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IMPROVING THE TECHNOLOGY OF AERATION OF THE FOOD SYSTEM OF MOUSSE AT HORECA ENTERPRISES

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There is an interest in sweet dishes such as aerated desserts, which are gaining popularity among consumers. Raw materials of plant origin, used in the technology of aerated products, are intended mainly to improve their quality characteristics. Especially for enrichment with protein substances, micro and macro elements, vitamins, as well as to obtain a product rich in dietary fiber content. In the segment of aerated dessert products, a distinctive feature of which is the multistage of the production process and the need to use special equipment, technologies involve the use of foam and structure-forming food additives. For the formation of a whipped and stable structure, as well as the addition of surfactants that can cover the surfaces of bubbles and prevent their coalescence, food additives of various origins are used. Therefore, it is relevant to investigate the foaming ability and stability of aerated desserts and improve the technological parameters of the processes or foam structures of desserts. It is necessary to take into account the structural and mechanical properties of aerated dessert products, which are the main characteristics of the quality of aerated desserts. Thus, it is relevant to devise technologies for aerated desserts and food additives in their composition, which will serve as a stabilizing agent, as well as a dietary supplement.

A recipe for aerated dessert – mousse based on fermented milk cheese with the introduction of a complex additive into the recipe – was developed. The optimal amount of food additive in the composition of aerated dessert, which is 3 % of the recipe composition, has been established, which will ensure the stability of the food system of aerated products, in particular mousses. The influence of the additive on the structural and mechanical properties of the food system of dessert has been investigated.

The experimental data could be used for improving technologies for the production of aerated desserts

Keywords: collagen hydrolyzate, aerated desserts, mousses, structure-forming agent, dispersion, foamy food systems

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1. Introduction

Sweet aerated (whipped) desserts belong to a wide range of culinary products (mousses, puddings, soufflés, creams, whipped cream, blancmange, parfait, etc.), which differ significantly in nutrient composition and nutritional characteristics. Characteristic features of aerated desserts, which are produced in the field of HoReCa (hotel and restaurant business) are a light, creamy, smooth, soft structure. Thus, the HoReCa sector is trying to create meals rich in macronutrients, vitamins, minerals that are necessary to strengthen the immune system. Consumption of aerated desserts plays a significant role in the nutrition of different age groups of the population due to the presence in the recipe of desserts of dairy and vegetable raw materials [1].

Aerated food emulsions make up an important class of foods. An important characteristic of these systems is their plastic behavior, due to the presence of a significant yield strength. The integrity of these systems is mainly due to the interaction between the main structural units, which are gas bubbles, emulsion droplets and, in the case of ice cream, ice crystals [2, 3]. Foams are thermodynamically unstable dispersed systems that drain, coarsen, and merge; for their successful application, it is important to extend and control their service life. However, such foams usually live only a few hours due to the processes of coalescence and disproportionation [4, 5].

The formation of foam helps reduce the surface tension of the liquid. It is not possible to form foams in an aqueous solution without the use of surfactants, emulsifiers, or proteins due to the fact that hydrogen and oxygen molecules are bound by strong covalent polar chains. This creates surface tension and interferes with the formation of foam, very quickly destroying rare bubbles. In turn, surfactant molecules, emulsifiers or proteins have chains consisting of carbon and hydrogen atoms. For the formation and stabilization of foam, the foaming molecule must have a certain diphilic structure, namely, consist of hydrophilic and hydrophobic parts. Therefore, molecules make their way to the surface of the liquid: hydrophilic ends into the liquid, and hydrophobic ends into the air. By pressing between liquid molecules, surfactants, emulsifiers, or proteins reduce the number of bonds between liquid molecules and reduce surface tension [6].

In order to stabilize the foam structure of aerated desserts, a food additive can be offered that contains collagen hydrolyzate, gelatin, viburnum juice (anthocyanins), L-ascorbic acid (fine powder, $1,070\cdot10^{-6}$ m), which has a white color, has no smell and taste. This will make it possible to use it as a dietary supplement to various foods, including as part of aerated desserts [7, 8]. A food additive can affect the processes of structure formation and foaming in the production of aerated desserts, as well as the quality indicators of the finished product.

