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MICROSTRUCTURE OF CREAMS MADE FROM WHIPPED CREAM WITH POLYSACCHARIDES AND VARIOUS SPECIES OF SUGARS

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Abstract. In 2013, WHO adopted the "Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020" that set strategic goals for food manufacturers. The goals included lower fat content, complete elimination of trans fats, lowering the energy value of products. Tortes and cakes are high-calorie confectionery products as a lot of buttercream is used to decorate them. Particular attention is paid to buttercreams made from whipped cream. Its complex emulsion-foamy structure is formed by whipping cream from dairy cows, its fat content being not less than 33%. In order to create healthy products, reduce the energy value of buttercreams, lower their cost, it is practical to use cream from dairy cows with a lower fat content of 20%. The emulsion-foamy system of whipped cream can be stabilized by introducing hydrocolloids (sodium alginate, j-carrageenan) that have thickening, surfactant properties. To expand the range of buttercreams of mass consumption, in particular products for children, for functional nutrition, it is practical to apply not only sucrose, but glucose, fructose, and lactulose as well. The paper presents the results of studying the microstructure of buttercreams made from low fat whipped cream with different sugars. It is shown that the presence of sodium alginate and j-carrageenan introduced into the formulation substantially changes the pattern of the froth compared to the classic buttercream made from cream with 33% of fat. The samples with polysaccharides have clearly shaped pores homogeneous by size. The amount of air in such creams is smaller compared to traditional semi-processed products. When adding glucose, in the total mass of the sample, small pores prevail due to low solubility of sugar at the temperatures of whipping 275–277 K (2–4°C). In buttecreams with fructose, the structure is characterized by a significant number of large pores formed due to higher viscosity of the dispersion medium with fructose. It has been determined that during storage, the microstructure rearranges, up to 70 % of air is lost, and the pores of the smallest volumes remain, which is due to the fusion of air bubbles and compression of the gel carcass of polysaccharides. The experimental samples of buttercreams do not lose plasticity, their structure remains stable for five days of storage.

Key words: creams from whipped cream, emulsion-foamy system, microstructure of creams, sodium alginate, j-carrageenan, fructose, glucose.

Introduction. Formulation of the problem

The texture of buttercreams made from whipped cream differs in ampleness and plasticity, which is achieved by intense saturation of the cream with air bubbles during whipping, and by their uniform distribution throughout the entire dispersion medium. By changing the recipe of buttercreams we change the quality of foam formation in the cream and the physico-chemical parameters of the finished product. It is possible to explain the differences in the structure of emulsion-foam systems by analyzing the microstructure of buttercreams.

Analysis of recent research and publications

Buttercreams made from whipped cream to decorate tortes and cakes are complex dispersed systems. They are obtained by combining the crystallization-coagulation structure (partially destroyed by whipping) of milk cream – the dispersion medium – and air – the dispersed phase – in the process of whipping, bubbles of which are enveloped by proteins. In the course of formation of an emulsion-foam dispersion system, three processes are taking place simultaneously [1-3], due to which the internal microstructure of the buttercreams is formed: a) particles of the dispersed phase are deformed and crushed, resulting in an increase in the surface tension at the phase interface; b) surfactants move to the newly formed phase interfaces and are adsorbed on them, thus reducing the surface tension of the system; c) bubbles of the dispersed phase stick together, which can lead to an increase in their volume and partial coalescence.

The most important parameter determining the quality of buttercream is the amount of milk fat, which should be at least 33%, according to the traditional technology. A change in the amount of fat in the cream is reflected in its structure, which naturally changes in the course of whipping at low temperatures. During cooling and whipping, fat globules are subjected to a shear stress due to the rotation of the whipping mechanism. Fat particles split, and this results in partial coalescence of fat globules and their rearrangement into other agglomerates, the surface of which is covered with milk proteins. Destabilization of fat takes place in the system. It means the release of individual agglomerates of fat globules [4,5]. The authors have proved [6] that to obtain a good texture of whipped emulsion products, a small portion of emulsified fat should be destabilized. By this, the product aquires an attractive dry appearance, and leaves a creamy, harmonious sensation when consumed. Reducing the amount of fat in the buttercream formulation and the presence of structure stabilizers (sodium alginate or carrageenan) will have a significant effect on the viscosity of the dispersion medium. Accordingly, the rearrangement of fat globules and their agglomeration will take place to a lesser extent.

It should be noted that stabilization of the foam structure depends on the size of the fat globules and their agglomerates. Scientists [7,8] have found that, as the critical value of the diameter of the fat globules or their aggregates ($D_{50.3}$ = 0.85 μm) increases, the melting rate slows down the drainage rate. Fat globules and agglomerates block the foam lamellae, which results in decreased plasma drainage. Moreover, they form bridges between the air bubbles, supporting each other and thus increasing the resistance to melting. Proteins with intact membranes and their agglomerates have a similar effect.

