

Описано технологію одержання гомогенної м'ясо-кісткової пасту, отриманої після багатостадійного подрібнення на дзиги-дробарці та мікроподрібнювачі «Супермасколойдер». Актуальність дослідження полягає в переробці м'ясо-кісткової сировини на харчові цілі, тим самим підвищуючи безвідходну технологію в м'ясопереробній промисловості. Досліджено вплив процесу охолодження та параметрів тонкого подрібнення на якісні показники та мікроструктуру м'ясо-кісткової пасту після подрібнення. Із результатів досліджень встановлено, що зі зменшенням діаметра решітки дзиги-дробарки спостерігається збільшення температури м'ясо-кісткового фаршу з 16 °С до 26 °С. Досліджено зміну температури вихідної сировини на мікроподрібнювачі «Супермасколойдер» з різними зазорами між шліфувальними кругами (0,25 мм, 0,10 мм, 0,02 мм) в залежності від кількості води, що додається. Встановлено, що після подрібнення на мікроподрібнювачі з додаванням кількості води температура сировини на виході зменшується при зазорах 0,25 мм та 0,10 мм – з 34 °С до 17 °С, при зазорі 0,02 мм – з 37 °С до 19 °С.

При дослідженні функціонально-технологічних властивостей м'ясо-кісткової пасту з додаванням 50 % води встановлено, що м'ясо-кісткова паста володіє високою вологозв'язуючою (75,63 %) та жирутримуючою (73,38 %) здібностями. Вологозв'язуюча здатність м'ясо-кісткової пасту склала 65,3 %, емульгуюча здатність 55,8 %. Досліджено мікроструктуру та гранулометричний склад м'ясо-кісткової пасту з додаванням 50 % води. В результаті проведеного аналізу геометричних розмірів кісткових частинок виявлено, що при переробці м'ясо-кісткового фаршу на мікроподрібнювачі розміри кісткових частинок лежать в межах зазорів, що виставляються між шліфувальними кругами, консистенція м'ясо-кісткової пасту однорідна та мазеподібна

Ключові слова: м'ясо-кісткова паста, тонке подрібнення, дзига-дробарка, мікроподрібнювач, кістки забійних тварин, функціонально-технологічні властивості

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IDENTIFYING PATTERNS IN THE EFFECT EXERTED BY A COOLING PROCESS AND THE FINE GRINDING MODES ON THE QUALITATIVE INDICATORS OF A MEAT AND BONE PASTE

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1. Introduction

At present, much attention is paid to the development of the raw material base for the meat industry and the creation of innovative technologies for the production of healthy foods based on the new sources of raw materials. The relevant tasks for the meat processing industry are the rational use of the raw materials, as well as expanding the range of meat products that meet the requirements of safety and quality for healthy nutrition [1].

In the meat industry, significant attention is paid to the comprehensive processing of raw materials. The processing

of the raw materials of animal origin yields such valuable types of secondary raw materials as blood, by-products of category I and II, raw fat, non-food waste, as well as bone raw materials that can be used to produce additional food, fodder, and technical products [2].

The irrational use of secondary raw materials and waste from the meat processing industry can lead to environmental and economic problems [3]. A wider introduction of the integrated processing of secondary raw materials could allow their rational use as the main components in the technology of meat products, which would increase the volume and range of products [4].

In the production of meat products, the secondary raw materials, bones, remain underutilized by the technology [5]. Most small and medium-sized enterprises simply dispose of the bone raw materials; large enterprises direct the bone raw materials to produce glue, gelatin, fodder flour, etc. However, in terms of chemical composition, the bone is a rich source of mineral substances, dominated by the salts of calcium, sodium, iron, and potassium [6, 7].

The rational use of the bone raw materials implies their comprehensive processing, which, based on their chemical composition and morphological structure, should ensure the maximum production of useful products [8]. It is known that the amount of the formed secondary raw materials depends on the type of the processed primary raw materials and amounts to (% of live weight): in the processing of cattle – up to 56.6, small cattle – 82.4, pigs – 39.7 [2].

