UDC 637.334; 637.518; 664.38

EVALUATION OF THE USE OF MILK PROTEINS IN SAUSAGE PRODUCTION, IN PARTICULAR FOR THE FORMATION OF TEXTURED PROTEIN STRUCTURES

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https://doi.org/10.31073/foodresources2025-24-13

Subject. *The use of dairy components, in particular whey protein concentrates, in the composition of minced meat products, as well as textured protein products from dairy raw materials.* ***Purpose.*** *To study the effect of whey protein concentrates on the properties of sausage products, and also to evaluate the possibility and feasibility of using textured protein products from dairy raw materials in the formulations of these products.* ***Methods.*** *The objects of the study were samples of cooked sausages made with or without the use of whey protein concentrate. The following parameters were determined during the study: pH – by potentiometric method; protein content – by the Kjeldahl method; fat content – by the Soxhlet method; dry matter content – by drying the sample to constant weight at a temperature of 105ºC; lactose content – by the iodometric method; calcium content – by a method based on the precipitation of calcium with ammonium oxalate; water-binding capacity – by the pressing method; weakly bound water content – by the amount of pressed liquid; swelling – by measuring the product volume after mixing with water and swelling for 24 hours; hydration level – by the amount of bound water; gelling capacity – by the quality of the mass obtained by heating the hydrated product to 72ºC and subsequent cooling. Other known methods were also used.* ***Results.*** *Whey protein concentrates with a protein content of 34% and 70% were studied. The concentrate with a protein content of 70%, which was used for adding to sausage mince, proved to be more acceptable from a technological point of view. The studies of its functional and technological parameters gave the following results: pH of 1% solution – 5.26; water-binding capacity – 50%; fat-retaining capacity – 230%; solubility – 85%; emulsifying capacity – 90%; swelling capacity – 15%. The studied whey protein concentrate is characterized by good solubility, fat-retaining and emulsifying capacity, weak swelling capacity, and low water-binding capacity. The use of 5% whey proteins in the meat system instead of the same amount of meat raw materials allows to obtain a finished product with good sensorial indicators (taste, color), increases the content of protein and almost all essential amino acids, calcium, nitropigments, reduces the content of fat and final sodium nitrite. Evaluation of milk protein raw materials from the point of view of use in meat products confirms the feasibility of developing milk textured products and their use in minced meat products.* ***Scope of results.*** *The obtained scientific data can be used to develop technologies for minced meat products using whey protein concentrates and protein textured products.*

Key words: *dairy raw materials, meat products, milk protein, whey protein concentrates, textured protein products*

ОЦІНЮВАННЯ ВИКОРИСТАННЯ МОЛОЧНИХ БІЛКІВ У КОВБАСНОМУ ВИРОБНИЦТВІ, ЗОКРЕМА ДЛЯ ФОРМУВАННЯ ТЕКСТУРОВАНИХ БІЛКОВИХ СТРУКТУР

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***Предмет.** Використання молочних компонентів, зокрема концентратів сироваткових білків молока, у складі м'ясних фаршевих виробів, а також текстурованих білкових продуктів з молочної сировини. **Мета.** Дослідити вплив концентратів сироваткових білків на властивості ковбасних виробів, а також оцінити можливість та доцільність використання у рецептурах зазначених виробів текстурованих білкових продуктів з молочної сировини. **Методи.** Об'єктом досліджень слугували зразки варених ковбас, виготовлених із застосуванням концентрату сироваткових білків, або без такого застосування. Під час проведення досліджень визначали такі показники: pH – потенціометрично; вміст білка – методом К'єльдаля; вміст жиру – за методом Сокслета; вміст сухих речовин – висушуванням наважки до постійної маси за температури 105ºС; вміст лактози – йодометричним методом; вміст кальцію – за методом, базованим на осадженні кальцію оксалатом амонію; вологозв'язувальну здатність – методом пресування; вміст слабко зв'язаної вологи – за кількістю відпресованого соку; набухання – вимірюванням об'єму продукту після змішування з водою та набухання протягом 24 годин; рівень гідратації – за кількістю зв'язаної води; гелеутворювальну здатність – за якістю маси, отриманої при нагріванні гідратованого продукту до 72ºС та подальшому охолодженні. Також використовували інші відомі методи. **Результати.** Досліджували концентрати сироваткових білків молока з вмістом білка 34% та 70%. Прийнятнішим, з технологічної точки зору, показав себе концентрат із вмістом білка 70%, який був використаний для додавання у фарш ковбас. Дослідження його функціонально-технологічних показників дали такі результати: pH 1% розчину – 5,26; вологозв'язувальна здатність – 50%; жироутримувальна здатність – 230%; розчинність – 85%; емульгувальна здатність – 90%; набухання – 15%. Тобто, досліджений концентрат сироваткових білків 2 характеризується прийнятною розчинністю, жироутримувальною та емульгувальною здатністю, слабким набуханням, невеликою вологозв'язувальною здатністю. Використання 5% сироваткових білків у м'ясній системі замість такої ж кількості м'ясної сировини дозволяє отримати готовий продукт з прийнятними органолептичними показниками (смак, колір), збільшує вміст білка та практично всіх незамінних амінокислот, кальцію, нітризопігментів, зменшує вміст жиру та залишкового нітриту натрію. Оцінювання молочної білкової сировини, з точки зору її використання у складі м'ясних продуктів, підтверджує доцільність розробки молочних текстурованих продуктів та їх використання у складі м'ясних фаршевих виробів. **Сфера застосування результатів.** Отримані наукові данні може бути використано для розроблення технологій м'ясних фаршевих продуктів із залученням концентратів сироваткових білків і білкових текстуратів.*