The adsorption of proteins plays an important role in capturing the air bubbles, and the stability of the structure is ensured by the interactions between the accumulated mass of fat globules and the air bubbles. The microstructure of milk foams has been studied in detail by A. P. Belousov [9]. He investigated the surface activity of the layer located around the fat balls, and has found that the lecithin-protein complex of the layer demonstrates high surface activity both at the interface of water and fat and on the water surface (its interface with air), in comparison with any plasma substance. Therefore, with fat globules draining down from air bubbles, the lecithin–protein complex of the layer will pass from the surface of the ball to the surface of the bubble, and expel less surface-active plasma substances from it. The process of capturing fat globules by air bubbles was also investigated depending on the temperature of the cream: the fat content of the foam increases as the temperature increases from 278 to 283–288 K (from 5 to 10–15°C) and later decreases.

Investigations of the microstructure of the foam formed by whipping cream were continued by A. D. Grischenko [10]. The author has found that the average diameter of fat globules at the beginning of whipping rapidly decreases, and then, conversely, gradually increases. As the whipping process approaches its final stage, the number of air bubbles and the area of the boundary surface decrease. The larger the boundary surface, the shorter the whipping time is. The structured cellular system – aggregate foam – is formed by aggregation of floating fat globules. During this period, the amount of foam increases, mainly due to involving not the air, but the dispersion medium into the foaming process. Cream plasma substances are spent on forming a new surface, which is a result of splitting large air bubbles into smaller ones. Some of the plasma is mechanically held by the aggregate foam. However, after reaching a certain critical ratio between the amount of air and that of cream, the system loses its stability and quickly collapses.

Thus, foaming of cow cream is a complex process, in which the amount of the fat phase plays the most significant role. To make finished products cheaper and the whipping conditions simpler, manufacturers spread identical substitutes in the range of this group of decorative-purpose products. These substitutes are semi-processed products made from nondairy (vegetable) cream, mixtures consisting of milk fat substitutes, emulsifiers, stabilizers, preserving agents, etc. Sometimes the composition of whipping mixtures remains unknown. In our opinion, this approach is contrary to the principles of healthy nutrition that are aimed at using natural raw materials and eliminating industrial trans fats from formulations. It is advisable to use dairy cow cream to create healthy foods, while reducing the cost of production by using low-fat cream (for example, 20%). In such cases, hydrocolloids with thickening and surfactant properties will help stabilize the complex emulsion-foam system of whipped cream. There are reports that, to manufacture whipped emulsion-foam structures, hydrocolloids were used, which made the medium more viscous, and thus increased the system's stability and fat melting resistance, prevented destabilization of the fat. The studies [11] aimed at reducing the energy value of buttercreams have developed buttercreams made from whipped cow cream with the fat content 20%. The product's prototype was the recipe of buttercream made from gelatin-based whipped cream [12] that included low fat cream (20%), sugar, and gelatin. In the suggested technological schemes, gelatin is replaced with structure-forming agents of the polysaccharide nature – sodium alginate or j-carrageenan, which, unlike gelatin, have no specific flavours and aromas, emphasize the delicate creamy taste of buttercreams, ensure the stability of the whipped mass while it is formed and sold [13]. Unlike gelatin-based buttercream, polysaccharide-based samples have a fluffy, plastic consistency and still retain it when sold. Besides, to expand the range of whipped cream-based buttercreams for mass consumption, including functional nutrition, it has been suggested to use glucose or fructose to replace white crystalline sugar. It has been found that reducing fat in the formulations of whipped cream-based buttercreams, introducing hydrocolloids, adding different sugars lead to changes in the structural and mechanical properties of the product, and in its quality during the foaming process [14]. Accordingly, the microstructure of the foam will have some differences from the classical one. Probably the thickness of the films around air bubbles, the size of the bubbles of the dispersed phase will also be changed. In our opinion, a detailed microstructural analysis will allow determining the quality of the newly-formed emulsion-foam structure of buttercreams with an altered recipe composition. The size of the air bubbles, their shape, and volume provide clear information on the regularities of foaming of the experimental systems and the formation of their structural and mechanical parameters.

The purpose of the study is studying the microstructure of buttercreams made from whipped cream with the fat content 20%, with polysaccharides and various sugars – sucrose, glucose, and fructose.

The objectives are to investigate the effect of sodium alginate and j-carrageenan on the microstructure of buttercreams made from low-fat whipped cream, and to study the differences in the area and the pore sizes of the samples with sucrose, glucose, and fructose.

Research materials and methods

The object of research is the microstructure of buttercreams made from whipped cream with gelatin, sodium alginate, j-carrageenan, based on sucrose, glucose, fructose.

The following raw materials were used for the study:

– white crystalline sugar;

– cream *Ferma* with the fat content 33% and 20%;

– food gelatin;

– sodium alginate, j-carrageenan (produced by *GE Roeper GmbH*, Germany);

– glucose (DM–89.2%), fructose (DM–97.4%).