Therefore, it is relevant to search for structure-forming agents and their combinations obtained from the secondary raw materials of crop and livestock processing, as well as to study the impact on the structural and mechanical properties of aerated dessert products, namely the type of mousse.

2. Literature review and problem statement

The most important task of the food industry is not only to ensure a sufficient amount of environmentally friendly, high-quality agricultural products, but also to analyze the impact of agricultural raw materials on public health and the prevention of food diseases. The range of sweet meals is very diverse and large, and to encourage consumers, food companies are developing new recipes, trying to offer innovative products. One of the common sweet meals is desserts with a foamy (whipped) structure, developed using food additives of artificial origin of foaming and stabilizing nature. At the same time, the potential of functional and technological properties of raw materials is not used [9, 10].

Food aeration is one of the fastest growing operations in the food industry. Control of the structural properties of aerated foods requires accurate tools for measuring microstructural characteristics. The presence of air bubbles in gel-based foods provides an additional gaseous phase inside the food system, which creates a unique texture while reducing density, as well as changing the appearance, color, and feel in the mouth. Textural properties are an important component of the perception and acceptability of food quality [11, 12].

A review of studies was conducted to improve and develop new technologies and recipes for aerated desserts, namely mousses, among which few were found [13]. The study showed the successful inclusion of *L. paracasei* and inulin in chocolate mousse. Inulin did not interfere with the viability of *L. paracasei*. But the high content of inulin reduces the level of acceptability for organoleptic parameters. The study can be further expanded through the use of various sources of probiotics and prebiotics.

Paper [14] investigated microstructural differences between optimal and standard samples of yogurt mousse, which indicates that the fermentation process affects the microstructure and texture of the product. But studies related to the variation of other nutrients (such as fat and sugar) of the research product to understand its rheological, sensory, and microstructural behavior remain unresolved.

It has been investigated [15] that gelatin peptides inhibit the growth of ice crystals, resulting in the formation of smaller ice crystals, which are believed to cause less destruction of the microstructure of mousses undergoing a freezing-thawing cycle. But gelatin peptides are small for gelation, through which a protective barrier can be formed between the air bubbles to prevent coalescence. It is promising to use gelatin to inhibit the growth of ice crystals, due to its triple spiral structures.

Paper [16] studied the processing of mousse from fruits and jackfruit seeds as a substitute for sugar and vegetable fat. The authors preferred mousse made from animal ingredients over mousse made from herbal ingredients. The introduction of different stabilizers led to taste preferences, which did not differ significantly. There are also several studies that deal with the nutritious, instrumental textural and sensory characteristics of unfermented mousses, such as chocolate mousses, synbiotic mousses and frozen mousses. In [17], chocolate mousse with the addition of probiotic and prebiotic ingredients was developed. But no additional studies have been conducted to increase the shelf life of probiotic and symbiotic chocolate mousse.

Work [18] discusses the consequences of this mechanism for whipping emulsions. During the aeration of food emulsions, such as milk cream and ice cream, small gas bubbles are introduced, which are often stabilized by a layer of adsorbed emulsion droplets. It is shown that the maximum achievable volume of gas bubbles that can be turned on by whipping depends on the efficiency of gas injection during the first stage of whipping and, in addition, limited to packaging. The main factors relating to the latter limitation are the thickness of the emulsion droplet coating on the bubble surface, the ratio between the radii of the drop and bubble, and the fat content in the emulsion. There is a hypothesis that during whipping, the dynamic process of decay and coalescence of bubbles regulates the average size of the bubbles and the volume of gas contained in the foam, in accordance with the limitation of dense stacking of bubbles.

Agents used for aerated desserts include egg white (in "traditional" products), whey proteins, cream, sodium, and calcium stearoyllactylates, and lactic acid esters of fatty acid mono- and diglycerides. Some ingredients have both gelling/stabilizing and foaming properties. One of the dessert products that are often served in the field of HoReCa is mousse based on dairy raw materials. An important issue for obtaining a downed structure of the mousse remains the stabilization of the aerated food system, which is possible when using hydrocolloids of plant origin (alginates, gums, pectins, starches, etc.) in the complex. This approach is used in [19], where protein-vegetable semi-finished product was investigated, which showed foaming and stabilizing properties due to the content of surfactants and pectin substances. But it remains an unresolved issue to study the effectiveness of stabilization of protein-vegetable semi-finished product as a dispersed food system.

