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DEVELOPMENT OF TECHNOLOGY FOR OBTAINING FAT COMPOSITIONS WITH INCREASED OXIDATIVE STABILITY

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The object of research is the process of fat oxidation at elevated and standard temperatures.

Fats are used in chemical, pharmaceutical, food and other industries. Oxidative deterioration changes the composition of fats, reduces the efficiency of chemical reactions involving fats and the quality of final products. An urgent task is to increase the oxidative stability of fats.

The oxidative stability of fat compositions based on rapeseed, high-oleic sunflower and palm oils by the induction period at a temperature of 110 °C was investigated. The induction periods of the initial oils were 408.48 min., 795.87 min. and 630.2 min., respectively. Rational ratios of oils in the compositions were found: high-oleic sunflower: palm (50:50) %; rapeseed: high-oleic sunflower: palm (16.67:66.67:16.67) %; rapeseed: high-oleic sunflower: palm (33.33:33.33:33.33) %. The induction periods of the mixtures are 650.57 min., 710.56 min. and 670.56 min., respectively.

The increase in the oxidative stability of the developed compositions using the mixture of synthetic antioxidants (butylhydroxyanisole, butylhydroxytoluene and tert-butylhydroquinone) in an amount of 300 mg/kg of fat mixture was studied. The induction periods of the developed compositions were 910.80 min., 1279.01 min. and 1072.90 min., respectively.

The physicochemical parameters of compositions with the addition of antioxidants after 5 months of storage at a temperature of (20±2) °C were determined. The peroxide values of the compositions were 5.65; 3.28; 4.50 ½ O mmol/kg, respectively.

The research results make it possible to produce fats with increased oxidative stability and necessary properties, to predict induction periods of fat compositions depending on the concentrations of components. This will increase the profitability of production and the quality of fats obtained

Keywords: fat composition, oxidative stability, induction period, oxidation inhibitor, free radical process

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1. Introduction

A significant problem in the production and use of fats is various types of deterioration caused by hydrolytic and oxidizing processes. Changes in the composition and properties of fats as a result of oxidation complicate their use as components of lubricants, construction materials, food and cosmetic products, as raw materials for biodiesel fuel, etc. [1]. The use of oxidized oils as raw materials impairs the quality of finished products, requires an increase in the dosage of catalysts, etc. [2]. Thus, during chemical transesterification, a fat peroxide value of 1.0 ½ O mmol/kg causes deactivation of the sodium methoxide catalyst in an amount of 0.054 kg/t of oil [3].

The rate of oxidation is determined by the structure of fatty acids in triglycerides, temperature, etc. [4]. Oxidation occurs as a chain free-radical process, the initiators of which are active forms of oxygen [5]. Effective synthetic antioxidants (inhibitors of the process) are propyl gallate (n-propyl ester of 3,4,5-trioxybenzoic acid), phenolic compounds: butylhydroxyanisole, butylhydroxytoluene, tert-butylhydroquinone [6]. Phenolic antioxidants are used at elevated temperatures. Propyl gallate loses its effectiveness at a melting temperature of 148 °C [7].

Therefore, studies of the effectiveness of antioxidants and the development of fat systems stable to oxidation are relevant [8]. This issue is especially important when using fats at elevated temperatures. For example, temperatures of (90–115) °C are used during reactions of transesterification, alcoholysis, glycerolysis of fats [9].

There are types of oils that have the greatest industrial importance. Thus, from the point of view of oxidative stability, the use of high-oleic sunflower oil, in which the content of oleic acid reaches (75.0–90.7) %, is promising. Usually, this indicator in sunflower oil is (14.0–39.4) %. The oxidative stability of high-oleic sunflower oil, including at elevated temperatures, is 4 times higher than that of traditional [10]. Rapeseed oil is widely used as a raw material in chemical processes, in particular, in the production of biodiesel fuel based on fatty acid esters [11]. One of the common types of oils is palm oil. Due to the high content of solid triglycerides (melting point of oil (32–43) °C), palm oil is highly resistant to oxidative damage [12].

