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RESEARCH OF THE IMPACT OF A VEGETABLE PROTEIN COMPOSITION ON THE FUNCTIONAL AND TECHNOLOGICAL PROPERTIES OF NATIONAL MEAT PRODUCTS

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Abstract– The purpose of this research was to study the impact of a vegetableprotein composition on the functional and technological properties of national meat products. The paper showed the modern ways to improve the quality and nutritional value of meat products, including national meat products. The experiment used meat products from horse beef, beef, camel meat, mutton and a hydrated vegetable protein composition. Meat raw materials were filled with the hydrated vegetable protein composition with a different ratio of ingredients. To determine the rational amount of added protein and dietary fibers in meat products, the following values were studied on the test samples: pH value, moisture content, water-binding and water retention capacities, yield shear stress, mass loss during the heat treatment, shear stress and shear force. As a result of the research, an optimum ratio of the ingredients of the vegetable protein composition was determined. It has been found that meat raw materials with the vegetable protein composition have better functional characteristics than control samples.

INTRODUCTION

The food industry is an important sector for any economy as far as food production has a direct impact on the economic and food security of the state. The solution of the national food problem consists in the development of new food products, including those of meat. The addition of functional ingredients is the next step to improve the diet of modern man.

One of the methods to correct the chemical composition of meat products is to use systems with vegetable additives, different in their biochemical composition and, consequently, in their nutritional and biological value, and expedient, especially in terms of improving the functionality of new products. From this perspective, the technology development of new meat food products is a task that has not only a scientific and ecological value, but also a social importance.

Leading scientists of the meat industry in Kazakhstan and the CIS are working to improve this technology and to expand the range of meat products with a high biological value and preventive role, high consumer properties and extended shelf life, with the purpose of saving primary meat raw materials, increasing yield and reducing its cost (Abzhanova, *et al.*, 2012; Kizatova, *et al.*, 2012; Ìukhtarkhanova, *et al.*, ……….???). Their works are basically devoted to the production of various kinds of sausages, with the addition of raw materials of plant origin to their composition. This project suggests the establishment of a national meat product of a new generation with a high nutritional and biological value based on vegetable raw materials.

AN IMPORTANT PROBLEM OF THE MEAT FOOD INDUSTRY

The improvement of the existing kinds of national meat products and the creation of new types is one

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of the important problems of the meat food industry. This is due to the insufficient provision of the population with vital nutrients, including minerals, vitamins, amino acids, polyunsaturated fatty acids, dietary fibers, etc. In addition, it becomes important to study the functional properties of vegetable raw materials and their use in food products of a new generation.

In this regard, it is also planned to create national meat products of a new generation using the vegetable raw materials enriched with biologically active substances, which balance the amino and fatty acid composition of meat products and enhance their nutritional value.

The main raw materials of the meat industry are cattle, pigs, sheep, goats, poultry, horses and camels. Their quality depends on several factors, mainly breed, sex, age, feeding and housing conditions, methods and conditions of transportation and pre-slaughter preparation. The value of cattle is characterized, first of all, by high nutritional properties of the manufactured products - meat and meat by-products.

Lamb, mutton

Taste and nutritional value of lamb is exceptionally high. Mutton has as much protein, essential amino acids and minerals as beef and even more calories (beef – 1838 kcal per kg, mutton – 2256 kcal per kg). A distinctive feature of mutton is that its fat contains a relatively small amount of cholesterol. Some scientists believe (Zhuravskaya *et al.,* 1985; Uzakov, 2006; Tutelian, 2005; Dessislava, 2014) that it is due to the enhanced consumption of mutton that atherosclerosis is less widespread in those nations whose traditional occupation is sheep breeding. It was also proved that the consumption of mutton increases the resistance of dental enamel to caries, and serves to some extent as a preventive medicine against diabetes, age-related changes and other ailments (Skurikhina, *et al.*, 1998; Raes, *et al.,* 2004).

