ХАРЧОВІ ТЕХНОЛОГІЇ

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Quality Evaluation Research of Low-Calorie Milk Ice Cream

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A modern approach to nutrition requires the creation and further development of new types of ice cream that are more beneficial for health in comparison with the traditional ones. The solution to this issue lies in the creation of the low-calorie ice cream. It gets its distinctive properties and features due to the reduction of fat and sugar content along with the mixing of various functional components.

The aim of the research was to study the effects of milk processing products and plant ingredients on the quality of low-calorie milk ice cream.

The organoleptic, physical, chemical and microbiological indicators of low-calorie milk ice cream were examined. It was established that according to taste profiles, experimental samples of ice cream had good indicators of smell and color in the absence of extraneous odors. According to physical, chemical and microbiological indicators, samples of low-calorie milk ice cream met the requirements of the State Standard of Ukraine (DSTU) 4733:2007.Studies of the microstructure of low-calorie milk ice cream have shown that there is a tendency to increase the dispersion of the air phase in its samples. It is proven that the new low-calorie ice cream components possess properties of the moisture-binding components. The amount of sugar was reduced by a third comparing to the traditional composition of ice cream precisely due to the utilization of the components.

The composition of low-calorie milk ice cream in which the protein and vegetable components was substantiated, and the organoleptic, physical, chemical and microbiological parameters were studied. The expediency of the protein and plant components usage in low-calorie milk ice cream recipes has been proven.

Key words: low-calorie milk ice cream, quality, organoleptic indicators, physical and chemical indicators, microbiological indicators, microstructure, whey processing products.

Problem statement and analysis of recent research. Ice cream is the most popular dessert and is in steady demand among the population, especially children. A variety of raw materials are used in mixtures to produce ice cream. The main raw material used for the production of ice cream is milk and dairy products. Sucrose and other sweeteners, stabilizers, etc are also used in the recipes, while fruits, berries, vegetables, etc diversify the overall assortment of ice cream [1]. The composition of ice cream includes fats, proteins, carbohydrates, minerals, etc, which come in the form of true and colloidal solutions and emulsions. True solutions are formed by salts, lactose and sucrose, whilst emulsions are formed by fats. Milk proteins, stabilizers and a certain amount of calcium phosphate are in ice cream structure in the form of colloidal solutions [2]. The ice cream composition after freezing predominantly consists of ice crystals, in some cases it includes small amount of lactose crystals, agglomerated particles of fat, protein, stabilizer, which are all distributed in the plasma [3, 4].

In Ukraine, ice cream has been produced on an industrial scale for a long time [5]. To withstand the competition, manufacturers try to constantly improve and expand their range of varieties, however, the quality of ice cream itself is not always the center of the attention. The range of domestic ice cream variants consists mainly of products with a high fat content, but the demand for low-calorie ice cream, sour milk ice cream and ice cream enriched with functional ingredients is growing every year in the world [5, 6].

In recent years, the dairy products and nutrition department of the Institute of Food Resources of NAAS of Ukraine has been studying whey processing products obtained using membrane technologies [7, 8]. Nevertheless, the test usage of such ingredients as a component of ice cream recipes was not carried out, although there are already data available on the improvement of organoleptic characteristics as well as structural and mechanical properties of food products. [9, 10]. In addition, various structuring agents with fillers are used to secure a certain structure of the dessert. The final consumer properties of the finished product are formed due to the fillers and their features. Such structure formers include inulin and rice flour, which have a high moisture-binding capacity. They can be used as natural thickeners during the production of dairy products, in particular, ice cream [11, 12].

Therefore, it is relevant to carry out research on the substantiation of the composition and development of the technology of low-calorie milk ice cream, which has functional ingredients in its composition, in particular from milk processing products.

The aim of the research was to study the influence of milk processing products and plant ingredients on the quality of low-calorie milk ice cream.

Material and methods of research. The subjects of research were: Dairy raw materials (whole and skimmed milk, cream, skimmed milk powder, butter), vegetable ingredients (inulin, rice and sesame flour, apple powder), milk processing products (dry concentrate of whey proteins obtained by ultrafiltration, with a mass fraction of protein 80 % and whey dry demineralized with a demineralization level of 90 %, and a mass fraction of protein of 27 %), the finished product (low-calorie milk ice cream).

The selection of organoleptic indicators was carried out on the basis of literature data and a list of parameters was selected that play an important role when evaluating the quality of ice cream, namely: *color, taste, smell, consistency, aftertaste.* Each of the listed indicators was evaluated based on the maximum score of 5 points [13]. To compare organoleptic indicators of low-calorie milk ice cream, a quantitative descriptive (profile) test was used, which allows you to visually compare taste characteristics [14].

Physical, chemical and microbiological indicators of ice cream samples were determined according to DSTU 4733:2007 [15].

