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Application of a new brine of sprouted grains for delicatessen products from horse meat, beef, and pork

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ABSTRACT

The main task of the meat processing industry is to produce meat products as the primary source of animal protein that ensures the vital activity of the human body in the necessary volumes, high quality, and a diverse assortment. Providing the population with high-quality food products that are biologically complete, balanced in the composition of the primary nutrients, and enriched with target physiologically active components is one of the most priority scientific and technical problems to be solved. In this regard, a recipe for a new brine from sprouted grains for delicatessen products from horse meat, beef, and pork was developed. The composition of the new brine includes flavoring and aromatic ingredients, juice of sprouted grains, and juices of raw vegetable materials. The viscosity of horse meat, beef, and pork during massaging was studied. Thermodynamic parameters such as water activity and moisture binding energy of horse meat, beef, and pork using a new brine were studied. The data analysis shows that the values of the "aw" indicator and the moisture binding energy in the experimental samples of meat products are higher than in the control samples. Studies have found that with an increase in the activity of water and the moisture binding energy, the tenderness of finished delicatessen meat products with a new brine increases. As a result, it was found that the maximum amount of brine in horse meat is retained at 160 minutes of continuous massaging, in beef – at 130 minutes, in pork – at 120 minutes of mechanical processing.

Keywords: recipe, functional products, delicatessen products, brine, vegetable additives

INTRODUCTION

Currently, the most popular and priority products for consumers are functional products that help improve metabolism and increase the body's immune properties by correcting the protein, fat, and carbohydrate composition. The domestic food industry should respond to the growing concern of the population about maintaining health, which, on the one hand, is associated with an increase in consumer awareness of the relationship between nutrition and health and, on the other hand, with the deterioration of statistics on nutrition-related diseases **[1]**.

In this regard, research on the development of products with directed correction of the composition with the use of biologically active additives that contribute to strengthening all physiological functions of the human body is becoming relevant. The most promising essential product for functional nutrition is meat products, since the meat of slaughtered animals is a source of high-grade protein, has a high biological value, and is similar in terms of amino acid score to the standard recommended by FAO/WHO. This makes it a valuable raw material for the production of functional products **[2]**.

The healing properties of sprouted seeds have been known for a very long time. Even 3000 years B.C., the Chinese used bean sprouts for food. In Rus, our ancestors fed weak, sick children with sprouted grains, and the children quickly recovered and gained weight. Since the second half of the 20th century, sprouted seeds have been widely used in America and Western Europe. Sprouted seeds of various crops are increasingly being introduced into medical practice due to their amazing properties. Sprouts are not a health supplement artificially enriched with a particular substance. This is a very special, healing food, the only case when a complete living organism is used as food in a state of maximum activity. The healing effect of seedlings on the human body is determined by the changes that occur in the seeds during their germination **[3]**.

Regular consumption of sprouts stimulates metabolism and hematopoiesis, increases immunity, compensates for vitamin and mineral deficiencies, normalizes the acid-base balance, helps to cleanse the body of toxins and effective digestion, increases potency, and slows down the aging process. In addition to the general positive effect on the human body, the seedlings of each crop, having a certain set of useful substances, vitamins, and microelements in their composition, have a specific healing effect **[4]**.

Use in cooking: Cumin, ginger, and coriander are spicy seasonings used to flavor spicy dishes, such as meat, sausage products, and vegetables. They are also part of various spicy curry mixes. Application in medicine: Infusion of coriander, cumin, and ginger improves digestion and helps with flatulence. Aroma and taste: Plants have a very strong, peculiar smell **[5]**.

Delicacies occupy a very special place among all sausage products. No matter how unusual the sausage is, it will always remain a familiar product for everyone in the well-established form of a loaf. Delicacies are quite another matter. There are several time-tested traditional varieties of delicacies - boiled pork, carbonade, smoked and boiled pork, or beef fillet. In French, "delicacy" is translated as "dainty dishes". Indeed, few people can resist the spicy smell of pale pink pork belly. Delicacies are made according to traditional recipes that have survived to this day, with the addition of only natural spices **[3]**.

Using vegetable raw materials in the technology of meat products is one of the most promising directions in creating products with a given chemical composition **[6]**. Combining ingredients of animal and vegetable origin **[7]** in prescription compositions leads to mutual addition and enrichment of the missing biologically active substances **[8]**.

The above was the basis for conducting research at the Kazakh Research Institute of Processing and Food Industry; the subject is the development of meat delicacies balanced in amino acid composition from horse meat, beef, and pork with a new brine from sprouted grains.

Sprouted wheat grain and brine from such grain have enormous practical value for the food industry since they allow us to produce products with highly valuable substances. The benefit of sprouted grains of various crops for the food industry has been repeatedly noted in the specialized literature since any sprouted grain is rich in enzymes necessary for the digestion and assimilation of food, such as easily digestible monosaccharides. At the same time, it provides the human body with active energy in the form of ATP (adenosine triphosphate) since it is most actively synthesized and used during the germination period.

Scientific hypothesis

Theoretically, we hypothesize that as water activity and moisture binding energy increase, the tenderness of finished deli meats using the new brine increases. This paper presents the results of a study of delicacy products from horse meat, beef, and pork prepared from a new brine from sprouted grains, which was our goal.

MATERIAL AND METHODOLOGY

Samples

The study's objects were horse meat, beef, and pork, which were purchased from the Sozak et al. Company.

Chemicals

All reagents were of analytical grade and were purchased from Laborfarm (Kazakhstan) and Sigma Aldrich (USA).

Animals, Plants and Biological Materials

The study used beef, horse meat, and pork for analysis.

Instruments

We used AquaLab 4TE water activity analyzer (Decagon Devices Inc, USA), automatic amino acid analyzer AAA-881 (Mikrotechna, Czech Republic), and TMS-PRO Structure Analyzer (Food Technology Corporation, USA).