Horsemeat

Horsemeat is a nutritious product, rich in calories, which is widely used in the food industry. It has a high protein content (from 18 to 25%), and much less fat. Proteins of muscle tissue have a complete set of essential amino acids in a favorable ratio. Horse fat is similar in its properties to low melting poultry fat and vegetable oils. This is explained by its nutritionally valuable unsaturated fatty acids. Basically, horsemeat provides biologically important B vitamins, essential to the human body. Horse beef is also a source of vitally important microelements such as sodium, magnesium and chlorine, which are involved in creating the necessary buffering blood, blood pressure regulation, nervous, and muscular tissue function, formation and activation of the digestive enzymes. Horsemeat contains more organic acids such as lactic, aconitic, citric and succinic acid than beef. Almost all of the vitamins and minerals containing in meat are more easily digestible than those in the products of plant origin. The use of horsemeat, rich in essential vitamins and mineral elements, improves metabolism in patients suffering from obesity, atherosclerosis, hypertension, and the diseases of heart, liver and pancreas.

Camels

In the national economy of many countries, camels are used not only as draft animals but also as a raw material for the meat industry. Therefore, considerable attention is paid to the study of the biological characteristics of these animals and their meat productivity both in Kazakhstan and abroad.

Currently, only such a camel meat product as cooked sausages has become traditional, i.e. camel meat is not widely used in the meat processing industry. Therefore, there is a need to further study camel meat and its subsequent use in the production of meat products. Camel meat, being a unique medical, preventive and dietetic food product, can become one of the main revenue sources for the population of the southwestern Kazakhstan, engaged in the development of camel meat.

Beef

Beef is one of the oldest types of domestic meat. It is the meat from a cow, while the meat of young cattle - veal – is often considered a separate meat type due to its distinctive qualities (Hur, *et al.,* 2004).

The use of vegetable raw materials

An analysis of the theoretical background shows the modern ways to improve the quality and nutritional value of meat products, including national meat products. One of the perspective directions is the use of vegetable raw materials. Undoubtedly, an important role in the creation of healthy food products is played by vegetable raw materials, including grains and fruits. Due to the diversity of valuable micronutrients and functional ingredients regulating numerous body's reactions (dietary fibers, carotenoids, vitamins, polyunsaturated fatty acids, phospholipids, flavonoids, organic acids, probiotics, minerals), they are of exceptional interest for a healthy diet, being a valuable raw source for the creation of natural and high-quality food products (Heijnen, *et al.*, 2001).

An analysis of the domestic and foreign literature of recent years has shown that the use of natural biologically active substances in the form of natural vegetable components can provide a wide range of their food, medical and preventive application (Uzakov, *et al.*, 2013). Dry extracts of plants and berries are the most promising among the variety of ingredients considered. Products with these extracts stimulate metabolism, improve efficiency, strengthen the body's natural antioxidant mechanisms and enhance its activity, and have a beneficial effect on health (Lopez-Sebastian, *et al.*, 1998).

METHODS FOR IMPROVING THE QUALITY OF FOOD PRODUCTS

The nutritional value of meat products produced by traditional technologies often does not meet modern requirements of nutritional science: the proper balance of protein and carbohydrates is not maintained. Therefore, the addition of components to the composition of meat products, giving them medical and preventive properties, will solve the problem of nutritional deficiency.

In the modern food industry, there are various methods for improving the quality of food products and preventing their spoilage. The most cost-effective method, which is easy to implement, is the use of food additives. However, not all of them used in food products are safe for the human body. In this regard, special emphasis is currently placed on the creation of complex biologically active dietary supplements of natural origin, which not only improve the quality characteristics of the product, but also have a positive impact on human health.

In the technology of meat products, there is a steady trend towards the use of natural raw materials.

Soy Protein Products

Soy protein products are essential ingredients. They are used in the production of cooked sausages, sausages, frankfurters, meat loaves, semi-smoked, boiled-smoked and uncooked smoked sausages, various kinds of hams, pate, brawn, whole muscle beef products, pork, poultry, canned meat and chopped semi-finished products.

The use of soy protein products is the most popular way to improve the quality of minced meat products. There are two methods of adding protein: in the form of gel - with a preliminary hydration in the cutter; and in the dry form – added to the vegetable product in the initial stage of cutting.

These circumstances gave rise to the research of the development of vegetable protein compositions and their use in the production of national meat products.

