The effect of casein on the quality of ice cream with different fat content was studied. According to functional and technological characteristics, micellar casein was selected for the enrichment of ice cream. Using mathematical modeling in the environment of the MathCad-15 package, the mass fraction of micellar casein in the composition of ice cream with a fat content of 0 to 15 % was optimized in order to obtain a high-quality product. At the first stage, the response surface methodology was used to optimize the response functions (overrun, melting resistance, organoleptic characteristics) for the varied fat and protein content. In the second stage, a comprehensive quality score of ice cream was used for modeling as a function of estimates of individual quality indicators, converted into scalable values using weights. The inverse relationship between the values of the optimal protein content and the fat content of ice cream was determined. To achieve the maximum technological effect, in the composition of ice cream with a fat content of 0–5 %, 6–10 % and 11–15 %, the need for micellar casein is 6–5 %, 4–3 % and 2.5–1 %, respectively. According to the results of calculating the percentage of energy value introduced by total protein (more than 20 %), it was concluded that ice cream with a fat content of 0–5 % with mass fractions of micellar casein of 6–5 % and total protein of 9.7–8.7 % can be attributed to the category of products with high protein content. Ice cream with a fat content of 10–15 % with mass fractions of casein micellar of 3–1 % and total protein of 6.7–4.7 % can be attributed to a product with high protein content. The results of the study allow expanding the range of protein-containing ice cream to meet the needs of consumers of different groups

Keywords: ice cream, enrichment, micellar casein, composition optimization, comprehensive quality score

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DETERMINING THE EFFECT OF CASEIN ON THE QUALITY INDICATORS OF ICE CREAM WITH DIFFERENT FAT CONTENT

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1. Introduction

Priority criteria for consumers' food choice are health benefits, safety, attractive organoleptic characteristics, low caloric content and affordability. Due to this, the technologies of ice cream enriched with probiotics, biologically active ingredients, ice cream with sweeteners, lactose-free ice cream, etc. are rapidly developing in the world [1–4]. However, due to high quality indicators, ice cream with a high fat content is still in significant demand. Therefore, a promising area for improving the structure of consumer nutrition is to expand the range of low-fat and nonfat ice cream with improved organoleptic characteristics, including ice cream of high biological value, enriched with proteins. Whereas proteins as natural biopolymers are functional-technological compounds of specific action, their effect on the quality of ice cream can be unpredictable, especially in low-fat. Therefore, the compilation of recipes for nonfat ice cream and ice cream with a fat content of up to 15 % enriched with protein should be based on specific recommendations. Such recommendations can be developed as a result of scientific research on the specifics of the effect of proteins on the formation of quality indicators of ice cream of different chemical composition.

2. Literature review and problem statement

Characteristic defects of the consistency of ice cream with low milk solids content, as well as nonfat and low-fat ice cream, are coarse-grained structure, heterogeneous air phase, low resistance to melting [5]. That is why, to prevent these defects, hydrocolloids, including proteins, are added in milk formulas, which is also one of the ways to increase the biological value of the product [6]. Low-calorie ice cream with high protein content is also one of the options to solve the problem of protein deficiency, including in people who play sports, need to adjust their weight and figure, have a high daily physical activity [7].

To increase the nutritional value of food products, milk and milk protein concentrates, as well as protein isolates [8, 9] are used, in particular:

– dry whey, including demineralized, hydrolyzed;
– whey protein concentrates (WPC-UV, isolates);
– caseinates (sodium, calcium);
– casein, including micellar;
– plant protein concentrates.