To obtain a finely dispersed meat and bone paste, the meat and bone raw materials are treated in line with a mechanical grinding technique, mainly using power grinders, choppers, mills, hammer crushers, cone-inertia grinders, jet mills, etc. [9].

The micro-grinder “Supermasscolloider MKZA-10-15” by the Japanese company MASUKO SANGYO CO., LTD. is used to chop poultry, fish, and bones. Processing the bone raw materials at a micro-grinder makes it possible to obtain a meat and bone paste, completely free of the feeling of rigidity by the tongue. The degree of grinding is determined by fine-tuning a gap between the working bodies of the micro-grinder with a step of 0.02 mm per one scale division unit. The bone raw materials are ground by “Supermasscolloider MKZA-10-15” under the action of a centrifugal force, an impact load, a shear force, as well as other forces that arise when the raw materials pass between two grinding wheels [10].

The processing of the bone raw materials into a finely dispersed mass largely depends on the type of equipment used, the process duration, and the degree of grinding. When processing the bone raw materials, the effect of various external and internal factors on the quality of the obtained products should be taken into consideration.

Solving the issue of the rational and waste-free use of bone raw materials for food purposes and the development of new resource-saving technologies is an important scientific and practical task. That renders relevance to the studies aimed at developing the techniques for processing the meat and bone raw materials for food purposes and improving the waste-free technology in the meat processing industry.

2. Literature review and problem statement

The integrated processing of meat and bone raw materials mainly involves the production of meat and bone flour, which is added to the fodder of animal origin obtained from the non-food waste from livestock processing at meat processing plants. The meat and bone flour is used as a source of high-grade proteins because it contains all the essential amino acids necessary for the normal growth and development of young animals. Of particular importance in this regard is the fact that the protein in the meat and bone flour includes a large amount of lysine [11].

The author [12] developed a technique for the additional grinding of bone raw materials to specific sizes and determined the rational values for the main parameters of the grinding process. A technology was proposed for the manufacture of a series of sausage-type products, such as cooked sausages, frankfurters, wieners, using an additionally ground meat and

bone mass instead of minced meat in the formulation. The new technologies and formulations for minced meat products were developed with the replacement of part of the meat in the amount of 5...15 % with an additionally ground meat and bone mass. The optimal ratio of the main components in minced meat products was determined, which ensures their high nutritional and biological value. However, the issues related to the effect of the main parameters of the grinding process on the quality indicators of minced meat products remained unsolved.

In addition to processing the residues of the bone raw materials from cattle, there are known techniques for processing the bones of fish and pinnipeds. Thus, work [13] proposed a technique for processing the meat and bone raw materials with the production of whole fodder flour from pinnipeds. According to the technology, the meat and bone raw materials are frozen to a temperature of minus 4–6 °C and ground in two stages: at the first stage – to pieces the size of 10–20 cm; at the second stage – to 1–2 cm. Next, the ground raw materials are cooked at a temperature of 70–85 °C during 20–30 minutes under a forced air circulation. Following the end of cooking, the drying is conducted at a temperature of 85–95 °C under a vacuum to 4 kPa until the flour is obtained with a moisture content of not more than 10–12 %; followed by cooling and packaging in packets. The main advantage of a given technique is the reduction of energy costs and the production of flour with high protein content and low fat content. However, the issues related to changes in the temperature of the raw materials during grinding remained unsolved.

Paper [14] described the effect of the speed of the grinder screw, a feed diameter, the diameter of holes in the mesh, the number of holes, and the heat treatment, on the characteristics of meat grinding, that is, on the maximum grinding torque, the grinding energy, and the mass flow rate. The effect of the screw speed on the grinding energy and mass flow rate was more significant ($p < 0.05$) than that on the maximum grinding torque. The number of holes significantly affected the grinding energy and the mass flow rate but did not affect the maximum grinding torque. The results obtained in the cited paper could be useful in optimizing the grinding process. The disadvantage of the cited paper is the lack of data on changes in meat temperature during grinding, depending on the speed of the screw and the diameter of holes of the mesh.