One of the ingredients that improve the structure of meat products is processed soybean grain. Soybean grain is rich in complete proteins, which have as much biological and nutritional value as animal proteins, lipids containing unsaturated and high-saturated fatty acids, carbohydrates and a number of vitamins in the absence of cholesterol. Soybeans and soy products are perfectly balanced in calories and a nutrient level. They are almost completely absorbed by the human body. In addition, numerous scientific studies prove the preventive properties of soy products and their ability to suppress the development of various diseases (D'Souza *et al.*, 2004; Gatellier *et al.*, 2004).

The use of processed soybean products in both traditional and preventive nutrition is widespread in many countries, including the United States, Canada, some EU countries, Japan, China, and Korea.

The prospect of the use of soy as a vegetable protein can be explained by several factors. Firstly, economically developed countries have been successfully producing such protein products of soybean oil meal as isolates, texturates and concentrates. Secondly, soybean seeds are a unique high-protein source among the large variety of possible raw materials of a vegetable protein. Thirdly, the experience in the production of the food forms of soybean seeds and processed soybeans has shown that its seeds provide a diverse range of protein products that are directly used in human nutrition. Fourthly, soy proteins are characterized by one of the highest biological value among vegetable sources. Fifthly, soy proteins along with other vegetable proteins have a clinically and experimentally proven cholesterol-lowering effect.

Quality of soy protein

Today, much attention is paid to animal food because people have a tendency to connect their improved welfare with the increasing consumption of animal products. However, the World Health Organization is against this trend. The United States, having much animal protein, worry about getting it in sufficient quantities, but a new trend to eat more plant food made some people to think about protein deficiency. Despite the fact that animal food products are rich in protein, many plants also contain it in large quantities, especially soybean grain.

Another key factor in the quality of protein is the degree of assimilation. Protein being split into amino acids is absorbed by the human body. Although proteins differ in the degree of assimilation, this does not play an important role in determining their quality, because almost all of them are assimilated quite well. Protein extracted from plant food is absorbed by 85%, and from products based on refined cereals and meat – by 95%.

Thus, the quality of soy protein is determined by two factors: assimilation and a set of essential amino acids. Most soy products are easily absorbed: tofu, for example – by 92%, soyprotein isolate - by 95%, soybean meal - by 85-90%. This can explain the fact that soy products are widely used by many people who need a protein contained in soy.

The second factor of the quality of soy protein – the completion of the set of amino acids – can be challenged as the number of essential amino acids is still under consideration, and scientists cannot reach a consensus (Laemmli *et al.*, 1970; Jaswir *et al.*, 2000).

Soy is not only a rich source of protein. It also contains other nutrients such as calcium, iron, zinc, and many B vitamins. Soy products are also high in fiber. Despite being considerably different from each other in the substance content, all soy products constitute a nutrient complex.

Medical and preventive characteristics of soy protein

While determining the nutritional value of soy and soybean products, we should also take into account their medical and preventive characteristics. These food products are known to be called nutraceuticals and are in high demand among the population. Sociological studies conducted in many western countries show that a growing number of customers believe in the positive role of nutraceuticals, thinking that certain food products can eliminate or reduce people's dependence on medications (Strategic Analysis of US Neutraceuticals, 2004; Kolar Majda, *et al.*, 2009).

Oat is also widely used due to its rich composition and medical properties. Oat grains contain up to 60% of starch, 5-8% of fat, a lot of protein - 10-18% (second only to buckwheat), rich in such essential amino acids as tryptophan and lysine. Oat also contains essential oils, natural gums, a variety of vitamins B1, B2, B6, carotene, vitamin K, nicotinic and pantothenic acids. Oat is also a source of potassium, magnesium, phosphorus, iron, chromium, manganese, zinc, nickel, fluorine and iodine. Oat groats are rich in sulfur.

Oat is distinguished by an optimum ratio of carbohydrates, proteins, fats and vitamin B complex (40% of starch, 11-18% of protein and 4-6.5% of fat).

Oat has a tonic effect for the whole body. It contains a large group of vitamins and minerals:

1. vitamins B, A, K, copper, selenium, silicon, iron, zinc and fluorine;
2. vitamins A, E which are useful for beauty, hair and nail growth, skin elasticity;
3. vitamins B, F which contribute to the proper functioning of the nervous system, have a beneficial effect on the gastrointestinal tract and convert complex carbohydrates to glucose.

