

Frying composition based on ostrich fat and a natural antioxidant additive

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Abstract. The work is devoted to the influence of component composition on the quality of fat frying composition to improve the method of its production. Experimental versions of fat frying composition based on liquid and solid fractions of ostrich fat, as well as stabilizing additive CO₂-extract of marjoram served as objects of research. The method of preparation of the fat frying composition included reception of a fat component by wet melting of raw ostrich fat, with the subsequent division of fat into liquid and solid fractions; mixing of the liquid fraction with a stabilizing additive and combination of the received mass with the solid fraction. Moreover, during storage of the frying composition, the liquid fraction is at the top, and before its use the fractions are mixed. It was shown that the introduction of CO₂-extract of marjoram into the liquid fraction and increasing its concentration to 0.2 % reduces the degree of thermal oxidation of the product and slows down oxidative processes in the fat.

1 Introduction

The accelerated pace of life leads to increased popularity of fast food products, often showing undesirable effects on human health, which is closely related to changes in the rhythm and lifestyle, working conditions. The economic component is not unimportant, as fast food is cheaper on the background of natural counterparts, and in taste, nourishment and smell is not inferior to them [1, p. 1100]. Plant or animal fats play a dual role in this process: a technological substance and an essential component in food, containing a significant amount of nutrients and energy [2, p.20]. Fats represent complex multicomponent systems, each element of which in oxidation conditions changes according to kinetics of reactions taking place at present time [3, p.4]. In the process of frying, they perform the role of heat carrier, and also influence the quality of the finished dish and determine the final result, as during the cooking in deep frying the product undergoes not only physical, but also chemical changes [2, p.20]. At the first stage, primary oxidation products are formed, among them hydroxy and hydroperoxy compounds, dihydroperoxides and cis-transconjugated diene systems. Secondary and tertiary compounds are formed from

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them and their rate of formation, types and quantitative ratios are determined by the nature of lipids, oxidation conditions and the presence of antioxidants in the fat [3, p.4]. Accordingly, the quality of instant products will primarily determine the degree of absorption of frying fat by the finished product, the content in this fat of thermal oxidation products formed during the technological process and the depth of oxidative changes in fat during storage [4; 5, p. 6234].

Thus the questions of kinetics of frying process and changes of physical and chemical properties of frying fat at different stages of its use become actual.

The purpose of the work is the study of influence of components composition on the quality of fat frying composition for the improvement of the method of its production.

2 Materials and methods

The objects of the study were the experimental variants of fat frying composition based on liquid and solid fractions of ostrich fat, as well as stabilizing additive CO₂-extract of marjoram (tab. 1).

The method of preparation of frying fat composition included obtaining fat component by wet melting of raw ostrich fat in electro-activated medium (catholite), followed by separation of fat into liquid and solid fractions; mixing of liquid fraction with stabilizing additive at temperature 24-26 °C, combination of the obtained mass with solid fraction of fat component. Moreover, the method assumes that during storage of the frying composition the liquid fraction is in the upper part, and before its use the fractions are mixed.

The process of obtaining ostrich fat under laboratory conditions involved pre-crushing the purified raw fat to a particle size of 0.5 mm. Wet melting in an electrolyte was carried out in an HM-220VM vacuum homogenizer (Japan-Taiwan). Used water in the ratio 8:1 to the raw material mass complied with the requirements of GOST P 51232-98 [6, p.33; 7, p.95-96]. Duration of fat extraction at temperature 100 °C was 60 minutes. Division into solid and liquid fractions was carried out by filtration with vacuum under the filtering surface to intensify the process. Fat was separated from the water-protein phase by centrifugation at 6000 rpm for 5 minutes. The resulting fat was dehydrated at a rotary evaporator PE-8910 (Russia) at a residual pressure of 2666.44 Pa. The catholyte was produced in an electrolyzer by electrolysis of 10% NaCl aqueous solution. Direct current strength 0.5 - 0.6 A, voltage 40 - 42 V, pH 9 - 11, redox potential (ORP) (-400) - (-700 mV), sodium chloride mass fraction 4 g/100 cm³ [6, p.33; 7, p.95-96].

Potato slices with the thickness and width of 1×1 cm were used as test product, weight of portion for 1 frying - 200 g, weight of fat frying composition, loaded into the fryer - 400 g, frying temperature - 170-180 °C, frying time - 4-6 minutes.