Model samples of buttercreams were prepared according to the following technological schemes.

The buttercream from whipped cream with gelatin (the control sample) was prepared according to recipe 76 from the collection of recipes of tortes and cakes [12]. This method involves soaking the gelatin in some of the cream (1:10), heating the mixture to dissolve the gelatin completely (the temperature 333–338 K (60–65°C)), cooling down (to the temperature 313 K, or 40 ± 2°C), and adding it while the cream is being whipped together with powdered sugar.

The buttercreams made from whipped cream containing sodium alginate or j-carrageenan were prepared according to a patented production method [15,16]. To prepare buttercream containing sodium alginate, the amount of the structure-forming agent prescribed in the recipe was mixed with powdered sugar in the ratio 1:1, added to the cream, heated to a temperature about 358–363 K (85–90°C) to dissolve it completely, and cooled to the temperature 283 K (10±2°C). The cooled solution was added to the main part of the cream and whipped, while adding gradually the remaining part of the powdered sugar (fructose, glucose). To prepare buttercreams with j-carrageenan, the structure-forming agent was mixed with all the amount of powdered sugar prescribed by the recipe (if fructose and glucose are used, their amount is 50% of the total content prescribed by the recipe), diluted with cream, heated until dissolved completely at the temperature 363–368 K (90–95°C), and cooled to 278 K (5±2°C). The cooled solution was added while whipping the main part of the cream (for buttercreams with fructose and glucose, the remaining part of sugar should be added during the main whipping).

In the preparation of buttercreams, the recipe amount of sucrose was replaced by fructose or glucose equivalent in the dry matter content.

The microstructure of the foam systems was studied using an optical trinocular microscope. A preparation called *a crushed drop* was prepared: a drop of foam to be studied was put on the object-plate and covered with the cover-glass. The sample was placed under a microscope and took a photo of the sample with magnification 400x. The area of each bubble, that of the test sample, and the air concentration in the system were calculated using the photos by the formulae 1–3:

$$S_s = a \cdot b \quad (1)$$

where S_s is the area of the sample under study, m^2; a is the length of the photo, m; b is the width of the photo, m;

$$\Sigma S = S_1 + S_2 + ... + S_n \quad (2)$$

where $\sum S$ is the sum of the areas of the air bubbles, m^2; S_1, S_2…S_n is the area of each bubble, m^2;

$$\varphi_{air} = \sum S/S_s \cdot 100\% \quad (3)$$

where φ_{air} is the air concentration in the system, %; $\sum S$ is the sum of the air bubble areas, m^2; S_s is the area of the experimental sample, m^2.

By their area, the bubbles were divided into seven groups: 1) S – 0–0.005 m^2; 2) S – 0.006–0.01 m^2; 3) S – 0.011–0.025 m^2; 4) S – 0.026–0.05 m^2; 5) S – 0.051–0.1 m^2; 6) S – 0.11–0.15 m^2; 7) S – > 0.15 m^2.

The whipping (foaming) ability and the stability of the whipped cream were determined by the Lurie method [17,18]. The whipping ability was calculated by the formula:

$$W = \frac{V_f}{V_S} \times 100 \quad (4)$$

where V_f is the foam volume, m^3; V_s is the volume of the solution before whipping, m^3.

At the same time, the stability of the whipped cream was determined by the formula (5). Measurements were made during 5 days of storage at 279 K (6 ± 2°C).

$$St = \frac{h_2}{h_1} \times 100 \quad (5)$$

where h_1 is the height of the cylindrical tank, mm; h_2 is the foam height after keeping at rest during storage, mm.

The density [19] of the whipped cream was determined by the volumetric method. The density was calculated by the formula:

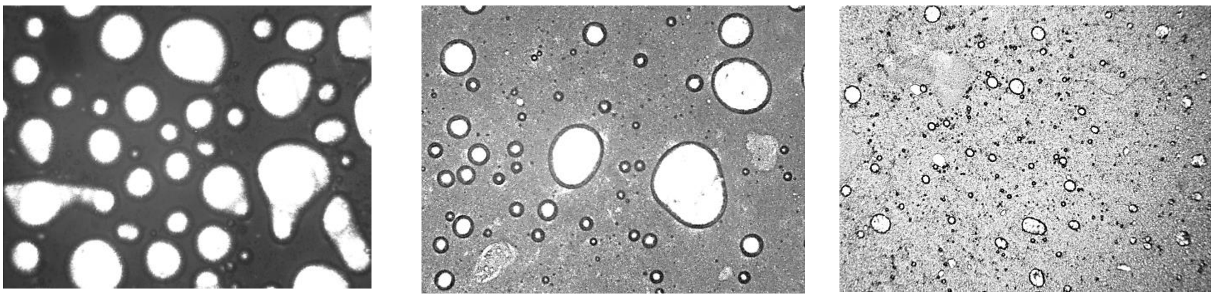
$$\rho = \frac{m}{V} \quad (6)$$

The results of the experimental studies were evaluated using methods of calculating the statistical reliability of the measurement results. The empirical data were approximated using MSExcel spreadsheets.

