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The use of buckwheat flour in the technology of semi-smoked sausage

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ABSTRACT

This article aims to substantiate the use of buckwheat flour in the technology of semi-smoked sausage based on the study of physicochemical, functional and technological, structural and mechanical and organoleptic parameters. It has been found that a small amount of buckwheat flour in semi-smoked sausage samples (up to 10.0% by weight of unsalted raw material) increases the moisture-binding capacity of the control sample by 1.1-1.8%. The study of the shear stress limit of the finished experimental samples showed that the maximum value of this parameter is 758 Pa. With increasing the dosage of hydrated buckwheat flour, the minced meat loosens, and the value of the shear stress limit in samples No.3 and No.4 is 420 and 390 Pa. The appearance, color, smell, aroma, consistency, taste and juiciness were studied in the produced samples of semi-smoked sausage. Histological examination of an experimental sample of semi-smoked sausage with a level of hydrated buckwheat flour of 6% was carried out. It has been found that introducing hydrated buckwheat flour into the minced meat up to 6% of the mass of raw meat material has a positive effect on the physical and chemical, functional and technological, structural and mechanical and organoleptic parameters of semi-smoked sausage.

Keywords: beef, semi-smoked sausage, meat product, buckwheat flour, pH, moisture-binding capacity

INTRODUCTION

The application of vegetable raw material in the technology of meat products is a topical direction. Vegetable raw materials are applied to manufacture functional products, including dietary, therapeutic and prophylactic, children's, and gerodietic products, etc.

It is proved by many scientists that the introduction of vegetative raw materials into recipes and technology of meat products improves physical and chemical, functional and technological, structurally mechanical and organoleptic parameters [1], [2], [3].

The combination of raw materials of meat and vegetative origin provides high food and biological value of meat products, allowing to minimise losses during thermal processing.

Using inexpensive vegetative raw materials as partial replacements of meat raw materials decreases the final cost of a product.

Creating recipes and technologies for new meat products will expand the assortment of functional products for wide layers of the population [4].

For the use of vegetative raw materials in the technology of combined meat products, it is necessary to define its dosage.

The finished product's quality depends on the components' composition and properties of raw materials. Analysis of literature data has shown that in the modern production of meat products, various herbal supplements are effectively used to regulate the properties of raw materials and finished products. In the development of new recipes and technologies of meat products, chickpea flour, sprouted rape seeds, pumpkin paste, carrot puree, apple powder, kelp, whey protein concentrate and so on are used [2], [5], [6], [7]. Scientists have proved the possibility

of using buckwheat flour in the technology of functional meat products. It was found that the use of buckwheat flour affects the quality indicators of meat products [8], [9], [10]. Buckwheat groats are rich in vitamins, minerals and starch and contain much protein and fiber compared to wheat. Buckwheat flour has a protein structure with high biological value and does not contain gluten. Studies show it is rich in antioxidant compounds such as polyphenols [8].

In this regard, it is assumed that the use of buckwheat flour will improve the physical, chemical, functional, technological, structural, mechanical, and organoleptic indicators of ground meat in the production of sausage products. To develop a new meat product (semi-smoked sausage), it was decided to use buckwheat flour as a vegetable filler.

Scientific Hypothesis

This article aims to substantiate the use of buckwheat flour in the technology of semi-smoked sausage based on the study of physicochemical, functional and technological, structural and mechanical and organoleptic parameters.

MATERIAL AND METHODOLOGY

Samples

For the manufacture of experimental samples of sausages, the following raw materials were used: 1st grade beef [11], lean pork, pork brisket [12], and buckwheat flour [13]. In the recipes of the experimental samples, additional raw materials were used: salt, sodium nitrite, granulated sugar, fresh garlic, ground black pepper, and ground pepper. All raw materials were purchased at the food market of Almaty.

Chemicals

The following chemical substances were used to obtain histological sections:

Technical formalin GOST 1625-89, grade FM, the highest grade (Chemical Industrial Reagent LLP, Shymkent, Kazakhstan).

Ethyl alcohol rectified from food raw materials (manufacturer: "DOSFARM LLP", Kazakhstan).

Paraffin GOST 23683-89, mark P 2 (food grade) (manufacturer: Turkey).

