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ARGUMENTATION OF EMULSIFIER PART IN THE RECIPE OF FOAM AND EMULSION DAIRY PRODUCTS CONTAINING VEGETABLE FATS

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Abstract. The study provides argumentation of a recipe for foam and emulsion dairy products containing vegetable fats. The aim of the study is to examine the impact of major recipe components on foaming capacity and foam stability. The task of creating persistent emulsion systems with a foamy structure is possible due to the use of scientifically-based blend of surfactants, vegetable oils, and stabilizers, which provide the necessary technological properties of semi-finished and organoleptic properties of finished products. Foaming capacity and foam stability were determined by the Lurie method. Surfactants are usually E472e (esters of glycerol and diacetyl tartaric acid ester of mono- and diglycerides DATEM), E472b (lactic acid esters of mono- and diglycerides LACTEM), E322 (lecithin). Selected surfactants provide direct formation of the emulsion with further interphase absorption layers along with the milk proteins at the temperature of 80 ... 85° C. In addition, they support desorption of milk proteins from the interphase surface at the temperature of 3 ... 13° C while whipping. It results in a partial inversion of the emulsion phase leading to the converse emulsion and fat crystallization. The studies allowed finding the rational content of dry and skimmed milk (3.5%), E472e (0.6%), E472b (0.4%), E322 (0.3%). These components provide texture of foam and emulsion dairy products and semi-finished products with the high foaming capacity, form stability and flexible consistency.
Keywords: food science, food technology, dairy product, vegetable fats, emulsifier, milk.

Introduction

The most promising direction of expanding the range of semi-finished products is the use of multifunctional semi-products, which are characterized by high technological properties and can be used as a basic components for culinary and confectionery products. It fully concerns raw products used for finish operations and prepared on the basis of vegetable oils.

The cream prepared on the basis of emulsion semi-finished products with the foamy structure occupies a large share in domestic production of culinary and confectionery products. Unfortunately, manufacturers are not satisfied with the technological properties of creams containing vegetable oils. The main drawback of these creams is low foaming capacity and foam stability influenced by technological factors, particularly pH and extenders. In addition, such creams have poor organoleptic properties due to the lauric fat, low system stability during reserving and tend to surface cracking.

Basics of manufacturing dairy products creating foam can be found in the research works by Kruglyakov P.M. (1990), E. Dickinson (1993) and others.

The technological process of production of emulsion and foam structure semi-products applies for extraction of reconstituted milk, fat emulsification, cooling prescription mixture, product getting needed properties and cutting down with the introduction of fillers to obtain the cream. Main prescription components that form a structure of foam and emulsion products are skimmed milk as a protein source, a surface-active agents (surfactants) and stabilizers. The choice of skimmed milk powder was based on economic and organoleptic assumptions. The use of milk compared to sodium caseinate provides a product with a full flavor; besides, milk is considerably cheaper than sodium caseinate. To maximize the effect of surfactants, skimmed milk is recovered with the sodium phosphate when heated. It allows decalcifying pare-caseinate-calcium phosphate complex and raising the surface activity of the milk proteins. To conduct research, we used food ingredients presented in the Table 1. The choice of surfactants is explained by ensuring the processes that allows you to obtain foam and emulsion products. Namely, surfactants must provide:

- The formation of direct emulsions with further interphase adsorption layers leading to obtaining milk proteins on the stage of emulsification;
- Desorption of milk proteins from the interphase surface of water and fat on the stage of foaming;
- Foaming before agglomeration of fat droplets;
- Crystallization of fat in the form of fine crystals (α-form).

The aim of our studies is to argue the rational composition of surfactants mixture which provides a partial desorption of the protein, optimal fat crystallization and maximum foaming capacity.

Table 1

Properties of Surfactants Used for Obtaining Foam and Emulsion Products

Surfactant	Properties of Surfactant
E472b lactic acid esters of mono- and diglycerides LACTEM	Nonionic surfactant, HLB = 3…5
E472e esters of glycerol and diacetyl tartaric acid ester of mono- and diglycerides DATEM	Ionic surfactant, HLB = 8…10
E322 lecithin	Amphoteric surfactant, HLB = 4

The formation of the product with foam and emulsion structure has the following stages. Milk proteins form a straight emulsion. Injection of E472e forms protein complexes and forces resistance of direct emulsions to increase. These emulsions initially promote aeration of a system. The complexes "protein E472e" are formed at the stage of emulsification of fat at t = 80 ... 85 °C. At the reduction of temperature, the protein is desorbed from the surface. Thus, E322 and E472b displace protein, which has the high-level hydrophobicity, from the interfacial surface. This leads to coalescence of the fat phase with further formation of fat crystals. Crystals of fat stabilize the foam by the adsorption of fatty crystals on the air bubbles and in the Gibbs-Plateau channels, preventing drainage of liquid.