The results of the studies are presented in Fig. 1-8 and in Table 1.

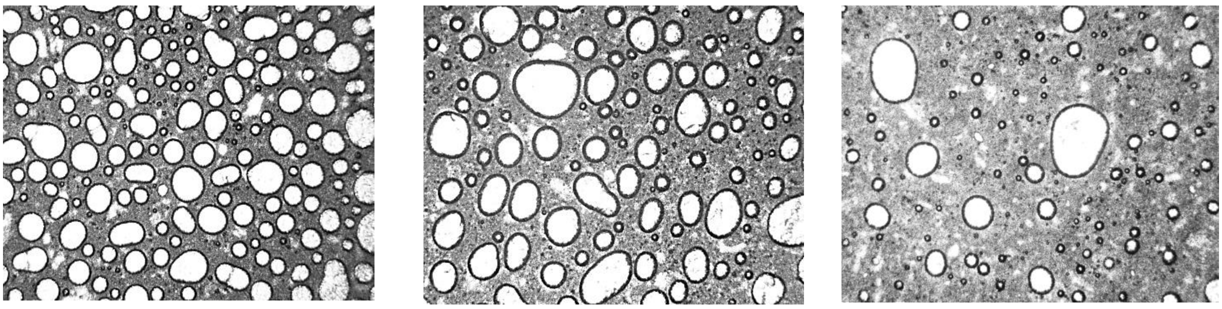
a) b)

Fig. 1. Whipped cream with the fat content 33 %: a) immediately after whipping; b) after 2 hours of storage



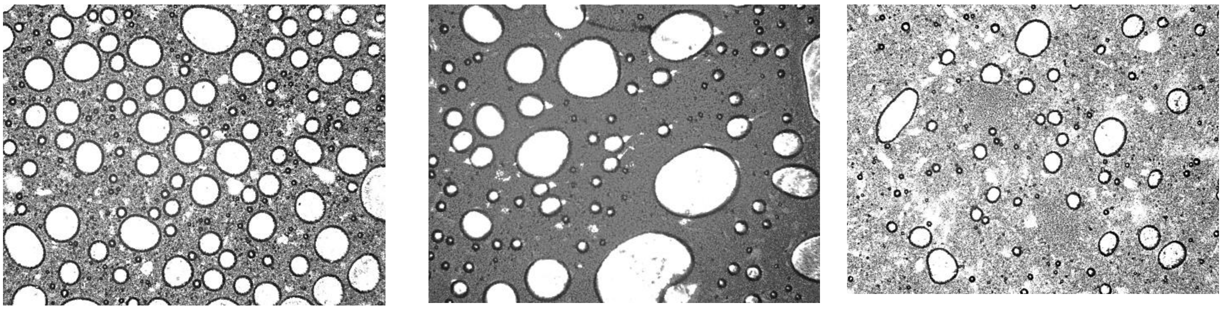
a) b) c)

Fig. 2. Whipped cream with gelatine: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



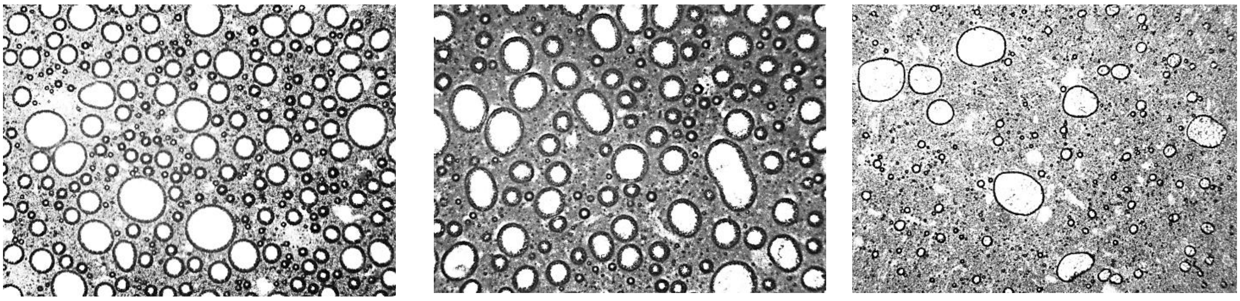
a) b) c)

Fig. 3. Whipped cream with sodium alginate and sucrose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