Thus, an important task is to increase the oxidative stability of fats, which are used in various directions. For the production of fats with high oxidative stability at elevated temperatures, it is promising to create fat compositions based on fats, the use of which is technologically and economically expedient. The simultaneous use of antioxidants for such compositions will make it possible to obtain oxidation-stable fatty raw materials for many industrial purposes.

2. Literature review and problem statement

Fats with increased oxidative stability are obtained by developing appropriate fat compositions and using individual antioxidants and multicomponent antioxidant systems.

The work [13] investigated the increase in the oxidative stability of rapeseed oil using plant antioxidants (extracts of thyme and motherwort). But the applied antioxidants are not effective at elevated temperatures for this type of oil.

The authors [14] examined the oxidative stability of rapeseed oil and its mixtures with methyl esters of fatty acids obtained from palm oil. The rational ratio of components is rapeseed oil: ethers (80:20) %. The disadvantage of the work is the lack of data on the effect of initial palm oil on the oxidative stability of mixtures, because usually the raw material for various industries is oil in its primary form.

Changes in the composition of refined rapeseed oil during heat treatment were investigated in [15]. When heating the oil at 60 and 180 °C for 8 hours, the content of phytosterols decreased by 10 and 40 %, and tocopherols by 7 and 30 %, respectively. Therefore, heat treatment of rapeseed oil leads to a decrease in the content of natural antioxidants, which further reduces oxidative stability. The disadvantage of the work is the lack of data on the use of antioxidants and the use of rapeseed oil as part of heat-stable fat mixtures, in particular, with more heat-stable oils.

The work [16] considered the oxidative stability of transesterified palm oil compared to mixtures of initial palm oil with medium-chain triglycerides. After 48 cycles of frying, the anisidine value of transesterified palm oil was 39.5 c. u. (for mixtures – 52.8 and 65.58 c. u.). This indicates higher stability of transesterified oil. But it is advisable to study the oil in its original form, since the composition and properties of transesterified oil depend on transesterification conditions, catalysts, etc.

The work [17] analyzed the oxidative stability of mixtures of palm and olive oils. Olive oil in an amount of more than 20 % showed a negative effect on the stability of the mixtures at temperatures of 120, 130 and 140 °C. But olive oil is commonly used as a component of fat mixtures for various purposes at standard temperatures and is not used when heated.

In [1], the kinetics of oxidation of sunflower and sesame oil mixtures were investigated. The 1:1 mixture had a longer induction period at 100 °C compared to sunflower oil (13.2 vs. 6.1 hours). The disadvantage of the work is the lack of research results on the effect of antioxidants on the stability of mixtures. In addition, the cost of sesame oil is quite high. The cost of sesame oil is $17.5/l, sunflower oil – $1.6/l.

The work [6] evaluated the oxidative stability of binary mixtures of methyl ethers obtained from soybean, sunflower, rapeseed, corn, cottonseed oils and used cooking oil. Rapeseed oil esters showed the highest induction period values (more than 6 hours) and are therefore the most effective biodiesel additive with low oxidation resistance. The study shows the effectiveness of using rapeseed oil as a raw material for the production of biodiesel fuel in terms of oxidation of the finished product. However, there is no information on the effectiveness of using mixtures of fats and antioxidants to increase the oxidative stability of raw materials and products.

Therefore, it is necessary to develop effective technologies for increasing the stability of both initial fatty raw materials and finished products obtained using fats. Scientific research is devoted to the study of the oxidation behavior of individual oils with and without the addition of antioxidants, as well as mixtures of oils with certain compounds (methyl ethers, etc.). But the study of the oxidation resistance of valuable industrial oils and their mixtures, as well as the effectiveness of using antioxidants for the maximum stabilization of fats and fat compositions, remains an unsolved question. Thus, it is advisable to develop fat compositions with increased oxidative stability based on oils that have important technological properties, in particular, high-oleic sunflower, rapeseed and palm oils.