These ingredients with different fractional composition, degree of processing and origin are characterized by functional and technological properties of different specificity and efficiency [10, 11]. But it should be noted that milk powder and whey bring excess lactose and mineral salts to the composition of ice cream, which adversely affects the organoleptic characteristics of the product (the formation of large lactose crystals, salty taste). Sodium and calcium caseinates in excess of 1 % give ice cream an alkaline taste. Casein obtained by the thermoacid method has a low solubility and therefore complicates the technology of protein-enriched ice cream. Whey protein concentrates slightly structure the mixture and usually give the product a bitter taste. But there is another alternative to traditional cow's milk proteins. Thus, the possibility of using camel milk casein hydrolyzate in an amount of no more than 2 % in low-fat ice cream to form a creamy consistency of the finished product was investigated. With increasing protein hydrolyzate content, the organoleptic properties of ice cream significantly deteriorate [12], which eliminates the possibility of using casein for enrichment. Protein isolates from fish and plants are used in ice cream as cryoprotectants, which not only counteract the freezing of water during low-temperature treatment, but also in quantities of 3 mg per 1 dm^3 significantly improve the melting resistance of ice cream [13]. But these proteins are too expensive and in the specified amounts can also not be recommended for enriching ice cream. The possibility of using high-pressure whey protein concentrate (WPC) in nonfat ice cream to improve taste and smell is also studied [14]. However, no significant effect from the use of whey protein concentrate was found.

Therefore, from the technological efficiency point of view, micellar casein, which is obtained by micro- and ultrafiltration from skim milk without the use of acids and high temperatures deserves the most attention. This method allows preserving the native structure of the protein and its natural properties [6]. This protein concentrate has a high level of digestibility and natural anabolic properties, fresh smell and mild taste. Micellar casein is popular in sports nutrition products because it has a complete amino acid profile and contains branched-chain amino acids (BCAA). A feature of micellar casein, in contrast to other protein concentrates, is high solubility in water and emulsifying and foaming activity. Depending on the method of purification, micellar casein contains from 70.0 to 85.5 % of high-quality protein [6, 9].

The content of basic prescription components in the composition of milk-based ice cream (sugar, fat, dry skim milk residue) is normalized within certain ranges for different types of ice cream. Other components are added to ice cream mixes according to the recommendations of manufacturers, in order to form the specified organoleptic characteristics of a particular type of product. At the same time, any new prescription ingredients, including proteins, can significantly affect the quality of the finished product in terms of surface activity, moisture-binding and structuring ability, stabilization of physico-chemical characteristics of the finished product [15].

Especially important technological function of milk proteins can be found in milk ice cream with high water content, in particular with a fat content of up to 5.0 %. Under the deficiency of dry substances, including fat, the organoleptic characteristics of such ice cream significantly deteriorate due to the loss of creamy taste and the formation of a coarse-grained structure. That is why many companies specializing in innovations in ice cream technology offer the use of concentrates of plant and milk proteins and polysaccharides, or mixtures of proteins and polysaccharides as mimetics of milk fat. Typically, the mass fraction of protein in milk-based ice cream in the composition of nonfat milk solids (NFMS) is from 2.0 to 3.7 % [16]. At the same time, the specified protein content is insufficient to classify ice cream as a product with a high protein content. According to EU Regulation No. 1924/2006 of the European Parliament and of the Council of 20 December 2006 [17], a food product with high protein content is one in which at least 20 % of the energy value of the product is provided by protein.

According to preliminary calculations of the energy value of ice cream of different fat content, the following conclusions can be drawn. Nonfat ice cream, which contains up to 5 % fat and 10–12 % NFMS, is as close as possible to the status of a product with a high protein content with its significant percentage contribution to the energy value. With increased fat content to 7.5 %, at least 3.5 % protein should be added to ice cream. For ice cream (mass fraction of fat from 8.0 to 11.5 %, and mass fraction of NFMS 10 %), the need for additional protein increases to 4.0–8.9 %. For ice cream with a fat content of 12 %, the addition of protein is from 9 % or more. However, the high protein content excessively thickens the mixture, significantly reduces the overrun of ice cream, the consistency of the product becomes too dense and viscous, a specific taste may appear while significantly reducing the size of ice crystals [18]. Thus, a formulation of high-protein ice cream enriched with a composition of casein and whey protein isolate in a ratio of 20:80 in the amount of 24 to 26 % was developed [6]. However, it should be noted that the recipe is made without taking into account the existing recommendations for maintaining a balance between the total dry matter content (from 25 to 40 %) and water (the rest). The following components are required in the composition of dry matter: sugar and sugary substances (from 12–14 to 16–17 %), nonfat milk solids (from 8 to 12 %). The fat content ranges from 0 to 20 %. That is, too high protein content reduces the normalized content of these components of ice cream and, accordingly, worsens the quality of the product. The developed recipe is also not universal with constant fat content.