Laboratory Methods

All analyses were conducted in an accredited laboratory of the Almaty Technological University and Kazakh Research Institute of Processing and Food Industry LLP. Laboratory studies of raw materials were carried out based on Almaty Technological University JSC (Almaty, Kazakhstan). The general chemical composition of the original grain and sprouted grain was determined: moisture, protein, carbohydrates, amino acid composition, and others. The pH, moisture, water activity, moisture binding capacity, and organoleptic properties of beef, horse meat, and pork delicacies were also studied.

The grain moisture content was determined according to GOST 13586.5-2015 **[9]**. The essence of the method is to dehydrate a sample of crushed grain in a drying cabinet (installation) with fixed parameters: temperature, drying time, and calculation of humidity as a percentage based on the change in its mass by weighing the sample before and after drying.

The grain protein content was determined according to GOST 10846-91 **[10]**. The essence of the method is the mineralization of organic matter with sulfuric acid in the presence of a catalyst, which forms ammonium sulfate; the destruction of ammonium sulfate with alkali, which releases ammonia; and the distillation of ammonia with water vapor into a solution of sulfuric or boric acid, followed by titration.

The grain carbohydrate content was determined by determining the mass fraction of soluble carbohydrates according to Bertrand according to GOST 26176-2019 **[11]**. The essence of the method lies in the ability of reducing sugars to reduce divalent copper in an alkaline medium into copper oxide (I), which is oxidized with ferric ammonium alum. This is followed by titration of the reduced divalent iron with a solution of potassium permanganate.

The grain amino acid content was determined according to GOST 32195-2013 **[12]** using an automatic amino acid analyzer AAA-881. An amino acid analyzer is a special compact liquid chromatograph designed for the analysis of amino acids on an ion exchanger column with a post-column derivatisation by means of ninhydrin and for the determination of biogenic amines.

The hydrogen ions (pH) concentrations of meat and meat products were determined according to GOST R 51478-99 **[13]**. The electrical potential differences between a glass electrode and a reference electrode placed in a sample of meat or meat products are measured. Calibrate the pH meter using a buffer solution with a known pH value close to the pH value of the analyzed solution at the measurement temperature. Insert the electrodes into the sample and set the temperature regulator of the pH meter to the sample temperature. pH measurements are carried out depending on the design of the pH meter. After the instrument readings have reached a steady value, read the pH value directly from the device scale with an accuracy of ±0.05 pH units. The arithmetic mean of three individual measurements is taken as the final result if the requirements for convergence of results are met.

The mass fraction of moisture in meat and meat products was determined according to GOST 33319-2015 **[14]**. The method is based on drying the analyzed sample with sand to constant weight at a temperature of 103 ±2 °C.

The water activity of meat and meat products was determined according to GOST ISO 21807-2015 **[15]** using an AquaLab 4TE analyzer. The Aqualab 4TE meter can measure water activity in 5 minutes or less (average reading time: 2.5 minutes) with an accuracy of ±0.003 aw. Internal temperature control allows you to set the temperature measurement from 15 to 50 °C and use the device anywhere – even outside the laboratory. Water activity can be used to predict the growth of microorganisms and determine the microbiological stability of food products and is also an important, quantitative criterion for assessing the length of time for which food products can be stored.

To determine the moisture-binding capacity of meat and meat products, the pressing method developed by the German researcher Hoffman is of particular interest, in which the moisture-binding capacity is judged by the volume of product moisture absorbed when the gypsum working fluid comes into contact with the object. However, the most widely used methods for practice are pressing on filter paper and centrifugation methods. The method for determining the moisture binding capacity of raw meat (according to Grau-Hamm as modified by Volovinskaya-Kelman) is based on the release of moisture from the test sample when it is lightly pressed, the sorption of the released water by filter paper and the determination of the amount of released moisture by the size of the spot area left by it on the filter paper. paper. The reliability of the results can be ensured by repeating the determinations three times or more **[16]**.

Organoleptic characteristics of meat and meat products were determined according to GOST 9959-2015 **[17]**. The following were determined: appearance, color, taste, smell (aroma), consistency and others through the senses. Organoleptic evaluation was carried out by specialist tasters with experience in assessing the quality of meat products. The tasting commission was created based on the selection of tasters, taking into account their sensitivity and ability to establish specific differences in color, taste, smell (aroma) and consistency of samples of meat products by GOST ISO 8586 (the competence of the tasters is confirmed by relevant documents).

All natural food products contain water in their composition in various quantities and states; their technological properties and shelf life largely depend on this. The "water activity" indicator is an important tool in developing technological processes and producing public catering products, as well as ensuring high quality and increasing the shelf life of food products. Considering the importance and greater information availability of the water activity indicator aw in the countries of the United Europe, its determination, along with the indicators "humidity" and "concentration of hydrogen ions" (pH), is mandatory when examining a number of products. In other foreign countries, the determination is included in the control algorithm for food quality **[18]**. Moisture activity was examined by AquaLab (USA), and the equipment was developed by academics Rogov and Chomanov **[19]** method of determining the moisture activity at the Rogov-Chomanov equipment is as follows: in sample No. 2 placed examined product, sample No. 6 is filled with distilled moisture. After fixing the samples at the equipment with opened valves No. 4, Air is pumped by vacuum pump No. 8. The duration of pumping is 5 minutes. Then, valves are closed, and after 6-8 min, fluid movement stops in the manometer. The manometer indication ΔP is the difference between the equilibrium vapor pressure of moisture over distilled moisture P_0 and the equilibrium pressure of moisture vapor over the product P_{pr}, i.e.,

$$\Delta P = P_0 - P_{pr} \tag{1}$$

The equation calculates the moisture activity value:

$$a_w = \frac{P_0 - \Delta P}{P_0} \tag{2}$$

Some of meat's most important sensory qualities are appearance, juiciness, taste, texture, and consistency. Textural characteristics are assessed by various indicators, which vary depending on the purpose of the study (for example, hardness, strength, elasticity, viscousness, juiciness, and stickiness **[20]**, **[21]**.