***Ключові слова:** молочна сировина, м'ясні вироби, молочний білок, концентрати сироваткових білків молока, текстуровані білкові продукти*

Introduction. The priority task of specialized specialists and scientists is to ensure the quality of meat and dairy products, as the ability to satisfy consumer needs and meet certain requirements for physical, chemical and sensorial indicators, and the safety of these products for the life and health of consumers [1]. Minced meat products are traditionally popular in Ukraine, which, along with a stable demand in the market, are distinguished by technological acceptability, that is, the ability to combine the composition and use new ingredients without deteriorating the quality and food safety of products [2, 3]. In particular, this applies to functional ingredients, primarily inorganic salts, plant proteins (soy, wheat and pea proteins) and animal proteins (caseinate and albumin) [4].

There is a growing interest in the use of milk proteins in the meat industry, which, unlike plant proteins, can be easily broken down by enzymes in the gastrointestinal tract and form peptides and free amino acids that are quickly absorbed into the blood. Unlike meat proteins, milk proteins do not contain purine bases, the excess of which impairs metabolism in the body. In meat product technology, milk protein preparations (dry milk, sodium caseinate, whey, skim milk) are used both to optimize functional characteristics and to increase the nutritional and biological value of finished products. Dairy products are used both fresh (whole milk, skim milk, cream, curd whey, cheese whey, casein whey) and concentrated (dry whole and skim milk, whey protein concentrates, food milk albumin, food casein, caseins). Most milk protein preparations contain water-soluble proteins (lactalbumins and lactoglobulins), have high water-binding, emulsifying, and foaming capacity. The most common industrial applications are dry whole and skim milk, dry protein concentrate, and sodium caseinate [5, 6].

Milk proteins are very close to muscle tissue in amino acid composition. Having low water-binding capacity, they nevertheless have a positive effect on this indicator due to their unique ability to interact with muscle proteins. In addition, milk whey proteins, due to lactose, have a positive effect on the color formation of meat products [7]. Dry milk is used to produce cooked sausages, frankfurters, wieners, etc., contributing to increased juiciness, improved taste and aroma [3]. However, the quality of dry milk in terms of sensorial, physical, chemical and microbiological indicators is unstable. The addition of dairy ingredients is used to improve the texture and sensory properties of sausages. Dry skim milk is widely used as a neutral filler with a good effect of binding water in minced meat products. However, lactose can lead to a change in the color of meat products, reduce the water-holding capacity, increase hardness and reduce the elasticity of these products [8].

Recently, there have been searches for rational technologies for obtaining milk proteins, including from secondary milk raw materials – whey. A promising direction is the use in concentrated form. Milk protein concentrate is characterized by high nutritional and biological value, high protein content, and the presence of important essential amino acids. In addition, milk proteins have a positive effect on the functional and technological properties of minced meat systems. According to information data, the complex use of meat raw materials and whey proteins of milk allows improving the quality of meat products. Therefore, the issue of using whey proteins as a recipe component of meat products is relevant. In connection with the above, the purpose of the work is to develop recipes and technology for the production of sausages with a partial replacement of meat raw materials with milk concentrate based on the results of studies of the effect of whey protein concentrate on the organoleptic, functional and technological properties of sausages, their nutritional value, which will allow obtaining high-quality products. and also rationally use raw materials [9, 10].

