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Electro-Activated Ostrich Fat Melting: An Innovative Solution

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ABSTRACT

This article presents the results of the development and selection of optimal technological parameters of electroactivated ostrich fat melting with adjustable melting temperature. The object of the research was the fat of an ostrich, which was melted by a wet method in an electroactivated fluid. The task of the study is to improve the electroactivated method of obtaining baked fat of ostrich, which provides separate production of fat fractions and allows to increase the performance of fat. Planning an experiment to optimize the conditions of ostrich fat production was carried out using a full factor analysis. As a paramount technological parameters that determine the yield and acid number of fat, we chose the hydrogen index of the electroactivating fluid X1(Z1) and the melting temperature of fat X2(Z2). The response function is adopted fat yield (Y1) and acid number (Y2). The choice of temperature is due to the various functional purposes of the resulting fat fractions: cosmetic (cream, lipstick, varnishes), food, feed and technical. It is established that the most favorable from a technological point of view are the temperature of melting from 63.0-75.0 and above at a pH of 10.83-11. The obtained ranges data, both for the pH value and for the temperature of the ostrich fat, were used to develop an electro-activated method for producing ostrich baked fat. Delivered technical result is achieved due to the physico-chemical effect of the electrolyte solution, contributing to the destruction of complex intracellular colloidal system, which includes fat. The shortening of the heat treatment period of the raw material ensures the prevention of deep hydrolysis of fat and improves the quality of the product obtained, in particular at a boiling temperature already at 53.0 ºC, the fat product will have a low acid number (0.4-0.6).

Keywords: ostrich fat, electrolyte, fat yield, acid number, fat quality, full factor analysis, electroactivated fat production.

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INTRODUCTION

In the structure of the range of consumer goods, products of animal origin, including fats of farm animals and poultry, which are necessary raw materials for the processing sectors of the national economy, occupy a significant amount in the harvesting of secondary products. Manufacturers of the fat industry are currently experiencing an acute shortage of domestic raw materials, accompanied by rising prices and fierce competition from imported analogues. Inadequate regulation of standards for export, import and re-export of products, lack of own raw materials, led to an increasing lag in the technological sphere of production of solid fats. The need to increase the production of high-tech products, to overcome dependence on imports, to neutralize the threat to food security put in the first place the problems of not only ensuring the quality of agricultural products, but also creating innovative technologies [1]. Important in the development of the range of fat products is giving them high consumer and new functional properties that ensure competitiveness and increase the export potential of Russian goods.

It should be noted that in addition to the traditional types of fats from farm animals and birds in recent years, the fat of the African ostrich has attracted increasing attention. Due to its properties, fatty acid composition, high nutritional value and easy digestibility, this product can certainly be considered as a new raw material resource for the food, cosmetic, pharmaceutical industry [2, 3]. Accordingly, the development of scientifically based approaches and practical principles for its collection, storage and complex processing will significantly expand the consumer market with attractive, sometimes exotic for our latitudes products of various functional purposes [4]. In this regard, there is an urgent need to find ways to get the ostrich fat with the desired properties as efficiently as possible without loss of product performance.

As is known [5], to extract fat from soft or hard fat-containing tissue, it is necessary to destroy the protein structure containing fat, transfer it from the intracellular phase to the extracellular one. Animal fats are obtained by dry, wet melting, digestion, extraction (hot water, steam, organic solvents), vibroextraction, pressing, separation, processing chemicals (alkalis, acids) [6, 7]. The most common are wet and dry melting, which provide for the denaturation of the protein membranes of fat cells when the raw material is heated, as a result of which they are broken. The dry method is based on the direct transfer of heat from the heating surface of the apparatus to the fat mass, most often at elevated temperatures, which can lead to oxidation of unsaturated fatty acids, and therefore we used wet melting in an electrolyte solution [8, 9]. An additional advantage of the chosen method, along with the intensification of fat recovery, is the possibility of obtaining a fatty product with a certain melting point and the neutralization of a specific odor characteristic of animal fats.

Objective: to develop and select the optimal technological parameters of electroactivated ostrich fat melting with adjustable melting temperature.

MATERIALS AND METHODS

The task of the study is to improve the method of electroactivated obtaining of baked fat of ostrich, providing separate production of fat fractions and allowing to increase the performance of fat.

The object of the research was the fat of an ostrich, which was melted by a wet method in an electroactivated fluid.

