UDC 664.94:546.3
DOI: 10.15587/1729-4061.2025.325772

DEVELOPMENT OF A STABILIZATION SYSTEM COMPOSITION FOR SAUCES AND DRESSINGS

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The object of the study is the stability of a model emulsion with a stabilization system including liquid soy lecithin, xanthan gum, and esters of fatty acids and sucrose (E 473) under the influence of changes in the pH of the aqueous phase. A way to solve the problem of stabilizing emulsion systems in an acidic environment (pH from 4.0 to 5.5) is considered by rationalizing the composition of the stabilization system of sauces-dressings. It is determined that the stability of the emulsion system stabilized by soy lecithin and xanthan gum increases with increasing pH. At the same time, in the pH range of 3.5–5.0 it remains at a relatively low level (60–82 %), which requires improvement of the stabilization system for sauces-dressings. A rational range of E 473 concentration in the stabilization system for sauces-dressings is substantiated. It was found that the introduction of E 473 at a concentration of 0.3 % contributes to a significant increase in the stability of model emulsion samples under conditions of low pH values. An approximate dependence of the stability of the emulsion system on the concentration of E 473 and the pH of the aqueous phase is proposed, which allows predicting the effectiveness of the stabilization system under given conditions. A feature of the results obtained is that the use of E 473 provides a significant increase in the stability of the emulsion system, which is critically important for preserving the physicochemical properties of dressing sauces, which most often have an acidic environment. From a practical point of view, the development allows for effective stabilization of food emulsion systems in a wide pH range, reducing the risk of phase separation. An applied aspect of using the obtained scientific result is the possibility of modeling and developing new formulations of emulsion products, in particular dressing sauces, with improved structural and mechanical characteristics

Keywords: stabilization system, sauces-dressings, esters of fatty acids and sucrose, pH of the aqueous phase, emulsion stability

Received 13.01.2025
Received in revised form 24.02.2025
Accepted date 20.03.2025
Published date 29.04.2025

How to Cite: *Kunitsa, K., Dikhtyar, A., Kotliar, O., Andrieieva, S., Gontar, T., Stankevych, S., Balandina, I., Obolentseva, L., Kolontaievskyi, O., Ryabev, A. (2025). Development of a stabilization system composition for sauces and dressings. Eastern-European Journal of Enterprise Technologies, 2 (11 (134)), 26–32. https://doi.org/10.15587/1729-4061.2025.325772*

1. Introduction

Emulsion fat systems are an important component of food products, in particular sauces-dressings, which occupy a significant share in the modern range of food products. Such systems combine high nutritional value and technological functionality, which allows creating products with the necessary rheological characteristics, texture and stability to spoilage [1, 2]. One of the key problems in the production of emulsion products is their stability, since changes in physicochemical parameters, in particular the pH of the aqueous phase, can lead to phase separation, a decrease in viscosity and disruption of the emulsion structure.

The selection of stabilization systems for emulsion products is a complex process that requires taking into account a number of factors. These include the nature of emulsifiers, their interaction with other recipe components, technological conditions of production, as well as the effect on the organoleptic properties of the final product. The effectiveness of emulsion systems depends on the type, concentration and ratio of emulsifiers, as well as their ability to stabilize emulsions in an acidic environment [3]. The problem of the stability of dressing sauces in an acidic environment is of particular importance due to the fact that many popular food products, in particular salad dressings, mayonnaises and sauces, have a pH in the range of 3.5–5.5 [4, 5]. In conditions of reduced acidity, traditional emulsifiers may show insufficient efficiency, which requires improving the composition of the stabilization system. The study of the mechanisms of influence of various stabilizers on the structural and mechanical characteristics of emulsions allows the development of formulations that provide not only increased stability, but also improved sensory characteristics of the product.

Thus, the development of an effective stabilization system for dressing sauces is a relevant area of scientific research. Determining the rational ratio of emulsifiers and consistency stabilizers allows to increase the stability of emulsion systems in an acidic environment, which should contribute to expanding the range of food products with improved technological and consumer characteristics. The results obtained can be used to create new recipes for sauces-dressings, adapted to modern market requirements and consumer expectations.

