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RESEARCH ON THE FUNCTIONAL-TECHNOLOGICAL PROPERTIES OF PROTEIN COMPLEX AND NATURAL COLOR IN THE COMPOSITION OF RESTRUCTURED HAM PRODUCTS

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Abstract:
The biopolymer complex of thermostable animal proteins (sodium caseinate, dry buttermilk, blood plasma Vepro 75 PSC), which have functional and technological properties, including stabilizing ability in the composition of restructured ham products, has been developed.
The results of research confirmed the advantages of using the developed biopolymer complex, which consists of increasing water retention capability, fat-holding capacity and stabilize the physico-chemical parameters of meat products
The possibility of replacement of nitrite used to form color characteristics of meat systems with nitrate in the composition of vegetable raw materials at combination with nitrite-reducing microorganisms has been studied. The vegetable concentrate obtained from sweet potato - potato and the starter culture - Staphylococcus carnosus were used as dye. The possibility of stabilizing the color characteristics of meat raw materials in the process of pickling has been proved by applying a new kind of natural color stabilizer.
The results of the study have practical importance and will help to expand the range of restructured ham products with natural ingredients.

Keywords: *biopolymer complex, meat systems, proteins, sweet potato, Staphylococcus carnosus starter culture, coloring, restructured ham product*

1. Introduction

Increasing demand of protein products and necessity to provide balanced diet of the population led to the occurrence and rapid development of new directions in the production of meat products. A significant potential resource for food proteins is milk protein concentrates and blood plasma proteins, which are used irrationally in the conditions of tough saving high value animal proteins [1]. At the same time, the creation of restructured ham products with high biological value requires the study of the color formation of meat products [2].

It is possible to use nitrate from vegetable raw materials in combination with nitrite-reducing microorganisms which are able to fully compensate the action of sodium nitrite as a color stabilizer for meat products. Quite a large amount of nitrite is present in vegetables, so in sweet potato the nitrite concentration can reach 1500-2800 mg / kg. That is, the juice of the sweet potato and its dry concentrates with a high content of nitrates can replace traditional sodium nitrite [3].
In order to develop foods of high biological value that meet the requirements of food security and to counteract the negative impact of sodium nitrite on

health, we investigated the possibility of replacing sodium nitrite with powdered juice of sweet potato in the presence of nitrite-reducing bacterial culture in order to color the restructured ham products low in myoglobin [4].

2. Materials and methods

Materials

The dye used was purchased from Chr. Hansen company, obtained on the basis of a combination of sweet potatoes Hansen™–coloring FruitMax®. Sweet potato powder has a dark red color, well soluble in water, the pH of 10% solution is 2.7 - 3.4. The dye fully complies with EU Foodstuffs Regulation EU / 178/2002 with the latest changes, 1881/2006 / EU, which sets the maximum level for the content of certain food ingredients.
Staphylococcus carnosus was used as the nitriding starter culture.

Methods

Determination of the total pigment content was carried out according to the conventional method, which is based on the extraction of pigments of meat first with water and then with hydrochloric acid acetone, followed by photocolorimetry of the extract at a wavelength of 540 nm relative to hydrochloric acid acetone [5].
Determination of the content of nitrosopigments was carried out by a method based on the extraction of nitrosopigments with a water solution of acetone, followed by determination of the optical density of solutions on a spectrophotometer at a wavelength of 540 nm relative to 80% water solution of acetone [5].
The content of nitrosopigments relative to the total number of pigments was calculated by the formula

$$NS = \frac{E_{540}^{NO}}{E_{540}^{PP}} 100$$

where NS - content of nitrosopigments, %;
E_{540}^{NO} - the optical density of the nitrosopigment solution;
E_{540}^{PP} - the optical density of the solution containing all the pigments present in the product.
Color characteristics were determined in the colorimetric system dCIELab: D65-10 using the Demo Paint program and the spectra of the spectrophotometer X-rite Ci 7600 / Ci 7800 with annex for solids.
Qualitative and quantitative composition of the amino acid mixture is determined by comparing the standard chromatogram and the studied mixtures of amino acids and calculating the peak area of each amino acid. *Amino acid fast* - the ratio of the content of the essential amino acid product to the corresponding content an indispensable amino acid "ideal protein" on the FAO / WHO scale (Food and Agriculture Organization, in conjunction with the World Health Organization):

AF = EAApr / EAAe

where AF - amino acid rate,%;
EAApr - the content of the essential amino acid in the product, g / 1 g protein;
EAAep - the content of the "essential protein" of the "essential protein" on the
FAO / WHO scale, g / l protein.
Standard research methods were used to determine the organoleptic, physicochemical parameters of model meat systems and restructured ham.
The penetration voltage was determined using a Ulab3-31M penetrometer, the depth of the indenter immersion in the test sample at a temperature of 20°C. Three measurements were made on the open surface of the sample at a distance of at least 10 mm from the edge of the product and at the maximum distance from the

points of other measurements, so that the deformed part of the surface did not enter the measurement area, then the penetration value was converted to the value of the penetration voltage.The water activity (aw) of model minced meat systems and meat chopped semi-finished products was determined using a rotronic Hygro Palm-23 analyzer [5].

