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INFLUENCE OF FOOD ADDITIVE "MAGNETOFOOD" ON PHYSICAL AND CHEMICAL PARAMETERS, FUNCTIONAL PROPERTIES OF MODEL MINCED MEAT SYSTEMS

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Abstract. The influence of a food additive"Magneftofud" (nanopowder of double oxide of two- and trivalent Ferum) on physical and chemical parameters, functional and technological properties of model beef minced meat have been studied. Also, their organoleptic parameters and the output of ready steaks made from them were investigated. Food additive "Magnetofood" was added to the beef minced meat in the amount of 0.05–0.15% to the mass of meat raw material. The water-binding ability was determined by the method of pressing; degree of oxidation by means of peroxide and acid numbers; output of the finished product and organoleptic indicators – by standard and commonly accepted methods; digestion of proteins of steaks – by the method of Pokrovsky A.A. and Yertanova E.D. It has been determined that due to the nanosize of Ferum oxide , a significant specific volume, developed active surface, affinity for proteins, thermal stability, the additive "Magnetofood" has antioxidant, sorption, complexing, structure-forming, stabilizing, water-binding, water and fat-retaining properties. Thus, the investigated additive contributes to the formation of new functional and technological indicators of beef meat systems and the improvement of consumer characteristics of the finished products obtained from them. The input of "Magnetofood" food additive in beef minced meat improves the organoleptic and functional-technological parameters compared to control: the moisture-binding capacity increases by 12.0–12.8%; output of finished products - by 1,5–4,5%. The growth of the total effect of digestion of proteins of prepared steaks (in 1,17-1,65 times) have been noted; reduction of the acid number (by 3,0–4,0%) and peroxide number (by 0,09–0,12 mmolol/kg). The results of the studies allowed to determine the rational amount of food supplement "Magnetofood", it is 0.15% to the mass of meat raw materials.

Key words: food additive "Magnetofood", minced meat, quality indices.

ВПЛИВ ХАРЧОВОЇ ДОБАВКИ «МАГНЕТОФУД» НА ФІЗИКО-ХІМІЧНІ ПОКАЗНИКИ ТА ФУНКЦІОНАЛЬНО-ТЕХНОЛОГІЧНІ ВЛАСТИВОСТІ МОДЕЛЬНИХ ФАРШІВ З ЯЛОВИЧИНИ

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Анотація. Досліджено вплив харчової добавки на основі нанопорошку подвійного оксиду дво- та тривалентного феруму «Магнетофуд» на фізико-хімічні показники та функціонально-технологічні властивості модельних фаршів із яловичини. Також досліджено їхні органолептичні показники та вихід виготовлених з них біфштексів. У м'ясні фарші з яловичини додавали харчову добавку «Магнетофуд» у кількості 0,05–0,15% від маси м'ясної сировини. Вологозв'язувальну здатність визначали методом пресування; ступінь окиснення за допомогою пероксидного та кислотного чисел; вихід готового продукту та органолептичні показники – стандартними і загально прийнятими методами; перетравлюваність білків біфштексів – за методом Покровського А.А. та Єртанова Е.Д. Визначено, що за рахунок нанорозмірів оксиду феруму, значного питомого об'єму, розвиненої активної поверхні, спорідненості до білків, термостабільності, добавка «Магнетофуд» має антиоксидантні, сорбційні, комплексоутворювальні, структуроутворювальні, стабілізувальні, вологозв'язувальні, водо- і жироутримувальні властивості. Таким чином, досліджувана добавка сприяє формуванню нових функціонально-технологічних показників м'ясних фаршевих систем та покращенню споживчих характеристик одержаних з них готових виробів. Введення харчової добавки «Магнетофуд» в фарші з яловичини сприяє покращенню органолептичних та функціонально-технологічних показників у порівнянні з контролем: вологозв'язуюча здатність збільшується на 12,0–12,8%; вихід готових виробів –

на 1,5–4,5%. Відмічено зростання сумарного ефекту перетравлювання білків готових біфштексів (в 1,17–1,65 разів); зменшенню кислотного числа (на 3,0–4,0%) та пероксидного числа (на 0,09 – 0,12 ммоль½О/кг). Результати досліджень дозволили визначити раціональну кількість харчової добавки «Магнетофуд», вона складає 0,15 % до маси м'ясної сировини.

Ключові слова: харчова добавка "Магнетофуд", м'ясний фарш, показники якості.