2. Literature review and problem statement

In work [6], the development of stable emulsions of chia oil in water using the method of layer-by-layer electrostatic deposition was considered. The obtained multilayer emulsions showed significantly higher stability (98 %) compared to single-layer emulsions. However, the issue of using natural stabilizers of emulsion systems remains out of consideration. To some extent, this issue was revealed in work [7], the results of which demonstrated that emulsions stabilized with chitosan can withstand high-temperature treatment at 121 °C. This opens up prospects for the use of such emulsions in sterilized products with a long shelf life. However, the development of effective stabilization systems for emulsion products that ensure their resistance to oxidative damage and delamination is of interest. The study also did not take into account the effect on the oxidative stability of the specified consistency stabilizers, which is somewhat outlined in the work [8]. There, the issue of stabilizing emulsion systems based on valuable food oils, in particular hemp oil, by adding natural antioxidants was considered. Rational concentrations of stabilizers were proposed (lecithin – 0.8–1.0 %; xanthan gum – 0.0–0.1 %), which allow significantly increasing the period of oxidation induction. The effect of β-carotene (0.012 %) was studied, which increases the period of induction of accelerated lipid oxidation by 1.58–2.08 times. However, issues related to long-term storage stability remained unresolved. To some extent, this aspect was revealed in the work [9], which investigated the stabilization of a dressing of increased nutritional value based on a blend of linseed, corn and sesame oils (1:2:1), enriched with natural antioxidants (tocopherols, sesamol, sesamolin). A rational ratio of ω-3:ω-6 fatty acids (1:1.7) was established and the induction period of accelerated oxidation at 80 °C was determined to be 4.1 hours. It was proven that such a dressing retains its organoleptic and physicochemical characteristics during 30 days of storage at 8±1 °C. The question that remained unresolved was the influence of flavorings and other components on the stability of the studied emulsions.

These issues have been investigated to some extent in works [10–13]. Thus, in work [10] it was proposed to use natural food powders (mustard powder, ginger, cinnamon) as stabilizers of the emulsion system. It was determined that mustard (0.3 % wt.) and cinnamon (2 % wt.) have the best emulsifying properties, ensuring emulsion stability for a month. In work [11], researchers substantiated the use of edible solid lipid nanoparticles with preservative action from propolis wax for stabilizing the “oil-in-water” emulsion. It was determined that such emulsions have better oxidation resistance compared to emulsions stabilized with polysorbate-80. In particular, the peroxide value of the emulsion of the developed composition after 30 days of storage was at the level of 1.8 mmol O_2/kg of oil, which is lower than that of traditional stabilized emulsions (2.7 mmol O_2/kg of oil). In turn, work [12] considered the use of emulsion hydrogels stabilized by proteins, which have potential in the food industry due to their natural composition. It was shown that the rheological and textural properties of hydrogels can be modified by changing the composition, oil concentration, method and gelation environment (pH, temperature, etc.). In the study [13], the effectiveness of the use of emulsifiers obtained from pea protein isolate and glycosylated xylo-oligosaccharide conjugates was analyzed. The results obtained indicate that the use of glycosylated xylo-oligosaccharide conjugates contributes to the improvement of emulsifying properties and stability of emulsion systems. This allows to consider it as a promising stabilizer for food emulsions. In the study [14], the possibility of protecting the oil phase based on chia oil from oxidation by creating microparticles was considered. The use of the ultrasonic emulsification method allowed to obtain stable emulsions of the “oil-in-water” type. The rational composition of the composition is 13.50 % oil and 3.87 % pea protein. It was proven that such a composition provides emulsion and chemical stability without phase separation for 7 days. The listed studies [10–13] did not take into account the effect of the pH of the aqueous phase of emulsion systems on labile components.