The addition of whey protein concentrate powder, buttermilk powder, and lactose powder to meatball mince improved the physical, chemical, and organoleptic parameters of the product [11]. The use of whole milk powder, skim milk, caseinate, regular whey, and modified whey protein at 2% was used in relation to a chicken fillet meat product. At the 2% (by weight) level, all milk proteins significantly reduced meat loss during cooking compared to the control, with caseinate showing the best results [12-14]. The addition of milk coprecipitate at 7 percent (by weight) to lean pork cutlet mince improved its water and fat binding properties, which increases the yield of the product and its coagulability [15]. Replacing meat protein (2%) with sodium caseinate, milk protein isolate, or whey protein isolate in ground beef had a negative effect on the stability of the emulsions, but contributed to a decrease in losses. Overall, the addition of milk protein resulted in softer, lighter, and less red products compared to meat controls [16].

Scientists are searching for rational technologies for obtaining milk proteins, including from secondary milk raw materials – whey, which has high nutritional and biological value [17]. It contains up to 50% of milk dry matter, complete proteins, finely dispersed milk fat, which affects its digestibility, carbohydrates, water-soluble milk vitamins, up to 50% of fat-soluble vitamins, and minerals. Products obtained from whey have dietary and therapeutic and prophylactic properties. Whey is used in the meat industry to improve the taste of the final product, impart aroma, improve texture, and consistency of the product as a whole. The introduction of whey masks the salty taste of meat products, improves color due to the reducing properties of lactose present in it. The addition of whey helps to reduce the residual content of sodium nitrite in meat products and increase the amount of nitrosopigments. It is known that the introduction of whey into the composition of syringe brines in the production of smoked meats helps to increase the yield of finished products by 3-5% [9]. The use of whey for meat products is limited due to the low protein content, high content of minerals and lactose, which negatively affects the organoleptic and physicochemical characteristics of the finished product. In this regard, new methods of using whey in meat products arise. One of the promising areas of whey processing is concentration and demineralization, which improve the organoleptic, physicochemical indicators while maintaining nutritional and biological value. Despite the high biological value of whey, the problem of its rational use remains relevant. The solution to this problem, as mentioned, is facilitated by the development and creation of membrane technology, thanks to which whey processing is possible. Membrane processes, in particular ultrafiltration, occur under pressure using cellular or inorganic materials. These processes have found wide application in various industries for the purification and concentration of liquid media. The technology for obtaining whey protein concentrates with a protein content of 35–80% is based on the ultrafiltration method. During ultrafiltration, the content of amino acids increases, and, what is especially valuable, such essential ones as lysine, isoleucine, threonine, etc. At the same time, the ratio of the sum of replaceable amino acids to the sum of essential ones remains almost the same. Whey protein concentrates (the amount of essential amino acids excluding tryptophan is up to 42%) are a rich source of sulfur-containing amino acids, which is especially important in dietary nutrition. During ultrafiltration, the content of macro- and microelements in the concentrate increases. First of all, this concerns such elements as calcium, phosphorus, magnesium, since a significant part of them is associated with whey protein molecules and therefore remains in the concentrate [18].

Whole milk powder and skim milk powder are used to produce sausages. Whole milk powder has a high protein and fat content because it is a powdered form of raw milk obtained by drying, during which water is removed to a water content below 5.0%; this preserves the composition of raw milk and increases its shelf life [19]. When whole milk powder was added to minced emulsion-type sausage made from chicken fillet, the crude fat, protein and ash content in samples with whole milk powder was significantly higher than in the control samples. The redness of the samples increased significantly with the increase in the content of this ingredient, the yield of samples involving whole milk powder was significantly higher than that of the control sample, and the TPA structure profile analysis indicators were also better [20].