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Introduction. Formulation of the problem

Analysis of the consumer market of Ukraine shows that among meat products, semi-finished products are steady leaders by the volume of production (Fig. 1) [1].

In the period since 2000, the production of meat semi-finished products has increased by 4,5 times. At present, their share constitutes approximately 35% of the total volume of all meat products, which is due to a fairly high nutritional value and consumer qualities of products. In addition, compactness, versatility, and the speed of cooking are important factors that give a separate niche to semi-finished products in the food market.

At the same time, competition in the market of semi-finished products, the diversity of sources and technological approaches to the processing of raw materials, require continuous improvement of their quality to ensure steady consumer demand for them.

Among the technological measures in this direction, the application of dietary supplements and ingredients improving the properties of minced meat and ready-made products deserves special attention. They are introduced into the manufacture of meat products of all assortment groups, have a wide range of effects on meat systems in order to guarantee a preset level of quality indicators. The list of nutritional supplements and ingredients is constantly expanding, and added, however, multi-purpose nano-powder food supplements are not used [1-5].

Therefore, the application of new nutritional supplements containing nanoparticles and the study of their impact on meat products' quality is an urgent task.

"Magnetofood", which has a range of specific properties: high surface, reactive and sorption activity and energy potential; the ability to electrostatic and coordination interaction with ionogenic groups of proteins, fats, carbohydrates, as well as the formation of supramolecular ensembles with biopolymer matrices and solvato complexes with water dipoles, was suggested as a nanopowder nutritional supplement. In addition, the nutritional supplement "Magnetofood" has low cost. The whole complex of characteristics is promising for the creation of new functional and technological indicators of meat products and use of the additive "Magnetofood" as an improver of meat minced meat systems [Patent UA № 126502 Food Additive "Magnetofood"].

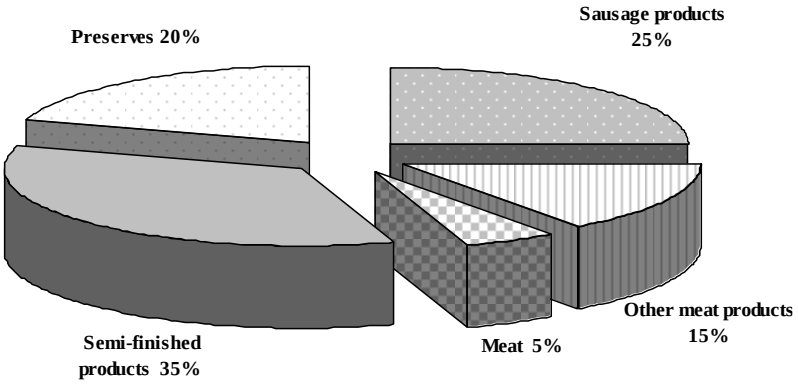

Fig. 1. Specific gravity of meat products by species

Analysis of recent research and publications

Meat industry is one of the active users of food supplements in the manufacture of products. The use of food supplements in the meat industry is due to several circumstances; causes and directions of using food supplements in the meat industry [2-17].

One of the most commonly used supplements is glutamic acid E620 and its salts (E621, E622, etc.), without which today almost a single enterprise of the meat processing industry cannot manage. These substances can enhance the taste of products made from meat, especially when using low-grade raw

materials, while causing “a sense of pleasure”. This property was called “glutaminone effect” [2-6].

Another group of food supplements widely used in the meat industry are the additives for enhancing the water-binding ability of meat and meat products. These are natural thickeners (in particular, kappa-carrageenan and agar) [7,8], phosphates and other additives that increase yield of the finished products, reduce the loss and migration of moisture during defrosting, heat treatment, improve the texture and consistency, color and taste of the finished products, slow down the scalding of fats [7,9,10]. However, the excess of recommended doses of phosphates leads to the loss of taste and aroma of products and pearlescent shine appears at the cut.

Citrates that promote the swelling of muscle fibers, i.e., binding of the added water, are used as a moisture-binding agent (MBA). However, with their overdose, the appearance of finished products deteriorates [2,7,11].

High VZZ possesses and modified starches, but they are unstable both to high and to low temperatures, to acidic environments, the presence of salts [3,7].