Electroactivated method of obtaining melted ostrich fat with adjustable melting temperature included grinding fatty tissue (raw fat), mixing it with the aqueous phase - electrolyte (catholyte), heat treatment, fat separation and its further dehydration by distillation at a residual pressure of 20 mm Hg . The choice of temperature is due to the various functional purposes of the resulting fat fractions: cosmetic (cream, lipstick, varnishes), food, feed and technical. Taking into account the fatty acid composition of ostrich fat, its low melting point (30-31 ºC) and solidification (20-21 ºC), the following temperatures for obtaining a fat product were chosen: 39 ºC at the first stage of processing; on the second - 45 ºC, on the third - 55 ºC, on the fourth - 65 ºC and on the 5th one - 75 ºC. The time of melting was 20 minutes with constant mixing of raw materials at each stage of heat treatment. Electroactivated water (catholyte) was prepared by electrolysis of a 10% aqueous NaCl solution with a direct current of 0.5-0.6 A and a voltage of 36-50 volts, with a pH of 9-11 with a redox potential (-400) - (-700) mV and a mass fraction of NaCl 3-5% [8]. During the development of technological parameters for the production of electrolyte, a method was taken to obtain ostrich baked fat using electro-activated liquid (patent No. 2382072, published February 20, 2010, Bul. No. 5) [9]. Thus, the proposed set of features provides a separate receipt of the fat fraction of ostrich fat, characterized by different melting points, which can significantly expand the scope of their application.

To achieve this goal and objectives, we used methods of mathematical modeling, in particular, full factor analysis. When choosing the technological parameters of obtaining a fatty product with desired properties, the specifics of each of the factors affecting not only its yield, but also the quality of ostrich fat were taken into account. When wet, the raw material is in contact with water and at high temperatures, the fat released in the molten state is able to emulsify, to undergo hydrolysis with the formation of free fatty acids, which is highly undesirable. Accordingly, an important stage in the planning of an experiment to optimize the conditions for electroactivated ostrich fat using regression analysis was to establish the main factors and response functions on the basis of which the experimental matrix was formed. Finding the point of the center of the plan or level was found by the equation:

$$Z_{j0} = \frac{Z_{jmax}+Z_{Jmin}}{2} \quad (1)$$

where: Z_j^{max} – maximum value of j - factor;
Z_J^{min}- minimum value of j - factor;
J=1,2……k - factor number.
The interval of variation of the factor was calculated by the formula:

$$\Delta Z_j = \frac{Z_j^{max} - Z_J^{min}}{2} \quad (2)$$

The required number of experiments in the full factorial experiment (FFE) was determined by the equation:

$$N = n^k = 3^2 = 9 \quad (3)$$

where: k - number of factors (in our case, k = 2);
N – number of levels (FFE three levels "+", "0", "-").

The regression equation is as follows:

$$\bar{y} = b^0+b_1x_1+b_2x_2+b_{11}x_1^2+b_{22}x_2^2+b_{12}x_1x_2, \quad (4)$$

where: b^0 — free term of the equation;
$x_1, x_2…x_n$— factors determining the level of the parameter being studied;
$b_1, b_2…b_n$— regression coefficients with factor indicators characterizing the level of influence of each factor on the effective parameter in absolute terms.

The equation coefficients were calculated using Statistika 6.0 software in coded units.

The coefficient of the linear part of the regression equation b_j in FFE was determined by the equation:

$$bj= \frac{1}{N}\sum_{i=1}^{n} x_{ji} y_i \quad (5)$$

where: j=1,2,3……k– factor number;
i– experience number.

Transition from the coordinate system Z_1, Z_2, Z_3,…..Zk to the immense coordinate system X_1,X_2, X_3,……….X_k carried out by the following linear transformation:

$$X_j = \frac{Z_j - Z_j^0}{\Delta X_i} \quad (6)$$

RESULTS AND DISCUSSION

As a primary technological parameters that determine the output and acid number of ostrich fat, the pH value of the electrically activated fluid *X_1(Z_1)* and the melting temperature of fat *X_2(Z_2)* were chosen. The output function of the fat product *(Y_1)* and the acid number *(Y_2)* were taken as the response function.

The levels of variation of these factors are given in table.1.