In the case of aerated dairy products, gelatin exhibits not only stabilizing but also foaming properties that can be compared with similar characteristics of chicken egg white [20]. But in the presence of stabilizers such as egg white or gelatin, fat can cause significant deviations in low-density whipped confectionery.

In [21], the possibility of using skimmed milk proteins as a foaming agent, as well as cornel kernel (*Cornus mascula*) and thorns (*Prunus spinosa*), as a stabilizer of the foam structure, was considered in the technology of whipped desserts. But due to the technological properties inherent in skimmed milk, in particular, coagulation and denaturation in an acidic environment, and berry raw materials, in particular, high acidity, heterogeneity of the structure, their joint use in the composition of recipe mixtures is almost impossible.

Hydrolyzate of proteins of cheese whey was developed, according to the results of the study of the biofunctional properties of the obtained hydrolyzate in vitro and in vivo, an antioxidant, hypotensive and hypocholisteremic effect was proven. Despite the high ability of the obtained hydrolyzate, additional foaming agents were introduced into the system, which ensured the production of a stable foam emulsion. Various foaming agents are able to accelerate the formation of foam structures and ensure uniform distribution of air or gas bubbles in the process of aerating the mixture [22].

It is promising to use collagen as a food additive in the composition of dairy products to restore cartilage and connective tissue, normalize microflora and, at the same time, to provide the necessary structure of the product [23, 24].

The technologies for the production of aerated desserts did not use collagen hydrolyzates from fish raw materials, which have such rheological properties as foam and structure-forming, stabilizing properties. Collagen hydrolyzate improves the structural and mechanical properties of foam structures, quality indicators, and extends the shelf life of aerated desserts. Paper [25] reports the results of studies to increase the strength of gelatin gel of animal origin using hydrocolloids of plant origin (modified starch), where it is claimed that dialdehyde starch provides synergistic improvement in the strength of the gel. But the issue of studying synergistic interaction with fish gelatin remained unresolved. The reason for this may be that the composition of fish gelatin and modified starch is not suitable for giving the desired texture to the product and other organoleptic properties. Collagen from hydrobionts is hypoallergenic, as it is 96 % identical to human collagen and has an immunostimulating, hepatotropic effect, as well as a pronounced osteotropic effect.

When assessing the quality of aerated desserts, namely mousses, it is necessary to investigate their structural and mechanical properties, which directly affect the consumer's perception of the finished dessert. One of the important characteristics of desserts with a foam structure is the dispersion of the foam, which provides the necessary stability of the food texture over time (the smaller the size of the air bubbles, the more stable the food system is) [26]. Foam systems, which include aerated desserts, are characterized by the size and concentration of the air fraction. Therefore, it is advisable to conduct research and identify the size and number of air bubbles.

In [27] it was found that the formation of a stable structure of whipped foam depends on the interaction between the balls of fat and between the balls of fat and air bubbles. For the stability of the emulsion, it is necessary to introduce surfactants or emulsifiers into the formulation, and in order to increase the stability of the emulsion, a stabilizer can be added, which in turn will increase the viscosity of the aqueous phase. Thus, they should dissolve only in this phase and increase its viscosity due to the formation of a colloidal solution [28].

One of the most important characteristics of the foam is its dispersion, characterized by the average size of the bubbles, their distribution by size or limit of the solution-gas section per unit volume of foam. To form a stable foam structure of aerated polycomprotein desserts, including mousses, substances with surfactant properties should be added to their recipes: food emulsifiers, foaming agents, and foam stabilizers [29]. Such properties may be exhibited by a complex additive based on collagen hydrolyzate.

Problem areas in the field of food technology relate to the lack of an integrated technological approach to the study of the foaming properties of structure-forming agents and the dispersion of aerated desserts. The technological parameters of the system, such as pH, the temperature of obtaining the foam structure, the duration of whipping, temperature conditions, the concentration of the structure-forming agent, are not taken into account.