Insoluble dietary fibers of various origin (wheat, soy, oat, peas, apple, citrus, etc.) are more and more widely used as a mechanical detergent. They improve consistency and uniformity of products, increase output of finished products, reduce losses during heat treatment and preserve the structure of products during freezing (defrosting). Their disadvantage is the absence of antioxidant and antimicrobial activity [3,11-12].

Recently, natural phytosanitary compounds and probiotics have been used for the enrichment and improvement of technological properties of meat products. Their disadvantage is the loss of functional properties during heat treatment [11,12].

For the manufacture of safe and high-quality meat products, dietary supplements of antioxidant and antimicrobial action are used: essential oils, vegetable and marine fats. They are an alternative to nitrile salts. The disadvantages include low moisture-retaining ability and insufficient yield of the finished products [12-14].

Food emulsifiers reduce the risk of fat and water separation, reduce losses in heat treatment, improve the texture and formulation of the product, but they do not possess antioxidant and antimicrobial activity [7,15-17].

Recently, nanopowders of silver, titanium dioxide and silicon dioxide have been used as polyfunctional dietary supplements, but the use of these additives in food products is limited and fuctional-technological, microbiological, physico-chemical parameters have not yet been sufficiently studied [17].

Having analyzed the information material, aimed at studying the issues related to the possibility of using dietary additives in the development of high quality meat products with an extended shelf life. It is possible to conclude that their use will improve the quality of meat products, slow down the processes of oxidative and microbial damage, i.e., form the given functional and technological properties. At the same time, the literature gives little information about the impact of meat products with the addition of complex food additives, including nanopowders on their quality and shelf life.

For the formation of the necessary functional and technological properties of meat products, a dietry supplement based on iron oxides "Magnetofood" may be offered [Patent UA № 126502 Food Additive “Magnetofood”], which is the scienti nm and with a large specific surface and chemical potential [18-25]. According to chemical composition of “Magnetofood” – double ferrous oxide ($FeO{\cdot}Fe_2O_3$ or Fe_3O_4), obtained by the advanced technology, which allows to receive nanoparticles of a given size; adjust physico-chemical and functional-technological properties; reduce complexity of the technological process and cost price of the final product [18,26-28]. Due to Fe (II), “Magnetofood” exhibits restorative properties and can be used as an antioxidant supplement that prevents oxidation of fats and fat-free products, and thus improves their quality and shelf life [28,29]. Taking into account biocompatibility of the "Magnetofood" additive with living organisms and its positive effect on the human body [17,20,21], it is possible to use a dietary supplement based on Fe_3O_4 nanopowders ("Magnetofod") as an additional source of easily digestible iron [17,19,30].

Nanoobjects, which include nano-powder based on iron oxides Fe_3O_4 ("Magnetofood"), have enormous potential and carry a lot of important fundamental discoveries, new functional and technological properties and promising technological applications [31,32]. The interaction of nanoparticles of a dietary additive based on nano-powder Fe_3O_4 (“Magnetofood”) with biopolymers (proteins, proteids, carbohydrates, lipids) is a composite of complex chemical reactions. The process of nucleation – creation of a new, stable phase with an initial metastable phase passes through. The supramolecular organization of “Magnetofood” nanoparticles and the structure of the organic matrix play an important role. The result is the formation of spatial nanostructures, which significantly affect functional and technological properties of raw materials and semi-finished products. In food systems, such supplements, in particular, a nutritional supplement based on Fe_3O_4 nanopowders (“Magnetofood”), may exhibit reducing, antioxidant, bacteriostatic, sorption, complexing, emulsifying, wetting moisture-retaining, fat-retaining properties [19-21,33-36].

However, the unknown influence of a food supplement based on Fe_3O_4 nanopowders (“Magnetofood”) on physical-chemical parameters and functional-technological properties of comminuted meat products, in particular minced beef.

Therefore, study of the influence of the nutritional supplement “Magnetofood” on qualitative and functional-technological indicators of meat semisolid products is an urgent task.

The purpose and tasks of the study. The purpose of the work is to determine influence of the nutritional supplement “Magnetofood” on the physical-chemical parameters and functional-technological properties of model minced beef.

To achieve the main goal, the following **tasks** were set:

– to study the influence of the dietary supplement “Magnetofood” on physical and chemical parameters (acid and peroxidic numbers) of the minced beef and to evaluate its antioxidant effect during the storage of minced meat in a cooled state;

– to study the influence of the dietary supplement “Magnetofood” on functional and technological parameters: the moisture-retaining ability (WF) of the minced beef;

– to study the influence of the dietary supplement “Magnetofood” on organoleptic parameters and the yield of meat-cut half-finished products made from minced beef;

– to study the influence of the dietary supplement “Magnetofood” on the rate of digestion of proteins of ready-meal processed semifinished proteolytic enzymes.