Oat reduces the blood sugar level that is why it is recommended for those who suffer from diabetes.

The useful property of oat is that it eliminates excess fluid, edema and all of the toxins that the human body generates and stores. From this perspective, oat is recommended for use after the prolonged medical treatment. It also helps to fight against kidney stone disease and reduce cholesterol. Oat has a beneficial effect on the gastrointestinal tract: it soothes and normalizes the entire digestive system. It is also useful for the intestine as it combats constipation. Oat strengthens the nervous system and is helpful for depression. It is also used to enhance immunity and to treat cough. Oat is useful for the liver and thyroid as well. Oat grains contain amino acids, similar in their composition to the muscle protein, useful enzymes and organic compounds.

Currently, one of the perspective directions of food enrichment as shown by patent and information researches is the addition of natural antioxidants that provide the stability of the components during storage and ensure the functional features of the product (Dessislava, *et al.*, 2014; Abilmazhinova, *et al.*, 2015).

In recent years, Lycium barbarum (L. barbarum) or Chinese wolfberry is of particular interest as a natural antioxidant. Currently known as the goji berry, it is a kind of woody plants of the genus Lycium (Solanaceae), grown in China, Tibet and other parts of Asia. It produces bright orange-red, ellipsoid berries 1–2-cm deep. Ripe fruit was used in Asian traditional herbal medicine and as a functional product. Lycium concentrated fruit extract was used as an ingredient for the preparation of various alcoholic beverages (UK Food Standards Agency, 2007).

The advantage of goji berries is that they help to slow down the aging process, to restore and preserve eyesight, kidney and liver functions. Recent studies show that L. Barbarum extract and

its active compounds (polysaccharides (LBP) have a biological activity – they delay the aging process, ensure neuroprotection, enhance the metabolic activity, regulate the blood glucose level in patients with diabetes, protect against glaucoma, have antioxidant properties, act as immunomodulators and have the antitumor activity.

In recent years, L. Barbarum fruits are sold as food products and food additives in many countries, including North America, Australia, New Zealand and Southeast Asia.

MATERIALS AND METHODS

Meat and meat products are one of the main products of animal origin in the human diet, an irreplaceable source of fat, complete protein, vitamins, minerals and other vital substances.

The research used a number of physical, chemical, physico-chemical, microbiological and organoleptic methods of analysis.

Determination of moisture content

Moisture content was determined in accordance with GOST 9793-74 by drying of the product sample in the oven at 150°C to constant weight.

Apparatus, reagents and materials

The materials used are mincer, drying oven, laboratory balances, metal weighing bottles, desiccator and glass rods.

Procedure

The sample of the twice-pulverized product, weighing 2.3 g, with an accuracy of 0.001, is dried in a metal weighing bottle with a glass rod in the oven at 150°C for 1 h.

Moisture content is calculated according to the following formula:

$x^1 = (m^1 – m^2)\ 100/(m1- m)$ (1)

where x – moisture content, %;

m^1 - mass of the weighing bottle with the sample before drying, g;

m^2 - mass of the weighing bottle with the sample after drying, g;

m - mass of the weighing bottle, g.

Determination of fat content

Fat content was determined in accordance with GOST 23042-86 by extracting the total fat from meat and meat products.

Apparatus, reagents and materials

General purpose laboratory balance of 2-class accuracy, with maximum weighing limit of 200 g and a permissible weighing error of ± 0.001 g, laboratory drying oven, metal weighing bottles with a diameter of 50 mm and a height of 25-35 mm, desiccator, petroleum or ethyl ester.

Procedure

After determining the moisture content, the dried sample is quantitatively transferred into the weighing bottle and filled with 10-15 mL of solvent (petroleum or ethyl ester). Fat is extracted for 3-4 minutes, 4-5 times repeatedly. During the process, the sample is periodically stirred with a glass rod and the solvent is poured out along with the extracted fat. After the final draining, the solvent residue is evaporated in the air. The weighing bottle with the defatted sample is dried in the oven at 105°C for 10 min.