3. The aim and objectives of the study

The aim of the research is to develop fat compositions with increased oxidative stability based on rapeseed, high-oleic sunflower and palm oils using synthetic antioxidants. This will make it possible to obtain multipurpose fats with increased resistance to oxidation at elevated temperatures, to predict the oxidative stability of the fat composition depending on the concentration of components. The study of changes in the physical and chemical parameters of fat compositions during storage under standard conditions will allow predicting the shelf life of fats under real storage conditions.

To achieve the aim, the following objectives were accomplished:

– to investigate the dependence of the oxidative stability of fat compositions based on rapeseed, high-oleic sunflower and palm oils on the concentration of components at elevated temperatures;

– to determine the effect of the mixture of synthetic antioxidants on the oxidative stability of fat compositions with rational concentrations of components at elevated temperatures;

– to investigate the effect of the mixture of synthetic antioxidants on the change in the physical and chemical parameters of fat compositions with rational concentrations of components during storage under standard conditions.

4. Materials and methods of research

4. 1. The object and hypothesis of the research

The object of research is the process of oxidation of fat compositions based on rapeseed, high-oleic sunflower and palm oils at elevated temperatures and under standard conditions.

The main hypothesis of the study is the effect of the concentration of components and the presence of synthetic antioxidants on the oxidative stability of the fat composition. The study assumed that concentrations of palm and high-oleic sunflower oils have the most significant effect on the induction periods of fatty compositions. A simplification is adopted that the most effective is the simultaneous use of three synthetic antioxidants (butylhydroxyanisole, butylhydroxytoluene and tert-butylhydroquinone) to maximize the oxidative stability of fats. Standard research methods are applied.

4. 2. Examined materials and equipment used in the experiment

The following reagents and materials were used:

– refined deodorized rapeseed oil according to DSTU 8175 (CAS Number 120962-03-0);

– refined deodorized frozen high-oleic sunflower oil according to DSTU 9127 (CAS Number 8001-21-6);

– refined bleached deodorized palm oil according to DSTU 4306 (CAS Number 8002-75-3);

– butylhydroxyanisole, purity 98.0 % (CAS Number 25013-16-5);

– butylhydroxytoluene, purity 99.0 % (CAS Number 128-37-0);

– tert-butylhydroquinone, purity 97.0 % (CAS Number 1948-33-0).

4. 3. Methods for determining the physicochemical indicators of oils and fat compositions

Physicochemical indicators are determined using generally accepted methods given in the international documentation on the analysis of oils and fats. To determine the mass fraction of moisture and volatile substances, the standard method for determining this indicator, intended for animal or vegetable fats and oils according to ISO 662, was used. Method A was used, which is applied for liquid and solid fats and oils (with different acid values) because liquid (rapeseed and high-oleic sunflower) and semisolid (palm) oils were studied. To determine the acid value, the standard method was chosen – according to the international standard ISO 660. The method is based on the fact that a sample of oil or fat is dissolved in an appropriate mixture of solvents, and the acids present are titrated with an ethanol or methanol solution of sodium or potassium hydroxide. The peroxide value is determined according to ISO 3960. This regulatory document defines a method for the iodometric determination of the peroxide value of animal and vegetable fats and oils with the visual determination of the endpoint.

4. 4. Methods for determining the induction periods of oils and fat compositions

Induction periods were determined by the method of differential scanning calorimetry (DSC) in isothermal mode at a temperature of 110 °C according to ISO 11357-1, as it is an operational and reliable method for measuring the degree of oxidation of fats. DSC is a common method in thermal analysis. The DSC method is based on measuring the difference in heat fluxes coming from the test sample and the control sample for comparison. DSC allows you to measure characteristic temperatures and the amount of heat released or absorbed during thermophysical processes or chemical reactions occurring in samples when the temperature changes. In the course of processes related to the release or absorption of heat (chemical reactions, phase transitions, etc.) in the sample, deviations from the monotonic dependence of the signal on time (anomalies) are observed on the DSC curves. This allows measuring the induction period in the test samples.