The quality of the fat frying composition and efficiency of the marjoram CO₂ stabilizing additive were evaluated according to the oxidation stability (oxidation stability) according to GOST 53160-2008. The measurements were carried out at 110 °C on a 743 Ransimat (Metrohm Ltd., Herisau, Switzerland). Determination of the level of hydrolytic deterioration of frying fat was carried out according to the acid number in accordance with GOST R 546073-2014. The acid number (AF) was measured according to GOST 31933-2012. Degree of thermal oxidation of frying fat was determined according to GOST R 546073-2014. The method is designed to determine the change in the quality of frying fats during prolonged frying of culinary products in frying. In the process of heating fats at 170-190 °C, the intensity of the UV absorption band of 232 nm wavelength increases, which corresponds to the absorption of conjugated diene chromophores. Value of specific absorption should not be more than 15 that corresponds to limit value of oxidation products in frying equal to 1 % [8, p.165].

The research of influence of components of the composition on quality of fat frying composition and selection of its optimum variant was carried out with the use of method of Scheffe's simplex lattice for polynomials (ξ) of the third order (tab. 2).

The mass fraction of liquid (X_1), solid (X_2) fractions of ostrich fat and CO_2 - marjoram extract (X_3) were chosen as optimization factors. Response functions: level of hydrolytic deterioration of fat (K_h), mg KOH/g - y_1 ; resistance to oxidation, h - y_2 ; degree of thermal oxidation - y_3 . The levels of variation of the studied factors were converted into coded values from 0 to 1.0 (tab. 1).

Table 1. Variation levels of frying fat components

Designation of factors in kind	Factors to be investigated	Levels of factors in coded values					
		0	0,25	0,33	0,5	0,75	1,0
		Levels of factors in natural values					
Z_1	Liquid fraction of ostrich fat, g	30,0	37,5	39,9	45,0	52,5	60,0
Z_2	Solid fraction of ostrich fat, g	40,0	45,0	46,6	50,0	55,0	60,0
Z_3	Stabilising additive) Marjoram CO_2 -extract, g	0,01	0,06	0,07	0,10	0,15	0,2

Proceeding from technological and techno-economic requirements, planning of experiment was carried out on a concentration triangle, presented in the coded and natural values of factors in figure 1.

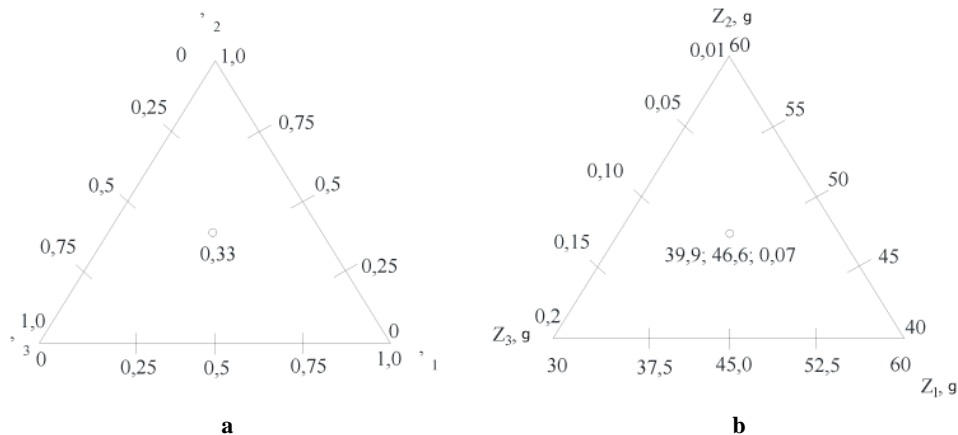


Fig. 1. Field of study of the fryer composition: a – The plan of the experiment in coded values, b – Experiment plan in natural units.

When the simplex-split experiment was conducted to check the adequacy of the equation, experiments were conducted at additional points (control) to be able to improve the resulting model, in case of inadequacy. The adequacy of the regression equations was examined by calculating the variance of reproducibility and the value (t), distributed according to Student's law, by comparing it with the table value of $t_{\rho/2l}(f)$: ρ is the significance level; l is the number of control points; f is the number of degrees of freedom of the reproducibility variance. The hypothesis of the adequacy of the equation is accepted when $t_{exp} < t_{table}$ for all control points.