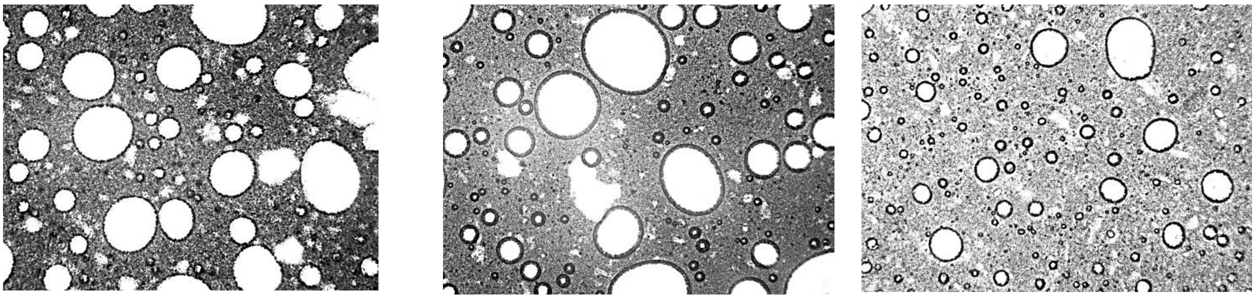
a) b) c)

Fig. 4. Whipped cream with sodium alginate and fructose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



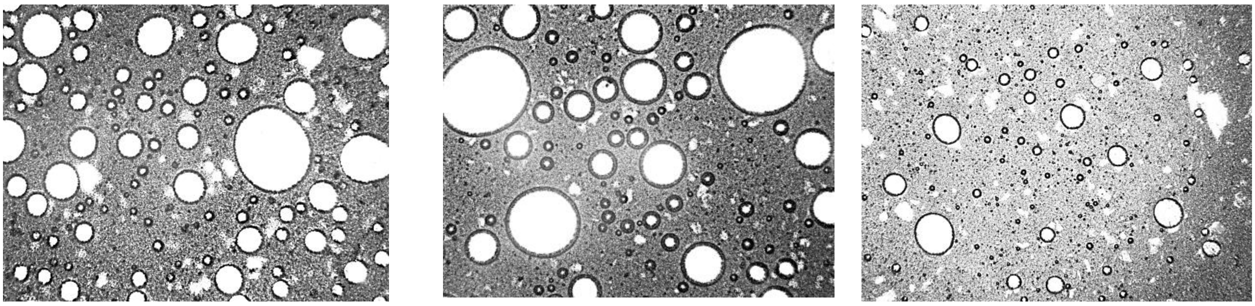
a) b) c)

Fig. 5. Whipped cream with sodium alginate and glucose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



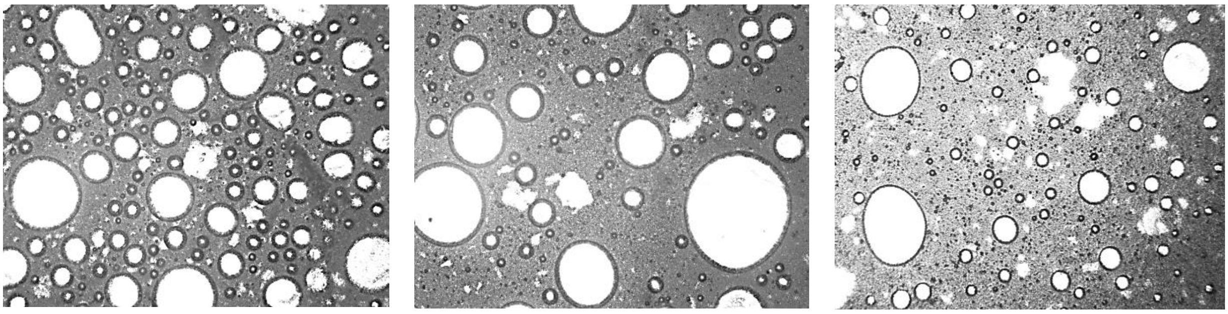
a) b) c)

Fig. 6. Whipped cream with j-carrageenan and sucrose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



a) b) c)

Fig. 7. Whipped cream with j-carrageenan and fructose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage



a) b) c)

Fig. 8. Whipped cream with j-carrageenan and glucose: a) immediately after whipping; b) after 2 hours of storage; c) after 5 days of storage

Table 1 – Characteristics of the microstructure of buttercreams with different sugars