Hematoxylin regression and eosin alcohol staining kit "MEDIX" (manufacturer: Russia).

Fir balsam (manufacturer: Russia).

Instruments

For salting, the meat was spritzed with a salting solution. The salted meat was stored in a "Biryusa" refrigerated cabinet. Meat was chopped in a MP-300 meat grinder, and minced meat was mixed in a HO-25V mixer. Minced meat was dosed with an ASAN syringe. Active acidity in meat products was determined using a pH-410 device.

Heat treatment of semi-smoked sausage samples was carried out in SPAKO universal heat chamber for all sausage products. The temperature of the finished samples was controlled by an infrared thermometer with a laser pointer and a Testo 826-T4 penetrating food probe.

Samples were cut on an MSM-2850 semi-automatic microtome-cryostat. The obtained preparations were studied using a Biolam P1U4 microscope under 3.2-40 objective lenses with an eyepiece magnification of 13×

Laboratory Methods

Moisture content was determined by drying [14]. The concentration of hydrogen ions of meat and meat products (pH) was determined by a potentiometric method based on measuring the difference of electric potentials between the glass electrode and the reference electrode placed in the meat or meat products sample. Determination of moisture-binding capacity (MBC) – by pressing a sample under a 1 kg load and subsequent calculation by the difference of masses before and after pressing and the area of a wet spot determined by a planimeter according to the method of Grau and Hamm in modification of Volovinsky and Kelman and expressed in % to the total mass of moisture in the product. Shear stress limit (Pa) in sausage minced meat was determined by the dip cone method. Histological studies of raw sausage with enzyme and buckwheat flour were conducted using standard methods [15], [16]. Histological studies of finished semi-smoked sausage products with enzyme and buckwheat flour were carried out according to the same standards as for raw sausage [15], [16].

Description of the Experiment

Sample preparation: In the experiments, the research object was semi-smoked sausage in a casing with a diameter of 45 mm. To study the influence of buckwheat flour on the quality and yield of semi-smoked sausage, buckwheat flour produced according to TU 9293-002-43175543-03 was used. Organoleptic parameters of the flour were as follows: color – light brown, homogeneous and without extraneous inclusions; smell – peculiar to the culture from which it was made; taste – fresh, peculiar to the culture. To determine the amount of water required for the hydration of buckwheat flour for its use in the recipe of semi-smoked sausage, this vegetable raw

material has determined the physicochemical, functional and structural-mechanical parameters: pH, moisture-binding capacity and the shear stress limit of minced meat.

Number of samples analyzed: A total of 18 samples were analyzed.

Number of repeated analyses: All measurements of instrument readings were carried out three times.

Number of experiment replication: Number of repetitions of each experiment to determine one value was three times.

Design of the experiment: Studies of pH, moisture-binding capacity, shear stress limit, organoleptic characteristics, and microstructure of meat products were conducted according to standard methods.

Statistical Analysis

In conducting research, a complex of standard and modified methods of definition of physical and chemical, functional and technological, and histological properties of raw materials and ready products was applied. The reliability of the results is confirmed by multiple repetitions and reproducibility of experimental data, mathematical processing and approbation of the technology of a new meat product in conditions of the joint-stock company "Almaty Technological University". Statistical processing was performed in Microsoft Excel 2016 and with Statistica 12.0 (USA). The accuracy of the obtained experimental data was determined by the Student's test with a confidence probability of ≤ 0.05 for the number of parallel determinations of 5 minimum. The linear programming problems were solved using the MS Excel spreadsheet "Solution search" (Excel Solver).

RESULTS AND DISCUSSION

The complete recipes for the model samples of semi-smoked sausages are shown in Table 1. The salting of raw meat in all variants of the experiment was carried out with a previously prepared brine under the recipe of experimental samples of semi-smoked sausage [17]. Following the research methodology, five samples of cased semi-smoked sausage were produced [17].

Table 1 Recipes for semi-smoked sausage samples (100 kg).