Fat content is determined by the formula:

$x21 = (m^1 + m^2)\ 100/m0$ (2)

where x^2 – fat content, %;

m^1 - mass of the weighing bottle with the sample after drying and before defatting, g;

m^2 - mass of the weighing bottle with the sample after defatting, g;

m0 - mass of the sample, g.

Determination of ash content

This method is based on the combustion of the organic part of the sample, followed by the calcination of the mineral residue at 500-600°C, which corresponds to a dull red heat of the muffle walls.

Apparatus, reagents and materials

General purpose laboratory balance of 2-class accuracy, with maximum weighing limit of 200 g and a permissible weighing error of ± 0.001 g, porcelain crucibles, water bath, electric stove, muffle furnace, petroleum or ethyl ester, magnesium acetate.

Procedure

After defatting, the content of the weighing bottle is transferred into the weighed and precalcined crucible. The sample residue in the weighing bottle is washed away with a small amount of solvent, which is then removed by heating in a water bath. 1 mL of magnesium acetate is added to the dry defatted sample in the crucible.

The crucible with the sample is carbonized in the electric stove and then placed in the muffle furnace for 30 minutes at 500-600°C. In the same way, 1 mL of magnesium acetate is mineralized.

Ash content is calculated by the formula:

$x^3 = (m^1 – m^2)\ 100/m0$ .. (3)

where x^3 - ash content;

m^1 - mass of ash, g;

m^2 - mass of magnesium oxide obtained after the mineralization of magnesium acetate, g;

m0 - mass of the sample, g.

Determination of protein content

Protein content was determined in accordance with GOST 26889-86. The method is based on the formation of a purple-colored complex as a result of the interaction of the peptide bonds of proteins with cupric copper ions in an alkaline medium.

Apparatus, reagents and materials

Spectrophotometer or photoelectric colorimeter, volumetric flasks with a capacity of 100 cm^3, pipettes of 0.1-5.0 cm^3, measuring cylinders with a capacity of 0.1-5.0 cm^3, potassium sodium tartrate, copper sulfate, potassium iodide, solution of the sodium hydroxide with a molar concentration of 0.2 mol/dm^3, crystalline serum albumin, distilled water, paper filters.

Procedure

4 mL of biuret reagent is added to 1 mL of the test solution containing 2.10 mg of protein, and is stirred and held at room temperature for 30 min. The absorbance of the solution is measured by a spectrophotometer or photoelectric colorimeter at a wavelength of 540 nm. The amount of protein in the solutions is determined from the calibration graph, which is built on the standard solution of serum albumin, containing 10 mg of protein in 1 mL. When constructing the calibration graph, the same conditions should be observed as when determining the protein content in the test solutions.

Determination of water-binding capacity

The method is based on the exudation of water from the test sample under light pressing, the sorption of the exuded water by filter paper and the determination of moisture amount by the size area of a spot on the filter paper.

Apparatus, reagents and materials

Torsion balance, ashless filters, glass or plexiglass plates, planimeter.

Procedure

The sample of ground beef (0.3 g) is weighed on a torsion balance on a polyethylene circle, 15-20 mm in diameter. After that, it is transferred onto an ashless filter placed on a glass or plexiglass plate so that the sample is under the circle. From above the sample is covered with the same plate as the bottom and put under a load of 1 kg for 10 min. Then the load and the bottom plate are taken away, and the spots around the pressed meat are outlined with a pencil. The external outline emerges when the filter paper is dry. The size of the spots formed by the adsorbed moisture of the pressed meat is measured by planimeter.

The size of the wet spot (external) is calculated from the difference between the total spot area and the spot area formed by meat. The bound moisture content is calculated according to the formulas:

$x^1 = (A\text{-}8,\ 4B)\ 100/m0$ .. (4)

where x^1 - bound moisture content, % to meat;

A - total moisture content of the sample, mg;

B - wet spot area, cm^2;

m0 - mass of the meat sample, mg;

x^2 - bound moisture content, % to total moisture.

$x^2 = (\grave{A}\text{-}8,4B)\ 100/\grave{A}$

Determination of the water retention capacity by the heating method

The method is based on the exudation of water from the test sample of the product by heating.