The use of milk proteins for the production of textured products, in particular, used as analogues of meat raw materials, has long been in the focus of attention of scientists and specialists. Thus, in [21] a technological scheme is given and the process of production of a textured milk product and raw materials and ingredients used for this purpose are described in detail. The main requirements for finished products: water content of no more than 57% (the ability to contain it is not less than 35 g per 100 g of the product), fat of no less than 10%, protein of no less than 23%, lactose of no more than 2%, ash of no more than 3.5%, pH 6-6.5. In traditional sausages and semi-finished products, it can be added from 10% to 15%. It is advisable to use it in such quantities that products with such an additive do not differ in appearance, consistency and taste from the same products without it. Textured milk protein is mainly used in cooked sausages, frankfurters, canned meat, cutlets, meatballs, rolls and other products. The production of a textured product is also described in an article published in the same years [22]. It was shown that a textured protein composition imitating meat or cheese consists of a parallel group of fibers, and the following conditions must be met in each group: the fibers are located near each other or parallel along the entire length; the number of fibers is the same along the entire length of the group; the length of most of the fibers corresponds to the length of the group as a whole; the length of the longest fibers approaches the largest dimension of the group. This composition is formed into a product in which groups of fibers form a flat sheet structure, arranged in several layers or twisted. The layers of fibers are separated by separate layers of a usually non-textured binder. The formation of most of the fibers occurs simultaneously. The physical and chemical properties of structured proteins, in particular milk proteins, depend on the technological parameters of their production before texturing (active acidity, level of lactic acid process and temperature, condition and duration of gel processing). For example, with an increase in the active acidity (pH) of the extruded material, the degree of ionization of amino groups increases, which in turn leads to an increase in water-absorbing (degree of swelling) and water-binding properties [23].

Texturization of food products allows changing or shaping the structure to achieve desired sensory characteristics or nutritional values. Examples of textured products are soy meat, soy nuggets and dairy products with a desired structure. Very often, the structure is important and different texturization methods are used to modify it: blow extrusion, 3D printing, fiber spinning and high pressure on the textured food material. Protein is mainly used for texturing food. The swelling or expansion of the food material is mainly due to the pressure difference. These changes in the structure of the food can be analyzed using methods such as structure profile analysis and TPA and microstructural analysis [24].

Whey protein concentrate (80% protein) was textured using thermoplastic extrusion to obtain textured whey protein and was used to make lean patties. A comparative sensorial analysis of textured whey protein patties and patties with added vegetable protein (control) showed that there were no significant differences between the appearance and texture of the patties, instead the taste, aftertaste and overall impression were significantly different [25, 26].

The positive trend in terms of reducing the environmental impact of replacing natural meat with its plant analogues has given impetus to the development of extrusion technologies. High-moisture extrusion cooking and shear processing are used to obtain fibrous meat-like products. However, the scientific basis for these processes is not entirely clear. It is necessary to focus on research into the effect of thermomechanical processing on the physical and chemical properties and phase behavior of proteins and their mixtures. The processes of extrusion cooking and shear processing can be considered a set of basic unit operations, including (1) mixing and hydration, (2) thermomechanical processing, and (3) cooling. When analyzing the design of an extruder, the so-called adapter plate, which is located between the working cylinder and the matrix and can be of decisive importance for the fibrillation process, is often ignored [27].

The purpose of the work is assessment of the possibility and feasibility of using milk raw materials for the production of sausage products, in particular for obtaining textured structures based on milk protein, which, by their properties, would be acceptable for partial and/or complete replacement of meat raw materials in the said products.

Materials and methods. The objects of the research were: dry whey protein concentrates obtained from casein whey by ultrafiltration with a protein content of 34% and 70%; sausages produced using whey protein concentrate. At the first stage, the chemical composition, functional and technological properties, and amino acid composition of the whey protein concentrate were studied. At the second stage, the effect of whey proteins on the sensorial, functional and technological, and rheological characteristics of cooked sausages, their nutritional value were studied on model samples of cooked sausages, and permissible levels of introducing a dairy product instead of part of the meat raw material were determined.