Moisture content was determined according to DSTU ISO 1442:2005 Meat and Meat Products. Moisture content test method (control method) (ISO 1442: 1997, IDT).

Mass fraction of fat - according to DSTU ISO 1443: 2005 Meat and meat products. The method of determining the total fat content.

Mass fraction of protein - by the Kjeldahl method "Agricultural food products. General guidelines for the determination of nitrogen content by the Kjeldahl method (ISO 1871:1975, IDT)".

Organoleptic indices of cutlets - according to DSTU 4823.2:2007 Meat products. Organoleptic evaluation of quality indicators. General requirements.

Moisture-absorbing capacity (MAC) and moisture-holding capacity MHC were determined by centrifugation [5].

Moisture-absorbing capacity of model meat systems (MAC, %) was evaluated by the method of Grau R. and Hamm R. in the modification of V.P. Volovinsky and B.I. Kelman by the ratio of mass fractoin of free and bound moisture [5].

Materials. Preparation of experimental samples

A mixture of animal protein (sodium casein, buttermilk, dry pork blood plasma (75 PSC) blood plasma at a ratio of 1: 1: 1) in the amount of 3% was added to replace meat raw materials in model meat systems made from low-fat pork (50%) and turkey meat (50%). As a control system was selected a protein-free meat system and colored with sodium nitrite in an amount 0.0075% sodium. The obtained samples of forcemeat were mixed at 12 ° C for 15 min, formed in the form of loaves, left at 10 ° C for 180 min to undergo the reaction of reduction of nitrate to nitrite and heat treatment according to the standard technological scheme for cooked meat products.

The statistical analysis

All the analytical determinations were performed at least three times and the value reported for determined characteristics was the average value ± of the standard deviation (S.D). The statistical analysis was performed at the Microsoft Excel statistical software version 2010.

3. Results and discussion

The ratio of amino acids in a food product and diet (amino acid formula) of essential amino acids is important for ensuring protein synthesis in the body. Tryptophan is taken as the unit in this ratio; the amount of other essential amino acids should be 3-4 times more. This is such an important factor that in a number of diseases mixtures of free amino acids or their mixtures in the form of hydrolysates of natural raw materials are used, for example, in enteral and parenteral nutrition. Naturally, the special enrichment of meat products, usually containing 15 ... 20% protein, even with some amino acids, will position them as therapeutic and prophylactic.

One such solution is the use of biopolymer complexes based on functional-technological proteins in the composition of restructured ham products, which are capable of providing a stable quality level of biologically complete meat products

In order to substantiate the composition of restructured ham products of higher biological value, by the method of calculation of amino acid score, the authors selected and balanced the amino acid composition of the biopolymer complex with animal proteins (sodium casein, buttermilk, blood plasma 75PSC in ratio 1:1:1), that made it possible to approximate it by the content of essential amino acids to the standard FAO/WHO.

According to the results of the calculation, the amino acid composition of the biopolymer complex was selected and balanced:sodium casein, buttermilk, blood plasma 75PSC in ratio 1:1:1), that made it possible to approximate it by the content of essential amino acids to the standard FAO/WHO. (Table 1)

Table 1.

Amino acid composition of the biopolymer complex of blood plasma proteins, sodium caseinate and buttermilk in a ratio of 1:1:1

Name of amino acid	Amino acid composition, g / 100 G protein					Amino acid score,%, of protein			
	Vepro 75 PSC	sodium caseinate	buttermilk	protein mixture	FAO/WHO	Vepro 75 PSC	sodium caseinate	buttermilk	protein mixture
Valine	4.1	6.2	9.2	6.5	5.0	82.0	124.0	184.0	130.0
Isoleucine	3.4	4.5	7.9	5.3	4.0	60.0	112.5	197.5	132.5
Leucine	6.7	7.3	16.7	10.2	7.0	95.7	104.3	238.6	145.7
Lysine	5.7	7.4	14.2	9.1	5.5	103. 6	134.5	258.2	165.5
Methionine + cystine	4.6	2.1	4.7	3.8	3.5	131.4	60.0	134.3	108.6
Threonine	4.2	3.2	8.7	5.4	4.0	105.0	80.0	217.5	135.0
Tryptophan	1.2	1.2	15.9	6.1	1.0	120.0	120.0	1590	610.0
Phenylalanine + tyrosine	7.0	4.2	16.3	9.2	6.0	116.7	70.0	271.7	153.3
Sum	**36.9**	**36.1**	**93.6**	**55.6**	**36.0**				

Animal proteins selected as the biopolymer complex (sodium caseinate, buttermilk and blood plasma Vepro 75 PSC) are thermostable functional proteins that have the ability to stabilize meat systems.