Name of raw material	Control, (Ukrainian) sausage, 1 sort	Sample No.1 (4% buck-wheat flour)	Sample No.2 (6% buck-wheat flour)	Sample No.3 (8% buck-wheat flour)	Sample No.4 (10% buck-wheat flour)	Sample No.5 (12% buck-wheat flour)
Beef, 1st grade	50.0	50.0	50.0	50.0	50.0	50.0
Half fat pork	25.0	21.0	19.0	17.0	15.0	13.0
Pork brisket	25.0	25.0	25.0	25.0	25.0	25.0
Buckwheat flour	-	4.0	6.0	8.0	10.0	12.0
Salt	3.0	3.0	3.0	3.0	3.0	3.0
Sodium nitrite	0.05	0.05	0.05	0.05	0.05	0.05
Sugar	0.1	0.1	0.1	0.1	0.1	0.1
Fresh garlic	0.065	0.065	0.065	0.065	0.065	0.065
Black pepper ground	0.05	0.05	0.05	0.05	0.05	0.05
Allspice ground	0.06	0.06	0.06	0.06	0.06	0.06

Working out and defining organoleptic and physicochemical indicators of the ready products (pH, moisture-binding capacity) according to the standard methods also were spent in conditions of the educational-production laboratory of the Almaty technological university [17]. Physico-chemical, functional-technological, structural-mechanical and histological properties of experimental combined minced meat determine the quality of finished sausage products [17]. The quantitative content of key nutrients determines meat systems' functional and technological properties, primarily myofibrillar proteins and lipids, and their qualitative (amino- and fatty-acid) composition [18]. Functional and technological properties of meat raw materials change in time during the development of autolytic changes, during mechanical processing (massing, tendering, grinding of varying degrees), during curing in salting, heat treatment and other technological influences [19]. Moisture-binding capacity and the minced meat components' cohesiveness significantly influence the finished product's properties

[20]. The results of the pH of the control and experimental samples of semi-smoked sausages depending on the level of introduction of buckwheat flour are presented in Figure 1.

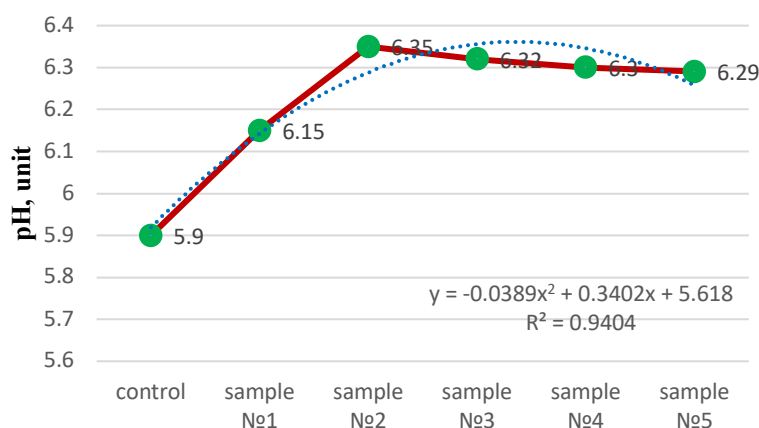


Figure 1 The change in pH in the control and experimental samples of semi-smoked sausage, depending on the level of introduction of buckwheat flour.

(Ukrainian) smoked sausage was used as a control. In the control sample, the pH value was 5.9 units. The maximum pH value was observed in sample No. 2 - 6.35 units. With increasing the dosage of buckwheat flour, the active acidity gradually decreased from 6.32 to 6.29 units. The moisture-binding capacity index determines the degree of moisture retention inside the product [21]. The moisture-holding capacity index in semi-smoked sausage samples was unequal in the experiments. The highest value was found in the experimental sample, 71.3% (Figure 2).

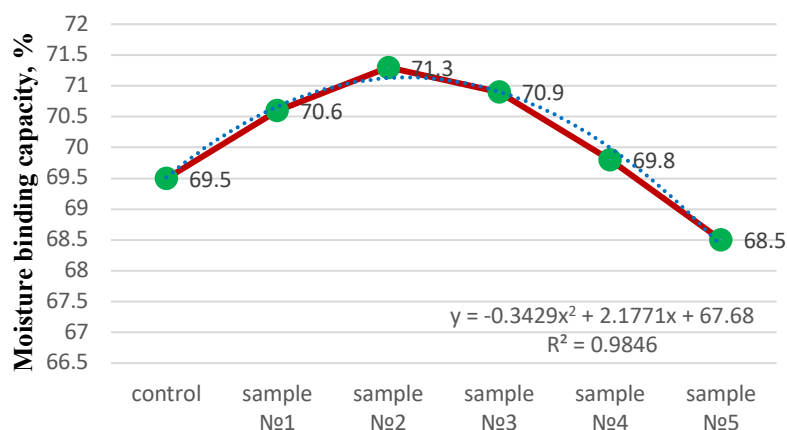


Figure 2 Changes in moisture-binding capacity in the control and experimental samples of semi-smoked sausage, depending on the level of introduction of buckwheat flour.