Table 1: Levels of variation of conditions for ostrich fat

Factors	Z_j^{min}	Z_{j0}	Z_j^{max}
pH	9,0	10,0	11,0
Temperature, ºC	39,0	55,0	75,0

To obtain a complete regression equation with interaction coefficients, an experiment plan was drawn up for n = 3^2 in coded and natural units, which includes the «actual plan» and auxiliary columns used to process the experiment already performed (Table 2)

Table 2: Full factorial experiment to optimize the conditions for melting fat in terms of product yield

№ experience	Factors in natural scale		Factors in a dimensionless coordinate system		Y_1, %	$Y_{calc.}$	$(Y_1-Y_{calc.})^2$
	Z_1,	Z_2, ºC	X_1	X_2			
1	11	55	+1	0	72,0	72,02	0,04
2	10	75	0	+1	69,0	68,42	0,34
3	9	55	-1	0	64,0	60,99	9,06
4	10	39	0	-1	58,0	52,42	31,14
5	11	75	+1	+1	77,0	75,72	1,64
6	9	75	-1	+1	56,0	57,88	3,53
7	9	39	-1	-1	41,0	45,38	19,18
8	11	39	+1	-1	55,0	56,22	1,49
9	10	55	0	0	62,0	66,54	20,61
10	10	55	0	0	66,0	66,54	-
11	10	55	0	0	68,0	66,54	-
12	10	55	0	0	64,0	66,54	-

Note: Z_1, - pH; Z_2 - temperature of heating

Using Statistika 6.0 software, a mathematical model of the conditions and parameters of ostrich fat was developed in coded units to obtain the optimal yield of a fat product, where this indicator is represented as a Taylor formula:

$$y_i = 66{,}54 + 7{,}17x_1 + 8x_2 - 1{,}62x_1^2 + 1{,}75x_1x_2 - 6{,}12x_2^2 \qquad (7)$$

Calculating the reliability of the coefficients by student's criterion, the tabular value of which for this case with p = 0.05 is 4.3, it was revealed that only 4 coefficients are significant and, accordingly, the final regression equation has the form:

$$y_i = 66{,}54 + 7{,}17x_1 + 8x_2 - 6{,}12x_2^2 \qquad (8)$$

To check its adequacy by the Fisher criterion, the residual variance was calculated: $S^2_{res.}$=19,25 and dispersion of reproducibility $S^2_{rep.}$ =4. The number of degrees of freedom for residual dispersion f_1=8, and for dispersion reproducibility - f_2=u-1=2. Based on the value of the Fisher criterion: F = 4.8 it was determined that the equation adequately describes the experiment, since the condition $F<F_{1-p}(f_1, f_2)$ for p=0,05 $F_{1-p} = (f_1, f_2)$=19,3.

Analyzing the obtained values of the coefficients of the equation, we can conclude that both the hydrogen index of the electrolyte and the temperature of melting have an approximately equal effect on the yield of the fat product. It is important to emphasize that a significant increase in temperature may adversely affect the performance of fat.

Graphic display using the Torah lines to select the technological zones of temperature and pH of the electrolyte is shown in Fig. 1.

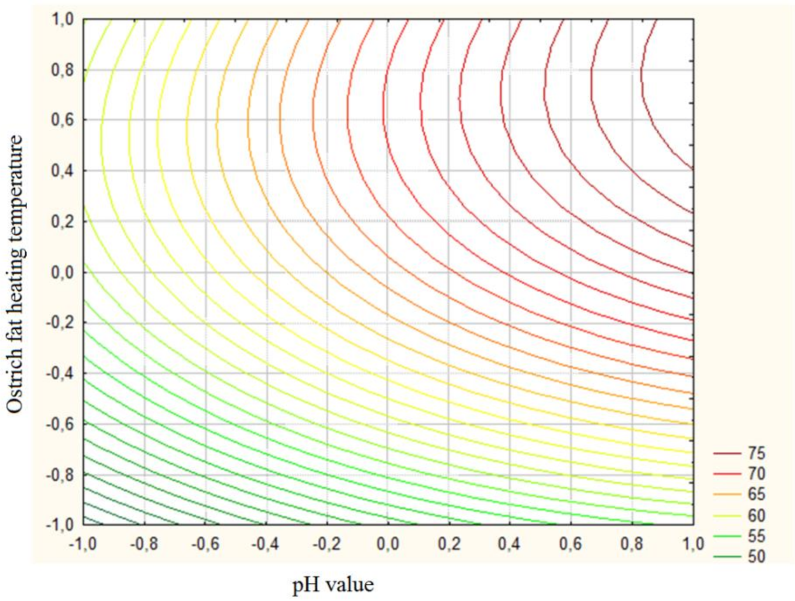

Figure 1: Regions of values of pH and temperature factor for the selection of technological parameters of electroactivated ostrich fat melting

As can be seen from Fig. 1, the range of values of the selected factors for ensuring the specified conditions for the ostrich fat output is in the upper region of the graph and the optimal criteria for its melting have not been established. The best zone for the pH in coded units is in the range of 0.83-1.0, and for the temperature of melting, respectively, 0.4-1.0.