Thus, the use of milk proteins in ice cream to enrich and give it certain consumer properties is quite limited. Given that proteins are intended to be used in ice cream mainly as hydrocolloids with a fairly low total content, and existing developments are not universal for ice cream of different fat content, the following conclusion can be made. The development of a scientifically sound composition of protein-enriched ice cream with varied fat content and in compliance with the general requirements for dry matter content is a promising research area.

3. The aim and objectives of the study

The aim of the study is to identify the effect of casein on the quality of ice cream of different fat content. This will increase the nutritional value of the product and improve the nutrition structure of consumers.

To achieve the aim, the following objectives were set:

– to construct adequate regression equations that reflect the effect of the content of micellar casein on the quality of ice cream of different fat content;

– to analyze the response surfaces to determine the optimal protein content in the composition of ice cream of different fat content, maximizing the individual and comprehensive quality scores of ice cream.

4. Research materials and methods used to optimize the composition of protein-enriched ice cream

4. 1. Researched materials and equipment used in the experiment

The study was performed using Willmax 80 (Gadyachsyr LLC, Ukraine) micellar casein with a mass fraction of 80 %.

Drinking cow's milk, skimmed cow's milk powder, dry cream, butter, Cremodan SE 406 stabilization system (DuPont ™ Danisco®), white crystalline sugar were used as basic recipe ingredients.

The mass fraction of sugar in all samples was the same – 15 %. The content of stabilizer for ice cream according to the manufacturer's recommendations is set at 0.4 %, and for nonfat ice cream – 0.6 %. The mass fraction of nonfat milk solids in all ice cream samples was 10 % (including milk protein – 3.7 %, milk sugar – 5.45 %).

To improve the hydration process, micellar casein was added to the ice cream mixture at a temperature of 40–45 °C by pre-mixing with sugar in a ratio of 1:3. The mixtures were filtered, pasteurized at a temperature of 85±2 °C for 5 min, homogenized at a pressure of 10+2.5 MPa, cooled to a temperature of 4±2 °C. After keeping for at least 2 hours, the mixture was frozen in a batch freezer. Soft ice cream samples were hardened and stored for at least 48 hours.

Samples of mixtures were frozen using the FPM-3,5/380-50 "Elbrus-400" freezer (JSC "ROSS", Kharkiv, Ukraine) in the training laboratory of the Department of Technology of Milk and Dairy Products of NUFT.

The mixtures were homogenized using a laboratory homogenizer-dispersant 15M-8TA "Lab Homogenizer & Sub-Micron Disperser" (GAULIN CORPORATION, Massachusetts, USA).

Ice cream samples were hardened and stored in a "Caravell" A/S freezer (Denmark) at a temperature of minus (22±1) °C.

4. 2. Methods of determining the properties of ice cream samples and optimizing its composition

Studies of the organoleptic characteristics of ice cream were performed on a 10-point scale (taste and smell – 6 points; consistency – 3 points; color and appearance – 1 point).

The overrun of soft ice cream was determined by the weight method by the difference between the weight of the samples of the same volume of the mixture and ice cream, expressed as a percentage, according to the formula:

$$S = \frac{M_1 - M_2}{M_2} \cdot 100, \tag{1}$$

where M_1 is the weight of the beaker with the mixture, g; M_2 is the weight of the glass of ice cream, g.