The results showed that the moisture-binding capacity of the minced meat in the experimental samples differed [17]. Thus, the highest value of the moisture-binding capacity was found in the experimental sample No. 2 – 71.3%. A relatively small amount of buckwheat flour in semi-smoked sausage meat samples (up to 10.0% by weight of unsalted raw material) increases the moisture-binding capacity of the control sample by 1.1-1.8 [22]. At the same time, the lowest values of the moisture-binding capacity have been noted in the samples with flour in the amount of 10 to 12.0% (69.8 and 68.5%, respectively). This fact is explained by the inability of buckwheat flour under heat treatment to transfer some of the released free moisture into the gel-like state [22]. The moisture-binding capacity gradually decreased by increasing the hydrated buckwheat flour content in the experimental samples' minced meat [23]. The lowest moisture-binding capacity values were obtained for samples with 10.0 and 12.0% buckwheat flour content – 69.8 and 68.5%, respectively. The decrease in the moisture-binding capacity in the experimental products is explained by the increase in the combined minced meat mix of the amount of moisture contained in the hydrated buckwheat flour [22]. Therefore, the combined minced meat mixture in the experimental samples becomes crumbly [17].

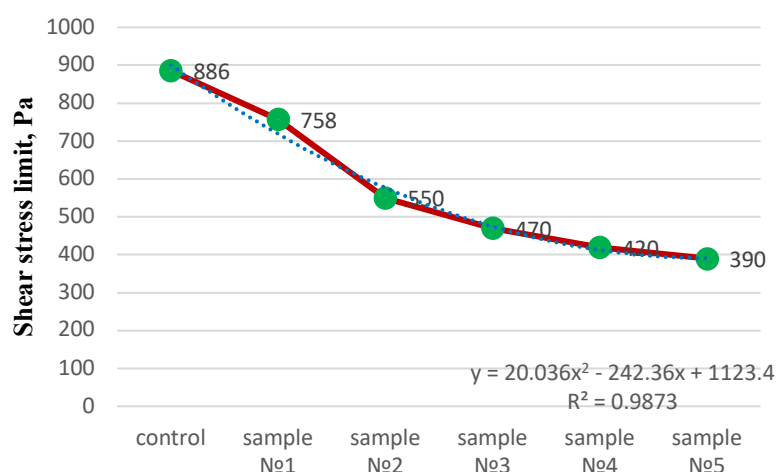


Figure 3 Change of shear stress limit in the control and experimental samples of semi-smoked sausage, depending on the level of introduction of buckwheat flour.

The prepared test samples' shear stress limit showed that this parameter's maximum value is 758 Pa. With increasing the dosage of hydrated buckwheat flour, the minced meat loosens, and the value of shear stress limit in samples No. 3 and No. 4 is 420 and 390 Pa (Figure 3). The studied physicochemical, functional-technological and structural-mechanical indicators of the minced meat system correlate with organoleptic indicators of the experimental product [17].

The appearance, colour, smell, aroma, consistency, taste and juiciness were studied in the produced samples of semi-smoked sausage. The results of the organoleptic evaluation of the tested samples are shown in Table 2. The appearance of the examined samples differed significantly from each other by the variants of the experiment. The best was the control sample and variants with hydrated buckwheat flour in the quantity of 6 and 8% to the weight of meat raw material (5 points), and the worst were variants with 10 and 12% of buckwheat flour (4 points) [17]. The colour characteristics of semi-smoked sausage (on the cut) also differed between the variants. In this respect, preference was given to the control and experimental samples with 6.0% hydrated buckwheat flour (5 points) [17].

Table 2 Organoleptic assessment of experimental variants of smoked sausages.