A fodder supplement, proposed by the authors of [15], is a protein-mineral supplement for broiler chickens with the addition of bone flour. Of interest is a technique to obtaining a fodder additive using the cattle bones, crushed to a size of 1–2 mm, by mixing them with the waste from flour and/or cereal production and adding sea salt. The resulting paste is sterilized, treated with ultraviolet radiation, dried, and ground into flour. The disadvantage of the proposed grinding techniques is the large size of the pieces, which makes it unacceptable to use the product for food purposes. In addition, to obtain a finished product, the meat and bone raw materials are subjected to additional operations (heat treatment, drying).

In Japan, a technique for making a meat and bone paste was proposed [16], which involved the grinding of the meat and bone raw materials in two stages – large grinding and fine grinding. However, the issues related to the modes of fine grinding in the process of obtaining a meat and bone paste remained unsolved. The resulting meat and bone paste can be used for the quick preparation of soups and broths.

Article [17] reports a technique for the production of meat and bone paste from the secondary products from processed poultry and farm animals. The technique for making a meat

and bone paste involves preliminary grinding of the raw materials with the addition of water, hydrothermal treatment, and homogenization. The raw materials are ground to a size of 1–30 mm with the addition of water in a ratio of 1:0.2–4.0; the hydrothermal treatment is run in a continuous stream under a steam pressure of 0.2–1.0 MPa for 0.3–10 min followed by homogenization. The indicated hydrolysis parameters provide high indicators of the digestibility and homogeneity of the resulting meat and bone paste. The end product is obtained in the paste and dry form. The meat and bone paste is used in the food industry as a food additive in the production of minced and sausage products replacing 10–15 % of the raw meat materials with non-traditional ones, as well as for enriching products with naturally digestible calcium. However, the issues related to the fine grinding modes and their effect on the quality of raw materials remained unsolved.

Work [18] describes the treatment of the biological waste from chicken bones with acid, alkali, and an acid-alkaline solution, followed by thermal calcination at 700, 800, and 900 °C, in order to obtain bioceramic hydroxyapatite. The work emphasizes the effect of the heat treatment and chemical pretreatment of biological waste from chicken bones on the microstructural and physical and chemical properties of hydroxyapatite. The pure crystalline phase of hydroxyapatite is obtained only at a calcination temperature above 700 °C. It was found that the bone particles calcined at a temperature of 900 °C did not contain other phases of toxic elements than the crystalline hydroxyapatite whose maximum crystallite size was 36.10 nm. A decrease in the calcination temperature leads to a decrease in the crystallite size. The average particle size of the hydroxyapatite pre-treated by acid, calcined at 900 °C, is about 600 nm. The chicken bones pre-treated with acid, calcined at 900 °C, yield hydroxyapatite with improved properties required for biomedical applications compared to the alkaline and acid-alkaline pretreatments. However, a given technique for processing bone raw materials does not allow its further use for food purposes.

Thus, processing the bones into a finely dispersed mass for use in the production of various types of meat products is a promising direction when solving tasks related to processing the secondary raw materials for food purposes. The processing of the meat and bone raw materials into a finely dispersed paste makes it possible to add this product to sausages, meat semi-finished products, pate, and canned meat.

In the process of slaughtering and further processing of meat, up to 22 % of the carcass is the bone tissue, which, in the current conditions of medium and small enterprises, is not processed but simply disposed of, often polluting the environment. Resolving the issue of the rational and waste-free use of bone raw materials for food purposes is an important scientific and practical task.

3. The aim and objectives of the study

The aim of this study is to identify the effect exerted by the low-temperature processing of the meat and bone raw materials and the fine grinding parameters on the physical-chemical, technological properties, and the microstructure of a meat and bone paste.

To achieve this aim, the following tasks were set:

- to develop a technology for producing a meat and bone paste from cattle bones;
- to examine a temperature change in the meat and bone mince in the process of grinding at a chopper cutter and a

micro-grinder, depending on the geometric parameters of cutting mechanisms and the amount of added water;

- to explore the functional and technological properties of a meat and bone paste;
- to examine the microstructure of a meat and bone paste.