To some extent, this aspect was investigated in [15], where the stability of astaxanthin in emulsion systems was considered. It was found that its chemical degradation increases with increasing temperature, but the physical stability of the emulsion is maintained at temperatures up to 70 °C. It was determined that pH 4–5 negatively affects the stability of the emulsion, which is important for the development of stable food systems with an acidic pH of the aqueous phase. An important role in the stabilization of emulsion systems is also played by biopolymer stabilizers that are able to ensure the stability of emulsions even when the pH changes [16]. For example, the creation of conjugates of sodium caseinate with κ-carrageenan made it possible to obtain stable emulsions with high indicators of emulsifying activity and interfacial stability. The Maillard reaction, carried out using ultrasonic heating, contributed to the improvement of the physicochemical characteristics of the emulsions. Thus, it is interesting to search for consistency stabilizers that are effective in different pH ranges.

One of the options for such stabilizers is the complexation product of sodium caseinate (NaCas) by complexing with monoesters of fatty acids of hexaglycerol, described in [17]. In addition, the study [17] considers the possibility of improving the emulsifying properties of sodium caseinate (NaCas) by complexing with monoesters of fatty acids of hexaglycerol. Hexaglycerol monooleate (HGMO) was the most effective, which contributed to increasing the stability of emulsions even in a wide pH range. The use of the NaCas-HGMO complex allows obtaining stable emulsions containing lipophilic bioactive substances.

Thus, there is a need to expand scientific data on the development of the composition of a stabilization system for sauces-dressings, which will ensure the stability of emulsions during storage. In view of this, it is appropriate to consider a study devoted to identifying the influence of the pH of the aqueous phase on the stability of an emulsion with a system of consistency stabilizers of a reasonable composition. In particular, it is of interest to study the influence of the component of the stabilization system E 473 on the stability of a model emulsion in an acidic environment, the pH value of which directly participates in the formation of quality indicators of the finished product. This will allow expanding the range of emulsion products of high quality with a long shelf life.

3. The aim and objectives of the study

The aim of the study is to develop the composition of a stabilization system for dressing sauces, which will ensure the stability of the model emulsion during storage. The results obtained will allow determining the optimal ratio of the components of the stabilization system and the influence of the pH of the aqueous phase on the stability of the emulsion, which will contribute to improving the quality and duration of preservation of the organoleptic properties of the product.

To achieve the aim, the following objective were solved:

– to investigate the influence of the pH of the aqueous phase on the stability of the emulsion with a stabilization system of a reasonable composition;

– to determine the influence of the component of the stabilization system E 473 on the stability of the model emulsion in acidic conditions.

4. Materials and methods of the study

4. 1. Object and hypothesis of the study

The object of the study is the stability of a model emulsion with a stabilization system including fatty acid esters and sucrose (E 473), under the influence of changes in the pH of the aqueous phase and various components of the stabilization system, under storage conditions.

The main hypothesis of the study is the possibility of ensuring the stability of the model emulsion in dressing sauces. This can be achieved by optimizing the ratio of the components of the stabilization system, in particular, sugar esters of fatty acids (E 473), lecithin and xanthan gum, which will reduce the risk of delamination and preserve the organoleptic properties of the product during storage.

The study assumes:

– the stabilization system including fatty acid esters and sucrose (E 473), lecithin and xanthan gum ensures the stability of the model emulsion during long-term storage;

– when E 473 is added to the stabilization system, the efficiency of emulsion stabilization in acidic conditions (pH 4.0–5.0) increases, which contributes to the preservation of the physicochemical and organoleptic properties of sauces-dressings.

The study adopted a simplification: the model emulsion consists of an oil composition that includes hemp and corn oil in constant proportions, given their stability to oxidation and physicochemical properties. The stabilizers used, such as lecithin and xanthan gum, have standardized characteristics, which allows minimizing the impact of changes in their composition on the results of the study.