Thus, it suggests that it is advisable to conduct a study into the effect of a complex food additive on the technological parameters of aerated desserts such as mousse.

3. The aim and objectives of the study

The aim of this study is to improve the technology of production of aerated dessert, which will make it possible to shorten the technological process of aerated structure formation and increase the sensory and technological characteristics of the finished product.

To accomplish the aim, the following tasks have been set:

– to determine the effect of the complex additive on the foaming ability and foam stability of the prototype of the mousse;

– to investigate the effect of a complex additive on the dispersion of the developed mousse.

4. The study materials and methods

The object of our study is the technology of production of mousse from dairy and vegetable raw materials using additives.

The hypothesis of the study assumes that the introduction of a complex additive to the recipes of aerated desserts can serve not only as a technological additive that contributes to obtaining a high quality product. The introduction of a complex additive contributes to the enrichment of the product with biologically active substances, which will make it possible to position the finished product with certain functional properties, namely protective (immunostimulating, hepatotropic, osteotropic).

The subject of research is the technology of aeration of the mousse food system using an additive, which will make it possible to reduce the technological process of dessert production. Control recipe of mousse was selected for the prototype according to the Collection of recipes "Lemon mousse" No. 900 (Table 1).

The preparation of a prototype of mousse was carried out in accordance with the traditional technology of mousses and according to the classical recipe [30]. The composition of the complex additive: collagen hydrolyzate – 77.8 %, gelatin – 19.45 %, viburnum juice (anthocyanins) – 1.5 %, L-ascorbic acid – 1.25 %. The development of a complex additive was carried out in the laboratory at the Department of Technologies of Restaurant and Health Nutrition, Odesa National Technological University (Ukraine).

Since the mousse is a complex three-phase system, a polydisperse, heterogeneous system consisting of a gelling phase, a fatty phase, an aerated phase (air bubbles), for the stability of the foam it is necessary to use substances with surfactant properties that can ensure the stability of the aerated product. Therefore, methods for determining the foaming ability and stability of mousse foam with the introduction of an additive, as well as determining the dispersion of the foam were chosen.

The preparation of a prototype of mousse was carried out in accordance with traditional technology, by improving the classical recipe of mousse. Since in food systems the complex additive exhibits complexing, emulsifying, moisture-retaining, moisture-binding, stabilizing, structure-forming properties, in this regard, it is relevant to study the structural and mechanical properties of aerated desserts, in particular mousses when introducing a food additive into the formulation [25, 31–34].

The foaming ability and stability of the foams of the finished product (mousse) with the introduction of a complex additive were determined. A sample of mousse 6 g was dissolved in 25 cm^3 of distilled water, thoroughly mixed until a homogeneous suspension, transferred to glass cylinders by 500 or 1000 cm^3 with glued tape of millimeter paper, thoroughly washed off the remnants of the product, and brought the volume of liquid in the cylinder to 300 cm^3.

To determine the technological parameters for the production of mousse, the effect of the additive on the foaming properties and stability of the foam was investigated.

The foaming ability was investigated according to the following technological parameters: t=20, 30, 40 °C; τ=30, 60, 90, 120 s, and at different speeds (1, 2, 3 speeds of the Zelmer mixer): speed 1=3–4 s^{-1}; speed 2=4–6 s^{-1}; speed 3=6–9 s^{-1}.

Foaming ability is calculated from the following formula:

$$F=\frac{H_f}{H_s}\times 100\,\%, \quad (1)$$

where F is the foaming ability of protein, %;

H_f is the height of foam above the level of liquid, cm^3;

H_s is the height of the protein solution before foaming, cm^3.

To obtain the foam structure, the whipping duration was chosen: 30, 60, 90, and 120 s at temperatures: t=20, 30, 40 °C.

The stability of the foam was estimated by the height of the foam after 1...2×30^2 with the cylinders in a calm state and calculated from the following formula:

$$S=\frac{H_f\times 100\,\%}{H_{f.a.}}, \quad (2)$$

where S is the foam stability, **%**;

H_f – initial height of foam, mm;

$H_{f.a.}$ – the height of the foam after aging for 1...2×30^2, mm [35].

