The influence of physico-chemical methods on the process of ostrich fat warming

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Abstract. The work is devoted to the study of the influence of technological parameters and optimization of the duration of the process of fat extraction in the presence of electroactivated liquid. The introduction of innovative technologies that allow the rational use of animal fats. The proposed new technical solutions are aimed at obtaining fat with a controlled melting point, high yield and consumer properties, reducing water consumption, energy consumption and industrial waste, reducing the environmental load on the environment. The foregoing gave reason to consider the chosen area of research quite promising. A catholyte with desired properties, obtained by electrolysis of an aqueous solution of NaCL with a mass fraction of 4 g/100 cm³, was used as the aqueous phase in wet ejection. The main technological factors were chosen pH of the electroactivated medium, the temperature of the expulsion of raw fat and the duration of the process. It has been revealed that the use of an electrochemical activated medium in wet fat pushing of fat reduces the risks of the formation of free fatty acids and cross-linking compounds. Due to the complex effect of physical and chemical factors, the process of fat extraction without loss in yield of the final product has been intensified. Reducing the duration of heat treatment of raw materials helps to prevent deep hydrolysis of fat and improves the quality of melted fat.

1. Introduction

Oil and fat industry is one of the oldest industries in Russia, which in turn is developing rapidly [1]. Fats of animal origin are characterized by valuable chemical composition and can be used to create various functional products. In addition to traditional types of fats from farm animals and birds, in recent years, the fat of African ostrich has attracted increasing attention. Due to its properties, fatty acid composition, high nutritional value and digestibility, this product, of course, can be considered as a new raw material resource for the food, cosmetic and pharmaceutical industries [2].

Domestic scientists are actively working on the development and implementation of healthy food products, reducing unit costs in the production of oil and fat products [3-6]. Issues of expanding resource capabilities through the introduction of innovative technologies that make it possible to rationally process and use fats, creating new healthy products with the maximum preservation of the balance of valuable components in them, are characterized by promise and significance.
The formation of the quality of the finished product and its output, which is taken into account when developing technologies and lines for processing fat, is significantly affected by the method of extracting fat. Animal fats are obtained by dry or wet ejection, evaporation, extraction (hot water, steam, organic solvents), vibroextraction, pressing, separation, treatment with chemicals (alkalis, acids) [7]. There is an effective way to drain ostrich fat with an electrolyte, which is introduced instead of the aqueous phase in wet heating [8]. The phenomenon of electrochemical activation was discovered in 1875 by engineer V. Bakhir. The product of electrochemical activation are solutions with changing properties over time, respectively, it is usually used for production purposes and technologies using electroactivated liquid [9, 10-14]. The use of devices for electrochemical activation of water began in 1992, and on behalf of the Russian government in 1998 it was recommended that ministries and departments use technologies based on this technology in medicine, agriculture and industry [15]. The proposed new technical solutions are aimed at obtaining fat with a controlled melting point, high yield and consumer properties, reducing water consumption and energy consumption, production waste, reducing the environmental load on the environment, which determines the relevance of this study. The purpose of the work is to study the influence of technological parameters and optimize the process of fat extraction in the presence of electroactivated liquid to ensure quality and high yield of ostrich ghee.

2. Materials and methods
The objects of study were: ostrich fat, melted wet in the presence of electroactivated liquid and technologically parameters of the fat extraction process. As the aqueous phase we used catholyte obtained by electrolysis of a 10% aqueous solution of NaCl with a constant current of 0.5-0.6 A and a voltage of 40-42 volts, with a pH of 9-11 and a redox potential (-600) - (-700) mV and a mass fraction of NaCl of 4 g / 100 cm³. The selection of optimal concentrations of sodium chloride and voltage to obtain an electrolyte (catholyte) with high biological and physico-chemical activity was carried out empirically and by calculation [16].

Fat was heat treated in an open stainless-steel tank at various temperatures and with constant mixing of pre-ground fatty raw materials. Research on quality indicators of melted fat was carried out in accordance with GOST R54676-2011 Edible bird fats, GOST R ISO27107-2010 Animal and vegetable fats and oils. Studies were performed in triplicate and processed statistically.

