemical composition of the bone is as follows: water — 13.8–44.4%, protein (collagen) — 32.0–32.8%, minerals — 28.0–53.0%, fat — 1.3–26, 9% [22]. The fat obtained from various types of bone differs in the content of lecithin and unsaponifiable substances (they are found in the greatest amount in pork bone fat). In terms of the content of saponifiable substances (0.2–0.3%), edible bone fat is much superior to fats obtained from soft fat raw materials from the same types of livestock [23]. The main organic part of the bone is the bone collagen (ossein); it accounts for 93% of the total amount of bone proteins, the rest is glycoproteins, lipids and glucosaminoglycans (chondroitin sulfate, keratan sulfate and other glucosamines and galactosamines). The composition of ossein (%): moisture 70, proteins 25–28, minerals 3, fats 0.2 [24].

The use of bone raw materials for food purposes is one of the key areas of sustainable saving of raw materials in the processing of animal food products. The processes of fine and ultrafine grinding of bones make it possible to obtain a pasty mass without either large and small fractions of bone particles [25,26].

The purpose of this article is to study the chemical, amino acid, fatty acid and mineral compositions of meat pate with the addition of chicken bone meat-and-bone paste.

Materials and methods

Obtaining a paste-like mass from chicken bones

At the initial stage of the test research, a technological scheme for processing chicken meat-and-bone raw materials was developed. To conduct research on the grinding of meat-and-bone raw materials, chicken bones (bones of the neck, drumstick, wings, breast) obtained after deboning were used. The chicken meat-and-bone raw materials were deboned at the first stage. Chicken meat-and-bone raw materials were obtained from meat processing enterprises and large meat plants in Semey city, East Kazakhstan region of the Republic of Kazakhstan.

Next meat-and-bone raw materials are pre-frozen for 60 minutes at temperatures within minus 18 °C to minus 20 °C in the freezers. After that, the frozen raw material is fed into the hopper of the crusher with a hole diameter of the output grate of 5 mm, and crushed. After grinding the chicken meat-and-bone raw materials, the meat-and-bone minced mass was obtained. After that, the meat-and-bones minced mass is added into a meat mixer along with the ice water. After mixing, minced meat-and-bones is crushed on a micro grinder "Supermasscolloyder", where the gap between the grinding wheels is 0.1 mm. After grinding the mass in the micro grinder, a homogeneous chicken meat-and-bone paste without bones, coarse connective tissue, blood clots and films is obtained [25].

Technology of the meat pate production

The technological process of meat pate production with the addition of meat-and-bone paste consists of receiving raw materials, blanching, grinding, cutting, filling shells, boiling loaves, cooling loaves, packaging, labeling and storage. The formulation is presented in Table 1.

Table 1. Recipe for meat pate

Raw material	Control sample	Test sample with 20% of meat-and-bone paste
Poultry meat	60.70	40.70
Beef liver	17.60	17.60
Meat-and-bone paste	—	20
Pork fat	5.30	5.30
Onion	6.30	6.30
Carrot	5.70	5.70
Parsley (dry root)	0.60	0.60
Ground black pepper	0.05	0.05
Cooking salt	1.05	1.05
Broth	2.70	2.70
Total	100	100

Raw materials received for production are tested in accordance with the current technical conditions and standards. Next, the liver is trimmed, cover film, bile ducts and other inclusions are removed. After trimming, the raw materials are soaked in running water for 2 hours to remove blood clots. The raw veined liver is cut into slices and blanched at 105 °C (water to liver ratio is 3:1) for 15–20 minutes. Before cutting, the raw material is ground on a grinder with a grate opening diameter of 2–3 mm. The chopped meat is sent for cutting at a temperature of 10–12 °C for 3–4 minutes.

Pate preparation. Beef liver, meat-and-bone paste, bacon, spices are pre-weighed. The components of the pate are mixed in a cutter with a sequential adding of raw materials: first, poultry meat, beef liver, then salt and pepper are added. The duration of cutting is 3–7 minutes. The second stage provides for addition of the fatty meat raw materials, meat-and-bone paste, onions, carrots. At the end of cutting, the paste mass should be homogeneous, spreadable and pasty mass.

Filling shells with minced meat (forming loaves). The shells are filled with minced meat with vacuum fillers. After filling the pate masses are sent for heat treatment. The meat pate is cooked in the heat chambers at a temperature of 80–85 °C until the temperature in the center of the loaf reaches 72–75 °C. After cooking, meat pate are cooled in the cooling chambers with a temperature of 0 to 6 °C and a relative humidity of 95% until the temperature in the mid of the pate loaf reaches no higher than 6 °C.

Determination of the chemical composition

The total chemical composition was defined by the method of one portion of the test sample. The method consists in successive determination of moisture, fat, protein and ash content in one sample of the product using a device for determining the moisture and fat content of meat and dairy products via accelerated method [27].