Studies and identification of the size and number of air bubbles were carried out using the method of microscopy, we determined the size of bubbles in the food system. Microscopy was performed in passing light with a magnification of 100 times using the Microscope MICROmed XS-3330 LED equipment.

Table 1

Recipes of "Creamy cheese mousse of protective action" and mousse "Lemon mousse" No. 900 (control)

Name of raw materials	Raw material consumption per 100 g of finished products, g (gross)	
	"Lemon mousse"	"Creamy cheese mousse of protective action"
	No. 1 (control)	No. 2
Lemon	23.8	0.0
Sugar	3.0	10.01
Gelatin	0.27	1.51
Fermented milk cheese, 5 %	0.0	20.02
Banana	0.0	17.91
Complex supplement	0.0	3.01
Cream, 33 %	0.0	17.18
Drinking water	70.0	31.6
Output	104.1	100.2

The following equipment was used for the manufacture of mousse: Zelmer mixer (BSH Hausgeraete GmbH company, Poland); electric scales (Rotex RSK 10-P, China).

Optimization of the mousse formulation was carried out according to the main macronutrients, in accordance with the norms corresponding to the recommended human needs through mathematical modeling and using linear programming using the MS Excel editor. The study of amino acid composition showed that the consumption of 100 g of mousse "Creamy cheese of protective action" satisfies the daily need for valine by 12.97 %. The shelf life of mousse is 5 days at a temperature of (5±1) °C in a glass container. Microorganisms of such a group as *E. coli* bacteria, *Staphylococcus aureus*, *Salmonella spp.*, were not detected throughout the entire shelf life, which meets the requirements of regulatory documentation and indicates sanitary cleanliness and safety of products [36]. Below are photographs of the prototype mousse immediately after cooking (Fig. 1).

a *b*

Fig. 1. "Creamy cheese mousse of protective action" immediately after preparation: *a* — top view; *b* — side view

The following raw materials were used for the study: fermented milk cheese ("Prostokvashino" DSTU 4554:2006), cream ("Prostokvashino DSTU 7519:2014), banana (DSTU 4033:2001), sugar (DSTU 4623:2006), complex additive: gelatin (TU U 24.6-00418030-002:2007), viburnum juice, collagen hydrolyzate (CH) (utility model patent No. 79357) [37], L-ascorbic acid.

5. Results of studies into the influence of technological parameters on the formation of the aerated structure of the food system

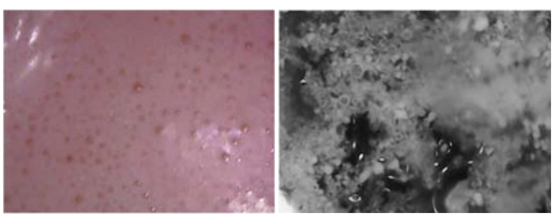
5. 1. Investigation of the effect of a dietary supplement on the foaming ability and foam stability of mousse

The results of experimental studies on foaming ability (FA) are given in Table 2, and micrographs of mousse with a magnification of 100 times are shown in Fig. 2–5.

Table 2

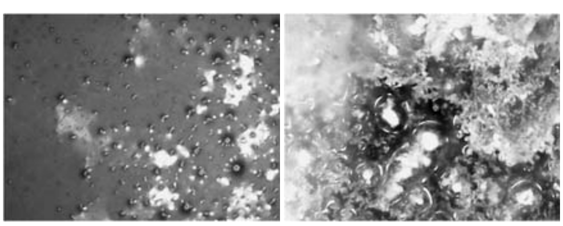
Foaming ability of "Creamy cheese mousse of protective action"