Requirements to the process of coalescence are to form small crystals and their small clusters. The fat crystals must be coated with a surfactant in order not to cause precipitation of the foam (fat does not have to be a defoamer). To form crystals of fat requires the use of fat-soluble surfactants (E472b, E322), which will form α- small crystals of fat. It provides the required rheology properties of cut products, particularly stable form and structure, as well as flexibility. Crystals should be no more tan 30mkm; as larger crystals are felt in mouth.

Method

When conducting research, methods for determining the foaming capacity and foam stability were used. The concept of the method consists in determining the height of a foam column and time of its destruction. Foaming capacity and foam stability was determined by the Lurie method (Lurie, 1967, p.143) [4]. The calculation was performed according to the equations:

$$ПС = \frac{V_n}{V_p} \times 100,$$

where $ПС$ – foaming capacity, %;
V_n – foam volume, m^3;
V_p – volume of a system before blending, m^3.

$$СП = \frac{Bn^{60}}{Bn} \times 100,$$

where $СП$ – foam stability, %;
Bn^{60} – height of foam after (60×60) standing a long time, m;
Bn – initial foam height, m.

Results

At the first stage of the research, we identified foaming capacity and foam stability in the model systems without fat. Indicators were checked in 24 hours during the standing of the systems at t = 6 ... 8 °C. Foam stability was fixed in 60 × 60s. To obtain model systems, skimmed milk (DSM) was used along with non-lauric substitute of cocoa butter and surfactants (E472e, E472b, E322), which have been observed in Table 1.

We found out (Fig. 1) that the injection of up to 3.5% of DSM increases the foaming capacity of the system to 518.5 ± 1%. Further increase in concentration will not affect the time for foaming capacity. It should be noted that the foam systems based on DSM are of low resistance. Thus, in the investigated concentration range, foam stability is 28 ... 31%. By fixing content of skimmed milk at 3.5%, the effect of surfactants on the foaming process in model systems was determined.

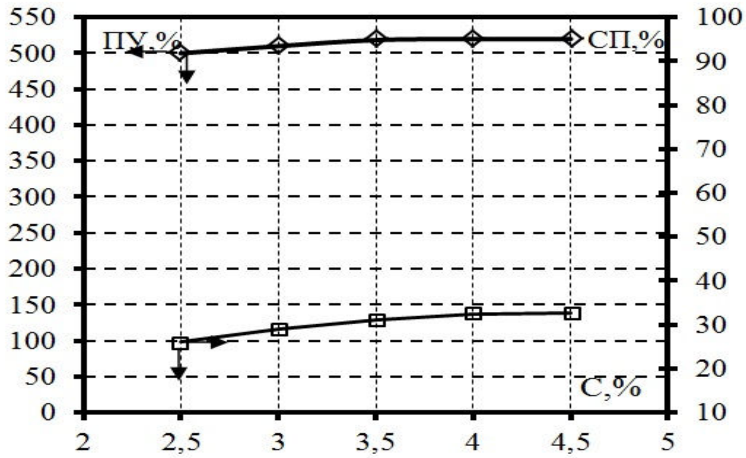

Fig. 1 Relationship between foaming capacity (◊), foam stability (□) and level of content of skimmed milk

Studying the relationship between surfactants and foaming capacity shows that the injection of surfactant leads to the decrease of foaming capacity (Fig. 2). Besides, the injection of E472e reduces the foaming capacity to 460 ... 470%. These results suggest that E472e does not cause desorption of the protein from the interphase surface, unlike E472b. Increasing E472b from 0.2% to 1.4% leads to a decrease of foaming capacity from 500.0 ± 1% to 315.0 ± 1%.