Research materials and methods

In the researches minced beef was used according to DSTU 6030: 2008, polyfunctional food supplement “Magnetofood” [Patent UA № 126502 Food additive “Magnetofood”; 23-25,33,34] and generally accepted methods of research [37-43].

A food supplement "Magnetofood" was introduced as a powder when stirring minced meat in the amount of 50–150 g per 100 kg of beef. (This amount of supplement was established by previous studies) [19]. The study of the influence of "Magnetofood" additive on meat cut products was carried out on model systems. As a basic formulation in the studies, the recipe for the semifinished beef stew was chosen (Table 1) [42].

Table 1 – Recipes for meat cut into semi-finished products

Name of the component	The amount of component (kg) per 100 kg of basic raw material
1st grade beef	100.0
Cooking salt	1.0
Black grinded pepper	0.1
Drinking water	12.0
The binder mixture	2.4

For their preparation, they took meat: low-fat beef. After stripping and trimming, the beef was ground on a meat grinder with a diameter of the openings of the original grating $(2–3)\cdot10^{-3}$ m. The obtained minced meat was divided into control and experimental samples. In the experimental samples, the powder of the additive "Magnetofood" was injected as a mixture with salt and spices in the amount of 0.05% (sample 1), 0.10% (sample 2), 0.15% (sample 3) relative to the mass of meat raw material. The samples were then thoroughly mixed for (5–7)·60s at a temperature 18±1ºC, maintained (10–12)·60s. After that, the indicators of MBA and DO were determined. The control sample is minced meat without the addition of “Magnetofood”. In the manufacture of steaks from the received minced meat, semi-finished oval-flattened forms with a sharpened tip in the thickness 2.0–2.5 cm, which are then panned in crackers, are processed. Preformed semi-finished products are immediately sent to heat treatment or placed in a refrigerating chamber for cooling at a temperature (6±1)°C. Semi-finished products are put in a frying pan or a sheet of fat, heated to a temperature 150–160°C and roasted (3–5)·60s on both sides to the formation of roasted crust. Then they are brought to readiness in the oven at a temperature 250–280°C for (5–7)·60 sec. Ready-cooked cut meat products have a temperature in the center not lower 90±1°C.

In the process of performing experimental work, the authors used standard research methods:

– Sampling for physical and chemical research was conducted according to GOST 4288-76, GOST 7269-79;

– moisture binding ability (MBA) was determined by the method of pressing modified by Krayjuk L.N. and co-authors [37];

– degree of oxidation (DO) of the lipid component of minced meat during storage in a cooled state by means of peroxide [DSTU ISO 3960-2001] and acid numbers [GOST R 50457-92 (ISO 660-83);

– the output of the finished product (OFP) was determined as the difference in the weight of the initial semi-finished product and the finished product [38];

– organoleptic parameters were determined by standard research methods [38,39];

– digestion of proteins of the samples of prepared steaks in vitro by the enzymes of the gastrointestinal tract was determined by the method of Pokrovsky A.A. and Yertanova E.D. [25,26].

The method is based on the consistent influence of the object under research on the protein substances by the proteinase system consisting of pepsin and trypsin, with continuous removal of the products of hydrolysis by dialysis from the sphere of reaction. The above method imitates the conditions existing in the body. The degree of proteins digestion in the samples was determined by the difference between the amount of protein that was spent on digestion and the amount of proteins remaining in the product after the sequential processing of the experimental samples with pepsin and trypsin. Accumulation of hydrolysis products was

determined by Lowry's color reaction and expressed in terms of units (mg tyrosine and 1 g protein).

Results of the research and their discussion

At the first stage of the research, rational mass fractions of the dietary substitute "Magnetofood" were determined and the dynamics of changes in the moisture-binding ability (MBA) and the degree of oxidation (DO) of the lipid component of minced meat during the storage in the cooled state was studied.

Table 2 shows the dependence of ultrasound on the mass fraction of "Magnetofood" additive in minced meat. For the reliability of the data, MBA was detected by two methods: compression and centrifugation.