4. 2. Materials used in the experiment

The following materials were used during the research:

– liquid soy lecithin (produced in Ukraine), according to DSTU 4597/CAS 8002-43-5;

– esters of fatty acids and sucrose, E 473 (produced in China), according to CAS 68603-24-7;

– refined corn oil (produced in Ukraine), according to DSTU GOST 8808/CAS 8001-30-7;

– refined hemp oil (produced in Ukraine), according to TU U 10.4-39224310-001/CAS 89958-21-4;

– xanthan gum (produced in China), according to CAS 11138-66-2;

– citric acid (produced in Ukraine), according to DSTU GOST 908/CAS 77-92-9;

– distilled water (produced in Ukraine), according to DSTU ISO 3696/CAS 7732-18-5.

4. 3. Method of obtaining model samples of sauce-dressing

Model samples of sauce-dressing were obtained as follows. The prepared lipid raw material and fat-soluble emulsifiers (oils, lecithin, E 473) are mixed when heated to 35 °C. Xanthan gum and citric acid are dissolved in the prepared water to vary the pH. Then, the oil raw material is gradually added to the resulting aqueous solution with thorough mixing, then the emulsion system is subjected to homogenization (speed not less than 1000 rpm) for 5 minutes.

4. 4. Method of determining the stability of model samples of sauce-dressing

The stability of model samples of sauce-dressing was determined according to DSTU 4560 by centrifugation for 5 min at a speed of 1500 min^{-1}. Then, the model samples were exposed to boiling water and centrifuged repeatedly under the specified conditions, followed by determination of the degree of phase separation.

4. 5. Research planning and statistical processing of results

The experiments were carried out in triplicate. To determine the dependence of the stability of model samples of sauce-dressing with different emulsion stabilizers on the pH of the aqueous phase, the method of single-factor regression with graph construction using the Microsoft Excel software package (USA) was chosen. The statistical model of dependence (1) was determined by approximating the experimental results by constructing a trend line. The quality of the dependence equation (1) and the completeness of the influence of the pH of the aqueous phase on the stability of the emulsion system were assessed using the approximation reliability value, which is equal to 0.990, respectively. This allows to conclude that the high influence of variations in the pH of the aqueous phase on the variations in the stability of the emulsion system.

To process data on the dependence of the stability of the emulsion system on the content of E 473 and the pH of the aqueous phase (2), mathematical methods were applied using the Stat Soft Statistica v 6.0 software package (USA). The significance of individual coefficients of the regression equation (2) was carried out using the Student's test (t) by testing the hypothesis that the corresponding parameter of the equation is equal to zero. To assess the quality of the regression equation (2) and the completeness of the influence of the selected factors, the coefficient of determination R^2 was determined. The obtained value R^2=0.951 allows to conclude that the variation of the E 473 content and the pH of the aqueous phase have a significant influence (greater than 95 %) on the variation of the stability of the emulsion system. To establish the significance of the regression model, the Fisher test (F) was calculated, based on the assumption that the equation is statistically insignificant (R^2=0; null hypothesis). The calculated value of Fisher's exact test was F (2.15)=18.542 and was greater than its critical tabular value F_{tab}(2.15)=3.68 at a significance level of p=0.05 and the number of degrees of freedom df_1=2 and df_2=15. This result allows to reject the null hypothesis and, with a probability of 92 %, to recognize the value of the coefficient of determination R^2=0.94 as significant, and the model as significant.

5. Results of research on the development of the composition of the stabilization system for sauces-dressings

5. 1. The influence of the pH of the aqueous phase on the emulsion stability with a stabilization system of a justified composition

The study of the influence of the pH of the aqueous phase on the emulsion stability was carried out using a model sample of the emulsion system, the composition of which is justified in [8] and is given in Table 1.

Table 1

The composition of the model sample of the emulsion system

Name of the component	Content, %
oil composition consisting of:	70.0
hemp oil	42.0
corn oil	28.0
distilled water	29.0
stabilization system consisting of:	1.0
lecithin	0.9
xanthan gum	0.1

A graphical representation of the obtained dependence is shown in Fig. 1.