4. Materials and methods to study the qualitative parameters of a meat and bone paste

The objects of our study were the samples of frozen meat and bone paste made from cattle bones. To grind the meat and bone raw materials, costal bones with the remains of **slaughtered cattle** meat were used. Before the study, the raw materials were stored in freezers at a temperature of ((–18) °C–(–20) °C).

The Shakarim State University, Semey, Republic of Kazakhstan, provided the equipment for processing the bone and meat raw materials: a chopper cutter and the micro-grinder “Supermasscolloider MKZA 10-15” (Japan) (Fig. 1).

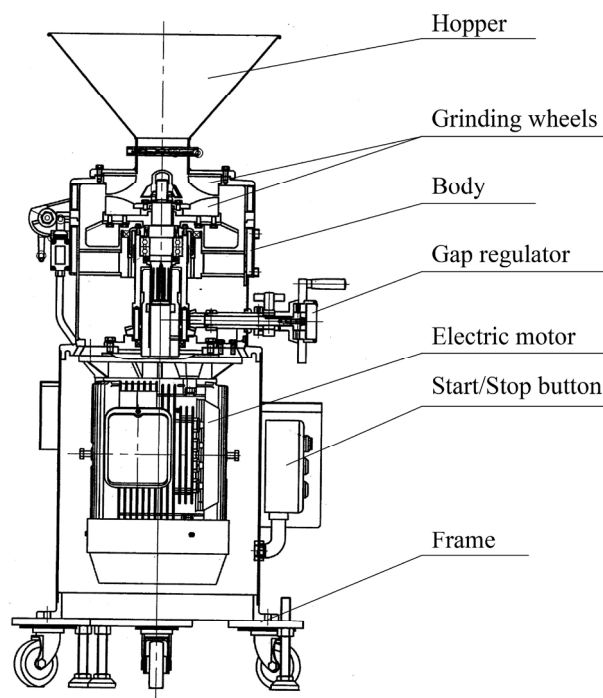


Fig. 1. General view of the micro-grinder “Supermasscolloider MKZA 10-15” (Japan)

4.1. Determining the moisture-binding and fat-retaining capacity

The procedure for determining MBC. The content of the water bound in meat was determined by the R. Grau and R. Hamm method, modified by VNIIMP. The method is based on determining the amount of water released from meat at light pressing, which is absorbed by filter paper, forming a wet spot [19].

The fat-retaining capacity is calculated after determining the MBC by drying the residue of the product to constant weight. The fat-retaining capacity is determined based on a coefficient defined by refractometry.

4.2. Determining the microstructure and size of bone particles

To determine the granulometric content after ultrafine grinding, we studied the microstructure of the bone particles in

a meat and bone paste. The bone particles were measured using the "JSM-6390LV" scanning electron microscope (JEOL, Japan). To prepare a sample for scanning under a microscope, the meat and bone paste was treated with a 2-% NaOH solution while heating in a boiling water bath to completely decompose the meat cuts and tissues. The remaining bone particles were dried at a temperature of 103–105 °C. The dried bone residue was analyzed under a microscope.

5. Results of studying the qualitative characteristics depending on a grinding degree of the meat and bone raw materials

5.1. The technology of making a meat and bone paste

At the initial stage of the experimental research, a scheme for processing the meat and bone raw materials was developed, which implied a sequential grinding of the meat and bone raw materials, freezing them in advance to a temperature of ((-18) °C–(-20) °C) in freezers.

To grind the meat and bone raw materials, costal bones with the remains of the **slaughtered cattle** meat were used. The costal and vertebral bones were obtained from the meat processing enterprises and large meat pavilions in the city of Semey, Republic of Kazakhstan, and cut to the size of 50–70 mm. Next, the meat and bone raw materials were pre-frozen for 60 minutes at a temperature of ((-18) °C–(-20) °C) in freezers. Freezing provides long-term storage at low temperatures. This is explained by preventing the development of microbiological processes and a sharp decrease in the rate of enzymatic and physical and chemical changes.

Next, the frozen raw materials are fed to the hopper of a chopper cutter with a hole diameter of the output mesh of 8 mm. After grinding, the resulting meat and bone mass is frozen to a temperature of ((-18) °C–(-20) °C) and again crushed at the chopper cutter with a hole diameter of the output mesh of 5 mm. Ice water is added to the resulting meat and bone mass in the ratio of raw materials to water 1:0.5 to be frozen for 1 hour.