Sample and control variants	Appearance	Colour	Smell/aroma	Consistency	Taste	Juiciness	Total score
Control	great	attractive	inherent in the meat product	tender	delicious	juicy	great
I sample -4% buckwheat flour	excellent	attractive	inherent in the meat product	tender	delicious	juicy	great
II sample-6% buckwheat flour	excellent	attractive	inherent in the meat product	tender	tasty enough	juicy	great
III sample-8% buckwheat flour	good	good	insufficiently meaty	insufficiently	tasty enough	moderately juicy	good
IV sample-10% buckwheat flour	satisfactory good	satisfactory	no meat smell	tender	insufficiently tasty	not too juicy	average
V sample-12% buckwheat flour	unsatisfactory	unsatisfactory desirable	no meat odour	loose	unpalatable, tastes of buck-wheat flour	dry	average

Samples of semi-smoked sausage with 8 and 10.0% buckwheat flour scored 5 and 4 points, respectively. The lowest score was given to experiment No. 5 with 12% buckwheat flour to the weight of unsalted raw material.

When evaluating the samples of semi-smoked sausage in terms of smell and aroma the best indicators were noted in the control and the experimental sample with the content of buckwheat flour in the amount of 6% (5 points) (Table 2). Increasing the proportion of buckwheat flour in the raw meat material to 10% results in a slight aroma and aftertaste, reducing the meat product's taste (4 points) [17]. Significant differences characterized the flavour index of the semi-smoked sausage samples under study. When buckwheat flour was added to the raw meat up to 8%, the taste of the additive was barely perceptible in the product samples (5 points). A further increase in additive content in the samples resulted in a stronger taste of buckwheat flour and worsened the taste of the meat product [17]. The remaining samples each received a score of 3 for smell and flavour (Figure 4).

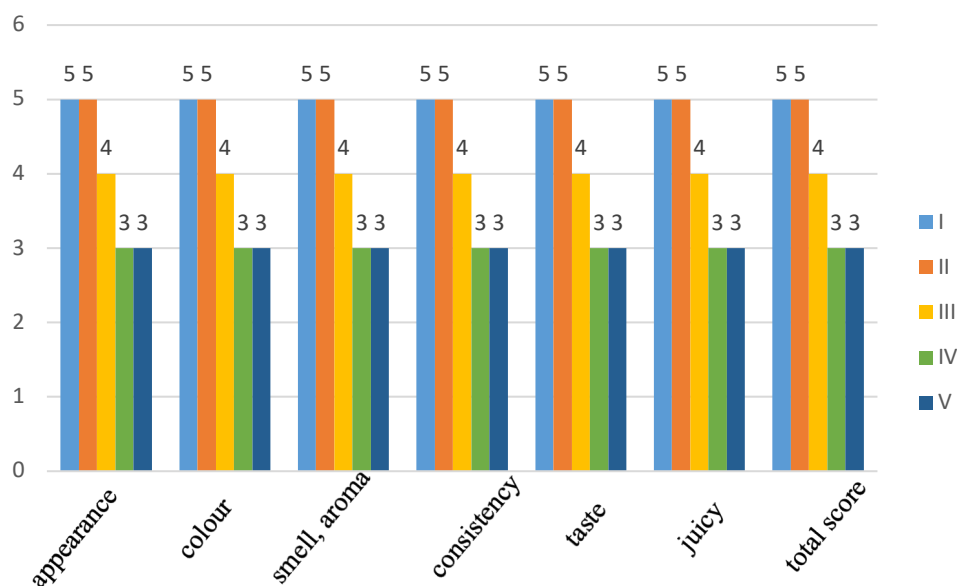


Figure 4 Histogram of organoleptic evaluation of experimental variants of semi-smoked sausage. Note: I sample; II sample; III sample; IV sample; V sample.