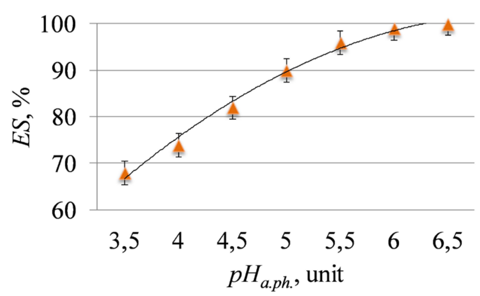

Fig. 1. Dependence of stability of model samples of the emulsion system on the pH of the aqueous phase

Equation (1) presents the approximate dependence of the stability of model samples of the emulsion system (ES ($pH_{a.ph.}$), %) on the pH of the aqueous phase ($pH_{a.ph.}$, units):

$$ES\left(pH_{a.ph.}\right) = -0.6429 \cdot pH_{a.ph.}^2 + 10.857 \cdot pH_{a.ph.} + 56.429. \quad (1)$$

The given dependence allows to adequately calculate the stability of the emulsion system in the pH intervals of the aqueous phase 3.5–7.0.

The general trend of increasing stability with increasing pH is explained by the improvement of the rheological characteristics of the aqueous phase and the increase in the stabilizing ability of the emulsifier. The obtained experimental results demonstrate significant variability of emulsion stability depending on the pH of the aqueous phase. At pH 3.5–5.0, the stability of the system remains at a relatively low level (60–82 %), which may indicate insufficient effectiveness of the available stabilizers in an acidic environment. In the conditions of production of sauces-dressings, especially those containing acetic or citric acid, the pH of the product is often within 3.5–5.0. Thus, a decrease in stability in this range can lead to partial stratification, coalescence of oil phase droplets and deterioration of the consistency of the final product.

5. 2. Determination of the effect of E 473 on the stability of a model emulsion in an acidic environment

In order to increase the emulsion stability in a wide pH range, it is advisable to investigate the possibility of introducing an additional component of the stabilization system that can function effectively in conditions of variable acid-base balance. One of the promising stabilizers may be esters of fatty acids and sucrose (E 473), which are known for their ability to form stable emulsions in an acidic environment.

To assess the effectiveness of E 473 as an additional stabilizer, a basic model of the emulsion system was used, the composition of which was previously studied (Table 1). The experimental samples differed in the concentration of E 473 (0.1–0.5 %) in the stabilization system. The introduction of E 473 into the stabilization system had a positive effect on the stability of the emulsion in an acidic environment. As shown in Fig. 2, even at low pH values (4.0–4.5) of the aqueous phase of the model samples of the emulsion system, an improvement in emulsion stability was observed compared to the control sample without the addition of fatty acid esters and sucrose.

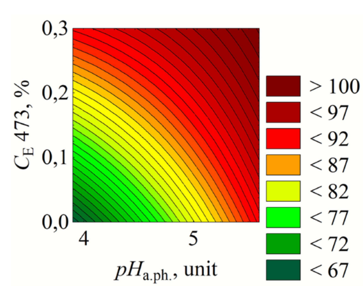

Fig. 2. Dependence of stability of model samples of the emulsion system on the content of E 473 and pH of the aqueous phase

Equation (2) presents the approximate dependence of the stability value of model samples of the emulsion system (ES (C_{E473}, $pH_{a.ph.}$), %) on the pH of the aqueous phase ($pH_{a.ph.}$, units):

$$ES\left(C_{\text{E 473}}, pH_{a.ph.}\right) = 30.66 + 5.24 \cdot C_{\text{E 473}} + \\ +206.1 \cdot pH_{a.ph.} + 1 \cdot C^2_{\text{E 473}} - \\ -29.6 \cdot C_{\text{E 473}} \cdot pH_{a.ph.} - 25 \cdot pH^2_{a.ph.}. \quad (2)$$

The given dependence allows to adequately calculate the stability of the emulsion system in the intervals of E 473 content 0.0–0.3 % and pH of the aqueous phase 4.0–5.5. The results of the study confirm the effectiveness of fatty acid esters and sucrose (E 473) as a component of the stabilization system for emulsion products exposed to low pH values. The introduction of E 473 at a concentration of 0.3 % allows to significantly improve the stability of the emulsion, reducing the risk of phase separation. The most pronounced effect is observed at pH=4.0–4.5, which is critical for preserving the physicochemical properties of sauces-dressings.