The resulting meat and bone mass was stirred and crushed again at the chopper cutter with a hole diameter of the output mesh of 3 mm. After grinding, the minced meat was divided into 6 samples of the same weight with the addition of water in certain proportions (Table 1).

Table 1

Title and designation of the minced meat and bone samples		
Sample No.	Sample designation	Sample title
Sample 1	MP-0	minced meat and bone without water
Sample 2	MP-25	minced meat and bone with the addition of 25 % of water
Sample 3	MP-50	minced meat and bone with the addition of 50 % of water
Sample 4	MP-75	minced meat and bone with the addition of 75 % of water
Sample 5	MP-100	minced meat and bone with the addition of 100 % of water
Sample 6	MP-150	minced meat and bone with the addition of 150 % of water

The obtained samples were frozen for 1 hour to a temperature of ((-18) °C–(-20) °C). After freezing, each meat and bone mince sample was consistently ground at the micro-grinder "Supermasscolloider" with the following gaps between the grinding wheels: 0.25 mm, 0.10 mm, 0.02 mm. The scheme of grinding the meat and bone raw materials is shown in Fig. 2.

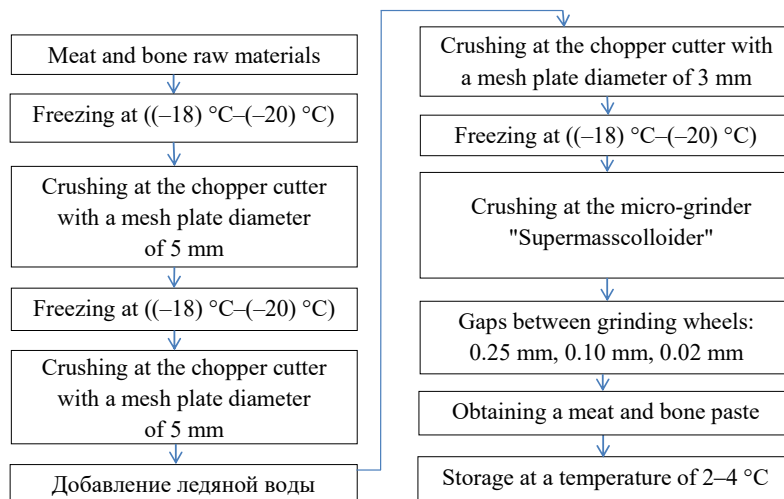


Fig. 2. The scheme of grinding the meat and bone raw materials

At the output from the grinder, a meat and bone paste is obtained of tender, spreading consistency without a feeling of stiffness on the tongue. The resulting meat and bone paste is stored at a temperature of 2–4 °C until further study [20].

5.2. Results of studying the temperature characteristics depending on a grinding degree of the meat and bone raw materials

During the operation of the machine in the grinding process, a product heats up under the action of forces. An increase in the temperature of a meat and bone mince is observed, which can lead to protein denaturation. At heat treatment, which causes the denaturation of protein substances, the structure of the meat and bone paste is strengthened and the water retention capacity is reduced. To prevent the overheating of a product, it is necessary to control the grinding time and temperature. The temperature is reduced by adding ice water to the meat and bone mince.

During the grinding process at a chopper cutter, there is a temperature change in the starting raw material, depending on the mesh diameter (Table 2).

Table 2

Change in the temperature of a meat and bone mince at the output from a chopper cutter at various mesh diameters	
Mesh diameter, mm	Raw material temperature at the output, °C
8	16
5	22
3	26

Table 2 shows that a decrease in the diameter of the mesh leads to an increase in the temperature of the meat and bone mince, from 16 °C to 26 °C. The highest temperature was recorded at a diameter of the output mesh of 3 mm. The increase in temperature occurs due to the generation of heat resulting from the mechanical work during the destruction

of bone tissue, the friction forces of the bone raw materials against the working bodies of the machine, the work of the elastic and plastic deformation of the bone raw materials.