Cooked meat texture is determined by connective tissue, myofibrillar proteins, and related components, the contributions of which vary according to concentration, quaternary structure, and strength of intermolecular bonds. The texture of meat is one of the important culinary properties that determines its tenderness, juiciness, and pleasantness when eating. It can be different: from soft and tender to dense and elastic. Proper meat processing before cooking, such as marinating, braising, or frying, is essential for optimal texture. When instrumentally assessing the texture of meat, texturemeters are often used – devices that analyze the resistance of tissues both during shear and compression of the sample **[22]**, **[23]**.

Texture analysis on the analyzer TMS-PRO (Figure 1) is carried out as follows: The texture analyser moves in either an up or down direction to squash or stretch a food sample. The traveling beam is fitted with a load cell measuring the food's response as a force. The load cell acts like an upside-down laboratory balance in a compression test. It is "triggered" when the sample surface is detected, giving a constant start point to the texture test. The texture analyser then travels to either a "target" distance or load, recording the force response of the sample to the deformation imposed. Time is the common variable in all texture tests, e.g. the faster we travel the less time a sample has to respond.

The traveling beam then returns, and the sample adjusts to the conditions created. Probes and fixtures manipulate forces, recreating conditions exposed to the food during handling or consumption.

The energy put into the sample has to be absorbed, stored, or returned. We measure this response in graphical form and can assign numbers to sensory characteristics. Instrumental results are correlated to sensory panels, and sensory characteristics such as hardness, cohesiveness, stickiness, etc., can be calculated **[24]**.

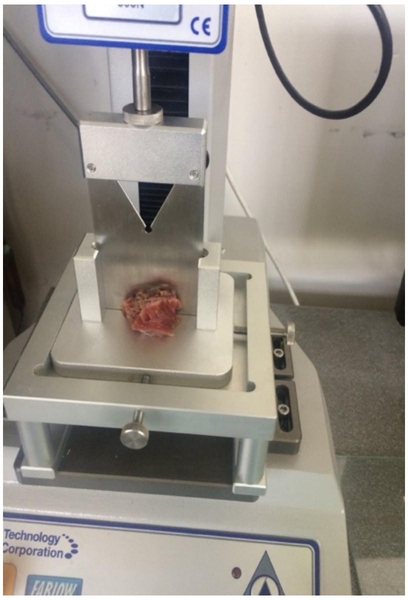

Figure 1 TMS-PRO Structure Analyzer.

The samples were thawed in air at 15 °C to a core temperature of 0-4 °C and measured at 10-12 °C. The meat was deboned and cut into cubes measuring 60 × 60 × 30 mm in width, length, and height, respectively.

The meat texture was examined as follows: A TMS-PRO Structure Analyzer with a force sensor of 1000 N and a movement speed of 500 mm/min was used for the study. A meat sample of about 300 g is placed on a cutting table between the cutting knife and the force plate to carry out measurements. The texture analyzer cross moves downward, compressing the meat sample. The moving beam is equipped with a strain gauge to measure the reaction of the product force to deformation. The load element acts like an inverted laboratory balance in a compression test. Data collection can be "triggered" and begin when a sample surface is detected, providing a constant starting point for repeated testing. The texture analyzer crossbar then moves either a programmed distance or a programmed load, recording the force response of the meat sample to the applied deformation. The traverse is then returned, and the meat sample reacts to the conditions created. The forces are manipulated using sensors and devices that recreate the conditions to which food is exposed during chewing or processing. The energy put into the sample is absorbed, stored, or returned. Next, the results were obtained in graphical form. Instrumental results almost always correlate with sensory panel scores, and sensory characteristics such as hardness, cohesiveness, and tack can be calculated.

Description of the Experiment

Sample preparation: For the experiment, boneless muscles were used and removed from beef, horse meat, and pork carcasses two days after slaughter. Each muscle was cut into six samples weighing about 300 g. To prepare the delicacy, a new brine was used (1 litre each), which contained the following ingredients: Geleon 209 M, sodium chloride (table salt), sodium nitrate, cumin, black pepper, ginger, cinnamon, onion juice, carrot juice, sprouted wheat juice, garlic juice and kiwi juice. A control sample of brine, also 1 litre, was prepared from the following ingredients: Geleon 209M, sodium chloride (table salt), and sodium nitrite. To prepare 1 kg of delicacy meat, 400 ml of brine was needed. The prepared brine was cooled to a temperature of 0 to 4 °C, and then the prepared samples of beef, horse meat, and pork were weighed and filled with the appropriate brines.

Number of samples analyzed: We analyzed three samples.

Number of repeated analyses: All measurements of instrument readings were performed two times.

Number of experiment replications: The number of repetitions of each experiment to determine one value was two times.

Design of the experiment: To experiment in the laboratory, brine for beef, horse, and pork was obtained. To get 1 kg of meat delicacy, 400 ml of brine is needed. The composition of the control brine includes galleon 209M, salt, and sodium nitrite. The experimental brine added flavoring and spicy aromatic ingredients: cumin, black pepper, ginger, coriander, onion juice, carrots, sprouted grains, garlic, and kiwi. The prepared brine was cooled to a temperature of 0 to 4 °C. The raw meat prepared for salting was weighed and then injected with brine, giving the product the necessary organoleptic characteristics **[25]**, **[26]**.

Based on the results obtained, a recipe for a new brine was developed from flavoring aromatic ingredients, sprouted grains juice, and raw vegetable juices (Table 1).

Table 1 Brine for delicatessen meat products (percentage of substances in ml).