4. 5. Research planning and results processing

Scheffe's three-factor simplex-lattice design was used to plan research and calculate mathematical dependence. The results were processed in the Stat Soft Statistica v6.0 package (USA) environment. Each experiment was repeated twice. Scheffe's simplex-lattice designs are used to optimize the determination of the composition of three-component systems. The designs include graphical visualization of the results as "composition-property" diagrams, which allow efficient determination of rational concentrations of the three test components and analysis of the simultaneous effects of the components on the response function. Therefore, the use of Scheffe's design meets the objectives of the study.

The determined physicochemical indicators of test oil samples (rapeseed, high-oleic sunflower and palm) are presented in Table 1.

Table 1

Physicochemical indicators of initial oils

Indicator	Values of indicators for oils		
	Rapeseed	High-oleic sunflower	Palm
Mass fraction of moisture and volatile substances, %	0.06	0.09	0.07
Acid value, mg KOH/g	0.15	0.18	0.1
Peroxide value, ½ O mmol/kg	1.56	1.79	0.95

Thus, the starting oils meet the requirements of DSTU 8175 (CAS Number 120962-03-0), DSTU 9127 (CAS Number 8001-21-6), DSTU 4306 (CAS Number 8002-75-3), respectively.

The dependence of the induction periods of mixtures of experimental oils (fat compositions) on the concentrations of the components was determined. The induction period is a slow phase of the chemical oxidation reaction, after which a rapid chain process begins. Factors and ranges of variation:

– x_1 – mass fraction of rapeseed oil: (0–100) %;

– x_2 – mass fraction of high-oleic sunflower oil: (0–100) %;

– x_2 – mass fraction of palm oil: (0–100) %.

The response function (y) is the period of induction of fat compositions, determined in the isothermal mode at a temperature of 110 °C by the DSC method, min. In the Stat Soft Statistica v6.0 package (USA), the coefficients of the regression equation, the significance of the coefficients according to the p-criterion ($p>0.05$), the calculated values of the response function, the coefficient of determination (0.840) are determined. p-criterion represents a 95 % confidence probability. Table 2 shows the experimental design matrix.

Table 2

Experimental design matrix

Experiment number	Factors of variation		
	Mass fraction of rapeseed oil, %	Mass fraction of high-oleic sunflower oil, %	Mass fraction of palm oil, %
1	100.00	0	0
2	0	100.00	0
3	0	0	100.00
4	50.00	50.00	0
5	50.00	0	50.00
6	0	50.00	50.00
7	66.67	16.67	16.67
8	16.67	66.67	16.67
9	16.67	16.67	66.67
10	33.33	33.33	33.33

In the Statistica package, calculations were made using the "3 Factor mixture design" module, which combines the procedures necessary for data processing. Thus, the following tabs are applied:

– Coeffs (calculation of equation coefficients, standard error, 95 % confidence interval);

– "Observed, Predicted, and Residual Values" (determination of estimated values of the response function);

– "ANOVA" (analysis of variance).

5. Research results on the development of fat compositions with increased oxidative stability

5. 1. Study of the dependence of the oxidative stability of fat compositions on the components concentration at elevated temperature

According to the experimental design given in Table 2, the experimental values of the response function are determined, the calculated values are determined by equation (1). The results are presented in Table 3.

Table 3

Experimental (y_e) and calculated (y_c) values of the induction periods of fat compositions

Experiment number	1	2	3	4	5	6	7	8	9	10
y_e, min.	408.48	795.87	630.20	540.35	510.25	650.57	550.67	710.56	530.47	670.56
y_c, min.	411.08	779.41	598.90	560.25	509.99	669.16	540.44	689.60	539.35	699.80

The dependence of the induction period of the fat composition (y) on the mass fractions of the components in real variables, in natural form, is as follows:

$$y=4.21\cdot x_1+7.79\cdot x_2+5.98\cdot x_3. \quad (1)$$

Based on the processing of the obtained experimental data, the dependence of the induction period of the fat composition on the mass fraction of the components was constructed as a "composition-property" diagram (Fig. 1).