A two-factor experiment was applied to optimize the technology for producing fat with desired properties. The use of factor analysis in the work made it possible to implement the main possibilities of planning an experiment to select the conditions of the technological process for obtaining ostrich fat. When setting goals, it was necessary not only to find the regression equation, which describes the dependence of certain factors, but also to search for their optimal values. As a result of the calculations, an equation was obtained that has the following form:

\[ \bar{y} = b_0 + b_1 x_1 + b_2 x_2 + b_{11} x_1^2 + b_{12} x_1 x_2 + b_{22} x_2^2 \]  

where \( b_0 \) - is a free term of the equation;
\( x_1, x_2,...,x_n \) - factors determining the level of the studied effective parameter;
\( b_1, b_2,...b_n \) - regression coefficients at factor indicators characterizing the level of influence of each factor on the effective parameter in absolute terms.
The main technological factors were the pH of the electroactivated liquid \( X_1 (Z_1) \) and the temperature of the crude fat \( X_2 (Z_2) \). The response function is the yield of melted ostrich fat \( (Y_i) \).

3. The discussion of the results
To establish the dependencies and justification of the modes of fat pushing out, which determine its high yield by the proposed technology, a series of experiments was carried out and an experiment matrix was compiled (table 2). The levels of textured space are shown in table 1.
### Table 1. Variation levels of selected factors for ostrich fat accumulation

| Factors   | $Z_i^{\text{min}}$ | $Z_i$ | $Z_i^{\text{max}}$ |
|-----------|-------------------|------|------------------|
| pH $X_1(Z_1)$ | 9.0 | 10.0 | 11.0 |
| Temperature $X_2(Z_2)$, °C | 45.0 | 75.0 | 100.0 |

### Table 2. A full factorial experiment optimizing the conditions of fat accumulation by product yield

| Experience Number | Factors on a natural scale $^a$ | Factors in a dimensionless coordinate system | $y_{1,\text{exp.}}$, % | $\hat{y}_{\text{est.}}$, % |
|-------------------|-----------------------------|----------------------------------|------------------|--------------------|
|                   | $Z_1$, pH | $Z_2$, °C | $x_1$ | $x_2$ |                     |                     |
| 1                 | 11 | 75 | +1 | 0 | 84 | 85.4 |
| 2                 | 10 | 100 | 0 | +1 | 95 | 94.8 |
| 3                 | 9 | 75 | -1 | 0 | 86.2 | 85.4 |
| 4                 | 10 | 45 | 0 | -1 | 76.5 | 77.2 |
| 5                 | 11 | 100 | +1 | +1 | 92.3 | 92.3 |
| 6                 | 9 | 100 | -1 | +1 | 90.9 | 91.1 |
| 7                 | 9 | 45 | -1 | -1 | 75.1 | 74.8 |
| 8                 | 11 | 45 | +1 | -1 | 74.0 | 73.5 |
| 9                 | 10 | 75 | 0 | 0 | 89.0 | 88.5 |

$^a$ Additional experiments in the center of the plan $Y_1 = 88.9; Y_2 = 90.0; Y_3 = 90.1; Z_1$ - hydrogen indicator (pH), $Z_2$ - temperature, °C

Based on the data obtained (table 2), a mathematical model was calculated for the conditions for expelling ostrich fat. The dependence of the output on the set parameters is presented in the form of a regression equation (1) and Torus lines on the plane (Figure 1).

$$y_i = 88,4556 - 0,3167X_1 + 8,7667X_2 - 3,0833X_1X_1 + 0,625X_1X_2 - 2,4333X_2X_2. \ (2)$$

When checking the coefficients of the equation (2), it was determined that only 5 of them are significant; respectively, the final regression equation has the form:

$$y_i = 88,4556 + 8,7667X_2 - 3,0833X_1X_1 + 0,625X_1X_2 - 2,4333X_2X_2. \ (3)$$

Having calculated the Fisher criterion, it was found that the resulting mathematical model adequately describes the experiment. As can be seen from the coefficients of the equation, the fat yield depends not only on the melting temperature, but also on the complex effect of the studied factors. Moreover, if we consider the unilateral influence of the catholyte pH, then, under the given experimental conditions, it does not have a significant impact. At the same time, it was determined that a significant increase in both the hydrogen index of the catholyte water phase and the temperature leads to a decrease in fat yield.