Apparatus, reagents and materials

Water bath, milk butyrometer, glass rods.

Procedure

The sample of the thoroughly minced meat weighing 4-6 g is evenly placed with a glass rod on the inner surface of the widest part of the milk butyrometer. It is tightly stoppered and its narrow part is put down on a water bath at the boiling temperature for 15 minutes, after which the mass of the released moisture is determined by the number of the butyrometer's scale divisions.

Water retention capacity (WRC) of meat (%) is calculated as follows:

WRC = M – MRC .. (5)

Moisture releasing capacity (MRC) of meat (%) is calculated as follows:

MRC = ànm-1 × 100, .. (6)

where M - total mass of moisture content in the sample, %;

division value of the butyrometer: $\alpha = 0{,}01$ cm^3;

n – number of the scale divisions of the butyrometer;

m – mass of the sample, g.

Determination of viscosity using a digital rotational viscometer (DRV)

The method is based on determining the relative dynamic viscosity with the simultaneous measurement of the temperature of the test sample in digital form.

Apparatus, reagents and materials

Digital rotational viscometer (DRV)

Procedure

The measuring cup with the rotor is filled with the test sample. The cup is placed on the base spot, the rotor is mounted on the gimbal and the thermometer is immersed in the sample, making sure that it does not touch the rotor. After setting the uniform rotation mode and its centering on the digital display, the result of the viscosity measurement is fixed.

Determination of cutoff voltage

Cutoff voltage was measured by a universal testing machine "ST-1" and calculated according to the formula:

.. (7)

where Qavg – cutoff voltage, Pa,

P – shear force, N,

b – cutoff width, b=0,003 m,

r – radius of the product sample, m,

h – height of the product sample, m,

n – number of the samples, loaded into the chamber in a single layer.

Determination of shear force

Shear force was determined by using a Warner-Bratzler device. The test sample was placed in such a way that the fiber direction was perpendicular to the direction of the cutting tool. To calculate this figure the following formula was used:

Wsh = S· Vtr· δ / Vch· π· R2 ·havg ·n, (8)

where Wsh - shear work, J/m^2 ;

Vtr – traverse speed, m/s;

Vch – diagram chart speed, m/s;

S - surface under the stress-strain curve bounded from the left by the vertical line that defines the release of the ten-edged blade through the slots in the bottom of the chamber, N · m.

RESULTS

To determine the rational amount of added protein and dietary fibers in meat products, the following values were studied on the test samples: pH value, moisture content, water-binding capacity (WBC) to the total moisture, yield shear stress (YSS), mass loss during the heat treatment, shear stress and shear force (SF).

In the technology development of combined meat products, it is necessary to take into account the functional and technological properties of each component – water-binding and water retention capacity, moisture absorption speed.

Analysis of the literature shows the modern ways to improve the quality and nutritional value of meat products, including national meat products. The experiment used first-rate trimmed meat from the hip of beef, mutton and horse beef, the chemical composition of which is presented in Table 1.

Analysis of data in Table 1 shows that the main components of meat - water, fat and protein - are dependent on each other. The first-rate trimmed mutton with high fat content (13.60 ± 0.40%) has less

Table 1. Chemical composition of trimmed raw meat

Name of raw meat	Content, %			
	Moisture	Protein	Fat	Ash
First-rate trimmed beef	67.80±0.61	19.00±0.10	12.3±0.71	0.9±0.02
First-rate trimmed mutton	67.50±0.50	17.30±0.65	13.60±0.40	1.2±0.02
First-rate trimmed horse beef	71.50±0.25	19.00±0.15	9.40±0.30	1.1±0.02

water (67.50 ± 0.50%), less protein (17.30 ± 0.65%), whereas the first-rate trimmed horse beef contains more moisture (71.50 ± 0.25%), more protein (19.00 ± 0.15%) and less fat (9.4 ± 0.30%).