Determination of amino acid composition

The amino acid composition was determined using high performance liquid chromatography[1]. The method is designed to determine the concentration of 18 amino acids in the food products, using high-performance liquid chromatography with the help of a computer system for information recording, processing and storing.

Calculation of amino acid score

Amino acid score was calculated by the following formula:

$$АКС = \frac{m_1}{m_2} \cdot 100\%, \quad (1)$$

where:

m_1 — is the content of essential amino acid in the test product, g/100 g of protein;

m_2 — content of an essential amino acid in an ideal protein, g/100 g of protein.

To assess the balance of essential amino acids relative to the reference protein, the coefficient of rationality *Rc* was calculated by the following formula:

$$Rc = \frac{\sum_{i=1}^{n} A_i K_i}{\sum_{i=1}^{n} A_i}, \quad (2)$$

where:

Ai — content of the essential *i-th* amino acid, mg/g of protein;

Ki — utility coefficient of the *i-th* amino acid.

Determination of fatty acid composition

The fatty acid composition was determined by the method of gas chromatographic determination of fatty acids and cholesterol in food and blood serum[2]. The technique is designed to determine the composition of fatty acids (myristic palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, arachidonic acids) and total content of cholesterol in the food products, their mixtures (rations) and blood serum.

Determination of the mineral composition

Mineral composition were determined according to regulatory documents R4.1.1672–03[3] "Guidelines for quality control and safety of biologically active food additives", GOST 26928–86[4] "Food-stuffs. Method for determination of iron", GOST 33824–2016[5] "Foodstuffs and food ingredients. Stripping voltammetric method for determination of toxic elements (cadmium, lead, copper and zink)".

Statistical processing

The results of measurements were processed in Excel-2016 and Statistica software. The results of the analyzes were statistically significant at $p \leq 0.05$. Data are presented as mean value ± standard deviation.

Results and discussion

The chemical composition of meat pate is presented in the Table 2. The results show that the addition of meat-and-bone paste leads to a decrease in moisture content (by 0.23% and fat by 1.22%), an increase in protein (by 0.52%). In the test sample, the proportion of minerals increased significantly from 1.3% to 2.23% in comparison with the control sample.

Table 2. Chemical composition of meat pate

Parameters	Control sample	Test sample with 20% meat-and-bone paste
Moisture, %	59.76 ± 0.81	59.53 ± 0.94
Protein, %	17.46 ± 0.28	17.98 ± 0.31
Fat, %	21.48 ± 0.38	20.26 ± 0.33
Ash, %	1.30 ± 0.02	2.23 ± 0.03*
Energy value, kcal	263.16	254.26

* $p < 0.001$

At the next stage the amino acid composition of meat pate was researched. The results are presented in the Table 3 below. From the Table 3 it can be seen that the content of essential and non-essential amino acids prevails in the test sample of meat pate, which pate was produced with addition of meat-and-bone paste, than in the control sample.

As it follows from the above given data, the total amount of essential amino acids in the control sample of the meat pate was 3,889 mg/100g, the test sample — 5,209 mg/100g. The predominant essential amino acids were as follows: leucine (807 and 1,083 mg/100 g); lysine (727 and 996 mg/100 g) and valine (584 and 764 mg/100 g). The total amount of amino acids in the control sample of meat pate was 10,486 mg/100g, in the test sample it was 13,793 mg/100g.

According to the amino acid composition, the addition of meat-and-bone paste up to 20% instead of poultry meat increases its content of all amino acids. Thus, the content of isoleucine increased (from 196 mg/100 g to 661 mg/100 g), leucine (from 807 mg/100 g to 1083 mg/100 g), threonine (from 454 mg/100 g to 610 mg/100 g).

[1] Measurement procedure MN1363–2000 "Method of determination of amino acids in food products using high-performance liquid chromatography". Approved by the Chief State Sanitary Doctor of the Republic of Belarus on July 14, 2000.

[2] Measurement procedure MN1364–2000 "Method of gas chromatographic determination of fatty acids and cholesterol in food and blood serum". Approved by the Chief State Sanitary Doctor of the Republic of Belarus on July 14, 2000.