Table 2 – MBA dependence on mass fraction of "Magnetofood" additive in minced meat

Samples	MBA, %, determined by the method	
	Compression	Centrifugation
Control	67.3±0.9	67.2±0,9
Sample 1	71.6±0.9	71.4±0,9
Sample 2	75.8±0.9	75.6±0.9
Sample 3	75.9±0.9	75.7±0.9

Analysis of the obtained data (Table 2) indicates an increase in the moisture-binding ability of minced beef with an increase in the mass fraction of "Magnetofood" supplement. The maximum high level of MBA is achieved with the quantity of "Magnetofood" 0.15% of the mass of meat raw materials: with the increase of MBA by 12.8% compared with the values of the control sample.

The observed regularities of the dynamics of minced beef MBA under the influence of "Magnetofood" supplement, evidently, indicate a change in the hydration mechanism in the stuffing system. "Magnetofood" nanoparticles have lower moisture content than minced meat. Therefore, the increase in the mass fraction of "Magnetofood" supplement in minced meat in the first stage reduces the mass fraction of moisture in the samples, due to the redistribution of moisture in the ground meat system. At the second stage, the mass fraction of moisture begins to increase due to the ability of "Magnetofood" to the sorption and hydration processes in the minced meat system. This is connected with the fact that on the surface of "Magnetofood" nanoparticle (Fe_3O_4) there are differently polarized sections ($^{+\delta}Fe$) i ($^{-\delta}O$). Fe^{2+} and Fe^{3+} cations of "Magnetofood" particles are structurally formed ions. High tensity of the electric field created by the ferromagnetic ions of magnetic nanoparticles increases polarization of the molecules of the substances in the vicinity, which contributes to the additional ordering of dipoles, H_2O in particular, outside the surface of nanoparticles and their chemisorption. Chemical activity of "Magnetofood" nanoparticles is determined primarily by electrostatic dipole-dipole (van der Waals) and ion-dipole interactions. Donor-acceptor (coordination) interactions, for example, hydrogen bonds [36], also take part in the adsorption of moisture on the surface of "Magnetofood" nanoparticles.

To prove the antioxidant action of "Magnetofood" dietary additive, the degree of oxidation of lipids in the stuffing systems under the influence of "Magnetofood" was determined. The optimal mass fraction of "Magneetofood" supplement in the model mince was also determined by the identification of the following physical and chemical parameters: acid (AN) and peroxide (PN) numbers (Table 3, 4). The samples were stored in closed containers at a temperature of 5ºC for 24 hours, with physico-chemical parameters determined immediately after the preparation of samples, 4 hours, 10 hours, 16 hours and 24 hours later.

Table 3 – Acid number of minced beef with various mass particle "Magnetofood" during storage

Experimental samples of beef minced meat	Acid number, mg KOH/g				
	Shelf life of samples, hours				
	0	4	10	16	24
Control	0.97	0,98	0.99	1.00	1.01
Sample 1	0.96	0.96	0.96	0.96	0.97
Sample 2	0.95	0.95	0.95	0,95	0.96
Sample 3	0.94	0.94	0.94	0.94	0.95

Analyzing the experimental data of the acid number (AN) dependence on the shelf life (Table 3), we can note that the values of AN correspond to the standard. In samples with "Magnetofood" AN is smaller and does not change for 16 hours, but increases only 24 hours later (by 1%), while in the samples without "Magnetofood" it constantly increases (24 hours later by 4%). It means that the introduction of "Magnetofood" in the mince systems not only slows down the processes of fats hydrolysis (the accumulation of free fatty acids), stabilized by nanoparticles in supramolecular complexes, but absorb some of fatty acids on the particles due to the developed specific surface, amphotericity of ferrum cations and high sorption activity [20,26,27]. The best effect is achieved with a mass fraction of "Magnetofood" of 0.15% of the meat raw material mass.

Analyzing the experimental data of the dependence of the PN from the shelf life (Table 4), it is possible to notice that the magnitude of the PN gradually increases in all samples, with the value of the peroxid number of stuffings with the addition of "Magnetofood" is less 0.09–0.12 mmol½O / kg in comparison with the control.

This is connected with the formation of intermediate complexes of "Magnetofood" nanoparticles with Oxygen atoms of peroxide radicals and hydrogen peroxides [20,26,27]. Optimum by the rational content of "Magnetofood" additive is a mass fraction of 0.15% of meat raw material mass.