For the selection of the technological parameters of electroactivated obtaining of ostrich fat with an adjustable temperature of melting and preserving its quality characteristics, the coded units were converted to natural values (Table 3).

Table 3: Areas of factor space for obtaining optimal fat yield

Response function	Values of selected factors			
	Hydrogen indicator (pH)		Temperature of heat	
	coded units	natural values	coded units	natural values, ºC
Fat yield (Y_1)	0,83-1,0	10,83-11	0,4-1,0	63,0-75,0

Considering the areas of influence of selected factors on the ostrich's fat yield (Fig. 1) and regression coefficients, it can be summarized that the most favorable from a technological point of view are warming temperatures from 63.0-75.0 ° C and higher at catholyte pH 10.83 eleven.

At the next stage of the experiment, it was important to establish areas of optimal values of pH and ostrich fat boiling temperature to obtain a finished fat product with low acid values. The experimental design for k = 3^2 in coded and natural units for obtaining the full regression equation with interaction coefficients in terms of the acid number of the ostrich baked fat is presented in Table 4.

Table 4: Full factorial experiment of fat melting in terms of acid value

№ experience	Factors in natural scale		Factors in a dimensionless coordinate system		Y_2, mg potassium hydroxide / g	$Y_{calc.}$	$(Y_2-Y_{calc.})^2$
	Z_1	Z_2, ºC	X_1	X_2			
1	11	55	+1	0	0,35	0,362	0,0001
2	10	75	0	+1	0,40	0,390	0,0001
3	9	55	-1	0	0,80	0,978	0,0318
4	10	39	0	-1	0,43	0,510	0,0064
5	11	75	+1	+1	0,20	0,189	0,0001
6	9	75	-1	+1	1,35	1,256	0,0089
7	9	39	-1	-1	0,90	0,816	0,0071
8	11	39	+1	-1	0,65	0,645	0,0001
9	10	55	0	0	0,55	0,452	0,0095
10	10	55	0	0	0,50	0,452	-
11	10	55	0	0	0,45	0,4525	-
12	10	55	0	0	0,50	0,452	-

Note: Z_1, - pH; Z_2 - temperature of heating

To develop and establish the necessary conditions and technological parameters for obtaining ostrich fat with an adjustable temperature of melting, maintaining high rates of its output and quality, a mathematical model was calculated in coded units using the Statistika 6.0 software. The value of the acid number is presented in the form of the Taylor formula:

$$y_i = 0{,}4525 - 0{,}3083x_1 - 0{,}005x_2 + 0{,}2175x_1^2 - 0{,}225x_1x_2 + 0{,}0575x_2^2 \quad (9)$$

Statistical analysis of the coefficients of the presented equation showed that only one of the six inaccuracy coefficients can be excluded from the equation, since the temperature of melting of the fat product is significantly lower than the pH of the electroactivated fluid for a given range of experimental criteria.

$$y_i = 0{,}4525 - 0{,}3083x_1 + 0{,}2175x_1^2 - 0{,}225x_1x_2 + 0{,}0575x_2^2 \quad (10)$$

Further, the residual dispersion, the dispersion of reproducibility ($S^2_{res.}$= 0,01149 and S^2_{rep}=0,00085) and the value of the Fisher criterion, which is equal to F = 13.5. Thus, we can reliably speak about the adequacy of the regression equation, since the condition $F<F_{1-p}(f_1, f_2)$. The number of degrees of freedom for the residual dispersion f_1=7, and the number of degrees of freedom of dispersion of reproducibility - f_2=u-1=2. Based on the value of the Fisher criterion: F = 13.5, it is determined that the equation adequately describes the experiment, since the condition $F<F_{1-p}(f_1, f_2)$ for p=0,05 $F_{1-p} = (f_1, f_2)$=19,3. Tabular value $F_{1-p} = (f_1, f_2)$ amounted to 19.16 at p = 0.05.