At the next stage of our experimental study, we investigated a temperature change in the meat and bone paste at the output from the “Supermasscolloider” micro-grinder, depending on the amount of added water. The results are shown in Fig. 3.

Fig. 3 shows that for all the gaps between the grinding wheels (0.25 mm, 0.1 mm, 0.02 mm) the temperature of the raw materials at the outlet decreases with the addition of water. Thus, at gaps between the grinding wheels of 0.25 mm and 0.10 mm, the temperature decreases from 34 °C (MP-0) to 17 °C (MP-150). At a gap between the grinding wheels of 0.10 mm, the highest temperature of 34 °C was registered in a sample of the meat and bone paste to which water had not been added (MP-0). With an increase in the proportion of water, a decrease in the temperature to 17 °C was observed (MP-150).

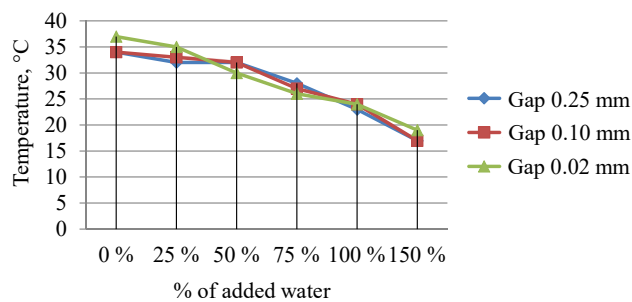


Fig. 3. Change in the temperature of raw materials at the output at various gaps between the grinding wheels

The highest temperature of the raw material was observed at a gap of 0.02 mm in a sample of the meat and bone paste without the addition of water (MP-0). At a gap of 0.02 mm, the temperature of the meat and bone paste, depending on the addition of water, decreases from 37 °C (MP-0) to 19 °C (MP-150).

At fine grinding, there is a sharp change in the structural and mechanical characteristics, the result of which is not only the physical and mechanical destruction of the tissue but also chemical changes. There is also an increase in the temperature in the cutting region, which can lead to protein denaturation. In this regard, the best variant of a meat and bone paste is the meat and bone paste with the addition of 50 % of water.

5. 3. Studying the functional and technological properties of a meat and bone paste

At the next stage of experimental research, we studied the functional and technological properties and the microstructure of the meat and bone paste with the addition of 50 % of water.

When studying the functional and technological properties, it was found that the meat and bone paste had high moisture-binding (75.63 %) and fat-retaining (73.38 %) capacities. The moisture-retaining capacity of the meat and bone paste was 65.3 %, the emulsifying capacity was 55.8 % (Fig. 4).

It is known that the protein part of a meat and bone paste is represented by the collagen and elastin fibers, which have the high moisture-binding and water-retaining capacities due to the immobilization of free moisture [21]. An important physical and chemical indicator is the water-retaining capacity, which affects the consistency of finished products

and the process of their microbiological spoilage since the amount of unbound moisture depends on the growth in the number of microorganisms [22].

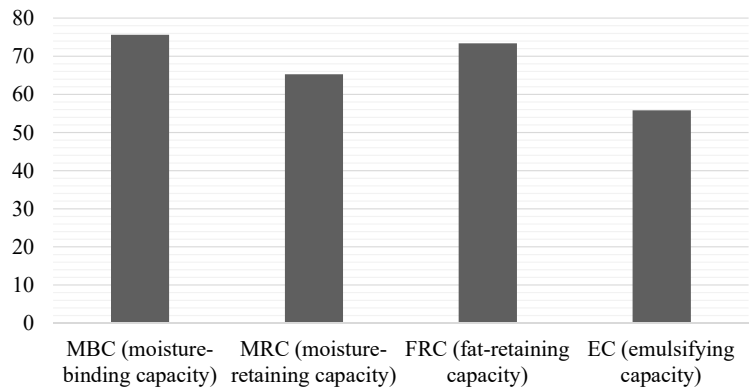


Fig. 4. Functional and technological properties of meat and bone paste

5. 3. Studying the granulometric composition and microstructure of a meat and bone paste

At the next stage, the granulometric composition and microstructure of a meat and bone paste were investigated. The size of the bone particles after grinding was determined by a microscopy method.