Known research methods were used. The following indicators were determined during the research:

- pH – potentiometrically;
- protein content – Kjeldahl method;
- fat content – Soxhlet method;
- dry matter content – drying sample to constant weight at 105ºC;
- lactose content – iodometric method for determining mass fraction of sucrose and lactose based on oxidation of reducing sugars with excess iodine in alkaline medium and determination of sugar content by difference between amount of iodine taken and excess iodine determined by titration of thiosulfate;
- calcium content – by method based on precipitation of calcium with ammonium oxalate;
- water binding capacity – pressing method;
- content of weakly bound water – by amount of pressed juice;

- swelling (g/cm3) – measuring the volume of the product after mixing with water and swelling for 24 hours at a temperature of 18 to 20ºC;
- hydration level – by the amount of bound water (protein:water ratio);
- gelling capacity – by the quality of the mass obtained by heating the hydrated product to 72ºC and subsequent cooling;
- total amount of pigments and nitrosopigments – by extracting pigments with an aqueous solution of acetone, followed by measuring the optical density at λ 540 nm;
- residual sodium nitrite content – using a method based on measuring the intensity of the color formed as a result of the interaction of sodium nitrite with sulfanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride;
- content of essential amino acids – using a Biotronik-2000 amino acid analyzer;
- rheological indicators – on the electromechanical universal testing machine SANS CMT2503 [28];
- microbiological indicators – according to the total number of microorganisms in 1 g of product.

The reliability of the results was guaranteed by analyzing studies conducted in triplicate.

Research results.

The work used whey protein concentrate obtained from casein whey by ultrafiltration followed by drying. Whey protein concentrate is a finely dispersed powder from light cream to cream color with a sour-salty taste, easily crumbling under mechanical action [10].

The chemical composition of concentrates with a protein content of 34% and 70% is presented in Table 1.

Table 1

Chemical composition of milk proteins

Content,% (by mass)	Demineralized milk whey powder	Whey protein concentrate 1	Whey protein concentrate 2
Dry matter	96.0	96.3	95.3
Protein	17.0	35.9	69.2
Fat	1.2	2.9	4.3
Lactose	72.6	50.1	17.2
Ash	5.4	7.4	4.6

In obtaining whey protein concentrate 2, the diafiltration process was additionally used, resulting in a concentrate with an increased protein content; the ash and lactose content was reduced. This concentrate was used in the subsequent work.

The biological value of the milk protein product is evidenced by the results of studies of the amino acid composition of whey protein concentrate 2, namely the content of essential amino acids (Table 2).

Table 2

Content of essential amino acids

Amino acid,% of protein	FAO/WHO scale	Whey protein concentrate 2	Egg protein	Soy protein	Beef
Valin	5.0	6.8	7.7	5.0	5.5
Isoleucine	4.0	7.7	5.5	4.9	4.2
Leucine	7.0	9.8	9.9	8.2	7.9
Lysine	5.5	8.6	7.9	6.3	8.5
Methionine (+cystine)	3.5	4.5	6.5	2.6	3.8
Threonine	4.0	5.3	5.8	3.8	4.3
Phenylalanine (+tyrosine)	6.0	7.2	11.0	8.2	7.7

As follows from the obtained data, whey protein concentrate 2 exceeds the level recommended by FAO/WHO in almost all essential amino acids, which allows us to see the increase in the biological value of meat products when using it.

Studies of the functional and technological indicators of whey protein concentrate 2 gave the following results: pH of 1% solution – 5.26; water-binding capacity – 50%; fat-retaining capacity – 230%; solubility – 85%; emulsifying capacity – 90%; swelling capacity – 15%. That is, whey protein concentrate 2 is characterized by good solubility, fat-retaining and emulsifying capacity, low swelling capacity, and low water-binding capacity.

The gelling capacity of whey protein concentrate 2 was evaluated by the formation of a gel at different degrees of hydration of the dairy product, heating the resulting mass to 72ºC and its subsequent cooling (Table 3). The viscosity of the resulting mass was judged by the indicators of the ultimate shear stress (Table 3).

Table 3

Functional-technological parameters of the whey protein concentrate 2

Hydration ratio	Sensorial characteristic	Ultimate shear stress, kN/m^2
1:1	Viscous mass	0.6020
1.0:1.5	Viscous mass	0.5100
1:2	Low viscosity mass	0.2435 (at 72ºC)
	Viscous mass	0.5110 (at 80ºC)

As follows from the data in the table, the viscosity of the hydrated mass (1:2) increases with an increase in temperature to 80ºC.

Microbiological parameters of whey protein concentrate 2 are presented in Table 4.