The consistency of semi-smoked sausage samples was not the same across the test variants. The samples absence or relatively small amount of additive ensured a fairly gentle consistency (5 points). With increasing the quantity of additive in the variants to 10,0 and 12,0% this indicator significantly decreased (4 and 3 points, respectively), and its maximum quantity (12.0%) worsened the product consistency to an unsatisfactory value (3 points) [17]. Regarding juiciness, all the samples tested were about the same (4-5 points). Thus, based on the total score of experimental samples, it was found that the introduction of buckwheat flour in an amount of up to 6-8% does not worsen the organoleptic quality of semi-smoked sausage [8], [9], [10], [17], [23], [24]. At the next stage of experimental research, histological studies were carried out an experimental sample of semi-smoked sausage with a level of hydrated buckwheat flour 6% [17]. The sample studied includes muscle, connective, fatty tissue, fine-grained protein mass, buckwheat flour fragments, and rounded muscle fibres. Muscle tissue is the main functional component of raw meat and a source of protein and consists of muscle fibres – a kind of multinucleated cells with an elongated shape [25], [26], [27], [28], [29], [30]. Figure 5 shows changes in the muscle tissue of thermally untreated and finished semi-smoked sausages. Weak striation disrupted tinctorial properties, and no nuclei of fibres were preserved. There are areas with indistinct boundaries between muscle fibres (sarcolemma and endomysium destroyed) (Figure 5) [29], [30], [31], [32], [33], [34], [35], [36], [37].



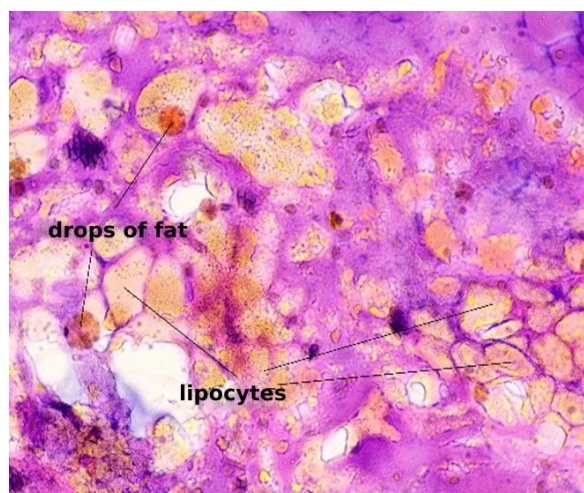
Raw sausage muscle tissue (sarcolemma destroyed, weakly distinguishable striations), $\times 200$
a) in a raw sample



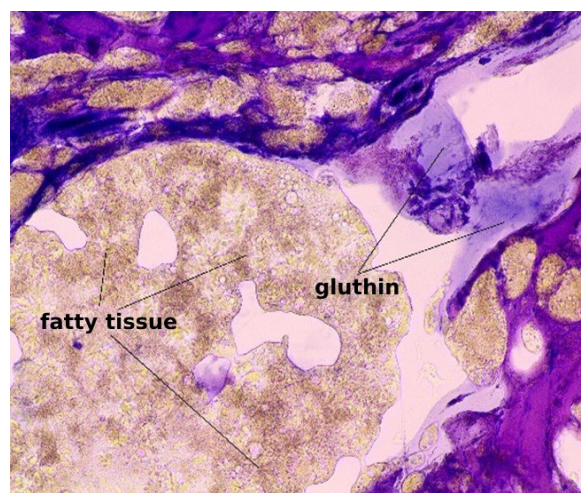
The muscle tissue of semi-smoked sausage (muscle tissue with swollen fibers) $\times 400$
b) in the finished sample

Figure 5 Changes in the muscle tissue of raw and finished semi-smoked sausages.

Fatty tissue in the form of lipocytes and fat droplets (Figure 6). Loosening and destruction of connective tissue elements were detected, and fibrous structures were subject to lysis [28]. There are fragments with destroyed edges among buckwheat flour particles with pronounced boundaries (Figures 7, 8, and 9). The distribution of the flour throughout the sample is uniform [29].

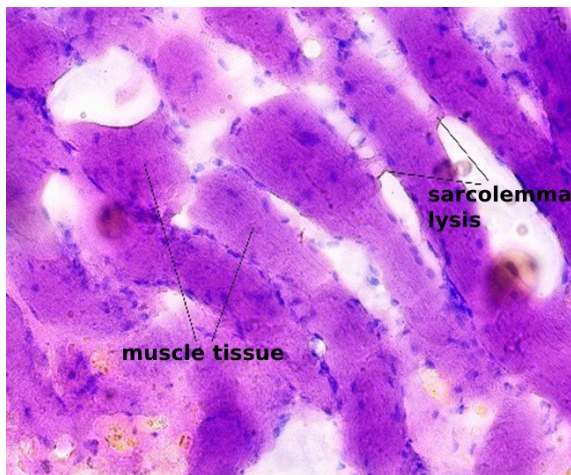


Fatty tissue, lipocytes, drops of fat in minced sausage, $\times 100$
a) in a raw sample



Fatty tissue and glutin in semi-smoked sausage, $\times 100$
b) in the finished sample

Figure 6 Change in the fatty tissue of thermally unprocessed and finished semi-smoked sausages.