Name of the raw material	Control brine	Experienced brine
Geleon 209 M	20	20
Salt	20	20
Sodium nitrite	0.2	0.2
Cumin	-	1.5
Black pepper	2	2
Ginger	-	0.5
Cinnamon	-	1
Onion juice	-	50
Carrot juice	-	50
Sprouted grains juice	-	50
Garlic juice	5	10
Kiwi juice	-	2

As a result of the research, a recipe for meat delicatessen products with the addition of brine of vegetable raw materials was developed (Tables: 2, 3 and 4).

Table 2 Recipe of delicatessen products from beef with the addition of brine of vegetable raw materials.

Raw materials, in kg per 100 kg	Meat delicatessen products
Beef of the category I	75.00
Brine with vegetable raw materials	25.00
Total	100.00

Table 3 Recipe of meat delicatessen products from horse meat with the addition of brine of vegetable raw materials.

Raw materials, in kg per 100 kg	Meat delicatessen products
Horse meat of category I	70.00
Brine with vegetable raw materials	30.00
Total	100.00

Table 4 Recipe of meat delicatessen products from pork with the addition of brine of vegetable raw materials.

Raw materials, in kg per 100 kg	Meat delicatessen products
Pork of category I	70.00
Brine with vegetable raw materials	30.00
Total	100.00

The appearance of deli meats is shown in Figure 2, 3 and 4.

Figure 2 Beef delicacy.

Figure 3 Pork delicacy.

Figure 4 Horse meat delicacy.

Statistical Analysis

The experiments were carried out in triplicate. Standard deviation values are given for all measurements. Differences in the measurements of the experimental and control groups were calculated using analysis of variance (one-way ANOVA) using Tukey's test. The measurement value p <0.05 was considered significant. The STATISTICA Microsoft Excel editor processed experimental data using mathematical statistics methods. Statistical processing was performed in Microsoft Excel 2010 in combination with XLSTAT.

RESULTS AND DISCUSSION

The nutritional value of brines based on sprouted grains and the valuable properties of such a brine make it urgent to create new delicatessen products from horse meat, beef, and pork with the addition of such a brine **[27]**. During the germination of grain **[28]**, the content of individual biologically active substances **[29]** increases significantly since many of them are necessary for the development and formation of a new plant, **[30]**. Let's consider some features of sprouted wheat grain, the solution from which is planned to be introduced into meat products. The characteristics of wheat grain during germination are shown in Figure 5.

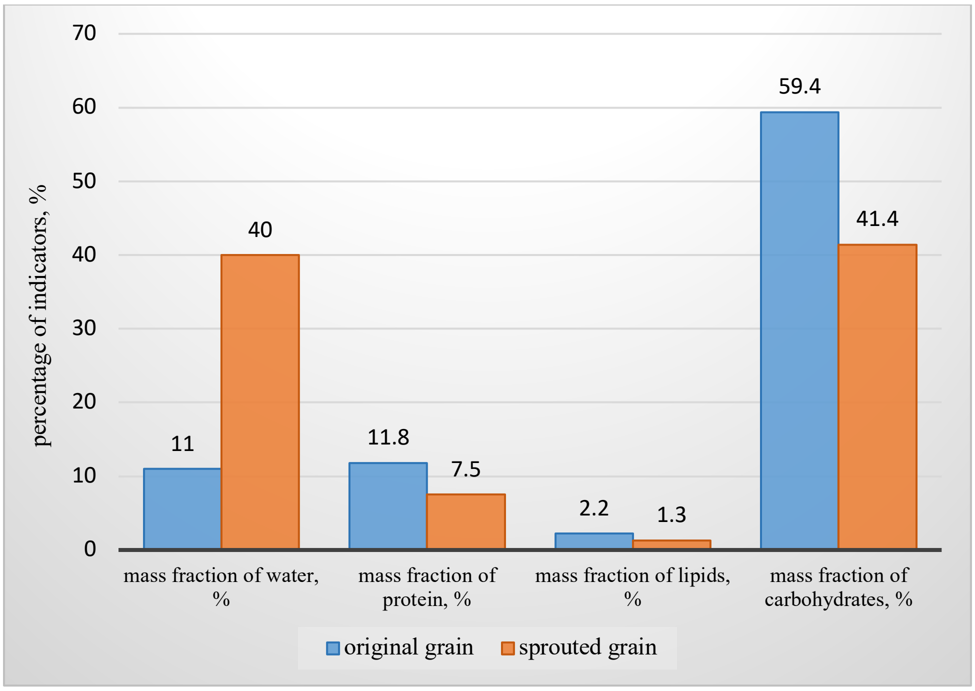

Figure 5 Comparative indicators of the original and sprouted grain (%).

As can be seen from the data presented in Figure 1, the sprouted grain has a more significant mass fraction of water **[31]** than the original non-sprouted grain but slightly lower indicators **[32]** in terms of the mass fraction of protein, carbohydrates, and lipids compared to the original grain **[33]**. This property of sprouted grain is because these substances are spent on the processes associated with the formation and development of the plant embryo **[34]**. At the same time, there is a large amount of various vitamins in sprouted grains, often exceeding the amount of vitamins in non-sprouted grains (Figure 6).