Whipping duration τ, s	FA_1 (3–4 s^{-1}), %	FA_2 (4–6 s^{-1}), %	FA_3 (6–9 s^{-1}), %
t=20 °C			
30	10	16	20
60	21.6	33.3	33.3
90	23.3	16.6	15
120	26.6	33	33
t=30 °C			
30	16.5	20	16.6
60	23.3	26.6	20
90	26	20	10
120	30	33.3	26.6
t=40 °C			
30	3.3	3.3	1.6
60	5	5	1.6
90	8.3	6.6	5
120	8.3	8.3	10



a *b*

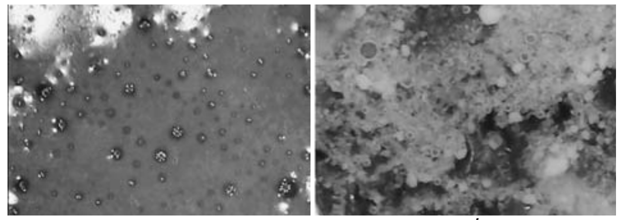
Fig. 2. Micrograph of "Creamy cheese mousse of protective action" after whipping for 30 s, at *t*=20 °C: *a* – top layer of foam; *b* – structure of the mousse



a *b*

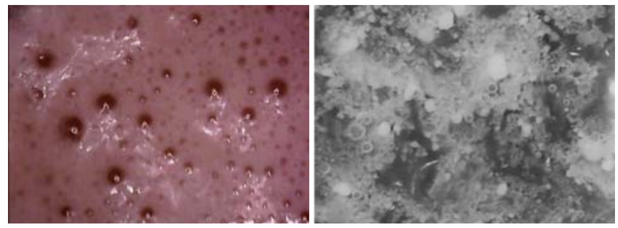
Fig. 3. Micrograph of "Creamy cheese mousse of protective action" after whipping for 60 s, at *t*=20 °C: *a* – top layer of foam; *b* – structure of the mousse

We investigated the foam stability (FS) of the prototype – mousse based on fermented milk cheese when a food additive was introduced into the formulation. We investigated the stability of the foam according to the following technological parameters: *t*=5, 10, 20, 30, 40 °C; τ=const=30 min (Table 3).



a *b*

Fig. 4. Micrograph of "Creamy cheese mousse of protective action" after whipping for 90 s, at *t*=20 °C: *a* – top layer of foam; *b* – structure of the mousse



a *b*

Fig. 5. Micrograph of "Creamy cheese mousse of protective action" after whipping for 120 s, at *t*=20 °C: *a* – top layer of foam; *b* – structure of the mousse

Table 3

Foam stability of "Creamy cheese mousse of protective action" after aging for 30 minutes

Whipping duration τ, s	FS_1 (3–4 s^{-1}) %	FS_2 (4–6 s^{-1}), %	FS_3 (6–9 s^{-1}), %
t=20 °C			
30	30 %	48 %	61 %
60	65 %	100 %	100 %
90	71 %	50 %	45 %
120	81 %	100 %	100 %
t=30 °C			
30	50 %	61 %	50 %
60	71 %	81 %	61 %
90	79 %	61 %	50 %
120	91 %	100 %	81 %
t=40 °C			
30	36 %	24 %	34 %
60	42 %	45 %	34 %
90	45 %	20 %	45 %
120	52 %	32 %	68 %

The food emulsion becomes less stable with increasing temperature. Thus, according to the indicators given in Tables 2, 3, one can determine the optimal whipping mode for mousse: at speed 3 for 120 seconds of whipping, at a whipping temperature of 20 °C. With such technological parameters of whipping of mousse, the greatest foaming ability and stability of the foam is observed.

5. 2. Determining the dispersion of mousse foam structure

The results of the distribution of air bubbles by diameter in the mousse based on fermented milk cheese (the top layer of foam and the structure of mousse) are given in Table 4 and Fig. 6–8, respectively.

Table 4

Distribution of the air fraction in the prototype of mousse based on fermented milk cheese (the top layer of foam)

Whipping mode	Distribution of bubbles (in %) by size, 10^{-3} m																
	Whipping tempera-ture, °C	0–0.011	0.011–0.021	0.021–0.031	0.031–0.041	0.041–0.051	0.051–0.061	0.061–0.071	0.071–0.081	0.081–0.91	0.091–0.101	0.101–0.111	0.111–0.121	0.121–0.131	0.131–0.141	0.141–0.151	Total %
30 s	20	49.1	42.4	7.1	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	30	25.3	0.0	13.8	17.2	13.8	0.0	0.0	0.0	20.7	0.0	8.0	0.0	0.0	0.0	1.1	100.0
	40	21.3	18.3	12.5	22.5	17.0	6.7	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.8	100.0
60 s	20	47.3	50.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	100.0
	30	18.8	60.0	0.0	13.3	6.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	40	27.4	65.2	6.3	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
90 s	20	48.8	0.0	42.7	0.0	7.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	30	51.0	0.0	46.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	40	0.0	59.1	35.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
120 s	20	69.5	0.0	2.1	23.2	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	30	60.0	30.3	4.4	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	100.0
	40	27.0	71.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