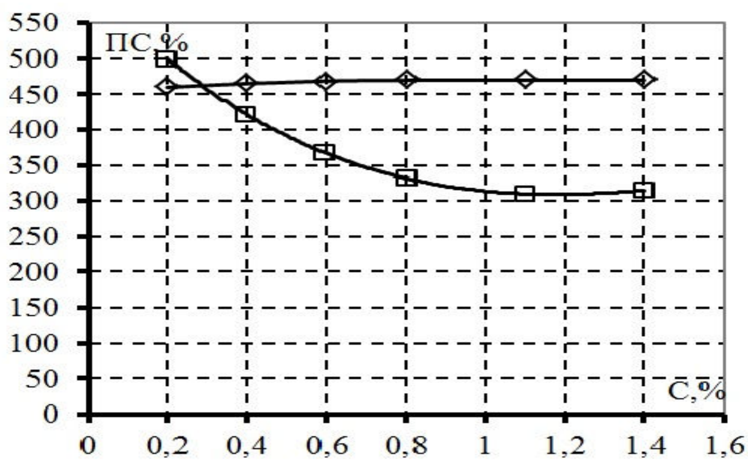

Fig. 2 Relationship between foaming capacity in the system "Surfactant – Skimmed milk" and the content of E472e (◊), E472b (□)

Due to injection of surfactants into the system, foam stability in comparison with using only skimmed milk increases (Fig. 3). It is seen that relationships have the extreme nature of peaks for E472e - 0.6 ... 1.0% and E472b - 0.4 ... 0.6%.

Injection of E322 in amount of 0.1% leads to a decrease of the foaming capacity from 518.5 ± 1% to 240.0 ± 1% and increase in the foam stability from 31.0 ± 1% to 79.0 ± 1%. Further increasing concentration of E322 leads to a zero-level foaming capacity and foam stability.

Current results of studies (Omel'chenko, 2013) allowed to justify the rational level of content of vegetable fat in recipes at 25%, while the fat content in the foaming capacity model system "Skimmed milk - vegetable fat" is 130.0 ± 1% and foaming capacity is 98.5 ± 1%.

We found that injection of surfactants into the model system "Skimmed milk - vegetable fat" with fat content about 25% stimulates increase in foaming capacity (Fig. 4). Relationship between the concentration of all surfactants and foaming capacity is extreme. The maximum increase is typical for E472e - that is 220.0 ± 1% at a concentration of 0.8 ... 1.0%. The minimum increase is typical for E322 and is 190.0 ± 1% at the level of concentration of 0.2 %.

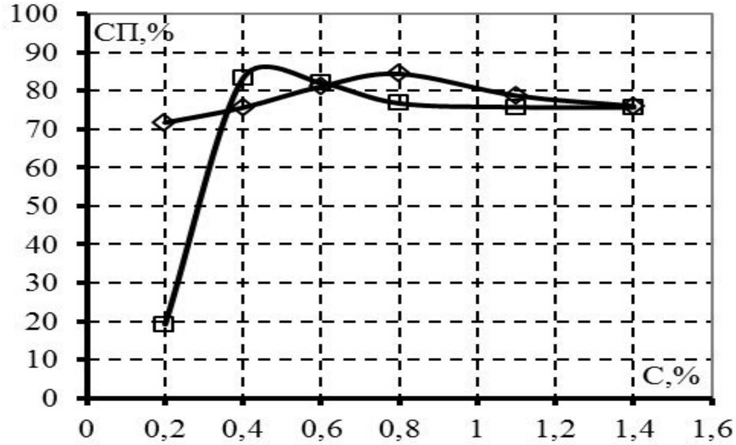

Fig. 3 Relationship between foaming stability in the system "Surfactant – Skimmed milk" and the content of E472e (◊), E472b (□)

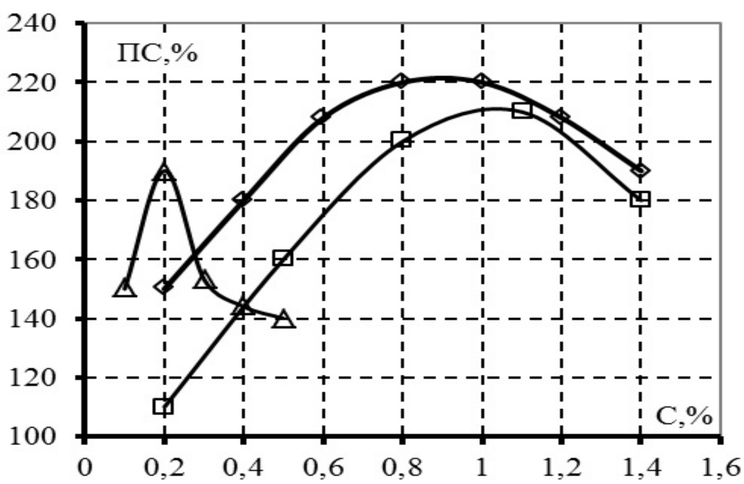

Fig. 4 Relationship between foaming capacity in the system "Skimmed milk – vegetable fat" and the content of E472e (◊), E472b (□)