Duration of storage	Air concentration, %	Foam stability, %	Distribution of air bubbles in buttercreams by the area, %						
			to 0.005m^2	to 0.01m^2	to 0.025m^2	to 0.05m^2	to 0.1m^2	to 0.15m^2	More than 0.15m^2
Buttercream made from whipped cream (cream with 33% of fat, sucrose)									
Immediately after whipping	52	100	10.7	26.2	34.5	21.4	5.9	1.3	-
After 2 hours of storage	44	66	28.6	30.4	12.5	14.2	7.1	3.6	3.6
After 5 days of storage	–	52	-	-	-	-	-	-	-
Buttercream made from whipped cream with gelatin (cream with 20% of fat, sucrose)									
Immediately after whipping	39	100	8.2	16.2	35.1	21.6	10.8	5.4	2.7
After 2 hours of storage	12	100	74.3	11.4	-	5.7	5.7	2.9	-
After 5 days of storage	3	100	92.3	2.6	5.1	-	-	-	-
Buttercream made from whipped cream with sodium alginate (cream with 20% of fat, sucrose)									
Immediately after whipping	51	100	37.5	25.6	31.0	5.9	-	-	-
After 2 hours of storage	43	100	36.4	21.8	26.4	13.6	1.8	-	-
After 5 days of storage	16	100	74.7	12.1	8.4	2.4	2.4	-	-
Buttercream made from whipped cream with sodium alginate (cream with 20% of fat, glucose)									
Immediately after whipping	44	100	64.2	18.9	13.8	2.4	0.7	-	-
After 2 hours of storage	40	100	28.3	24.5	34.0	12.3	0.9	-	-
After 5 days of storage	13	100	90.0	2.0	2.0	4.0	2.0	-	-
Buttercream made from whipped cream with sodium alginate (cream with 20% of fat, fructose)									
Immediately after whipping	40	100	49.7	17.5	20.9	11.2	0.7	-	-
After 2 hours of storage	34	100	63.9	10.9	9.6	9.6	3.6	1.2	1.2
After 5 days of storage	12	100	71.0	11.6	11.6	5.8	-	-	-
Buttercream made from whipped cream with j-carrageenan (cream with 20% of fat, sucrose)									
Immediately after whipping	34	100	20.5	18.2	34.1	9.0	15.9	2.3	-
After 2 hours of storage	29	100	47.6	14.3	19.0	7.1	4.8	2.4	4.8
After 5 days of storage	13	100	60.0	15.0	12.5	10.0	2.5	-	-
Buttercream made from whipped cream with j-carrageenan (cream with 20 % of fat, glucose)									
Immediately after whipping	30	100	73.7	7.0	11.4	4.4	3.5	-	-
After 2 hours of storage	27	100	71.2	5.8	9.6	5.8	3.8	1.9	1.9
After 5 days of storage	11	100	85.2	6.6	3.3	1.6	3.3	-	-
Buttercream made from whipped cream with j-carrageenan (cream with 20 % of fat, fructose)									
Immediately after whipping	22	100	65.4	10.3	15.4	1.6	-	1.3	-
After 2 hours of storage	20	100	64.2	9.4	15.1	5.6	1.9	3.8	-
After 5 days of storage	6	100	83.6	7.3	3.6	5.5	-	-	-

It has been established that the classic buttercream from whipped cream with 33% of fat has a high concentration of air in the system. The microstructure of its foam is represented by heterogeneous inclusions of air of varying volume. Round-shaped air bubbles are not observed, the air is held by the agglomerates of globules of milk fat destabilized in the course of whipping. This scheme is an illustration of the mechanism of formation of a whipped emulsion-foam system of pure cream. This mechanism is associated with hardening of fat globules around captured air bubbles and with distribution of protein molecules on their surface. This system will depend entirely on the temperature gradient supported while producing, storing, and selling buttercreams, since a slight temperature increase promotes the melting of milk fat, its flowing down, linkage of its molecules, and, finally, dividing the system into layers. It has been established that after two hours of storage, the buttercream made on the basis of cream of 33% fat content becomes less stable in comparison with its initial condition, and after further storage, it completely separates into layers. So, further research was considered to be inappropriate.

The figures show that the structure of all the foam samples changes during storage, and there are differences between the samples containing sodium alginate and j-carrageenan. A detailed analysis of these changes is given in Table 1. The presence of polysaccharides alters the viscosity of the dispersion medium [20] and thus has a significant effect on the nature of pore formation, on their size, shape, and number. The samples containing sodium alginate or j-carrageenan have a distinct pattern of round-shaped pores different in volumes and distributed at a distance greater than that in the control sample. That is, a more structured medium reduces the speed of the air bubbles by volume, and helps keep them more detached. Depending on the type of a polysaccharide, the pattern is slightly different. Among all test samples, the buttercream containing sodium alginate is more saturated with air, and has more pores homogeneous by volume. The pores are evenly distributed in the volume of the dispersion medium. They are smaller than the pores of buttercreams with j-carrageenan or gelatin. The samples with j-carrageenan or gelatin have both large and small pores, so their structure is less uniform, which results in larger distances among the air bubbles. In buttercreams with gelatin, there are several pores of indefinite shape, which indicates their merging due to their movement in the course of solidification of the buttercream. That is why, the air concentration values of the samples with sodium alginate are higher than those of the samples with gelatin by 13–30%, and of the samples with j-carrageenan by 30–40% (depending on the type of sugar).