In order to develop recommendations for the use of animal protein biopolymer complex as a functional and technological ingredient in the introduction in formulation of restructured ham of lean pork and turkey meat, the chemical composition and functional technological properties (FTP) of model meat systems with different level of its use were discovered. The development of a rational composition of restructured ham products of higher biological value was carried out by computer optimization based on the chemical composition of the recommended ingredients and the results of studies of their functional technological properties (FTP). Moisture retaining ability (MRA) and fat-holding capacity (FHC) were chosen as a function of the target, which is a criterion for the stability of moisture and fat retention in meat systems. Knowledge of FTP is necessary for the rational processing of raw meat. They make it possible to predict and directively regulate the quality characteristics of finished products. The results of the studies are presented in table 2.

Table2.

Chemical composition and functional technological properties of model meat systems
(n=3; P ≥ 95, mean ±SD**)**

Indicator	The content of the biopolymer complex of animalproteins, %			
	0 (control sample)	2	3	4
Moisture content, %	69.25±2.94	70.08±2.87	70.45±2.95	71.36±2.92
Protein content, %	16.39±0.74	17.24±0.63	18.26±0.67	18.35±0.64
Fat content, %	13.66±0.56	11.95±0.48	10.65±0.54	9.56±0.51
Ash percentage by weight of dry substance ,%	0.70±0.001	0.73±0.001	0.73±0.001	0.73±0.001
pH	5.9±0.21	6.03±0.22	6.04±0.20	6.04±0.21
MRA, %	67.90±2.76	74.70±2.54	75.1±2.78	75.79±2.63
FHC, %	68.00±2.15	74.52± 2.96	74.63±2.79	74.57±2.78
Output, %	112.35±3.17	121.14±3.27	125.19±3.49	125.61±3.46
Thermal treatment losses, %	11.66±0.43	9.51±0.41	7.19±0.39	7.05±0.39
Residual content $NaNO_2 \times 10^{-3}$	3.92±0.02	3.56±0.02	3.24 ±0.02	3.17±0.02
Cutting effort, Па$\times 10^{-5}$	1.79±0.03	1.71±0.03	1.63±0.02	1.62±0.05
Cut-off voltage, kP	21.35±0.67	20.54±0.59	20.07±0.62	19.93±0.59

According to the table 2, introduction of the biopolymer complex of animal proteins in the amount of 3% in the composition of the restructured ham of lean pork and turkey meat increases MRA of model meat systems by 10.1 ... 11.6%, and FHC - by 9.5 … 9.7%, which certainly contributes to the improvement of the structure of restructured ham. Introduction the biopolymer complex of animal proteins in the amount of 3% to the formulation of restructured ham of low-fat pork and turkey meat as a functional and technological ingredient allowed to increase their biological value by the content of essential amino acids by 13.2%, compared to the control. The results of the studies are presented in table 3.

Table 3.

Amino acid composition of restructured ham

Name of aminoacids	Control: Ham “For Breakfast” DSTU 4668: 200	The prototyp	Standard (chicken egg protein). g / 100
	Content of amino acids. g /100 g protein:		
Essential :	40.59±1.81	45.94 ±1.23	36
Valine	5.15±0.15	5.78 ±0.31	5.00
Isoleucine	4.29 ±0.21	4.92 ±0.18	4.00
Leucine	7.65 ±0.32	9.02 ±0.29	7.00
Lysine	7.73 ±0.31	8.75 ±0.29	5.50
Methionine + cystin	3.63 ±0.15	3.89 ±0.37	3.50
Threonin	4.25 ±0.20	4.64 ±0.56	4.00
Tryptophan	1.16 ±0.05	1.32 ±0.19	1.00
Phenylalanine + tyrosine	6.73 ±0.24	7.62 ±0.49	6.00

Table 3 data indicate that the test and control samples of ham do not contain limiting amino acids.

Among all prototypes of heat-treated restructured ham, the lowest score was obtained by the control sample, which was characterized by insufficient juiciness, fragility of the structure, lower output and higher by 2.15-4.61% losses in heat treatment. The best qualitative characteristics (high juiciness, denser and more elastic consistency) are characteristic of prototypes with biopolymer complex of animal proteins.