Fig. 3 shows a graph demonstrating the dependence of the stability of model emulsion systems on the content of E 473 at different pH values. Dependence (a) reflects the stability of the emulsion of the control sample without E 473, graph (b) shows the stability results of experimental samples with an E 473 content of 0.3 %.

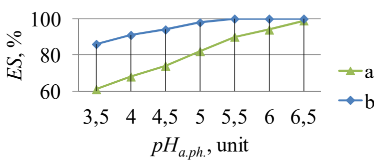

Fig. 3. Comparative analysis of emulsion system samples without E 473 (*a*) and with E 473 in an amount of 0.3 % (*b*) in the pH range of 3.5–6.5

As can be seen from the graph, the control sample of the emulsion system without the addition of the stabilizer E 473 demonstrates a significant decrease in emulsion stability in the pH range below 6.0, while the samples of the emulsion system with E 473 have a significantly higher level of stability at the same acidity values.

6. Discussion of the results of the development of the composition of the stabilization system for dressing sauces

The study of the influence of the pH of the aqueous phase on the stability of model samples of dressing sauces (Fig. 1, dependence (1)) confirms the importance of rationalizing the composition of the stabilization system to ensure the stability of dressing sauces in a wide pH range. Analysis of the obtained data shows that the pH of the aqueous phase has a significant effect on the stability of the model emulsion. When the pH decreases to 4.0, the phase stability decreases to 68 %, which is accompanied by partial stratification of the emulsion. This can be explained by changes in electrostatic interactions between lecithin and the surface of oil droplets: at low pH values, lecithin loses its effectiveness as an emulsifier due to a decrease in its ability to form micelles. With an increase in pH from 5.0 to 7.0, an improvement in phase stability is observed, which is associated with an increase in the emulsifying properties of lecithin and the strengthening of the hydrated layer of the stabilizing system. The maximum stability of model samples of emulsion systems (100 %) is achieved at pH=7.0, which indicates the formation of a stable spatial structure of the stabilizing system, which prevents the coalescence of oil droplets. At pH values below 5.0, a deterioration in stability is noted, which is associated with the denaturation of hydrocolloids and the weakening of intermolecular interactions between stabilizing agents. Thus, the results of the study confirm the need to maintain the pH of the aqueous phase within the range of 5.5–7.0 to ensure maximum stability of the emulsion system. Thus, the experimental data confirm the importance of careful selection of the composition of the stabilization system and pH control in the production of sauces-dressings to achieve high product stability.

The obtained research results (Fig. 2, dependence (2)) confirm the high efficiency of fatty acid esters and sucrose (E 473) as an additional component of the stabilization system for emulsion products, in particular for sauces-dressings, which have an aqueous pH of 4.0–5.5. The obtained data demonstrate that the addition of E 473 significantly increases the stability of the emulsion, especially in conditions of low pH. At a concentration of 0.3 %, the stability at pH=4.0 reached 91 %, which is almost 34 % more than in the control sample. This is explained by the amphiphilic nature of fatty acid esters and sucrose, which contribute to the formation of a stable double emulsion layer and reduce the coalescence of fat droplets. When the pH increased to 5.0–5.5, the efficiency of E 473 also appeared, although its contribution to stabilization was less pronounced, since the system already had sufficiently high stability values. The maximum value (100 %) was achieved at pH 5.5 and E 473 concentration of 0.3 %, which indicates the possibility of complete prevention of phase separation under the specified conditions. The explanation for such efficiency is the amphiphilic nature of fatty acid esters and sucrose, which allows the formation of stable emulsion structures by forming a double layer around fat droplets. This process significantly reduces the likelihood of coalescence, which is the main cause of emulsion instability, which is characteristic of some types of sauces.

The advantage of this study is the use of fatty acid esters and sucrose as a stabilizer in low concentrations (0.1–0.3 %), which provides an optimal balance between stabilization efficiency and economic feasibility. This makes the proposed solution technically efficient.