The value of the overrun rate of at least 80 % was considered satisfactory.

Melting resistance was determined by the time of accumulation of 10 cm^3 of liquid (melt) flowing from the ice cream sample in the form of a cylinder with a diameter of 30 mm and a height of 50 mm with heating at a temperature of 20±1 °C. Values of at least 41 minutes were taken as a satisfactory indicator of melting resistance.

The calculation of the optimal composition of ice cream enriched with micellar casein was performed in the MathCad 15 environment.

Existing models of recipe optimization were reduced to the task of regression analysis of experimental data by the method of multidimensional approximation. This method allowed finding the optimal values of micellar casein content at the variable fat content of ice cream, at which the specified physicochemical and organoleptic indicators of product quality are formed.

To optimize the response functions in order to develop a new type of protein-enriched ice cream, the authors used the methodology of the response surface using graphical 3D models [19].

In general, the response function is described by the following polynomial:

$$\hat{y}(x,b) = b_0 + \sum_{l=1}^{n} b_1 x_1 + \sum_{k=1}^{n} b_k x_k{}^2 + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} b_{ij} x_i x_j, \tag{2}$$

where $x \in R^n$ is the vector of variables, b is the vector of parameters.

The criteria of optimization of ice cream composition, overrun (S, %), melting resistance (C, min) and organoleptic indicators (OI, points) were chosen. The mass fraction of micellar casein (B, %) in the range from 0 to 6 % and the mass fraction of fat (F, %) in the range from 0 to 15 % were chosen as independent factors, which were varied.

The optimal ratio between the mass fractions of fat and milk protein in the composition of ice cream was determined using a comprehensive quality score (CS). This indicator takes into account the combined effect of protein and fat on overrun, melting resistance, organoleptic characteristics and on the weights of individual indicators.

The comprehensive quality score was defined as a function of estimates of individual quality indicators, converted into scaled values, taking into account the weights of individual indicators according to the formula (3):

$$CS_j = \sum \sqrt[M]{\prod_{j=1}^{n} CS_j^{M_j}}, \quad (3)$$

where M_j is the weight of the main characteristics $0 \le M_j \ge 1$, the comprehensive quality score $1 \le CS_j \ge 10$.

The following weights were adopted for the experimental data studied:

– M_1 – overrun (0.1);

– M_2 – melting resistance (0.15);

– M_3 – organoleptic characteristics (0.75).

Herewith:

$$\sum_{j=1}^{n} M_j = 1. \quad (4)$$

To convert the individual indicators in the range from 1 to 10, source data were scaled by the expression (5):

$$y = \frac{(y_{\max} - y_{\min}) \cdot (x - x_{\min})}{x_{\max} - x_{\min}} + y_{\min}. \quad (5)$$

5. Selection of algorithm for mathematical modeling of the composition of protein-enriched ice cream of different fat content

5. 1. Optimization of protein content in ice cream of different fat content using the response surface methodology

Modeling of ice cream composition was carried out under the effect of quantitative input variables (fat and protein content in the specified ranges) on the initial characteristics (overrun, melting resistance, organoleptic characteristics).

The nature of the distribution of experimental points in the factor space indicates that the dependences can take the form of second-degree polynomials:

$$S = b_0 + b_1 F + b_{11} F^2 + b_2 B + b_{22} B^2 + b_{12} FB, \quad (6)$$

$$C = b_0 + b_1 F + b_{11} F^2 + b_2 B + b_{22} B^2 + b_{12} FB, \quad (7)$$

$$OI = b_0 + b_1 F + b_{11} F^2 + b_2 B + b_{22} B^2 + b_{12} FB, \quad (8)$$

where b is a constant; F is the mass fraction of fat, %; B is the mass fraction of micellar casein, %.