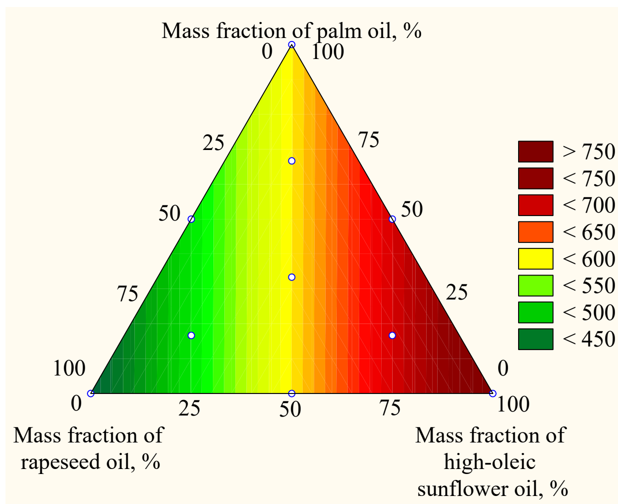

Fig. 1. Dependence of the fat composition induction period on the mass fraction of the components

Analysis of equation (1), the data in Table 2 and Fig. 1 shows the following. High-oleic sunflower oil has the maximum value of the induction period among the experimental oil samples (795.87 min.), and rapeseed oil has the minimum value (408.48 min.). An increase in the mass fractions of high-oleic sunflower and palm oils in the fat composition significantly affects the increase in the induction period. The induction periods for experiments No. 4, 5, 7, 9 are close to each other and exceed the induction period of the least stable of the test oils – rapeseed oil. The compositions corresponding to experiments No. 6, 8, 10 have the greatest oxidative stability. In these cases, the induction periods are longer than the induction periods of individual rapeseed and palm oils. So, in terms of oxidative stability, the rational ratios of oils in the compositions are as follows. Composition No. 1 – high-oleic sunflower: palm (50:50) %; composition No. 2 – rapeseed: high-oleic sunflower: palm (16.67:66.67:16.67) %; composition No. 3 – rapeseed: high-oleic sunflower: palm (33.33:33.33:33.33) %. The induction periods of the mixtures are 650.57 min., 710.56 min. and 670.56 min., respectively.

5. 2. Determination of the effect of synthetic antioxidants on the oxidative stability of fat compositions at elevated temperature

In order to determine the effect of synthetic antioxidants on the oxidative stability of fat compositions, the mixture of antioxidants butylhydroxyanisole, butylhydroxytoluene and tert-butylhydroquinone in equal proportions was used. The mixture of antioxidants was added to the fat compositions in an amount of 300 mg/kg of the fat composition. The induction periods of compositions No. 1–3 with rational concentrations of components, determined by the DSC method at a temperature of 110 °C, were 910.80 min., 1279.01 min. and 1072.90 min., respectively. Therefore, the use of the mixture of antioxidants significantly increased the oxidative stability of the developed fat compositions.

5. 3. Study of the effect of antioxidants on changes in the physicochemical indicators of fat compositions under standard conditions

When using fats, it is an urgent issue to preserve the initial composition and properties under standard storage conditions. The change in the physicochemical indicators of compositions with rational concentrations of components No. 1–3 during storage in standard laboratory conditions was studied: temperature (20±2) °C, air humidity no more than 70 %. The samples were stored in a leaky dark glass container. A comparative analysis of changes in the physicochemical indicators of compositions with and without the addition of antioxidants was performed. The results of the study are given in Table 3.