After grinding at the masscolloider with a gap of 0.25 mm, according to the results of measuring the bone particles, the average size was 0.21 mm. The largest size was 0.37 mm, the smallest – 0.14 mm (Fig. 5).

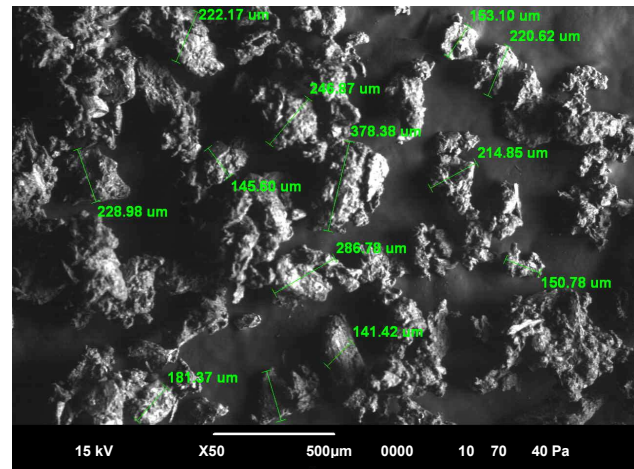


Fig. 5. The size of bone particles at a gap between the grinding wheels of 0.25 mm

After grinding at the masscolloider with a gap of 0.1 mm, according to the results of measuring the bone particles, the average size was 0.097 mm. The largest size was 0.19 mm, the smallest – 0.045 mm (Fig. 6).

After grinding at the masscolloider with a gap of 0.02 mm, the average size was 0.052 mm, according to the results of measuring the bone particles. The largest size was 0.095 mm, the smallest – 0.025 mm (Fig. 7).

Our analysis of the geometric dimensions of the bone particles has revealed that at processing the meat and bone mince at a micro-grinder the size of the bone particles was within the limits of the set gaps between the grinding wheels.

Our organoleptic evaluation of the meat and bone paste has found that the structure of the paste was homogeneous,

the texture was dense, elastic, with no obvious signs of looseness, the color was light brown.

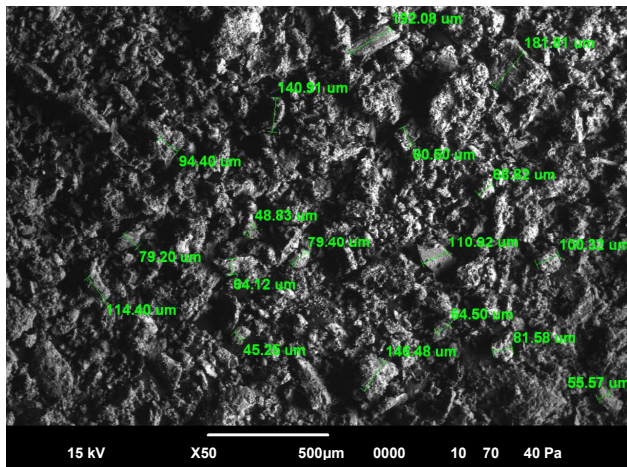


Fig. 6. The size of bone particles at a gap between the grinding wheels of 0.1 mm

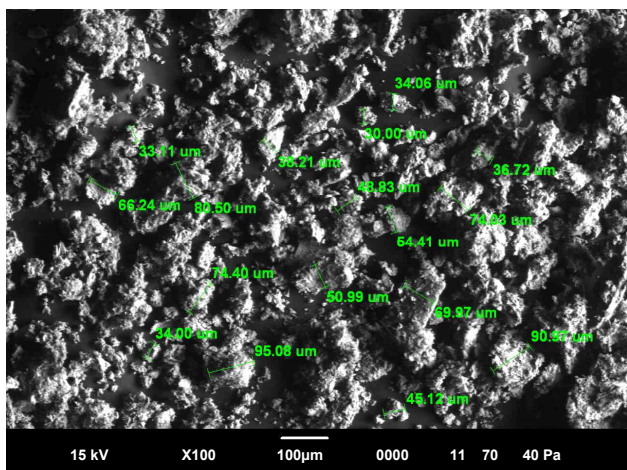


Fig. 7. The size of bone particles at a gap between the grinding wheels of 0.2 mm