The type of sugars added to the system has its effect on the microstructure, too [21]. In the samples with both sodium alginate and j-carrageenan, glucose added results in the largest number of small pores, fructose results in their largest volume. Such regularities are related to the physical and chemical properties of the sugars. For example, glucose at the whipping temperature 275–277 K (2–4°C) has rather low solubility, the lowest of all sugars; at low temperatures, glucose will try to form a crystal lattice due to the interaction between molecules and thus prevent the films of the dispersion medium from being stretched during the whipping process. As a consequence, air is captured in small portions. The high solubility of fructose, on the contrary, results in slightly higher viscosity of the dispersion medium compared to that caused by other test sugars. This contributes to less air in the system and the heterogeneity of the pore volume.

The dependencies of the air concentration in the buttercreams on the sample composition are the same as the dependencies determined while studying the effect of sugars on the whipping ability of the system. For example, the whipping ability of cream containing sodium alginate and sucrose is 170%, containing sodium alginate and glucose 146%, containing sodium alginate and fructose 143%, and the air content is 51%, 44%, 40%, respectively. The whipping ability of cream with j-carrageenan and sucrose is 159%, with glucose154%, with fructose129%, and the air content is 34, 30, and 22%, respectively.

During storage of buttercreams, a part of the dispersed phase, the air, is lost. In this case, the decrease in the number of bubbles of air is gradual, which is explained by different processes that take place in the dispersion medium. During the first 2 hours of resting the buttercreams, a well-developed gel-like frame is formed throughout the entire volume of the dispersion medium, and gelation makes its structure fixed. That is, in the first period of storage, the system is sufficiently mobile, causing the liquid flow out along the foam lamellae and merging of the drops into larger pores (some pores remain not round-shaped). Part of the air is not retained and is removed from the buttercream, which reduces the volume concentration of air. Depending on the type of a structure-forming agent and the speed of gel formation, the process of fixing the structure occurs in different ways. Since after 2 hours of resting, the samples with j-carrageenan lose up to 15% of air regardless of the type of sugar, and the samples with sodium alginate up to 17%, the systems with j-carrageenan become stable a little faster.

Mostly, the gelation process effects on the quality of gelatin buttercream. The development of a strong three-helix structure of a collagen molecule results in the loss of up to 70 % of the air after 2 hours, and up to 93% after 5 days.

After five days of resting, by the end of the period of selling buttercreams, the samples lose ≈ 70 % of air, and only the pores of the smallest volumes remain. This is due to the gradual compaction of the polysaccharide frame and the loss of a sufficiently large part of air. Thus, in the samples of buttercreams containing sodium alginate, ≈ 30% of the air from the primary volume remains, in the samples with j-carrageenan, 20–40%, in the samples with gelatin, 7%. This process causes changes in the quality of buttercreams. Their density increases: gelatin-based buttercreams increase the density by 24% from 628 g/cm^3; buttercreams with sodium alginate by 6% from 654g/cm^3; buttercreams with j-carrageenan by 8%

from 667 g/cm^3. Thus, depending on the qualitative composition of the dispersion medium, the quantitative and qualitative composition of the dispersed phase of buttercreams is formed, and, accordingly, its quality characteristics.

The regular formation of the structure with different polysaccharides and sugars modifies the distribution of air bubbles by their area. The calculations based on the photos taken show that the classic buttercream (control), immediately after whipping, has quite a number of pores with the areas 0.01 m^2 to 0.05 m^2 (82.1%). After two hours of storage, when 15% of air is lost, the areaof the pores changes towards the formation of larger bubbles, 0.05 m^2 to 0.15 m^2 (28.5%). After five days of storage, all air is lost from the samples, due to which, there is no air bubble distribution.

In low-calorie buttercreams based on the use of dairy cream with 20% of fat, the structure-forming agent itself significantly influences the size of the bubbles. Its individual character related to its type determines the different values of the area of the pores formed. For example, in the samples with gelatin, after whipping, there are pores with the area of all the groups established, including large sizes, over 0.1 m^2 (18.9%). In the samples of buttercreams containing sodium alginate and j-carrageenan, the nature of the pores changes dramatically, the ones with a smaller area prevail in the system. For example, immediately after whipping, in buttercream with sodium alginate and sucrose, there are 100% of pores ranging from 0.005 m^2 to 0.05 m^2, while in buttercream with j-carrageenan and sucrose, there are 97.7% of them, their area ranging from 0.005 m^2 to 0.1 m^2. That is, the structure of buttercreams with polysaccharides is finer, more homogenius and more uniform. The samples of buttercreams with glucose and fructose, regardless of the structure-forming agent, are characterized by a larger proportion of pores with the smallest area (pores up to 0.005 m^2): the buttercream with sodium alginate and glucose – 64.2%, with fructose – 49.7%, while buttercream containing sodium alginate and sucrose, 37.5%; whipped cream with j-carrageenan and glucose – 73.7%, with fructose – 65.4% (while buttercream with sucrose, 20.5%), due to the different viscosity of the systems.