3 Results

The task of the work was not only to select the ratio of the component composition, but also to study the degree of influence of the proportion entering into the recipe of the frying fat composition, liquid and solid fractions of the ostrich fat in the complex with stabilizing additive on qualitative characteristics of frying fat, and also to analyze the mechanism of their interaction.

Table 2. Third-order simplex lattice plan and results of response functions

Exp number	Planning matrix in coded values			Planning matrix in natural values, g			Response functions					
	X ₁	X ₂	X ₃	Z ₁ , g	Z ₂ , g	Z ₃ , g	y ₁ , mg KOH/g	ŷ ₁ , mg KOH/g	y ₂ , h	ŷ ₂ , h	y ₃	ŷ ₃
1	0	0	1	30,0	40,0	0,20	2,1	2,09	15,8	15,3	3,73	3,74
2	0	1	0	30,0	60,0	0,01	3,6	3,60	17,8	18,0	7,66	7,54
3	1	0	0	60,0	40,0	0,01	3,0	2,98	11,2	11,2	10,18	10,18
4	0,5	0,5	0	45,0	50,0	0,01	2,5	2,47	12,4	12,1	1,82	1,81
5	0	0,5	0,5	30,0	50,0	0,10	2,0	1,99	18,0	17,9	1,55	1,55
6	0,5	0	0,5	45,0	40,0	0,10	2,2	2,20	18,5	18,0	1,50	1,49
7	0,25	0,75	0	37,5	55,0	0,01	2,8	2,83	14,3	14,4	2,87	2,91
8	0,75	0,25	0	52,5	45,0	0,01	2,5	2,52	10,8	11,0	4,26	4,23
9	0	0,25	0,75	30,0	45,0	0,15	1,8	1,83	16,3	16,9	1,62	1,62
10	0	0,75	0,25	30,0	55,0	0,06	2,6	2,58	18,7	18,2	3,54	3,53
11	0,25	0	0,75	37,5	40,0	0,15	2,1	2,09	17,3	17,9	1,27	1,25
12	0,75	0	0,25	52,5	40,0	0,06	2,5	2,51	15,7	15,8	4,44	4,47
13	0,33	0,33	0,33	39,9	46,6	0,07	2,0	1,99	21,5	21,2	1,56	1,25
14	0,33	0,33	0,33	39,9	46,6	0,07	2,2	1,99	22,0	21,2	1,52	1,25
15	0,33	0,33	0,33	39,9	46,6	0,07	2,2	1,99	23,0	21,2	1,49	1,25
16	0,33	0,33	0,33	39,9	46,6	0,07	2,3	1,99	22,5	21,2	1,56	1,25

Note: y₁ - level of hydrolytic deterioration of fat (K_h), mg KOH/g; y₂ - resistance to oxidation, h; y₃ - degree of thermal decomposition.

y₁, y₂, y₃ – experimental values of response functions.

ŷ₁, ŷ₂, ŷ₃ – the calculated values of the response functions obtained according to equations (1), (2), (3).

According to the obtained data (tab. 2), the lowest indicator of acid number equal to 1.8 mg KOH/g and a significant resistance to oxidation 16.3 h were determined at the ratio of components of deep-fat: liquid fraction - 30.0 g, solid - 50.0 g and stabilizing agent - 0.10 g (experiment № 9). Positive results for hydrolytic deterioration and oxidation stability of the investigated product were also obtained in experiments No. 5 and No. 11, when adding the liquid and solid fractions of ostrich fat, respectively: 30:45 g and 37,5:40 g; CO₂-extract of marjoram - in an amount of 0,15 g. However, the lowest degree of thermal oxidation (1,25 units) was determined only in experiment No. 11, which indicates that the formation and decomposition of peroxides during a thermal effect on the frying fat was insignificant. Cyclic peroxides can decompose to form two compounds with a shortened chain (aldehyde and aldehyde-acid), which during further oxidation can form correspondingly one-base and

two-base acids, which together with free fatty acids increase the acid number of the fat [9 p.106]. It should be noted that increasing the concentration of marjoram CO₂-extract results in lower thermal oxidation of the product and slows down oxidation processes in fat, which is probably connected with the presence of substances in marjoram CO₂-extract that block the activity of free radicals.