The introduction of "Magnetofood" dietary supplement slows down destructive processes of multiple bonds (oxidation, polymerization, cyclization), which lead to the decrease in the degree of higher fatty acids unsaturation.

Table 4 – Peroxid number of minced beef with various mass particle "Magnetofood" during storage

Experimental samples of beef minced meat	Peroxid number, mmol ½O/kg				
	Shelf life of samples, hours				
	0	4	10	16	24
Control	0.40	0.42	0.45	0.47	0.50
Sample 1	0.35	0.36	0.37	0.39	0.40
Sample 2	0.33	0.35	0.37	0.38	0.39
Sample 3	0.31	0.33	0.35	0.37	0.38

The data of tables 3 and 4 testify to the antioxidant properties of "Magnetofood" nutritive additive, and hence the possibility of using "Magnetofood" as an antioxidant additive to cut semifinished meat products.

Experimental samples of mince systems enriched with the addition of "Magnetofood" acquired a consistence characteristic of beef minced [DSTU 6030: 2008]. The color of minced samples with "agnetofood" nutritional supplement – from light pink to dark red, depending on the concentration of "Magnetofood": 0.05–0.15%. After heat treatment, the finished products acquired a gray-brown color, indicating oxidation and complete denaturation of myoglobin [28].

Table 5 presents results of the influence of the dosage of "Magnetofood" dietary additive on the finished products output (FPO) and organoleptic parameters of the finished meat cut products (by a 5-point scale). It was found that when adding "Magnetofood" supplement to minced beef, the finished products output increased (FPO) compared with control by 1.5–4.5% (Table 5). The positive influence of "Magnetofood" supplement on FPO can be explained by an increase of meat proteins hydration when enriching beef stuffings with "Magnetofood" food supplement, and in particular, the above-mentioned dynamics of the increase of MBA of minced meat systems (Table 2).

Table 5 – Studying the influence of "Magnetofood" dietary supplement on FPO and organoleptic indicators of fininshed cut meat products (by a 5-point scale)

Name of the indicator	Investigated samples			
	Control	Sample 1	Sample 2	Sample 3
Finished product output, %	65.4±0,9	66.4±0.9	68.3±0.9	68.4±0.9
Appearance	4.0±0.2	5.0±0.2	5.0±0.2	5.0±0.2
Appearance in the section	4.0±0.2	5.0±0.2	5.0±0.2	4.0±0.2
Consistence	3.0±0.2	4.0±0.2	5.0±0.2	4.0±0.2
Smell and taste	5.0±0.2	5,0±0.2	5.0±0.2	5.0±0.2
Total	16.0±0.2	19.0±0.2	20.0±0.2	18.0±0.2

It has been experimentally established (Table 5) that the introduction of "Magnetofood" dietary supplement to minced beef leads to an increase in mass output of finished products. The fact that supramolecular ensembles with meat protein molecules are formed under the influence of the ionized "Magnetofood" nanoparticles explain this fact. They contribute to increasing the water-absorbing and moisture-retaining capacity of minced meat systems and products made from them [29]. This contributes to an increase in the mass of finished cut meat products.

The results of the above research (Table 5) indicate positive impact of introducing "Magnetofood" nutritional supplement on the organoleptic parameters of the finished meat cut products: the complex indicator for the organoleptic analysis increases by 2–4 points in comparison with the control sample. The ability of "Magnetofood" nanoparticles to complexize with polymeric protein matrices and interaction with ionogenic lipid group [29] of minced meat contributes to a uniform distribution of water and fat in the mince systems, increase of water and fat content and, consequently, improvement of organoleptic parameters; reduction of heat treatment losses; increase in the finished products output.

The rate of proteins digestion in the gastrointestinal tract by proteolytic enzymes is one of the main indicators that determine biological value of food products. The consequences of determining digestibility of proteins by the digestive enzymes in vitro have the potential to predict the degree of protein utilization by the body. Table 6 shows the results of the proteins digestion of beefsteaks made from the model minced beef, digestive enzymes in vitro.