Table 3

Physicochemical indicators of fat compositions

Indicator	Values of indicators for fat compositions								
	Initial			After storage for 5 months without antioxidants			After storage for 5 months with antioxidants		
	1	2	3	1	2	3	1	2	3
Mass fraction of moisture and volatile substances, %	0.07	0.08	0.07	0.09	0.10	0.08	0.09	0.09	0.08
Acid value, mg KOH/g	0.13	0.17	0.14	0.19	0.23	0.20	0.15	0.18	0.16
Peroxide value, ½ O mmol/kg	1.3	1.4	1.4	8.69	7.55	8.87	5.65	3.28	4.50

Table 3 shows that the peroxide values of samples stored in the presence of synthetic antioxidants are significantly lower than those without antioxidants. Acid values, which characterize the degree of hydrolytic deterioration, are also lower for samples with antioxidants. The mass fraction of moisture increased insignificantly for all samples as a result of storage. Therefore, the addition of synthetic antioxidants reduced the rate of spoilage processes in the samples of the developed fat compositions.

6. Discussion of the research results on increasing the oxidative stability of fat compositions

A technology for obtaining fat compositions with high oxidative stability under elevated temperature and standard storage conditions has been developed. According to equation (1), Table 2 and Fig. 1, the rational ratios of oils in the compositions were determined. Composition No. 1 – high-oleic sunflower: palm (50: 50) %; composition No. 2 – rapeseed: high-oleic sunflower: palm (16.67: 66.67: 16.67) %; composition No. 3 – rapeseed: high-oleic sunflower: palm (33.33: 33.33: 33.33) %. In this case, the induction periods of the mixtures are 650.57 min., 710.56 min. and 670.56 min., respectively.

Oxidation of fats occurs as a chain free-radical process, which is inhibited by antioxidants of various nature. In particular, the phenolic antioxidants butylhydroxyanisole, butylhydroxytoluene, and tert-butylhydroquinone are inhibitors that break chains by reacting with peroxide radicals. The rate of fat oxidation is significantly influenced by the structure of fatty acid residues in fat triglyceride molecules. Fats that have the highest concentrations of unsaturated, especially polyunsaturated, fatty acids in their composition are more susceptible to oxidative damage. In particular, methylene groups located in position 2 to the double bond in the fatty acid radical are primarily attacked during oxidation. Therefore, the selection of fatty raw materials with high resistance to oxidation and the use of antioxidants – oxidation inhibitors are decisive factors in the development of fats with increased oxidative stability.

As evidenced by the data in Table 2, among the studied oil samples, high-oleic sunflower oil has the highest oxidative stability (the induction period at 110 °C was 795.87 min). Therefore, an increase in the mass fraction of this oil causes a maximum increase in the induction periods of fatty compositions. The compositions corresponding to experiments No. 6, 8, and 10 have the greatest oxidative stability (Table 2). In these cases, the induction periods are longer than the induction periods of individual oils: rapeseed (408.48 min.) and palm oil (598.90 min.). So, in terms of oxidative stability, the rational ratios of oils in the composition are as follows. Composition No. 1 – high-oleic sunflower: palm (50: 50) %; composition No. 2 – rapeseed: high-oleic sunflower: palm (16.67: 66.67: 16.67) %; composition No. 3 – rapeseed: high-oleic sunflower: palm (33.33: 33.33: 33.33) %.

An increase in the stability of the developed fat compositions was studied using a mixture of synthetic antioxidants: butylhydroxyanisole, butylhydroxytoluene, and tert-butylhydroquinone, applied in an amount of 300 mg/kg of fat mixture. At the same time, the induction periods of the compositions at a temperature of 110 °C were 910.80 min., 1279.01 min. and 1072.90 min., respectively. Therefore, the induction period of composition No. 1 increased by 1.4 times, No. 2 by 1.8 times, and No. 3 by 1.6 times.

The change in the physicochemical indicators of the developed compositions with the addition of antioxidants after 5 months of storage at a temperature of (20±2) °C was studied. Peroxide values of compositions No. 1–3, which were stored with antioxidants, after 5 months of storage, were 1.5; 2.3; 2.0 times lower than the peroxide values of compositions without antioxidants, respectively. This is due to the action of oxidation inhibitors, which cause chain breaks in reactions with peroxide radicals. Consequently, the processes of oxidative deterioration in oils are slowed down.