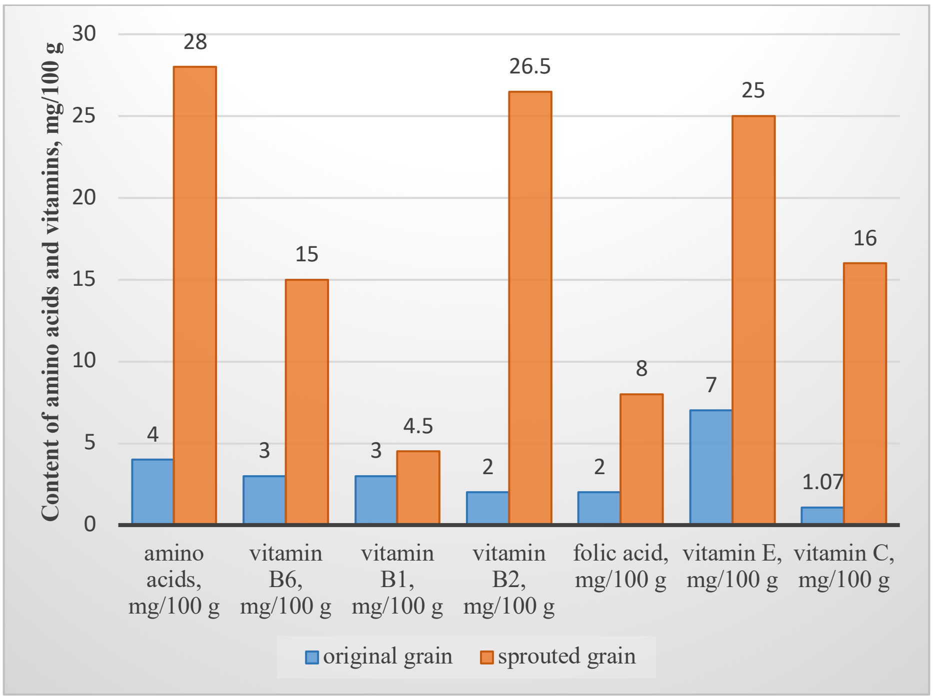

Figure 6 Comparative indicators on the content of amino acids and vitamins of the original grain and sprouted grain (mg/100 g).

The data presented in Figure 2 show that sprouted grain contains much more valuable acids and vitamins than ordinary wheat grain.

A number of research studies are devoted to the study of the benefits of using sprouted grain in the food industry **[35]**. Thus, several researchers prove that the use of sprouted grains gives products a specific taste range **[36]**, while the share of valuable substances in the finished product increases by a certain percentage (Figure 7) **[37]**.

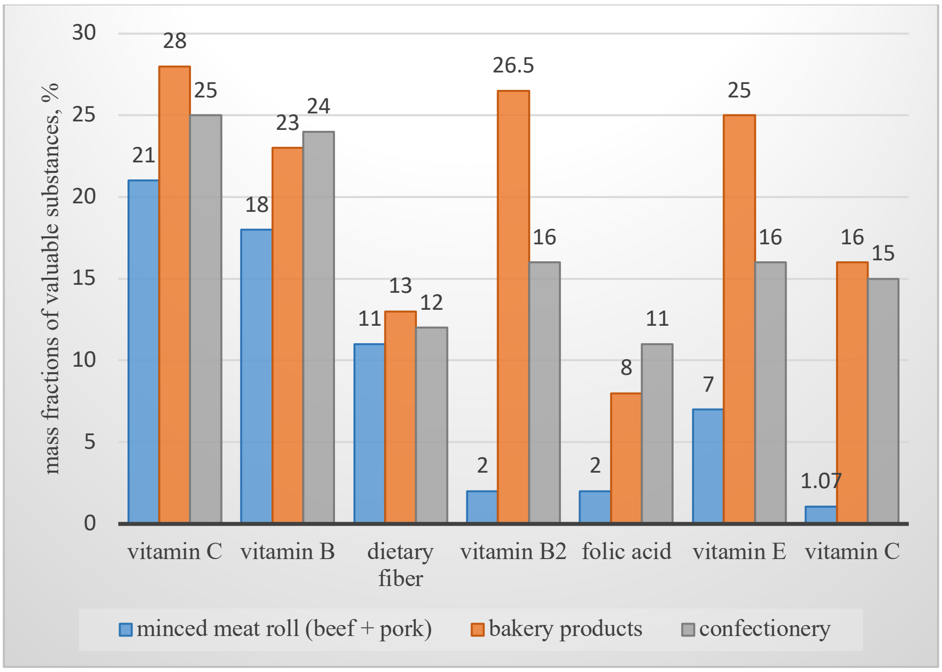

Figure 7 Comparative indicators for increasing the share of valuable substances in ready-made food products with the addition of sprouted grains (%).

The above data allow us to conclude the benefits and practical significance of sprouted grain in the food industry.

During the salting process, the meat matures under the action of tissue enzymes and enzymes of microorganisms **[38]**, which gives it the necessary functional and technological properties - plasticity, stickiness, and high moisture-binding ability **[39]**. When salted, the muscle tissue swells, increasing in volume, its moisture-binding ability increases, the concentration of hydrogen ions changes in the acidic direction **[40]**, and the meat acquires several new properties, including organoleptic ones **[41]**. Subsequently, the salting ingredients provide the desired color and aroma of the product and have an antioxidant and preservative effect **[42]**. So, products from pork, beef, and horse meat, after salting using a new brine based on sprouted grains **[43]**, have a moderately salty taste, a specific (ham) aroma, a stable pinkish-red color, become more tender, tasty and are better absorbed by the body **[44]**.

To calculate the optimal required amount of introduced brine, a study of the technological characteristics of meat delicacies with a level of syringing of 10%, 20%, and 30% of brines from vegetable raw materials was conducted.

The study's objects were experimental industrial samples of delicatessen products with different levels of syringing. The control for determining the relative biological value was meat delicacies prepared from the appropriate meat products with the addition of the following components (according to Table 1): Geleon 209 M, salt, sodium nitrite, black pepper, and garlic juice.

The results of studies of meat delicacies containing 10%, 20%, and 30% brine are shown in Table 2-4. The physical and chemical parameters of meat delicacies were studied (Tables: 5, 6 and 7).

Table 5 Study of physical and chemical indicators of delicacies from beef meat.

The amount of brine introduced, %	Physical and chemical indicators	
	pH	moisture, %
10	6.1 ±0.13 [a]	46.3 ±0.43 [a]
20	6.14 ±0.09 [a]	47.8 ±0.32 [b]
30	6.21 ±0.14 [a]	50.7 ±0.48 [b]
Control	6.30 ±0.13 [b]	50.3 ±0.37 [b]

Note: Indicated values: ± – standard deviation calculated from three parallel measurements. [a-b] values with different letters inside the graph mean a significant difference between different batches (p <0.05).