Analysis of experimental data of table 6 shows that pepsinol is higher in 31.7–73.8%, trypsinolysis – in 1.10–1.58 times in experimental samples of stewed beef steaks with the addition of "Magnetofood"; the total effect of digestion – in 1.17–1.65 times. Moreover, with the increase of "Magnetofood" dietary supplement in the mass fraction the degree of digestibility of proteins improves. This happens due to the fact that "Magnetofood" supplement activates enzymatic operation of pepsin and trypsin due to nanosizes and affinity for proteins [19,26,36]. "Magnetofood" nanoparticles due to affinity for proteins, its developed, chemically active surface,

complexing and structuring ability interacts with the enzymes of the gastrointestinal tract (pepsin, trypsin), which are simple proteins. The created complex "Enzyme protein+Magnetofood nanoparticles" contributes to better separation of proteins of meat cut products. That is, the introduction of "Magnetofood" supplement in the minced meat systems contributes to better digestion of proteins of finished meat cut semi-finished products.

Table 6 – Studying the influence of "Magnetofood" dietary supplement on the digestibility of beefsteaks proteins prepared from the model minced beef

Experimental samples of beefsteaks prepared from model minced beef	Content of protein in the sample, %	The amount of soluble products of protein hydrolysis, mg tyrosin per 1 g of protein in a product		
		Pepsin lysis	Trypsin lysis	Pepsin lysis + Trypsin lysis
Control	20.0	25.2	34.0	59,2
Sample 1	20.0	33.2	36.4	69.6
Sample 2	20.0	40.2	50.0	90.2
Sample 3	20.0	43.8	53.8	97.6

Thus, according to the data obtained, the introduction of "Magnetofood" nutritional supplement to minced beef is accompanied by an increase in their MBA, a decrease in the degree of oxidation (DO) of the lipid component of minced meat in the process of cooled storage, improvement of the consistency and other organoleptic parameters, with the hydration and enzymatic catalysis of the forehead system, and hence the output increases and the quality of the finished product improves.

However, the absence of a direct dependence of the effectiveness of using "Magnetofood" food supplement on the increase in its mass fraction indicates the necessity to regulate the amount of "Magnetofood" dietary supplement based on the comprehensive assessment of the quality of raw materials, finished products and economic characteristics of production.

The results of the research were the basis for the development of the recipes and technology of meat cut semi-finished products based on minced beef enriched by "Magnetofood"

Conclusions

Results of the research of the influence of "Magneetofood" nutritional supplement on the quality indices of minced beef showed that the addition of 0.05–0.15% of the nutritional supplement positively affects physico-chemical and functional-technological properties of minced beef, in particular, on the moisture-binding ability. Maximum high level of MBA is achieved with a mass fraction of "Magnetofood" 0.15%: while MBA increases by 12.8% compared to the values of the control sample, due to the ability of "Magnetofood" to the sorption and hydration processes in forehead systems.

The positive influence of "Magnetofood" dietary additive on physical and chemical parameters is proved: minced beef: acid and peroxide numbers.

The value of AN in the samples from Magnetofud does not change for 16 hours, but increases only in 24 hours (1%), while in samples without Magnetofood, it increases continuously (after 24 hours by 4%).

Indicators of peroxide number of minced meat with the addition of "Magnetofood" is less 0.09–0.12 mmol½/ kg compared to the control breakdown without "Magnetofood". This is due to the formation of intermediate complexes of "Magnetofood" nanoparticles with Oxygen atoms of peroxide radicals and hydrogen peroxides.

The increase of the of finished products in experimental samples of meat cut into semi-finished products with the addition of "Magnetofood" in comparison with the control of 1.5–4.5% due to the water-binding and water-retaining capacity of the food additive has been established.

The positive influence of the introduction of the food additive "Magnetofood" on the organoleptic parameters of the finished meat cut products is proved: the complex index according to the organoleptic analysis increases by 2–4 points in comparison with the control sample.

The activating influence of "Magnetofood" dietary additive on the enzymatic action of pepsin and trypsin is established. In experimental samples of steaks with the addition of :Magnetofood:, pepsinolysis is higher at 31.7–73.8%, trypsinolysis – in 1.10–1.58 times; the total effect of digestion – in 1.17–1.65 times.

Thus, the introduction of "Magnetofood" additive in the stuffing system slows down the processes of the hydrolysis of heat, increases the shelf life and improves the quality of meat forage systems and meat products made from them.

The best effect is achieved when introducing a nutritional supplement "Magnetofood" in the amount of 0.15% of the mass of meat raw material, which gives grounds to recommend the use of a nutritional supplement "Magnetofood" in the meat stuffing system as an improver of meat broiled semifinished products.

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