As can be seen, from the coefficients of the equation of pH of the electro-activated fluid has the opposite effect on the indicator of the acid number of ostrich fat. It is important to note that the cross-action of pH and temperature can adversely affect the value of the acid number, namely, a decrease in temperature and pH will contribute to an increase in the acid number of the product. A three-dimensional graphic representation of the dependence of the acid number on the selected factors is presented in Fig. 2

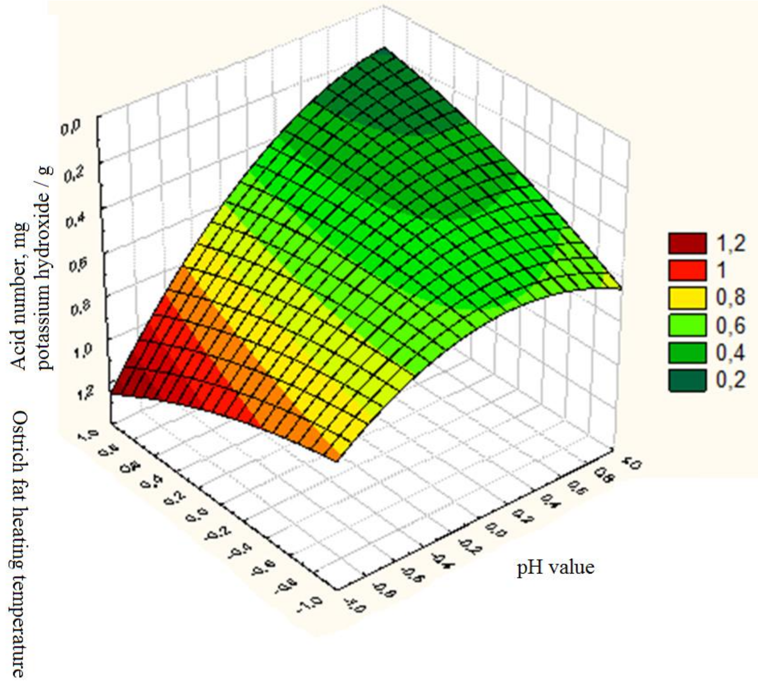

Figure 2: Dependence of the acid number from the pH and the temperature of melting fat ostrich

The graph (Fig. 2) illustrates the minimization of the acid number, the tendency of the value to zero. Saturated dark green color, set for an acid number of 0.2 mg potassium hydroxide / g, is located on top of the lined volume model. Its high values (from 1.0 - 1.2 mg of potassium hydroxide / g) are located at the bottom of the three-dimensional graphic image and occupy a small fraction of its area.

In fig. 3 shows a graph showing the range of pH values of the electroactivated fluid and the temperature of the ostrich fat boiling most favorable for obtaining the finished product with low acid value.

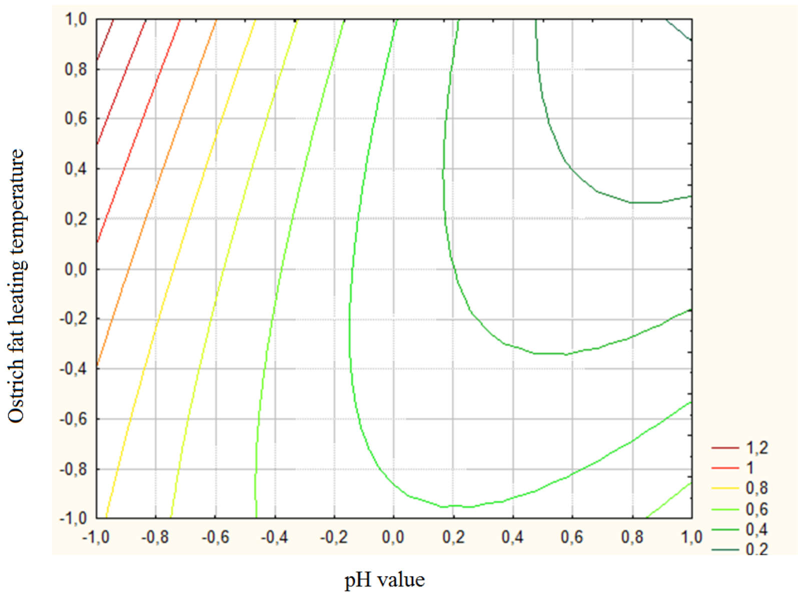

Figure 3: Regions of electrolyte pH and temperature of melting to obtain ostrich fat with low acid value

Analyzing the presented image (Fig. 3), it can be noted that a clear boundary of the optimum under the given conditions of the technological process was not achieved. At the same time, it is obvious that the lowest acid number can be obtained at a pH and a temperature of melting in the range of coded units from 0.9 to 1.0.