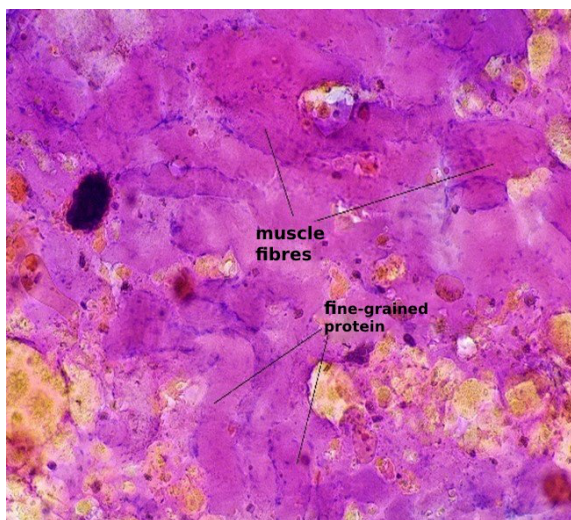


Muscle fibers with lysed sarcolemma and endomysium in minced sausage, $\times 200$
a) in a raw sample

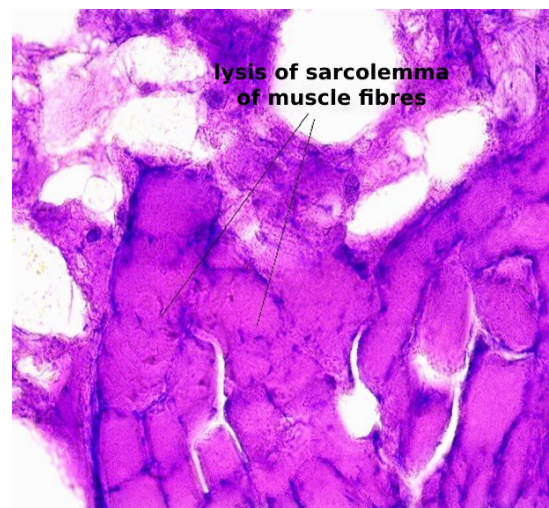


Muscle tissue of semi-smoked sausage, no nuclei, weak striation, $\times 200$
b) in the finished sample

Figure 7 Change in muscle tissue of thermally untreated and finished semi-smoked sausages.

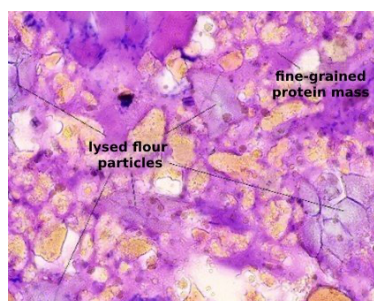


Fine-grained protein mass with lysed muscle fibers, $\times 100$
a) in a raw sample

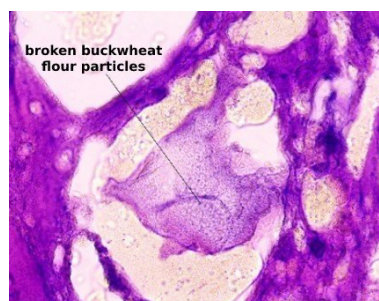


Lysis of the sarcolemma of muscle fibers of semi-smoked sausage, $\times 200$
b) in the finished sample

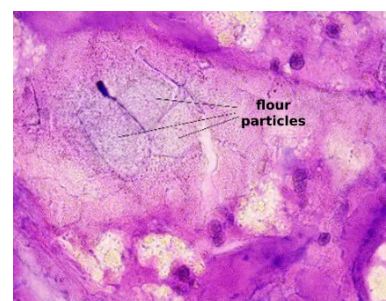
Figure 8 Lysis of sarcolemma muscle fibres of thermally untreated and finished semi-smoked sausages.