One of the promising areas is the use of vegetable raw materials. Undoubtedly, an important role in the creation of healthy food products belongs to vegetable raw materials, including crops and berries. Due to the diversity of wholesome micronutrients and functional ingredients in their composition (dietary fibers, carotenoids, vitamins, polyunsaturated fatty acids, phospholipids, flavonoids, organic acids, prebiotics, minerals), they are able to regulate numerous body reactions, and are of exceptional interest for a healthy diet and a valuable source of raw materials to create natural and high-quality food products.

To study the impact of a vegetable protein composition on the functional and technological properties of national meat products, the water-binding, water-retaining and fat-retaining capacities were studied.

The test samples were meat products from horse beef, beef, camel meat, mutton and a hydrated vegetable protein composition. Meat raw materials were filled with the hydrated vegetable protein composition with a different ratio of ingredients. The data obtained in the study of the functional and technological properties are presented in Table 2.

It has been found that meat raw materials with a vegetable protein composition have excellent functional characteristics that are superior to similar indicators of control samples. This shows that it is possible to obtain the formula of national meat products with high functional and technological properties.

Post-mortem changes in muscle tissue hydration are important in the technology of meat products, as

Table 2. Main functional and technological properties of meat raw materials with different levels of the vegetable protein composition

Name of samples	Indicators, %			
	Moisture content	Water-binding capacity	Water retention capacity	Fat-retaining capacity
Control	65.4 ±1.2	63.5 ±0.8	48.5±1.8	52.4±0.9
Beef with a vegetable protein composition (in the ration 2:1:0,5)	72.4 ±1.1	64.7±1.2	63.4±0.6	55.2±1.1
Beef with a vegetable protein composition (in the ration 2:1:0,75)	73.2±1.4	64.2±1.1	64.3±1.2	55.3±1.2
Beef with a vegetable protein composition (in the ration 2:1:1)	74.2±1.2	65.1±0.9	65.8±0.8	56.1±1.3
Control	69.5 ±1.2	64.5 ±0.8	46.5±1.8	50.4±0.9
Mutton with a vegetable protein composition (in the ration 2:1:0,5)	70.2 ±1.1	65.7±1.2	65.4±0.6	49.2±1.1
Mutton with a vegetable protein composition (in the ration 2:1:0,75)	72.5±1.4	66.1±1.1	66.3±1.2	56.2±1.2
Mutton with a vegetable protein composition (in the ration 2:1:1)	73.3±1.2	67.1±0.9	66.7±0.8	57.1±1.3
Control	71.5 ±1.2	66.1 ±0.8	65.7±1.8	52.2±0.9
Horse beef with a vegetable protein composition (in the ration 2:1:0,5)	72.4 ±1.1	66.9±1.2	66.4±0.6	53.1±1.1
Horse beef with a vegetable protein composition (in the ration 2:1:0,75)	73.5±1.4	64.2±1.1	66.9±1.2	54.3±1.2
Horse beef with a vegetable protein composition (in the ration 2:1:1)	74.1±1.2	65.1±0.9	67.1±0.8	55.2±1.3
Control	70.1 ±1.2	66.5 ±0.8	60.5±1.8	54.1±0.9
Camel meat with a vegetable protein composition (in the ration 2:1:0,5)	71.2 ±1.1	67.1±1.2	61.2±0.6	55.2±1.1
Camel meat with a vegetable protein composition (in the ration 2:1:0,75)	72.3±1.4	67.9±1.1	62.3±1.2	55.1±1.2
Camel meat with a vegetable protein composition (in the ration 2:1:1)	73.5±1.2	68.1±0.9	64.5±0.8	55.6±1.3

they have an impact on the mechanical properties of the meat. The dynamics of the process is consistent with the data on the solubility of proteins, which play an important role in tissue hydration. Biochemical metamorphosis during meat ripening in the protein system leads to the transformation of the structural and mechanical parameters that characterize meat tenderness.

The investigation of the structural and mechanical characteristics of raw materials and products of the meat industry is necessary for optimizing the technological processes and individual operations, and for controlling the compliance of raw material parameters with the accepted requirements at all stages of processing, which ultimately determines the quality of meat products.

Table 3 shows the changes in the indicators of water-binding capacity and the structural and mechanical properties of the muscle tissue of horse beef, beef and camel meat in the process of autolysis.