The least-squares method (LSM) was used to estimate the unknown parameters b_0, b_1, b_2. According to this method, the unknown parameters of the function are chosen so that the sum of the squares of the deviations of the experimental (empirical) values of Y_i from their calculated (theoretical) values Y_{ip} was minimal, i. e.:

$$S = \sum_{i=1}^{n} \left(Y_i - Y_{ip}\right)^2 = \sum_{i=1}^{n} \left(Y_i - \varphi\left(X_i, b_0, b_1, \ldots, b_k\right)\right)^2 \to \min. \quad (9)$$

There are two factors at the four levels for the study. In particular, the choice of four levels of mass fraction values of fat (0, 5, 10 and 15 %) is due to the existing division of ice cream in the food industry into separate types by fat content (low-fat, dairy, cream, ice cream). Four levels of casein mass fraction (0, 2, 4 and 6 %) are in the range that provides moderate structuring and the whipping ability of ice cream mixes. Usually the casein content in foods ranges from 2 to 4 %. Thus, the combination of protein and fat content ratios in certain ranges of values, within which there are technologically significant sub-ranges, determines the need for 16 experiments.

The set values of the input variable factors and the obtained values of the output characteristics are given in Table 1.

Table 1

Values of input variable factors and output characteristics

Sample number	Variable factors		Response functions		
	F, %	B, %	S, %	C, min	OI, points
1	0	0	54.0	35.0	5.5
2	5	0	59.5	41.0	7.3
3	10	0	64.1	43.9	8.2
4	15	0	68.0	45.0	9.0
5	0	2	70.2	40.1	8.5
6	5	2	81.8	49.5	9.3
7	10	2	96.2	56.0	10.0
8	15	2	98.0	58.0	10.0
9	0	4	83.0	46.4	9.4
10	5	4	95.0	54.5	10.0
11	10	4	86.1	54.5	9.5
12	15	4	86.0	55.8	9.4
13	0	6	94.5	53.0	10.0
14	5	6	80.1	53.0	9.6
15	10	6	78.0	54.8	9.2
16	15	6	70.1	57.3	8.8

The error of the approximating polynomials (6), (7) and (8) was estimated by the formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n-1}}, \quad (10)$$

where $\hat{y}_e$ are the values calculated using the regression equation, y_i are the values of the experimental data.

The obtained equations with the calculated coefficients have the form:

$$S = 30.763 + 5.56F - 0.21b_{11}F^2 + 14.764B - \\ -1.442B^2 - 0.407FB, \quad (11)$$

$$C = 21.875 + 2.758F - 0.073F^2 + 6.295B - \\ -0.396B^2 - 0.18FB, \quad (12)$$

$$OI = 3.593 + 0.578F - 0.014F^2 + 2.306B - \\ -0.204B^2 - 0.085FB. \quad (13)$$

For the overrun index, the standard deviation is σ_σ=4 %, for the melting resistance index – σ_c=2 min, for organoleptic indicators – σ_{OP}=0.7 points, which indicates a fairly high degree of reproducibility of the results of the study using the response plane.

Fig. 1–3 shows the graphical dependences of the response functions on the variable parameters – the mass fraction of casein and the mass fraction of fat in the composition of ice cream.

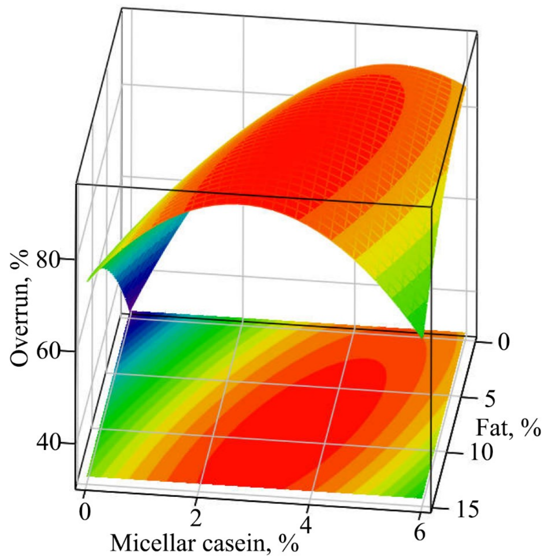

Fig. 1. Graphic dependence of ice cream overrun on mass fractions of micellar fat and casein