Fine-grained protein mass with lysed buckwheat flour particles, $\times 100$
a) in a raw sample



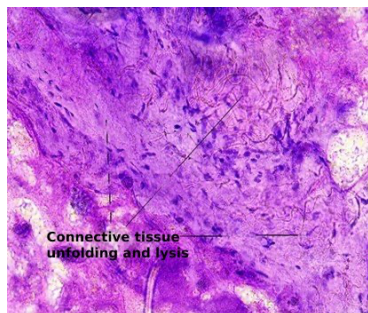
Broken buckwheat flour particles of semi-smoked sausage, $\times 200$
b) in the finished sample



Flour particles with lysed edges in raw sausage, $\times 200$
c) in a raw sample

Figure 9 Changes in buckwheat flour particles of thermally untreated and finished semi-smoked sausages.

Figure 10 shows that the fibrous structures of the connective tissue are swollen, in some places, have lost their structure and acquired the appearance of a granular mass. In some cases, a mass with gluten was formed. Fragments with broken edges were visible among buckwheat flour particles with pronounced boundaries. Flour distribution throughout the sample is uniform [29].



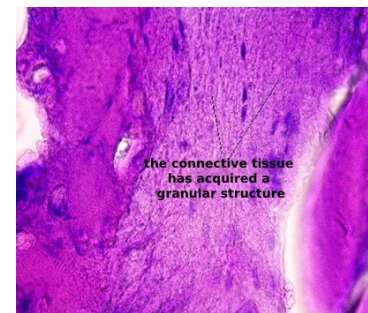
The connective tissue of raw sausage (unfolding and lysis), $\times 200$

a) in a raw sample



The connective tissue of semi-smoked sausage, $\times 200$

b) in the finished sample



Connective tissue in semi-smoked sausage (loss of fibrous structure and acquisition of granular mass), $\times 400$
(c) in the finished sample

Figure 10 Changes in the connective tissue of thermally untreated and finished semi-smoked sausages.



Figure 11 Experimental sample of semi-smoked sausage with 6% buckwheat flour.

Thus, it has been established that adding hydrated buckwheat flour to the mass of meat raw materials positively affects the physico-chemical, functional and technological, structural and mechanical and organoleptic parameters of semi-smoked sausages [17], [29], [38].

CONCLUSION

The study of active acidity of forcemeat samples of semi-smoked sausages showed that the maximum pH value was observed in experiment No.2 – 6.35 units. With an increasing dosage of buckwheat flour active acidity gradually decreased from 6.32 to 6.29 units. A relatively small amount of buckwheat flour in semi-smoked sausage samples (up to 10.0% by weight of unsalted raw material) increases the moisture-binding capacity of the control sample by 1.1-1.8%. At the same time the lowest values of the moisture-binding capacity have been noted in samples with flour in the amount of 10 to 12.0% (69.8 and 68.5%, respectively). The moisture-binding capacity gradually decreased with a further increase in the content of hydrated buckwheat flour in the minced meat of the experimental samples. The lowest moisture-binding capacity values were obtained for samples with 10.0 and 12.0% buckwheat flour content – 69.8 and 68.5%, respectively. A study of the shear stress limit of the finished test samples showed that the maximum value of this parameter was 758 Pa. With increasing the dosage of hydrated buckwheat flour, minced meat loosens, and the value of shear stress limit in samples number 3 and 4 is 420 and 390 Pa. The studied physico-chemical, functional-technological and structural-mechanical indicators of the minced meat system correlate with organoleptic indicators of the experimental product. The appearance, colour, smell, aroma, consistency, taste and juiciness were studied in the produced samples of semi-smoked sausage. Based on general organoleptic evaluation of experimental samples, it was established that the introduction of buckwheat flour in an amount of up to 6-8% does not worsen organoleptic quality indicators of semi-smoked sausage. Histological studies have been conducted on an experimental sample of semi-smoked sausage with 6% hydrated buckwheat flour. In general, it has been established that introducing hydrated buckwheat flour into the minced meat up to 6% of the raw meat material's mass positively affects the physicochemical, functional and technological, structural and mechanical and organoleptic parameters of semi-smoked sausages.

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