Table 6 Study of physical and chemical indicators of delicacies from horse meat.

The amount of brine introduced, %	Physical and chemical indicators	
	pH	moisture, %
10	6.0 ±0.16 [a]	45.9 ±0.24 [a]
20	6.12 ±0.19 [b]	48.5 ±0.29 [b]
30	6.23 ±0.07 [c]	50.5 ±0.36 [b]
Control	6.33 ±0.13 [d]	50.8 ±0.44 [b]

Note: Indicated values: ± – standard deviation calculated from three parallel measurements. [a-d] values with different letters inside the graph mean a significant difference between different batches (p <0.05).

Table 7 Study of physical and chemical indicators of delicacies from pork meat

The amount of brine introduced, %	Physical and chemical indicators	
	pH	moisture, %
10	6.13 ±0.06 [a]	45.8 ±0.73 [a]
20	6.16 ±0.19 [a]	47.7 ±0.58 [b]
30	6.24 ±0.10 [b]	50.6 ±0.41 [c]
Control	6.37 ±0.18 [c]	50.7 ±0.62 [c]

Note: Indicated values: ± – standard deviation calculated from three parallel measurements. [a-c] values with different letters inside the graph mean a significant difference between different batches (p <0.05).

From the data in tables 5, 6 and 7, it is clear that the pH and moisture content of delicacies made from beef, horse meat, and pork are closer to the content of control samples. This proves that brine from sprouted grains can be expediently used when introduced in an amount of 30% by weight of the products since the use of 30% brine allows you to maintain not only the cost-effectiveness of using the main raw materials but also the technological indicators of the raw materials at a fairly high level. Next, deli meats with 30% brine were studied.

Now, we focus on why the method of syringing was chosen out of all the methods available in the food industry for salting meat. According to the classical theory of cooking meat delicacies, the salting method is chosen based on what kind of finished product you need **[45]**. So, for example, for raw-dried delicatessen products, the dry method will be the optimal acceptable salting method. For such delicacies as carbonate, brisket, balyk, loin, and other similar products, it is necessary to choose a wet or salting method associated with syringing **[46]**.

In essence, syringing is also a wet method of salting since a solution of substances is used, but the method of bringing the solution to the meat product is different. If during the wet method of salting, the product is dipped in brine, then when syringing into lump meat, namely deep into the muscle tissue, a specially prepared brine is injected with a part of the production raw materials, salt and spices, after which it is subjected to heat treatment. This method of making meat delicacies improves the structure, consistency, and nutritional value of delicatessen products **[47]**. At the same time, as noted in the specialized literature in the food industry **[48]**, with this method of salting meat products, the consumption of brine, compared with the wet method of salting, is reduced by 70%, and in some cases, it can reach up to 80-90%.

Special importance is given to the viscosity of minced meat in manufacturing meat delicacies and studying their nutritional properties. The viscosity of minced meat is one of the most important indicators that characterize the quality and determine the readiness of minced meat **[49]**. Continuous viscosity monitoring allows for obtaining constant information about the course of the massaging process **[50]**, adjusting the amount of water introduced depending on the thermodynamic parameters of the raw material, and automating the technological process **[51]**.

Mechanical processing- massaging of salted raw materials – is chosen to speed up the salting process. Massaging was performed on an installation developed in the laboratory at 15-20 rpm at a temperature of 0-4 °C and 90% vacuum **[52]**. That is, from a technological point of view, a mechanical method-massaging was added to the chemical method of improving the properties of meat (syringing with a solution) **[53]**.

The viscosity of horse meat, beef, and pork was studied during massaging on the TMS-PRO structure analyzer (USA) (Figure 4). During the study, 6 variants of meat delicacies were obtained from horse, pork, and beef with the addition of experimental and control brines. 1 experience – horse meat with experimental brine, 2 experience – horse meat with control brine, 3 experience – beef meat with experimental brine, 4 experience – beef meat with control brine, 5 experience – pork meat with experimental brine, and 6 experience – pork meat with control brine (Figure 8).