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[4] GOST 26928–86 "Food-stuffs. Method for determination of iron". Moscow: Standartinform, 2010. — 6 p. (In Russian)

[5] GOST 33824–2016 "Foodstuffs and food ingredients. Stripping voltammetric method for determination of toxic elements (cadmium, lead, copper and zink)". Moscow: Standartinform, 2016. — 23 p. (In Russian)

Table 3. Amino acid composition of meat pate, mg/100g of the product

Name	Meat pate (control)	Meat pate (test)
1	2	3
Essential amino acids	3,889	5,209
Valine	584 ± 12	764 ± 25*
Isoleucine	196 ± 3.4	661 ± 14*
Leucine	807 ± 13	1083 ± 24*
Lysine	727 ± 22	996 ± 29*
Methionine	196 ± 4.2	277 ± 4.4*
Threonine	454 ± 10	610 ± 10 *
tryptophan	150 ± 4.9	196 ± 5.7*
Phenylalanine	471 ± 11	622 ± 22*
Non-essential amino acids:	6597	8584
Aspartic acid	1,099 ± 15	1,423 ± 30*
Glutamic acid	1,792 ± 41	2,233 ± 58**
Serine	572 ± 18	722 ± 21*
Histidine	287 ± 4.6	368 ± 9.9**
Glycine	545 ± 13	763 ± 14*
Arginine	747 ± 15	963 ± 25*
Alanine	529 ± 11	761 ± 19*
Tyrosine	339 ± 6.6	467 ± 9.5*
Cysteine	156 ± 3.4	195 ± 6.3**
Proline	531 ± 11	689 ± 13*
Total amount	10,486	13,793

* $p < 0.001$; ** $p < 0.01$

According to the amino acid composition of meat pate, the content of essential amino acids was researched by comparative analysis in the reference protein recommended by the FAO/WHO amino acid scale (Table 4), and the amino acid score of proteins was calculated, which determines the ratio of the content of each essential amino acid in the analyzed protein to their content in reference value.

Table 4. Amino acid composition of the meat pate

Amino acid	FAO/WHO reference value (mg/100 g)	The content of essential amino acids, mg per 100 g of protein		Amino acid score,%	
		control sample	test sample	control sample	test sample
Isoleucine	4,000	1,122.56	3,676.31	28.06	91.91
Leucine	7,000	4,621.99	6,023.36	66.03	86.04
Lysine	5,500	4,163.80	5,539.48	75.70	100.72
Methionine + Cystine	3,500	2,016.03	2,625.14	57.60	75.00
Phenylalanine + Tyrosine	6,000	4,639.17	6,056.73	77.32	100.94
Threonine	4,000	2,600.23	3,392.65	65.00	84.82
Tryptophan	1,000	859.10	1,090.10	85.91	109.01
Valine	5,000	3,344.78	4,249.16	66.89	84.98
General content of essential amino acid		23,367.66	32,652.9		
Protein content, g/100 g		17.46	17.98		

The calculation of the amino acid score showed that all essential amino acids in the control sample of the meat pate are limiting amino acids (LAA). In the test sample, all amino acids are limiting, except for lysine (100.72%), phenylalanine + tyrosine (100.94%) and tryptophan (109.01%).

The high amino acid score was recorded in a test sample of the meat pate. Thus, the highest amino acid score is calculated for tryptophan 109.01%.

At the next stage, the fatty acid composition of meat pate was studied. The biological value of new kinds of pate can be judged by the balance of the fatty acid composition of the lipid components in the product (Table 5).

Table 5. Fatty acid composition of meat pate

Name of the acid	Meat pate (control)	Meat pate (test)
1	2	3
Saturated fatty acids, %	37.865 ± 1.893	32.995 ± 1.650
$C_{14:0}$ myristic	1.014 ± 0.051	0.687 ± 0.034
$C_{15:0}$ pendadecanoic	0.147 ± 0.007	0.133 ± 0.007
$C_{16:0}$ palmitic	24.252 ± 1.219	20.884 ± 1.044
$C_{17:0}$ margarine	0.368 ± 0.018	0.309 ± 0.015
$C_{18:0}$ stearic	11.903 ± 0.595	10.747 ± 0.537
$C_{20:0}$ arachidic	0.180 ± 0.009	0.180 ± 0.009
$C_{21:0}$ geneucosan	—	0.025 ± 0.001
$C_{22:0}$ beguine	—	0.030 ± 0.002
Monounsaturated fatty acids, %	40.333 ± 2.017	43.308 ± 2.165
$C_{14:1}$ (cis-9) myristoleic	0.049 ± 0.002	0.046 ± 0.002
$C_{16:1}$ (cis-9) palmitoleic	3.029 ± 0.151	2.834 ± 0.142
$C_{17:1}$ (cis-9) margarinoleic	0.212 ± 0.011	0.163 ± 0.008
$C_{18:1}$ (cis-9) oleic	36.321 ± 0.151	39.698 ± 1.985
$C_{20:1}$ (cis-9) eicosene	0.484 ± 0.024	0.381 ± 0.019
$C_{24:1}$ (cis-15) celacholic	0.239 ± 0.012	0.254 ± 0.013
Polyunsaturated fatty acids, %	21.802 ± 1.090	23.625 ± 1.181
$C_{18:2n6t}$ linoleidine	0.057 ± 0.003	0.042 ± 0.002
$C_{18:2n6c}$ linoleic	19.692 ± 0.985	21.546 ± 1.071
$C_{18:3n6}$ Y-linolenic	0.088 ± 0.004	0.098 ± 0.005
$C_{18:3n3}$ linolenic	0.857 ± 0.043	0.842 ± 0.042
$C_{20:2}$ eicosadiene	0.325 ± 0.016	0.292 ± 0.015
$C_{20:3n6c}$ (cis-8.14.17) eicosatriene	—	0.020 ± 0.001
$C_{20:3n3c}$ (cis-11.14.17) eicosotriene	0.199 ± 0.010	0.196 ± 0.010
$C_{20:4n6}$ arachidonic	0.583 ± 0.029	0.587 ± 0.029