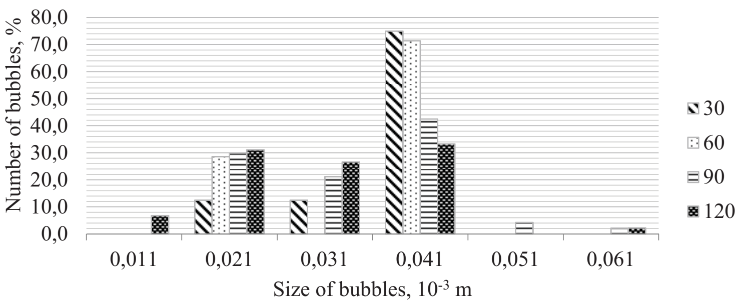


Fig. 6. Distribution of the air fraction in the prototype "Creamy cheese mousse of protective action" (the structure of mousse), at t=20 °C

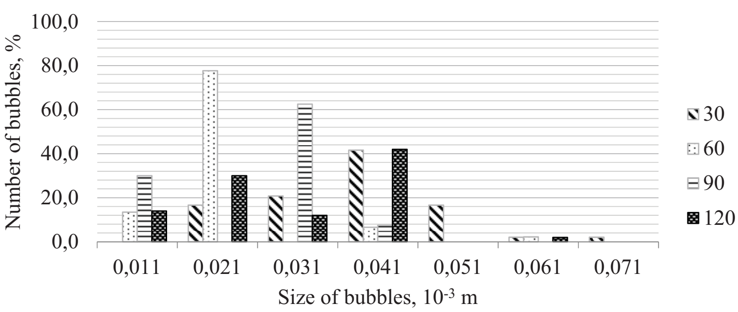


Fig. 7. Distribution of the air fraction in the prototype "Creamy cheese mousse of protective action" (the structure of mousse), at t=30 °C

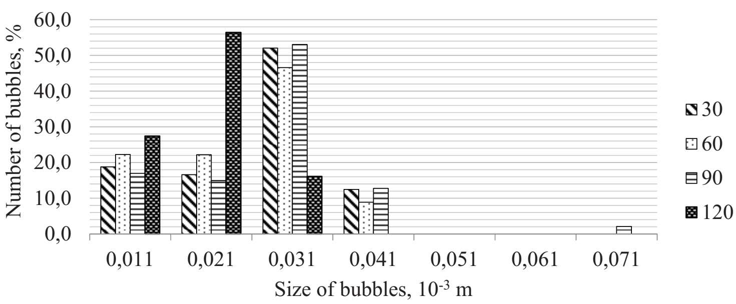


Fig. 8. Distribution of the air fraction in the prototype "Creamy cheese mousse of protective action" (the structure of mousse), at t=40 °C

Table 4 and Fig. 6–8 demonstrate that the maximum number of air bubbles has a diameter d=(0.011±0.021) mm and is 74 % for the mousse based on fermented milk cheese, namely in the upper layer of mousse foam, and 77 % – d=(0.011±0.021) mm for the mousse based on fermented milk cheese – the structure of the mousse.

The study of dispersion found that the foam structure of an aerated dessert with the addition of a complex additive has an average size of air bubbles (diameter 0.011–0.061 mm). The size of the bubbles decreases depending on the duration of whipping, and their number increases. Therefore, the largest foam structure is observed at t=20 and 30 °C and when whipped for 120 s.