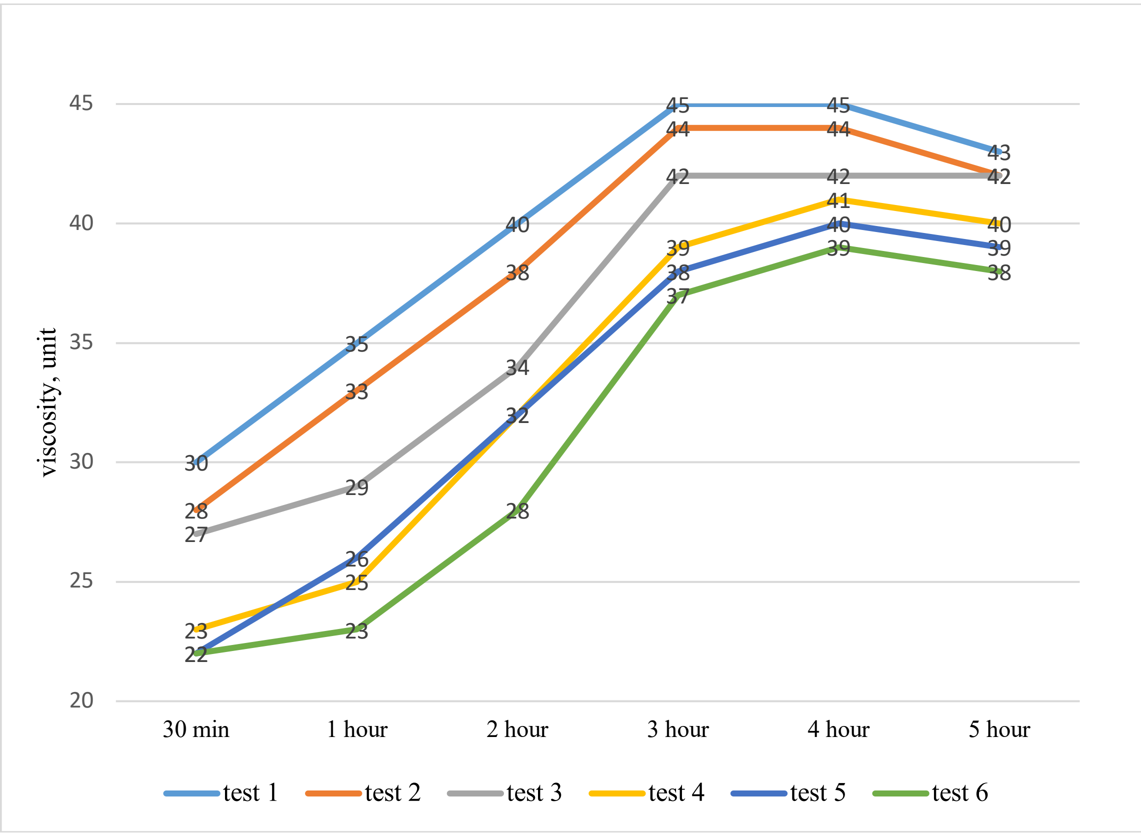

Figure 8 The dependence of the viscosity of meat on the duration of grinding.

Research found that with the duration of massaging 2-3 hours, the viscosity of meat products was 40.0-45.0 units, and further processing leads to a decrease in viscosity.

Tables 8, 9 and 10 show the control organoleptic indicators of meat products (by aroma, consistency, and taste) after the solution was introduced.

Table 8 Control organoleptic indicators of ready-made beef meat delicacies.

Name of the indicator	Name of the raw material for the product	
	Control sample	With the addition of a solution
Appearance	The surface is clean, dry, without shades	
Surface color	Dark red, light pink on the cut	Dark red, light pink on the cut with a slight shade of yellow
Smell	Pronounced meat, with a smoked aroma, with a hint of spices	Pronounced meat, with a smoked aroma, with a hint of spices and a fresh smell
Consistency	Elastic, without foreign inclusions	
Taste	Pleasant meat, slightly spicy, moderately salty, without an extraneous taste characteristic of this type of product	Pleasant meat, slightly spicy, moderately salty with a characteristic pleasant organic taste

The organoleptic characteristics of beef delicacies showed that the appearance of the control and test samples was clean, dry, and without shades. The surface color of the control sample is dark red, and light pink on the cut surface, the surface color of the test sample is dark red, and light pink on the cut surface with a slight tint of yellow. The smell of both samples: pronounced meaty, with a smoked aroma, with notes of spices; the sample under study has a fresh smell. The consistency of both samples is the same: elastic, without foreign inclusions. The sample's taste differs from a characteristic pleasant organic taste.

Table 9 Control organoleptic indicators of ready-made pork meat delicacies.

Name of the indicator	Name of the raw material for the product	
	Control sample	With the addition of a solution
Appearance	The surface is clean, dry, without shades	
Surface color	Pink, light pink on the cut	Pink, light pink on the cut with a slight shade of yellowness
Smell	Pronounced meat, with a smoked aroma, with a hint of spices	Pronounced meat, with a smoked aroma, with a hint of spices and a fresh smell
Consistency	Elastic, without foreign inclusions	
Taste	Pleasant meat, slightly spicy, moderately salty, without an extraneous taste characteristic of this type of product	Pleasant meat, slightly spicy, moderately salty with a characteristic pleasant organic taste

Organoleptic characteristics of pork delicacies showed that the appearance of the control and test samples was clean, dry, and without shades. The surface color of the test sample differs from the control sample with a slight tint of yellowness. The smell of both samples: pronounced meaty, with a smoked aroma, with notes of spices; the sample under study has a fresh smell. The consistency of both samples is the same: elastic, without foreign inclusions. The taste of the test sample differs from the control sample with a characteristic pleasant organic taste.

Organoleptic indicators of horse meat delicacies showed that the appearance of both samples was clean, dry, and without shades. The surface color of the control sample is dark brown, with dark red on the cut; the surface color of the test sample is dark brown, with dark red on the cut with a slight tint of yellow. The smell of both samples: pronounced meaty, with a smoked aroma, with notes of spices; the sample under study has a fresh smell. The consistency of both samples is the same: elastic, without foreign inclusions. The control sample has a pleasant taste, slightly spicy, moderately salty, without any foreign aftertaste characteristic of this type of product; the test sample has a pleasant taste, slightly spicy, moderately salty, with a pleasant organic taste.

Table 10 Control organoleptic indicators of ready-made meat delicacies from horse meat.

Name of the indicator	Name of the raw material for the product	
	Control sample	With the addition of a solution
Appearance	The surface is clean, dry, without shades	
Surface color	Dark brown, dark red on the cut	Dark brown, dark red on the cut with a slight shade of yellow
Smell	Pronounced meat, with a smoked aroma, with a hint of spices	Pronounced meat, with a smoked aroma, with a hint of spices and a fresh smell
Consistency	Elastic, without foreign inclusions	
Taste	Pleasant meat, slightly spicy, moderately salty, without an extraneous taste characteristic of this type of product	Pleasant meat, slightly spicy, moderately salty with a characteristic pleasant organic taste

The organoleptic indicators of the finished product using brine based on sprouted grain practically do not differ from similar indicators of finished meat products in which brine was not used.

Also, in the study to clarify the nature of the production process and the feasibility of using ready-made brine a number of thermodynamic indicators was analyzed: water activity, the moisture binding energy of horse meat, beef and pork for production of meat delicatessen products on the Testo 650 (Germany) and on the installation developed by academicians Rogov and Chomanov (Figure 9 and 10).