The use of the developed biopolymer complex of animal proteins in the amount of 3% in the composition of restructured ham of lean and turkey pork allows to obtain a functional product with the best organoleptic and technological properties, and balanced in chemical composition and biologically complete meat quality level.

At the next stage of the research, the coloring properties of the FruitMax® vegetable concentrate were investigated in the presence of a nitride-reducing starter culture of Staphylococcus carnosus, whose activity manifests itself at a pH higher than 5.5 and a temperature above 8 °C.

An analysis of the literature data [6, 7, 8, 9, 10] and our own experimental studies confirmed that the formation of coloring of meat products begins in the process of pickling. The reaction of formation of nitrosopigments intensively proceeds at pH 5.5… 6.0. At meat pH greater than 6.0, the nitrosomyoglobin (NOMb) reaction occurs at a slower rate. Temperature has a significant influence on the color formation of meat products. In the process of traditional pickling and cold smoking, about 40 ... 50% of NOMb nitrosomyoglobin is formed.

It has been found that the use of the sweet potato juice powder FruitMax® in the amount of 0.30, 0.35 and 0.40% in the presence of 0.025% Staphylococcus carnosus contributes to the accumulation of NO-pigment in an amount that is typical for color formation in the presence of sodium nitrite about 47.83… 48.23% to the total pigment (Table 4).

Usage of FruitMax® in the amount of 0.35 ... 0.40% leads to a more intensive formation of nitrosopigments and, as a consequence, to a lower content of residual nitrite in the product.

Table 4.

Influence of powdered juice of sweet potato on nitrosation in restructured ham ($n=3$; $P \geq 0.95$**)**

Amount of powdered sweet potato in the meat system,%	Common pigments, units of optical densit	NO-pigment content, % to the total pigmen	Number residual nitrite, mg / 100
0 (control *sample* $NaNO_2$)	0.634 ± 0.017	48.23 ± 0.22	3.26 ± 0.03
0,30	0.583 ± 0.019	47.53 ± 0.20	3.12 ± 0.05
0,35	0.621 ± 0.013	47.82 ± 0.21	3.10 ± 0.03
0,40	0.634 ± 0.017	47.83 ± 0.22	3.06 ± 0.03

The identity of the content of nitrosopigments in the test specimens, compared to the control, and characterized by the conversion of nitrate from vegetable raw materials by nitro-reducing microorganisms to nitrite, which interacts with myoglobin of meat. The result is a NO-pigment that gives the meat products typical pink-red color. The use of stained ham products in the presence of 0.025% Staphylococcus carnosus in the replacement of sodium nitrite for the formation of color of the ham products also reduces the residual content of sodium nitrite in the product and avoids the accumulation of carcinogens. Spectrophotometric measurement of the coloring of restructured ham products was performed using sweet potato juice powder in combination with nitrate-reducing microorganisms (Table 5).

Table 5.

Spectral characteristics of the coloring of restructured ham products

Nr. crt.	Name of dy	Concentration %	Color coordinatesCIELab		
			L (light shade intensity)	a (intensity of red color)	b (intensity of yellow color)
1	Sodium nitrite	0.0075	67.93	5.20	16.00
2	Juice Powder Sweet Potato 0.2	0.2 %	77.99	4.32	15.80
3	Juice Powder Sweet Potato 0.3	0.3 %	68.45	5.21	15.14
4	Juice Powder Sweet Potato 0.4	0.4 %	68.59	5.23	14.94

In Table 5 are presented spectral characteristics of the restructured ham have shown that, in light shade intensity, the test specimens are inferior to the control due to the natural coloration of pork and turkey meat. However, against the background of high enough indicator intensity of red color and a low value of "*yellowness*", the test specimens have a typical color of meat products pink and red, which confirms the feasibility of using in their composition a natural dye - powder juice of sweet potato FruitMax®, in the amount of 0.3… 0.4%, in combination with nitrate-reducing microorganismsThe prospect of further research is to develop basic formulations of restructured ham products of high nutritional value with protein complex and natural dye, as well as to clarify the technological modes of their production.

4. Conclusion

The biopolymer complex of animal proteins in restructured ham products exhibits functional technological properties, which is confirmed by the improvement of qualitative and structural-mechanical parameters, reduction of losses during heat treatment and increase of output of finished meat products.

Combinational variation in the composition of restructured ham products is promising and needs further improvement in order to obtain products of high nutritional and biological value.

Using juice powder of sweet potato FructMax® for color formation of the restructured ham in the presence of Staphylococcus carnosus in the replacement of sodium nitrite allows reducing the residual content of sodium nitrite in a product with low myoglobin content in meat raw materials and avoids the accumulation of carcinogens.

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