Table 4

Microbiological parameters of cheese whey powder and whey protein concentrate 2

Product	QMA&OAMO, CFU/g	Yeast content, CFU/g	Molds content, CFU/g	Coliforms in 0.01 g
Cheese whey powder	$3.6 \cdot 10^3$	0	0	Not detected
Whey protein concentrate 2	$7.0 \cdot 10^3$	0	20	Not detected

The effect of whey protein concentrate 2 on the quality of meat products, namely sausages, was studied on model samples of cooked sausages, the mince of which consisted of first-grade beef and semi-fat pork (1:1), 3% salt, 5 mg% sodium nitrite, 20% water. The concentrate was used as a substitute for meat raw materials, adding it at the stage of cutting in dry form. As a result of the experiments on sensorial parameters, preference was given to sausages with 5% replacement of meat raw materials – they had good taste and color. Therefore, further work was carried out on model samples of cooked sausages with 5% replacement of meat raw materials with the same amount of whey protein concentrate. The characteristics of the sausages are given in Table 5.

Table 5

Physical and chemical parameters of sausages

Sample	pH	Protein content,% (by mass)	Fat content,% (by mass)	Calcium, mg%
Control	6.04	18.8	10.1	8.0
Experiment	5.94	20.5	9.0	9.6

As follows from the data in the table, replacing 5% of meat raw materials with whey protein concentrate 2 contributed to an increase in protein content and a decrease in fat content in the finished product. Studies have shown that the content of such an important mineral element as calcium in whey protein concentrate 2 was from 40 to 50 mg%). It should be noted that calcium affects muscle tissue proteins, their structure, changing the structural and mechanical characteristics of raw materials, sensorial parameters indicators of the finished product.

Similar results were obtained by other researchers. In [29], it was indicated that whey protein concentrate included in the amount of 1, 2, 3 and 4% in the emulsion sausage from buffalo meat significantly improved its quality indicators. The addition of whey protein concentrate increased the protein content, water, water-holding capacity and the volume of extract release in the samples of emulsion sausages immediately after production. The pH values of the emulsion sausages from buffalo meat decreased with the inclusion of 1-2% whey protein concentrate. During 25 days of storage of such sausages in the refrigerator, the water, pH, water-holding capacity and the volume of extract release decreased. According to [30], whey protein concentrate included in minced meat significantly improved the quality characteristics of emulsion sausages from buffalo meat. It was found that the addition of whey protein concentrate increased the protein content, water-holding capacity and the volume of extract release in the samples of fresh emulsion sausages. The pH values of buffalo emulsion sausages decreased with the inclusion of 1–2% whey protein concentrate. The emulsion sausage had 33.25% maximum lightness compared to 66.75% darkness. The fresh emulsion sausage sample had a grayish-brown color. Whey protein concentrate also improved the sensory characteristics of the emulsion sausage. According to [31], the water used in the production of Mortadella sausage was replaced by 50, 75 and 100% liquid whey. The addition of liquid whey did not significantly affect the sensory characteristics, pH, color, emulsion stability and fluid released after thermal processing. The replacement of water by 75 and 100% liquid whey in the production of Mortadella sausage contributed to a lower percentage of fat released after thermal processing. Thus, liquid whey can be used to replace 100% of the ice used in the production of Mortadella sausage.

The introduction of whey protein concentrate into minced meat instead of part of the meat raw material caused, as follows from the data in Table 6, an increase in the water-binding and water-retaining capacity of the minced meat and a decrease in losses during its heat treatment. Apparently, this can be explained by the influence of milk proteins and calcium, which, interacting with muscle proteins, perform a "cross-linking" between protein molecules and form so-called "protein matrices", contributing to a decrease in weakly bound water and an increase in the water-binding system as a whole.

Table 6

Functional-technological parameters of mince meats with the whey protein concentrate 2 added (Experiment) or without it (Control)

Sausage sample	Pressed liquid, mg	Weakly bound water, % of total water	Water-binding capacity of minced meat before heat treatment,% of total water	Water-holding capacity of minced meat after heat treatment,% of total water	Losses during heat treatmen t,%
Control	97	46.4	94.2	66.7	10.5
Experiment	92	44.4	95.8	68.3	7.8

The experimental sample of cooked sausage had a more delicate consistency compared to the control, which was confirmed by tastings and the results of studies of the rheological properties of sausages, given in Table 7.

Table 7

Rheological characteristics of sausages formulate with whey protein concentrate 2 (Experiment) or without it (Control)

Cooked sausages	Cutting work, J/m^2	Shear force, N	Shear stress, N/m^2
Control	844	9.88	33.0
Experiment	788	8.94	31.4

Table 8 shows the color characteristics of sausages.