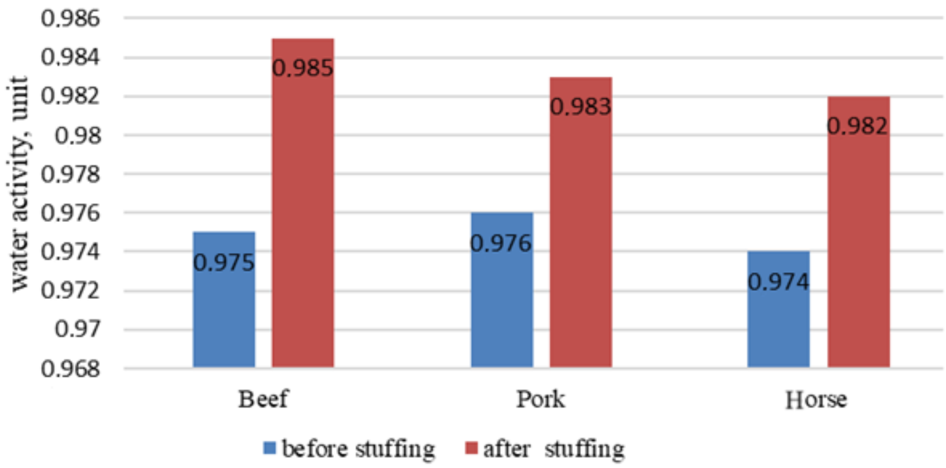

Figure 9 Water activity of horse meat, beef and pork.

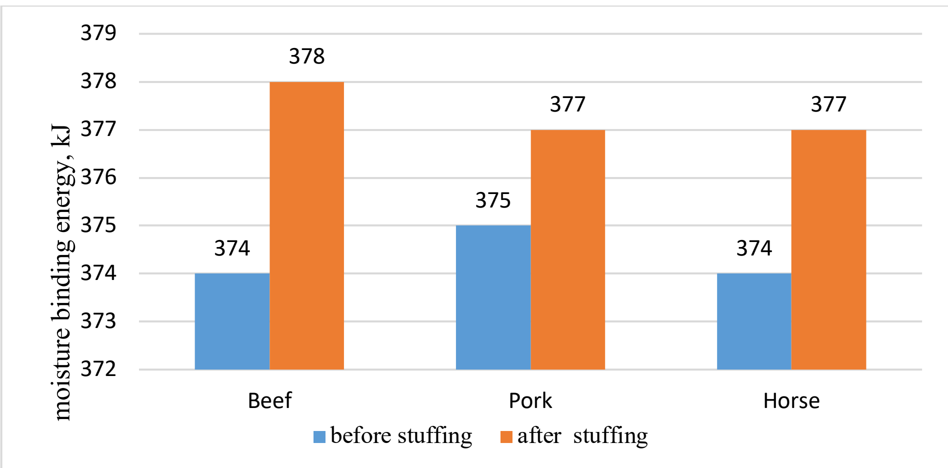

Figure 10 Moisture binding energy of horse meat, beef and pork.

The need for water control in production processes is due to the fact that controlling the water activity in beef, horse meat, and pork allows for maintaining the optimal structure, texture, stability of the products, density, and hydration properties. Studies have found that after syringing, the activity of water and energy value in various meat products increase (Table 11).

Table 11 Dynamics of the increase in energy value indicators in meat products after syringing with a special brine based on sprouted grains.

Name of the indicator	Name of the meat product		
	beef	pork	horse meat
Water activity (unit fraction)	0.975 to 0.985	0.976 to 0.983	0.973 to 0.981
Energy value (kJ)	374 -378	375-377	374-377

The increase in meat tenderness and water-binding ability is due to the fact that when brine is introduced into meat by syringing, muscle fibers break.

The use of brine from sprouted grains will not affect the taste preferences of delicacies consumers but will make their diet more useful in terms of obtaining additional nutrients. It is also assumed that the new products will interest adherents of a healthy diet.

During germination, the calorie content of the grain decreases, and the nutrients become easier for humans to absorb. In sprouted grains, starch is modified into dextrins and maltose, protein into easily digestible amino acids, and vitamins C, B6, B2, B6, E, and carotene are formed. Mineral substances and dietary fiber (fiber, hemicellulose, pectin, lignin) are preserved, concentrated mainly in the fruit and seed shells of the grain, which practically do not undergo qualitative changes during germination **[54]**. Sprouted grains are high in protein, vitamins and minerals, making them valuable to the product's nutritional value. The use of sprouted grains for delicacy meat products allows you to increase the economic performance of production by reducing the cost of raw materials and increasing the profitability of production: make the most efficient use of raw meat, reduce weight loss of finished products after technological processing, increase production volume and expand the range of high-quality food products. Therefore, using brine from sprouted grains reduces the cost of production and improves the organoleptic and physicochemical characteristics of deli meats.

CONCLUSION

The viscosity of horse meat, beef, and pork during massaging was determined, and the following thermodynamic parameters were also studied: water activity and moisture binding energy of horse meat, beef, and pork using a new brine. Studies have found that the tenderness of finished products increases with increased water activity and the binding energy of moisture with the substance. After massaging, the indicators of thermodynamic characteristics increased by 8-10% compared to the control. The data obtained shows that the maximum amount of brine in horse meat is kept at 160 minutes of continuous massaging, beef at 130 minutes, and pork at 120 minutes of mechanical processing. The results showed that the “aw” index and moisture binding energy in the experimental samples of meat products were higher than in the control samples. As a result, it was found that with increased water activity and moisture binding energy, the tenderness of finished gourmet meat products using the new brine increases. The developed recipe and technology for the production of May delicacies from horse meat, pork, and beef using brine from sprouted wheat grains is new and relevant for the social nutrition of various consumer groups, as it allows the production of food products with specified functional properties for the healthy nutrition of the population.

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