According to Fig. 1, high overrun ($S\geq80$ %) was obtained by using micellar casein in the range from 1 to 6 %, depending on the fat content. However, this indicator becomes unsatisfactory if less than 2 % of casein is added to nonfat and low-fat mixtures and if the casein content exceeds 5 % in mixtures with a fat content of 10 to 15 %.

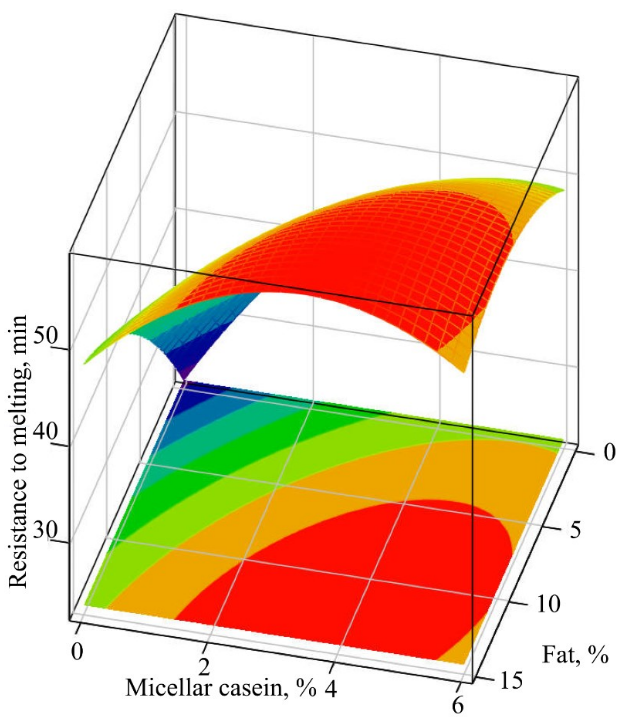

Fig. 2. Graphic dependence of ice cream melting resistance on mass fractions of micellar fat and casein

High melting resistance ($C\geq41$ min) (Fig. 2) was obtained in almost the entire range of the specified casein and fat content, except for systems that do not contain these components.

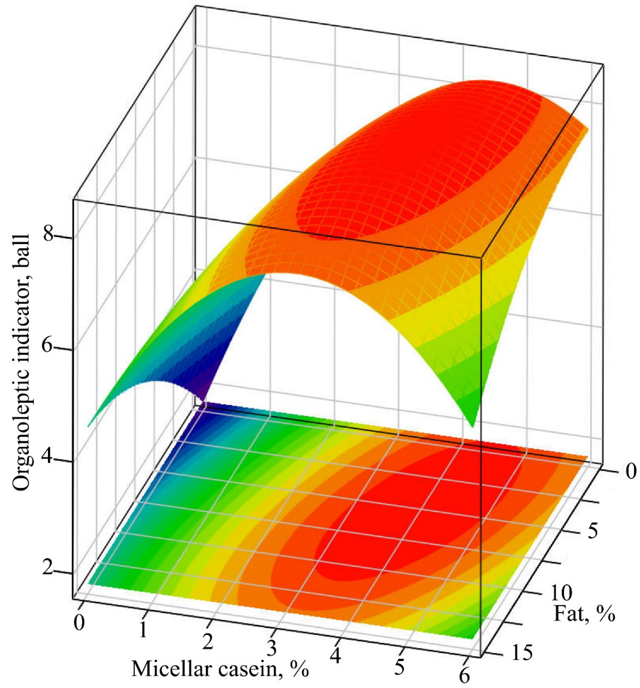

Fig. 3. Graphical dependence of the score of organoleptic indicators of ice cream on mass fractions of micellar fat and casein

At the same time, according to Fig. 3, the highest score of organoleptic indicators was obtained by samples with a fat content of 10–15 %, enriched with 2 % micellar casein, with a fat content of 5 % containing 4 % of casein, and a nonfat sample with 6 % casein.