During storage, the structure of the whipped cream-based buttercream changes, including the distribution of air bubbles. As part of the air is removed, the pores reduce their area, and the structure of any buttercreams is characterized by pores of a smaller area. For example: after two hours of storage, in the buttercream with gelatin and sucrose, there are 85.7% of pores with an area of 0.005 m^2 to 0.01 m^2, and 14.3% of pores with an area of 0.15 m^2 or more. And after five days of storage, when there is little air left in this sample, almost all microstructure of the buttercream is represented by the smallest pores with sizes up to 0.005 m^2. Similarly, the characteristics of buttercreams with polysaccharides change. However, after two hours of storage, both buttercreams with sodium alginate and those with j-carrageenan reduce the overall air concentration but a little, by about 10–15%, so they have pores in a wider range (from 0.005 m^2 to more than 0.15m^2).

The processes that occur in the structure of buttercreams during their storage will affect their structural and mechanical properties. It is known that increasing the amount of air, as a dispersed phase, forms such a parameter as the plasticity of buttercreams, which is important for characterizing the technological direction of buttercreams. Hence it can be assumed that buttercreams with polysaccharides, having a larger volume of the dispersed phase in their composition, will have more plasticity than the buttercream with gelatin, and among the sugar-containing ones, the highest plasticity will be of buttercreams with sucrose.

Conclusion

The results of studying the microstructure of buttercreams allow conclusions about the prospective use of sodium alginate or j-carrageenan to stabilize the emulsion-foam systems of buttercreams based on cow cream with the fat content 20%. It has been proved that changing the buttercream composition significantly changes its microstructure. In low-calorie buttercreams, it is the structure-forming agent itself that has a significant effect on the size of the bubbles: depending on the individual character of its type, pores with different areas are formed. In the samples of buttercreams with sodium alginate and j-carrageenan, pores with a smaller area predominate, the structure of buttercreams is fine, homogenious, and uniform. The samples with j-carrageenan have both large and small pores, so the structure is less uniform, which results longer distances among the air bubbles. That is why, by the table values of volumetric air concentration, the samples with sodium alginate exceed the ones with j-carrageenan by 30–40% (depending on the type of sugar). In the samples with sodium alginate and j-carrageenan, using glucose instead of sucrose results in the largest number of small pores, using fructose results in the largest volume of the pores due to the solubility of sugars.

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МІКРОСТРУКТУРА КРЕМІВ ІЗ ЗБИТИХ ВЕРШКІВ З ПОЛІСАХАРИДАМИ ТА РІЗНИМИ ВИДАМИ ЦУКРІВ

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Анотація. У 2013 році ВООЗ прийняла «Глобальний план дій з профілактики неінфекційних захворювань та боротьби з ними на 2013–2020 рр.», в якому означила стратегічні цілі для виробників харчової продукції, в тому числі зменшення вмісту жирів, повне усунення промислових трансжирів, пониження енергетичної цінності продукції. Торти й тістечка є висококалорійними кондитерськими виробами внаслідок використання в оздобленні значної частини кремів. Особливої уваги заслуговують креми із збитих вершків, складна емульсійно-пінна структура яких утворюється збиванням вершків молочних коров'ячих з жирністю не менше 33%. Із метою створення продукції здорового харчування, зменшення енергетичної цінності кремів, пониження їхньої собівартості, доцільним є використання вершків молочних коров'ячих з меншим вмістом жиру – 20%, а стабілізувати емульсійно-пінну систему збитих вершків можливо внесенням гідроколоїдів – натрію альгінату, j-каррагінану, здатних проявляти загущувальні, поверхнево-активні властивості. Для розширення асортименту кремів масового споживання, дитячого, функціонального харчування, доцільним є застосування поряд з сахарозою глюкози, фруктози, лактулози. У статті наведено результати досліджень мікроструктури кремів із збитих вершків пониженої жирності з різними цукрами. Показано, що присутність натрію альгінату і j-каррагінану, які вводяться в рецептуру, суттєво змінюють рисунок піни порівняно із кремом класичним на вершках 33%-вої жирності. Зразки з полісахаридами мають оформлені пори, однорідні за розміром. Кількість повітря в таких кремах менша, у порівнянні із традиційними напівфабрикатами. При додаванні глюкози, в загальній масі зразка переважають дрібні пори, що обумовлено низькою розчинністю цукру за температур збивання кремів 275–277 К (2–4°С). У кремах із фруктозою структура характеризується значною кількістю

великих пор, які утворюються завдяки вищій в'язкості дисперсійного середовища. Визначено, що в процесі зберігання відбувається переформування мікроструктури і втрачається до 70% повітря, залишаються пори найменших об'ємів, що пов'язано із злиттям пухирців повітря і стисканням гелевого каркасу полісахаридів. Дослідні зразки кремів не втрачають пластичність, їхня структура залишається стабільною протягом п'яти діб зберігання.

Ключові слова: креми із збитих вершків, емульсійно-пінна система, мікроструктура кремів, альгінат натрію, j-каррагінан, фруктоза, фруктоза.

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