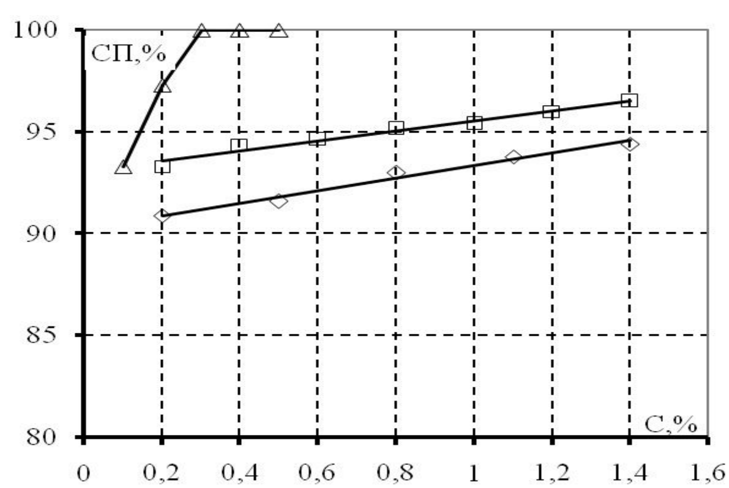

Fig. 5 Relationship between foaming stability in the system "Skimmed milk – vegetable fat" and the content of E472e (◊), E472b (□)

Foam stability in the model systems like «Skimmed milk – vegetable fat» increases through the surfactant injections (Fig.5) at 100% of E322. To achieve 100% of foam stability with the use of E472e and E472b over studied interval of concentration values was impossible.

Obtained results argue that the use of only surfactants does not lead to a product with predetermined properties. Therefore, we examined how the mix of E472e and E472b influences foaming capacity in the system «Skimmed milk - Surfactants» (Tables.2, 3).

Table 2

Foaming capacity in the system «Skimmed milk - Surfactants » dependent on E472e and E472b

Content of E472e, %	Content of E472b, %		
	0.4	0.6	0.8
	Foaming capacity, %		
0.6	410.0±1	420.0±1	440.0±1
0.8	450.0±1	440.0±1	440.0±1
1.0	450.0±1	430.0±1	400.0±1

The analysis of the table provides the confirmation of maximum foaming capacity of model systems containing 0,4% of E472b and 0,8…1,0% of E472e. The foam stability of these systems is 66…82%.

Table 3

Foaming capacity in the model systems «Skimmed milk - vegetable fat» dependent on E472e and E472b

Content of E472e, %	Content of E472b, %		
	0,4	0,6	0,8
	Foaming capacity, %		
0.6	280.0±1	250.0±1	240.0±1
0.8	280.0±1	250.0±1	240.0±1
1.0	280.0±1	250.0±1	240.0±1

Analysis of the experimental data provided in Tables 2,3 allows us to specify the concentration of E472e and E472b in terms of maximum foaming capacity, which is achieved when the content of E472b is 0.3 ... 0.4% and E472e is 0.6... 0.8%. Foam stability at these concentrations is 100%.

Mixture of E472e and E472b does not provide the necessary rheological properties of cut products. It necessitates the definition of a rational concentration of E322 to provide the necessary crystallization and agglomeration of fat. Studies have confirmed that the additional 0.35% of E322 provides the necessary rheology properties of foam and emulsion products based on vegetable fats.

Discussion

Experimental studies proved the feasibility of developing foam and emulsion dairy products based on vegetable fats by using a mixture of surfactants E472e, E472b, E322. The use of such surfactant mixtures for finish raw materials will provide high-quality products with high resistance.

Studies have allowed us to define the rational content of basic prescription components. Among them are skimmed milk (3.5%), E472e (0.6 %), E472b (0.4%), and E322 (0.3%), which provide the obtaining of direct, inverse and foam and emulsion systems at different stages of the process.

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