Therefore, it can be concluded that the recommended values of individual quality indicators (overrun, melting resistance and organoleptic characteristics of ice cream) do not allow determining the optimal mass fractions of raw ingredients (fat and protein). Overrun index of at least 80 %, melting resistance of at least 41 min and organoleptic characteristics, the maximum number of points of which is 10, were achieved in slightly different ranges of fat and micellar casein. That is why to optimize the composition of ice cream with a variable content of fat and micellar casein, it was decided to use a comprehensive quality score.

5. 2. Optimization of ice cream composition using a comprehensive quality score

According to Table 2, Fig. 4 shows the graphical dependence of the comprehensive quality score (CS) on the mass fraction of fat (F, %) and the mass fraction of micellar casein (B, %).

According to the maximum values of the comprehensive quality score ($CS\geq8$), the recommended content of micellar casein in ice cream of different fat content was determined.

In Fig. 4, shaded areas illustrate the technologically feasible ratios of casein and fat content in ice cream. Thus, for ice cream with a fat content of 0 to 5 %, the need for casein is from 6 to 5 %, a fat content of 6 to 10 % is in the range of 4.0–3.0 %, and fat content of 11.0 to 15.0 % is in the range of 2.5–1.0 %.

Table 2

Scaled values of individual indicators and calculated CS values

Experiment number	*S*, %	*C*, min	*OI*, points	*CS*, %
1	5.40	5.25	4.13	1.00
2	5.95	6.15	5.48	2.13
3	6.40	6.59	6.15	3.05
4	6.80	6.75	6.75	3.86
5	7.02	6.02	6.38	3.00
6	8.18	7.43	6.98	6.67
7	9.60	8.40	7.50	9.22
8	9.80	8.70	7.50	10.00
9	8.30	6.96	7.01	5.46
10	9.50	8.18	7.50	8.63
11	8.61	8.18	7.13	7.57
12	8.60	8.37	7.05	7.55
13	9.45	7.95	7.50	8.04
14	8.00	7.95	7.20	6.32
15	7.80	8.22	6.90	5.91
16	7.01	8.60	6.60	4.29

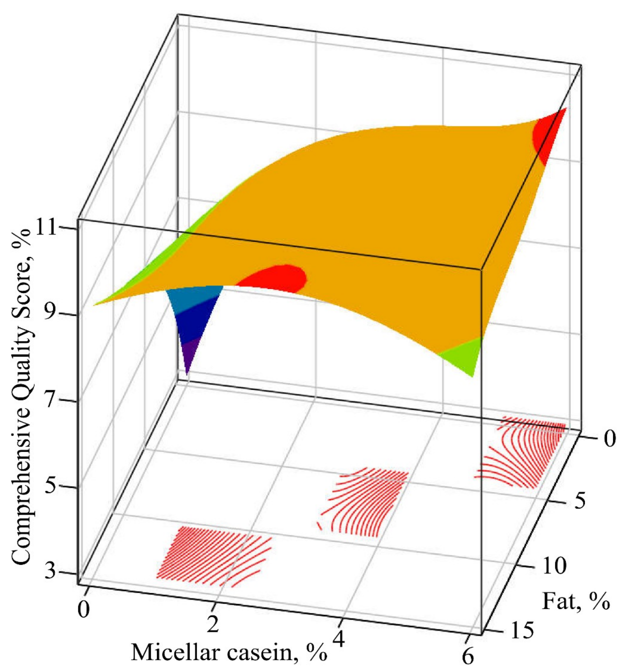

Fig. 4. Dependence of *CS* on the content of micellar fat and casein

According to the determined content of micellar casein in the composition of ice cream, the total content of milk protein in ice cream of different fat content, the energy value of ice cream and the degree of its protein supply were calculated.