6. Discussion of results of studying the effect of the cooling process and the fine grinding modes on the qualitative indicators of a meat and bone paste

Processing the meat and bone raw materials using low-temperature processes makes it possible to obtain a meat and bone paste with a delicate, spreading consistency. The freezing of the raw materials before grinding allows for a better grinding process and makes it possible to maintain an optimal temperature to prevent the overheating of the meat and bone raw materials during the process of grinding.

We have studied a temperature change in the meat and bone mince at the output from a chopper cutter at various diameters of the mesh and at a micro-grinder with various gaps. Based on our study, it was found that with a decrease in the diameter of the mesh of the chopper cutter there was an increase in the temperature of the meat and bone mince from 16 °C to 26 °C (Table 2). After grinding at a micro-grinder, depending on the addition of water, the temperature in the samples of meat and bone paste at the output decreases (Fig. 3). In general, a decrease in the temperature of the meat and bone paste with an increase in the amount of added

water is explained by a decrease in the friction force and a coefficient of friction between the bone tissue and the working body at the points of their contact due to the formation of an aqueous film. In this case, it should be considered that the generated heat is absorbed by water, due to its high heat capacity. It should also be noted that the addition of water to the meat and bone paste reduces the occurrence of the thermal denaturation of proteins, which begins, for muscle proteins, at 30–35 °C, while collagen fibers begin to swell and absorb water at 50–55 °C.

The moisture retention in a meat and bone paste is explained by the high hydration capacity of collagen, which is associated with the significant amounts of diamino- and amino dicarboxylic acids in its structure and, consequently, the large number of side polar groups of the molecule. In addition, collagen has a high fat-retaining capacity, due to its swelling during heat treatment, which leads to the retention of more fat in the inter-protein cells.

However, the developed technology for making a meat and bone paste, as well as the results of the effect of the amount of water on the temperature, functional and technological parameters, are limited only to the meat and bone raw materials from cattle (costal and vertebral bones). The established grinding modes are not acceptable for bird bones, due to the differences in their structure and composition.

Nevertheless, our study could be useful for meat processing enterprises in order to solve tasks of the waste-free processing of meat and bone raw materials for food purposes by fine grinding, improving economic efficiency, and expanding the range of functional meat products.

At the next stages of research, the effect of a meat and bone paste on the structural and mechanical, functional and technological indicators, the amino acid and mineral composition of pate formulations will be studied.

7. Conclusions

1. Technology has been devised for producing a meat and bone paste by successive grinding at a chopper cutter and at the micro-grinder “Supermasscolloider” with a delicate, spreading consistency.

2. It has been established that with a decrease in the mesh diameter of the chopper cutter (from 8 to 3 mm) an increase in the temperature of a meat and bone mince is observed, from 16 °C to 26 °C. We have studied the temperature of the output raw materials at the micro-grinder “Supermasscolloider” with various gaps between the grinding wheels (0.2 mm, 0.10 mm, 0.02 mm), depending on the addition of water to the minced meat. It was found in the process of grinding at the micro-grinder that the addition of ice water to the mass of the raw materials in the ratio 1:0.5 lowers the temperature of the meat and bone paste at the output to 15 °C.

3. In terms of the functional and technological properties, the meat and bone paste has high moisture-binding (75.63 %) and fat-retaining (73.38 %) capacities. Our analysis of the geometric dimensions of the bone particles has revealed that when the minced meat and bones are processed at a micro-grinder, the size of the bone particles is within the set gaps between the grinding wheels, and the consistency of the meat and bone paste is ointment-like.

4. Processing the meat and bone raw materials into a finely dispersed paste makes it possible to add the meat and

bone paste to sausages, meat semi-finished products, such as dumplings, cutlets, meatballs, etc. After appropriate processing, this product can also be added to baby foods, enriching them with valuable mineral and protein components.

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