Summarized data in Table 3 show the dominant influence of the nature and depth of the autolytic processes on the mechanical properties of a horse muscle tissue and their dependence on the structure. Due to the peculiarities of the autolytic processes, horse beef, camel meat, beef, and strength indicators have different values depending on the duration.

WBC of camel meat during the autolysis is reduced and has a minimum value (53.25±0.47) in 72 hours. Then according to the progression of death stiffening, the meat begins to increase, which is consistent with the data on the solubility of myofibrillar proteins that play a role in animal tissue hydration.

DISCUSSION

A promising direction in the production of national meat products is the use of meat and vegetable raw materials, the compositions of the raw materials of vegetable origin, as well as the physical processing methods. They accelerate the biochemical processes in muscle tissue, reduce the duration of salting and ripening, enhance the quality and flavor indicators of production.

The development of such products will solve a number of existing problems of the meat industry:

- to fill the domestic market with a wide range of national meat products of domestic production;
- to improve the efficiency of existing enterprises;
- to improve the quality and competitiveness of products;
- to provide the possibility to save meat raw materials, while not degrading the quality of the product.

Production of high-quality national meat products is a complex task. Its solution depends on the improvement of the complex and non-waste processing technology of agricultural raw materials, further automation and mechanization of agriculture and processing industries, reducing of raw material, energy and labor costs, an increase in labor and production discipline and professional development of personnel.

It should be taken into account that the share of imports exceeds the limit of economic independence in both the structure of food products sold in the domestic food market, and the raw material structure processed by the domestic food industry, including the meat industry. A complex solution of

Table 3. Dynamics of changes in WBC and the structural and mechanical properties of the muscle tissue of horse beef, beef and camel meat in the process of autolysis

Indicators	Duration of autolysis, h					
	0	24	48	72	96	120
Horse beef						
WBC, %	66.1+-0.5	53.5+-0.6	52.8+-0.4	52.7+-0.3	55.1+-0.5	56.3+-0.6
SF, N/m	18+-0.3	18.6+-0.2	19.4+-0.3	20.6+-0.7	18+-0.2	16.9+-0.4
YSS, kPa	27.6+-0.2	28.1+-0.2	28.6+-0.3	29.4+-0.4	28.2+-0.3	27.7+-0.2
Camel meat						
WBC, %	66.8±0.6	54.1±0.7	53.4±0.5	53.2±0.4	55.7±0.6	56.9±0.7
SF, N/m	18.2±0.4	18.8±0.3	19.6±0.4	20.8±0.8	18.2±0.3	17.1±0.5
YSS, kPa	27.9±0.2	28.4±0.2	28.9±0.3	29.7±0.4	28.5±0.3	28.0±0.2
Beef						
WBC, %	65.1+-0.5	53.8+-0.6	53.2+-0.4	52.9+-0.3	55.2+-0.5	55.9+-0.6
SF, N/m	17.8+-0.3	18.5+-0.2	19.5+-0.3	20.5+-0.7	18.1+-0.2	16.8+-0.4
YSS, kPa	27.4+-0.2	28.2+-0.2	28.5+-0.3	29.1+-0.4	27.9+-0.3	27.5+-0.2

a wide range of tasks associated with import substitution and the improvement of the technology of meat products with the addition of vegetable ingredients is of great importance.

CONCLUSION

The study provides a list and a brief description of the research methods of meat and vegetable raw materials, finished meat products and the preparation of national meat products in accordance with the relevant legal and technical documents used to conduct the experimental part of this research. In particular, it considers special methods of determining the parameters characterizing the nutritional value of raw materials and finished products.

As a result of the research of the water-binding and water-retaining capacities of the vegetable protein composition as well as the speed of water absorption, an optimum ratio of the ingredients of the vegetable protein composition is determined. The impact of the vegetable protein composition on the functional and technological properties of national meat products is studied.

The conducted theoretical and experimental research shows that after the addition of the vegetable protein composition to the product contents, when hydrated in the ratio 1:5, the mass fraction of moisture and protein is increased in the test sample as compared to the control sample, and the fat content is reduced along with the energy value of the product.

On the basis of this study, it can be argued that horse beef, mutton, camel meat and beef can be used as a meat raw material in the production of high-quality meat products of a new generation.

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