The results of the calculation are given in Table 3.

The values of the degree of ensuring the energy value of ice cream of different fat content due to the protein component given in Table 3 are of practical interest. This characteristic requires further analysis in terms of marketing promotion of a protein-containing product in the consumer market.

Table 3

Optimal content of micellar casein in ice cream of different fat content and the contribution of total protein to the energy value of ice cream with micellar casein

Indicator	Mass fraction of fat in ice cream, %			
	0	5	10	15
Mass fraction of micellar casein, %	6.0	5.0	3.0	1.0
Total milk protein content, %	9.7	8.7	6.7	4.7
Total sugar content (lactose and sucrose), %	20.45	20.45	20.45	20.45
Energy value, kcal/100 g	120.6	161.6	198.6	235.6
Degree of protein energy value, %	32.17	21.53	13.49	7.98

6. Discussion of the results of the study of protein effect on the quality of ice cream and their practical significance

A regularity has been revealed, which consists in reducing the technologically feasible need for protein when increasing the fat content of ice cream. For example, low overrun of ice cream (Fig. 1) is observed both for the lack of protein (foaming agent) and for its excessive content. The latter is explained by the fact that nonfat and low-fat ice cream is characterized by high water content (up to 70–75 %), including free, which requires increased moisture binding with food biopolymers. However, in ice cream its amount is reduced to 60 %. The reduction in the amount of water as a solvent with an excessive casein content explains the significant structuring of ice cream mixtures with high fat content with a corresponding decrease in their overrun ability. The same pattern, according to Fig. 4, for exceeding the optimal amount of micellar casein in ice cream of different fat content is observed for CS values.

The advantage of the obtained scientific work over others is that an algorithm has been developed to adjust the chemical composition of protein-enriched ice cream, depending on the fat content in the finished product.

For the successful introduction of protein-enriched ice cream into production, it is necessary to determine the status of a new product in the diet of consumers. So, according to Table 3, ice cream with high protein content includes nonfat ice cream and ice cream with a fat content of up to 5 %. It is in these samples of ice cream that protein contributes at least 20 % of the total energy value of the product. Ice cream with a mass fraction of fat of 10–15 % can be attributed only to the protein-enriched product. Excess of the micellar casein content of more than 3 % in a mixture with a fat content of 10 % and more than 1 % in a mixture with a fat content of 15 % leads to their excessive structuring. Excessive thickening of the mixtures is the cause of low overrun and, accordingly, too dense consistency of ice cream.

As for ice cream with a mass fraction of fat above 5 %, the composition of such a product should be refined. To give ice cream the status of a product with high protein content, its lack can be compensated by the combination of micellar casein with protein concentrates, which are less effective in structuring ice cream mixtures. At this stage, it is necessary to further investigate the structural and mechanical properties of mixtures for the production of ice cream containing proteins of different origins in different combinations with micellar casein. Also an important aspect is the enrichment of the product with essential amino acids to bring its amino acid composition closer to the composition of an ideal protein.

7. Conclusions

1. Adequate regression equations are constructed, which reflect the effect of micellar casein content on individual quality indicators of ice cream of different fat content. To optimize the content of protein-enriched ice cream, the feasibility of using a comprehensive quality score is proven.

2. The analysis of the response surfaces to determine the optimal protein content in the composition of ice cream of different fat content, maximizing the individual and comprehensive quality scores of ice cream is made. An inverse relationship between the optimal content of micellar casein and the fat content of the product is found. The results of scientific development make it possible to calculate the recipes of high-quality and useful for consumers of different groups ice cream with high protein content.

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