For scientific substantiation of a choice of proportions of fat fractions and stabilizing additive, the statistical analysis of the received results of properties of fat frying composition was carried out, the equations of regression (equations (1-3)) were calculated and graphic models of dependence were made (fig. 2):

a) Dependence of the hydrolytic deterioration index of fat on the factors investigated:

$$Y_1 = 2,987\chi_1 + 3,603\chi_2 + 2,009\chi_3 - 3,317\chi_1\chi_2 - 1,332\chi_1\chi_3 - 3,439\chi_2\chi_3 + 0,067\chi_1\chi_2\chi_3 \quad (1)$$

b) Dependence of the fat oxidation stability index on the factors investigated:

$$Y_2 = 11,171\chi_1 + 18,016\chi_2 + 15,318\chi_3 - 9,899\chi_1\chi_2 + 19,083\chi_1\chi_3 + 4,861\chi_2\chi_3 + 137,817\chi_1\chi_2\chi_3 \quad (2)$$

c) Dependence of the thermal decomposition index of fat on the factors investigated:

$$Y_3 = 10,1894x_1 + 7,6247x_2 + 3,7459x_3 - 28,4237x_1x_2 - 21,9043x_1x_3 - 16,552x_2x_3 + 47,9775x_1x_2x_3 \quad (3)$$

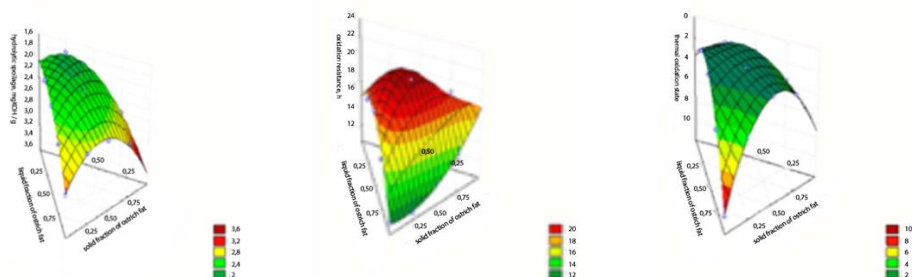


Fig. 2. Graphic model of the dependence of quality indicators of frying composition on the ratio of fat fractions and marjoram CO₂-extract in it: A) hydrolytic deterioration index, mg KOH/g; B) oxidation resistance index, h; C) degree of thermal oxidation

As can be seen from equation (1) and figure 1A, all three of the components examined can account for an increase in the hydrolytic deterioration index of the fryer composition. However, cross-exposure of the fat fractions and combining them individually with a stabilising agent will result in a reduction in the acid number of the fat (equation (1)). The amount of solid fraction of ostrich fat (equation (2), Figure 1B) has a greater influence on its resistance to oxidation, while the degree of thermal degradation, in contrast, is more dependent on the mass fraction in the formulation of the liquid fraction (equation (3), Figure 1B). Furthermore, analysis of the simplex-lattice plans and the calculated equations showed that the increase in the fat oxidation stability index was directly dependent on the cross-effect of the liquid fraction of ostrich fat and the CO₂-extract of marjoram. The same can be noted regarding thermal decomposition of fat: the decrease of peroxides in it directly depends on the ratio of the liquid and solid fractions in the frying composition formulation, as well as the joint mechanism of action of the liquid and/or solid fraction in combination with a stabilising additive to prevent formation of low-molecular acids.

Taking into account the results of the complex studies, the dependences established and the interaction between the components of the frying composition, its formulation was developed (tab. 3).

Table 3. Recipe for fat frying composition

Component name	Ratio, weight %
Liquid fraction of ostrich fat	30,0 – 39,9
Solid ostrich fat fraction	46,6 – 55,0
Stabilizing additive	0,06 – 0,10

In conclusion it is important to note that the use of ostrich fat obtained by the proposed technology, providing a given composition of liquid and solid fractions, the inclusion of a stabilizing additive in the form of CO₂-extract of marjoram allowed:

- increase the shelf life of the frying composition before its use due to the use of a natural antioxidant;
- in the process of use at frying at 175-185 °C decrease the level of hydrolytic deterioration of fat (K_h) from 1,8 to 2.0 mg KOH/g; increase resistance to oxidation from 21 to 23 hours; decrease the degree of thermal decay to 1,49-1,56;
- Increase the volume of the finished product per unit volume of frying compound used.

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