The obtained data on the rational concentrations of components in fat compositions, as well as the effect of synthetic antioxidants on the oxidative stability of the compositions, will allow obtaining multipurpose oxidation-resistant fats. The results of the research make it possible to predict the induction periods of fatty compositions depending on the concentrations of the components at elevated temperatures. This is especially relevant since the industry usually needs fatty raw materials with certain properties, in particular, consistency, melting and crystallization point, etc. Therefore, it is necessary to predict the oxidative stability of fat, which has a certain composition and possesses the necessary technological properties. The results regarding the effect of antioxidants on the peroxide values of the compositions under standard conditions allow estimating the shelf life of fats in real storage conditions, without increasing the temperature.

The works [1, 16, 17] present data on studies of the oxidative stability of mixtures of various oils and oils with fat derivatives. For example, the work [1] determined the kinetics of oxidation of mixtures of sunflower and sesame oils. The mixture of oils in a ratio of 1: 1 was more stable compared to sunflower oil (13.2 vs. 6.1 hours). The authors of the work [16] investigated the oxidative stability of transesterified palm oil compared to mixtures of initial palm oil with medium-chain triglycerides after 48 cycles of frying. The work [17] investigated the oxidative stability of mixtures of palm and olive oils. Adding more than 20 % olive oil is not advisable at temperatures of 120, 130 and 140 °C. Therefore, one of the most important principles for the development of fats with increased oxidative stability is the study of mixtures of fat components, which correlates with the principle applied in this work. But there is no data on the simultaneous use of technologically important types of oils and fats, for example, those used in the production of biodiesel, tropical oils, oils with high oxidation resistance. There is also insufficient data on the stabilization of such oils and fats by effective antioxidant systems. This issue is solved in the present work.

A limitation of the research results is that the obtained data refer to oils of a high degree of purification (refined deodorized). When using unrefined oils, the presence of accompanying substances and initial oxidation rates should be taken into account. The effectiveness of antioxidants for such oils may be low.

The weakness of the study is that only induction periods of oils at elevated temperatures were determined. However, data on changes in the oxidation indicators of oils and fats when aged at elevated temperatures are also of scientific and practical interest.

Promising areas of work on this topic are the study of the oxidative stability of fats and the effectiveness of antioxidants at temperatures above 110 °C. This will expand the use of fats and compositions based on them.

7. Conclusions

1. On the basis of differential scanning calorimetry studies, the dependence of the oxidative stability of fat compositions based on rapeseed, high-oleic sunflower and palm oils on the concentration of components at a temperature of 110 °C was investigated. The following rational concentrations of oils in fat compositions have been found. Composition No. 1 – high-oleic sunflower: palm (50:50) %; composition No. 2 – rapeseed: high-oleic sunflower: palm (16.67:66.67:16.67) %; composition No. 3 – rapeseed: high-oleic sunflower: palm (33.33: 33.33: 33.33) %. In this case, the induction periods of the mixtures are 650.57 min., 710.56 min. and 670.56 min., respectively.

2. As a result of experimental studies, the effect of a mixture of synthetic antioxidants butylhydroxyanisole, butylhydroxytoluene, and tert-butylhydroquinone on the oxidative stability of fat compositions with rational concentrations of components at a temperature of 110 °C was determined. The induction periods of compositions No. 1–3 were 910.80 min., 1279.01 min. and 1072.90 min., respectively.

3. Based on the studies, the effect of synthetic antioxidants on the change in the physicochemical indicators of fat compositions during storage under standard conditions: temperature (20±2) °C, air humidity no more than 70 % was determined. The peroxide values of compositions No. 1–3, which were stored with antioxidants, after 5 months of storage, were 1.5; 2.3; 2.0 times lower than the peroxide values of compositions without antioxidants, respectively.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, whether financial, personal, authorship, or any other, that could affect the study and its results presented in this paper.

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Availability of data

The manuscript has no associated data.

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