Table 8

Color characteristics of sausages formulate with whey protein concentrate 2 (Experiment) or without it (Control)

Sample	Total amount of pigments, units of optical density	Nitrosopigments		Amount of residual sodium nitrate	
		units of optical density	% of optical density	mg%	% of added $NaNO_2$
Control	0.196	0.122	61.6	1.40	28
Experiment	0.203	0.140	73.1	1.17	23

It follows from the data in the table that, despite the replacement of meat raw materials with whey protein concentrate, the sausage products (control and test) were virtually identical in color, which was confirmed by the tasting results. This can apparently be explained by the positive effect of lactose included in the concentrate (the lactose content in the test sample was calculated to be 0.9%). It can be assumed that the introduction of lactose into the mince leads to an increase in the content of nitrosopigments, which is explained by better conditions for the reduction of sodium nitrite and its binding to muscle proteins under the influence of lactose, which has a higher reducing capacity compared to sucrose. A decrease in the amount of residual sodium nitrite is also associated with the effect of lactose, which increases the degree of transformation of sodium nitrite and its binding to muscle proteins, improving the color of the product and increasing its harmlessness.

The protein quality indicator, which characterizes the biological value of a product, reflects the degree to which its amino acid composition corresponds to the body's needs for essential amino acids for the formation of protein (Table 9).

Table 9

Essential amino acids content in sausages formulated with whey protein concentrate 2

Amino acid	Amino acid content,% of protein		Ideal protein FAO/WHO	Amino acid score,%	
	Control	Experiment		Control	Experiment
Valin	5.50	5.68	5.0	110	114
Isoleucine	4.59	4.87	4.0	114	122
Leucine	7.90	8.26	7.0	112	118
Lysine	8.19	8.54	5.5	148	155
Methionine (+cystine)	3.10	3.21	3.5	89	92
Threonine	4.30	4.42	4.0	93	110
Phenylalanine (+tyrosine)	7.00	7.10	6.0	116	118

The results obtained show that the introduction of whey protein concentrate 2 into sausage mince allows to increase the content of essential amino acids in them (lysine - by 4.2%, leucine – by 4.5%, isoleucine – by 6%, valine and methionine+cystine – by 3%, threonine – by 2%). The use of this concentrate instead of meat raw materials did not lead to a deterioration in the microbiological parameters of the product (QMA&OAMO, CFU/g: control – 0.8 103; experiment – 6.2 102).

Thus, the obtained research results allow us to conclude that the complex use of meat and milk proteins makes it possible to improve the sensorial, functional and technological properties of meat products, and increase their nutritional value.

Also, the obtained results of studies of milk protein raw materials and their use in meat products provide grounds for probable positive results of the development of milk textured products, especially since there have been successful attempts to create and practically use such technologies, which, however, were not without certain shortcomings. For example, the peroxide-catalase treatment of milk was characterized by such disadvantages as the high cost of the catalase enzyme, low storage capacity of the milk-protein component, instability of the milk-protein component to plasticization, the danger of restoring the viability of residual foreign microflora during storage, accompanied by the decomposition of hydrogen peroxide. That is, the task is to create an improved milk-protein component with a neutral taste and aroma, with a pronounced fibrous structure, with good storage capacity. It is expected that this can be achieved by forming a multilayer fibrous mass, which, when heated, is well extracted into threads, which are then fixed due to cooling. At the same time, care should be taken to ensure that the resulting mass does not have a pronounced cheese taste and an undesirable aroma for the produced meat products.

Conclusion. The conducted analysis of information data allowed us to draw a conclusion about the relevance and feasibility of using milk raw materials, in particular whey protein concentrates as protein substitutes for meat raw materials in meat products. The conducted studies of the functional and technological properties of whey protein concentrate obtained by ultrafiltration and containing 70% protein. It was found that the use of 5% whey proteins in the meat system instead of the same amount of meat raw materials allows us to obtain a finished product with good sensorial properties (taste, color), increases the content of protein and almost all essential amino acids, calcium, nitrosopigments, reduces the content of fat and residual sodium nitrite, which is positive from the point of view of product safety.

The results of studies of milk protein raw materials and their use in meat products provide grounds for probable positive results in the development of textured milk products and their use in minced meat products.

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