6. Discussion of results of investigating the influence of technological parameters on the formation of the aerated structure of mousse

From the obtained data given in Tables 2, 3, one can determine the optimal whipping mode for desserts such as mousse: at speeds of 6...9 s^{-1} for 120 seconds of whipping, at a whipping temperature of 20 °C, with these parameters the highest foaming capacity is observed. With a whipping duration greater than τ=120 s, the foaming ability decreases because when whipping, the foam thickens and becomes more homogeneous. The stability of the foam acquires the greatest value at t=20 °C after whipping for 120 s, with a duration of aging τ=const=30 min.

Due to the higher fat content, namely cream in the recipe of mousse, foaming ability and stability are not high. This can be explained by the formation of complexes of fats with foaming agents, which adversely affect their foaming ability and foam stability.

There were also studies of foaming ability and foam stability at t=5, 10 °C. Foam was not formed, which may be due to the aggregate state of the protein and the ability to form intermolecular bonds between chemical elements. The above micrographs (Fig. 2–5) show that in these microstructures air bubbles are identified as perfectly spherical shapes, which are distributed by volume. Moreover, the introduction of a complex additive contributes to the formation of smaller air bubbles and a more uniform distribution of them throughout the entire volume of the whipped mass.

This does not fully make it possible to obtain a product with high rheological properties, which is ensured by foaming and foaminess of the food system.

It is necessary to clearly dose the components of the additive and control the technological process. It is important to identify critical control points at each stage of the production of a complex additive to prevent risks to food safety. This is regulated by the international quality control and safety system HACCP, which is relevant for HoReCa.

The advantages of this study are the examination of the complex influence of various technological parameters on foaming, foam stability, and dispersion of the foam structure of the finished product. The use of a complex of collagen and gelatin hydrolyzate, capable of forming colloidal solutions, allows us to recommend it for use as a source of digestible protein and a structure-forming agent in the production of whipped dessert products.

From the data illustrated in Fig. 6–8, it can be noted that the functionality of the complex additive, in this case, is reflected primarily in reducing the surface tension.

The limitations of the study are the temperature of the technological process of aeration, which occurs at a temperature not higher than 40 °C, which is due to the need to preserve in the native state the functional biologically active substances of the food system as much as possible.

The disadvantages of the study are the use of only one source of anthocyanins; the prospect is the study of different types of juices.

From the foam dispersion data, one can see a rather narrow peak at d=(0.011±0.012) mm for samples of "Creamy cheese mousse of protective action", which indicates a uniform whipping of the mousse.

Since aerated products are unstable food systems, the introduction of an additive allows you to stabilize the product, make it more homogeneous and stable during storage, which will improve the quality of the product.

The foaming capacity and foam stability of a complex additive with different ratios of hydrocolloids – gelatin and collagen hydrolyzate were previously investigated (20:80; 40:60; 50:50; 60:40; 80:20). The results showed that foaming is maximum when administering a complex additive in the ratio of collagen hydrolyzate and gelatin, as 80:20 (collagen hydrolyzate – 77.8 %, gelatin – 19.45 %, viburnum juice (anthocyanins) – 1.5 %, L-ascorbic acid – 1.25 %), namely in the amount of 3.0 % by weight of the recipe mixture (per 100 grams); it stabilizes the foam structure of the mousses. A promising study is the development of a complex of collagen hydrolyzate, gelatin, anthocyanins, and L-ascorbic acid with specified functional and technological properties with its introduction to the production technologies of aerated desserts.

7. Conclusions

1. It was established that the highest foaming ability and foam stability are observed at the following parameters: 6–9 s^{-1} revolutions, τ=120 seconds of whipping, at a whipping temperature of 20 °C. With increasing temperature, the stability of the foam decreases, because this reduces the adsorption of the foaming agent at the phase boundary and reduces the viscosity of the liquid. Due to the use of a complex additive as a foaming agent in mousses, it ensures the formation of a stable aerated structure.

2. Our studies into the effect of a complex additive on dispersion have shown that the greatest number of bubbles and their more even distribution throughout the entire volume of the food system in the sample "Creamy cheese mousse of protective action" are observed at t=20 and 30 °C and when whipping for 120 seconds. Summarizing the data on the distribution of air bubbles by diameter, it can be noted that the functionality of the complex additive, in this case, is reflected primarily in reducing surface tension.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

Data will be provided upon reasonable request.

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