The results of the conducted studies demonstrate a difference from existing scientific works [8–12]. In particular, in studies [8, 9] the main emphasis is placed on the use of natural antioxidants to increase the oxidative stability of emulsion systems, while in this work attention is paid to the stability of the emulsion structure under conditions of variable pH. The results of the study differ from work [10] in that the main emphasis is placed on the effectiveness of fatty acid esters and sucrose (E 473) in stabilizing emulsion systems in an acidic environment. While in work [10] natural food ingredients such as mustard powder and cinnamon were used as emulsion stabilizers. The difference from [11] is that the study focuses on the combined effect of emulsifiers and fatty acid esters on emulsion stability when changing pH, while [11] investigated the use of edible solid lipid nanoparticles from propolis wax to stabilize emulsions. The difference from [12] is that the fatty acid esters and sucrose used allow controlling the stability of the emulsion system by changing the concentration and pH of the medium. While [12] investigated the use of protein emulsion hydrogels, which have the potential for stabilization, but their effectiveness in an acidic environment remains poorly understood. Thus, unlike previous studies, the work focuses on the development of a comprehensive stabilization system that not only minimizes oxidative processes, but also ensures the stability of the phases of the emulsion structure. In particular, the use of E 473 at a concentration of 0.3 % allowed to increase the stability of the model emulsion at pH 4.0 by 34 % compared to the control sample. This is explained by the amphiphilic nature of fatty acid esters and sucrose, which contribute to the formation of a stable double emulsion layer and reduce the coalescence of fat droplets. The proposed approach opens up opportunities for further rationalization of stabilization systems taking into account changes in chemical composition.

One of the main limitations of this study is the use of a model emulsion system, which may not fully reflect all the complexities and variability of real food products. Therefore, when applying the results in practice, it is necessary to take into account possible differences in the composition and properties of oils, as well as the content of other components that may affect the stability of the emulsion.

The development of this study may consist in expanding the experimental conditions, in particular, studying the influence of a wider pH range, temperature fluctuations, and long-term storage conditions, which will allow obtaining a more accurate picture of the influence of the stabilization system on the behavior of emulsions.

7. Conclusions

1. The influence of the pH of the aqueous phase on the stability of the emulsion system of a reasonable composition was studied. It was found that the emulsion stability increases with increasing pH, which is explained by the improvement of the rheological characteristics of the aqueous phase and the increase in the stabilizing ability of emulsifiers. In the pH range of 3.5–5.0, the stability of the emulsion system remains at a relatively low level (60–82 %), which indicates the insufficient efficiency of the used stabilization system in acidic conditions. The calculated approximation dependence allows predicting the stability of the emulsion system within the pH range of 3.5–7.0, which contributes to further optimization of the recipe of sauces and dressings.

2. The results of the study confirmed the effectiveness of fatty acid esters and sucrose (E 473) as a component of the stabilization system for emulsion products exposed to low pH values. The introduction of E 473 at a concentration of 0.3 % contributed to a significant improvement in the stability of the model emulsion, reducing the risk of phase separation and ensuring the uniformity of its structure. The most pronounced stabilizing effect was observed in conditions of pH 4.0–4.5, which is critically important for preserving the physicochemical properties of sauces-dressings. The approximate dependence of the stability of the model emulsion system on the concentration of E 473 and the pH of the aqueous phase allows predicting the effectiveness of the stabilization system under given conditions. It was found that when the concentration of E 473 was increased to 0.3 %, the stability of the emulsion at pH=4.0 increased by 34 % compared to the control sample. This is explained by the amphiphilic nature of fatty acid esters and sucrose, which contribute to the formation of a stable double emulsion layer and reduce the coalescence of fat droplets.

Conflict of interest

The authors declare that they have no conflict of interest regarding this study, including financial, personal, authorship or other, that could influence the study and its results presented in this article.

Funding

The study was conducted without financial support.

Data availability

The manuscript has no linked data.

Use of artificial intelligence tools

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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