Conversion of coded units into natural values using the variation levels of given factors (Table 1) are presented in Table 5.

Table 5: Areas of factor space in terms of the acid number of the fat product

Response function	Values of selected factors			
Acid number (Y_2)	Hydrogen indicator (pH)		Temperature of heat	
	coded units	natural values	coded units	natural values
	0,9 - 1,0	10,89-11	0,9 - 1,0	73,0-75,0

From the presented values (Table 5) of the pH value and temperature of ostrich fat melting, it can be noted that in order to achieve low acid values of the product, it is necessary to rely when preparing electro-activated liquid at a pH close to 11, as regards temperature, the minimum value of the response function is the interval is 73.0-75.0 ºC.

Based on the obtained equation coefficients and graphic data, the process conditions were optimized for the pH of the electrolyte (catholyte) and the parameters of ostrich fat melting temperature, which made it possible to obtain five fractions of a fat product with specified characteristics without loss of its output. When predicting the properties of the finished product, it is important to consider that the coating of the graphic area (Fig. 3), in which the acid number does not exceed 0.4 mg of potassium hydroxide / g is in the range of pH values 10.2 -11.0 and the temperature of melting fat from - 53.4 ºC -75.0 ºC However, the use of high temperatures and low pH values of electroactivated water (catholyte) in the processing of fat will create prerequisites for increasing the acid number of the finished product.

CONCLUSION

In conclusion, it should be noted that the stated technical problem is achieved due to the physicochemical effect of the electrolyte solution, contributing to the destruction of a complex intracellular colloidal system, which includes fat. The shortening of the heat treatment period of the raw material ensures the prevention of deep hydrolysis of fat and improves the quality of the product, in particular, at a temperature of melting from 53.0 ºC, the fat product will have an acid number not exceeding 0.4 mg potassium hydroxide / g. The innovative component of the proposed technology for obtaining ostrich fat by electrochemical activation and the subsequent implementation of domestic scientific and technical solutions to create a line for complex processing of ostrich raw fat will allow us to offer modern systems for designing new high-quality functional products.

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REFERENCES

[1] Mintusov V.K. State policy of regulating food imports in Russia // Bulletin of the University FSBEI of HE "GUU" .2016.-№4.-p. 37-42.

[2] Gorbacheva M.V., Sapozhnikova A.I. African ostrich fat is a promising and safe product for the consumer market // Storage and processing of agricultural raw materials. 2012. N3. p. 8-10.

[3] Gorbacheva M.V., Sukhinina T.V., Strepetova O.A. Commercial ostrich farming: processing and selling of products // International Journal of Advanced Biotechnology and Research.2018, vol.9, no.1, pp. 1166 -1184.
[4] Gorbacheva M.V., Sapozhnikova A.I., Bobyleva O.V. Ostrich fat: a resource potential for the food industry // Storage and processing of agricultural raw materials. 2017.-№1.- p. 45-49.
[5] Pat 2591126 Russian Federation, IPC C 11 B 1/12. Installation for fat extraction in the electromagnetic field of ultra-high frequency / Selivanov I.M., Belova M.V., Belov A.A., Ershova I.G., Novikova G.V., Mikhailova O.V., Sorokina M.G. ., Petrova O.I. .; applicant and patent holder Autonomous non-profit organization of higher education "Academy of Technology and Management" (RU). - №2015116255 / 13; declare 04/28/2015; publ. 07/10/2016 Bull. N 19. 9 p.
[6] Paronyan V.K. Technology of fats and fat substitutes. Moscow: Light and food industry, 2004.- 352 p.
[7] Royenko T.F. Fats for food concentrates // Food industry. 2015. N 1 (23) .- p. 36-38.
[8] Gorbacheva M.V., Shvelidze E.M., Shcherbakova A.V., Tarasov E.V. The use of electro-activated water during wet warming up of ostrich fat // Mat. National Scientific and Practical Conference "Commodity Research, Technology and Expertise: Innovative Solutions and Development Prospects" - June 14-15, 2018 - Moscow: ZooVetKniga publishing house, 2018. –p. 290-296.
[9] Pat 2382072 C1 Russian Federation, IPC C11B1 / 12 C11B1 / 00 Method for producing ostrich baked fat, applicant and patentee Agricultural company Prirechensky, No. 2008150051/13; dec. 18.12.2008; publ.20.02.2010. N5. 6 p.