The important criterion for the biological and nutritional value of products is the qualitative and quantitative composition of lipids. Fatty acids are the main component of the lipids.

Analysis of the fatty acid composition of pate lipids showed that pate samples had a high content of oleic, palmitic, and linoleic acids. The presence of these acids in large quantities is due to the use of pork fat in the pate recipe. Test pate samples, compared to control, contain a greater amount of monounsaturated and polyunsaturated fatty acids, including oleic (39.698%), linoleic (21.546%).

From the Table 5 it can be seen that saturated fatty acids (SFA) in the control sample amounts to 37.8%, in the test sample — to 32.9%. Among the SFAs palmitic acid is especially prominent (24.252% and 20.884%, respectively). The test sample also contains a small amount of heneicosanoic (09.025%) and behenic (0.030%) fatty acids.

EFAs are used by the body as an energy material. SFA are used by the body as an energy source and their excess in the diet leads to a violation of fat metabolism and an increase of blood cholesterol [28,29]. Monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs), especially linoleic, linolenic and arachidonic acids, are of great importance. Among MUFAs, oleic acid occupies high share (36.321% and 39.698%). Oleic acid lowers plasma cholesterol levels and protects against cardiac arrhythmias. PUFAs are an essential component of cell membranes. They participate in the renewal of cells and intracellular metabolic processes in the body; they contribute to removal of cholesterol from the blood, which prevents the development of atherosclerosis [30,31]. Among the PUFAs in the control and test samples, linoleic acid occupies high share.

A slightly lower amount of saturated fatty acids in the test sample with chicken meat-and-bone paste is caused by the lower melting point of the chicken bone fat = 33 °C ± 0.5, compared to pork = 37 °C ± 0.5. Bone pastes feature high content of phospholipids in comparison with the other animal fats. It is explained by the presence of bone marrow in the paste. Lecithin is one of the main phospholipids, which is involved in cholesterol metabolism, promotes the removal of high-density cholesterol from the body. Bone fat has the highest degree (about 97%) of digestion in the body compared to other animal fats (pork — 90...96%, beef — 73...83%) [32].

In the next stage the mineral composition of the meat pate (Table 6) was investigate. As for the mineral composition, the calcium content is higher in the test sample (480 mg/100g) in comparison with the control sample (268 mg/100g).

Calcium, which comes into a body with food, is absorbed by only 20–30%, and the process of its digestion is quite complicated. The degree of digestion of this macro element depends on the form of its compounds, on the composition and properties of the food products, the pH value of gastric juice and a whole number of the other factors. Calcium in food is represented in the form of sparingly water-soluble or completely water-insoluble salts — mainly carbonates, oxalates, phosphates.

Table 6. Mineral composition of meat pate

Mineral substances, mg/100 g	Meat pate (control)	Meat pate (test)
Calcium	268 ± 7.2	480 ± 8.7*
Magnesium	40 ± 1.2	13 ± 0.3*
Iron	2.23 ± 0.05	1.65 ± 0.04*
Copper	0.006 ± 0.001	0.008 ± 0.001

* $p < 0.001$

The inhibitory effect of phosphates on digestion and absorption of calcium is caused by non-observance of the optimal ratio of calcium and phosphorus (1:1) in most kinds of food, especially meat products. The introduction of calcium in its optimal amount into the recipe of meat pate will normalize the ratio of calcium and phosphorus, which is not physiologically balanced in the raw meat itself, and is even more violated being exposed to the action of phosphates.

Conclusion

Thus, as a result of the conducted research, the technology and recipe for production of meat pate with the addition of chicken meat-and-bone paste was proposed. It was shown that the addition of meat-and-bone paste decreased the moisture and fat content and increased protein content. At the same time, the proportion of minerals, in particular calcium, increased significantly. According to the results of the analysis of the chemical substances, amino acids, fatty acids and mineral compositions, it was shown that the optimal amount of meat-and-bone paste introducing into the recipe of meat pate is 20%, instead of poultry meat. The production of new kinds of pate with meat-and-bone paste allows for a more complete and rational use of secondary raw materials, increase in the profitability of their industrial production and increase of sales profits.

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