As can be seen from the data in Figure 1, the region of effective factor space varies in a significant range of temperature and pH of catholyte. To determine the optimal ejection parameters, the coded pH values and ejection temperatures (Figure 1) were converted to natural units. It was determined that at a pH of 9.5-10.6 and a temperature of more than 95°-100°C, the fat yield will be over 95%.

It is known that at a more upward temperature of fat extraction, hydrolytic decomposition and the action of proteolytic enzymes are accelerated. At the first stage of processing, hydrolysis is due to the action of linden. When undercut, lipase adipose tissue is inactivated at a temperature of 60°C. Thus, the combined effect of two factors is of no small importance: the maximum temperature and the duration of its exposure. The shortest processing time is determined by the melting time of the fat and the exposure time of the raw materials to destroy pathogenic microflora at a given temperature [17].
Figure 1. Dependence of fat yield on the hydrogen index of electrolyte (catholyte) and the temperature of heating

Accordingly, an important stage in the work was to investigate the influence of temperature and duration of fat extraction on the qualitative characteristics of melted ostrich fat (Figures 2-4).

Figure 2. Change in the quality and yield of ostrich fat depending on the duration of warming at a temperature of 55°C
As can be seen from the graphic data (Figure 2), the electroactivated liquid (catholyte) intensifies the process of expelling fat. At a temperature of 55°C and a processing time of 35-40 minutes, the yield of the melted product was about 50%. In this case, the acid and peroxide numbers did not exceed 0.4 mg KOH / g and 1.5 mmol of active oxygen / kg, respectively. As the ejection time was increased to 60 minutes, the output productivity increased by 40% compared with the initial value (40%). The qualitative characteristics of ostrich ghee have changed slightly and meet the requirements of ghee.

Noteworthy (Figure 3) is a sharp increase in fat yield only in the time interval from 40 to 45 minutes. With a further cycle of processing the raw materials, the yield indicators change on average by no more than 1.0 - 1.5%, which indicates that there is no need to increase the duration of warming. The opposite tendency was noted in the acid and especially peroxides of ostrich fat (Figure 3).

Figure 3. Change in the quality and yield of ostrich fat depending on the duration of warming at a temperature of 75°C

Figure 4. Change in the quality and yield of ostrich fat depending on the duration of warming at a temperature of 100°C
As can be seen from the data in Figure 4, high fat yields (over 80-88%) were obtained after 30-35 minutes of expulsion at a temperature of 100°C. With a processing time of raw materials for 40 minutes, the yield of melted fat is 92%, followed by an increase of 2% on average, depending on the time of fat extraction. The revealed low indicators of acid and peroxide values of the finished fat product confirm the inactivating effect of the electrochemical activated medium. The complex of studies made it possible to establish that the most appropriate should be considered ostrich fat melting in the electrolyte (catholyte) for 50-45 minutes, regardless of thermal effects. At low processing temperatures, the fat extraction time can be increased up to 60 minutes, depending on the target installation.

4. Conclusion
It has been proved empirically and by calculation that the introduction of the aqueous phase of the electrical panel (catholyte) with the desired properties into the wet heating of ostrich fat contributes to the intensification of the process. Due to the complex effects of physical and chemical factors, the technological parameters of fat extraction are optimized. Reducing the duration of the heat treatment of raw materials prevents the deep hydrolysis of fat and improves the quality of the resulting product. In the course of research, the technology for wet ejection of ostrich fat in the presence of an electrochemically activated fluid was improved.

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