The microstructure of ice cream samples was determined using a Motic (Fischer Bioblock) light microscope with a video camera. A thin layer of the ice cream sample was applied to a glass slide where it was dried. Observations were carried out at a 400-fold magnification [16, 17].

Results and discussion. We developed the technology of low-calorie ice cream production, in which whey protein concentrate (WPC) and demineralized whey powder (DWP) were used for protein enrichment and as an emulsifier; inulin as a natural polysaccharide, stabilizer and prebiotic; apple powder, rice and sesame flour as a thickener.

As a check control, milk ice cream was used, its content as follows: fat is 4.0 % and dry matter is 29.1 %, including 15.5 % of sugar. The following was added to the experimental samples of low-calorie dairy ice cream: 1 – apple powder and DWP; 2 – sesame flour and DWP; 3 – rice flour and WPC.

The generalized results of the ice cream organoleptic evaluation are depicted in Figure 1.

According to the analysis of organoleptic data by taste profiles (Figure 1) all ice cream samples had good smell and color indicators following in the absence of extraneous odors. According to all organoleptic indicators the best sample was the ice cream with rice flour and WPC, which differed from the others in its vivid creamy flavor, dense consistency, absence of protein lumps and ice crystals (Figure 1).

It should be noted that the control checks and samples of ice cream with sesame flour or apple powder and DWP showed an intermediate value of the taste profile (Figure1). At the same time, the consistency of the control ice cream sample was rated at 4 points and was characterized as excessively "fluffy" with palpable ice crystals.

The results of low-calorie ice cream samples research according to physical, chemical and microbiological indicators are presented in table 1.

Analysis of the data obtained along the research (Table 1) shows that the value of the a_w indicator in all ice cream samples lies in a narrow range – from 0.957 to 0.962, as well as the cryoscopic temperature (negative (4.00–4.42 °C), which is associated with quantitative composition of carbohydrates."Water activity" (a_w) is an important parameter that must be taken into account during the development of dairy products with new composition and properties, to ensure the production of high-quality products [18]. In the case of its decrease, the possibility of using moisture for the metabolism of microorganisms decreases whilst the energy of the connection between the moisture and the material increases. At the same time, as a rule, it becomes more difficult for microorganisms to use the available moisture for their biological needs [19].

As a result of studies of physical, chemical and microbiological indicators of low-calorie milk ice cream, it was established that the mass fraction of dry substances, titrated acidity, the number of mesophilic aerobic and facultatively anaerobic microorganisms and bacteria of coliform group in the experimental samples were within the acceptable range according to DSTU 4733:2007 (Table 1).

Freezing is as important during the production of ice cream, as the parameters which affect the microstructure of the finished product [20]. Ice cream is frozen in two stages: the first defines a rapid but partial freezing in the freezer to a temperature of negative 4–5 °C with simultaneous air saturation of the mixture with intensive stirring, and the second is hardening, during which the partially frozen product is hardened without stirring in low-temperature chambers. During hardening and subsequent storage, already formed ice crystals and air bubbles increase in size, but new structural elements are no longer formed [20, 21]. The dispersion of structural elements of ice cream is determined mainly by their shape and size: the smaller and more evenly distributed they are in the total mass of ice cream, the better is the quality [21]. The shape and size of ice crystals and air bubbles largely depend on the speed of freezing and the degree of mechanical impact on the product. Therefore, the microstructure of the control and experimental ice cream samples during hardening was investigated (Figure 2).

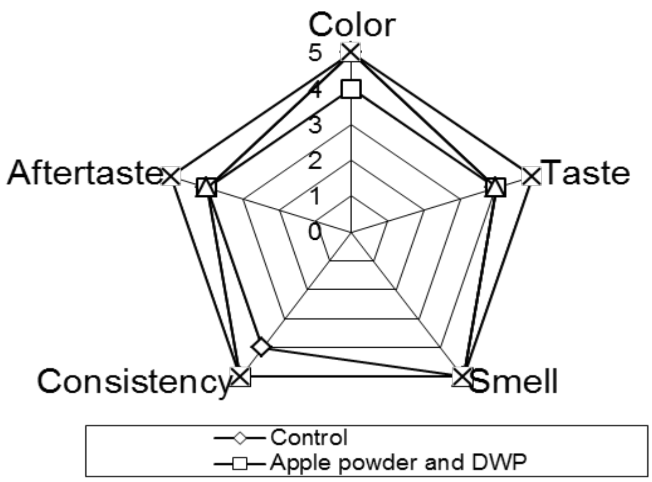

Fig. 1. **Organoleptic indicators of low-calorie milk ice cream.**

Table 1 – **Physical, chemical and microbiological indicators of low-calorie milk ice cream**

Indicator	DSTU 4733:2007	Ice cream with		
		apple powder and DWP	sesame flour and DWP	rice flour and WPC
Titrated acidity, °T	22	23±1	21±1	22±1
Active acidity, units of pH	–	6,622±0,043	6,982±0,026	7,012±0,013
Mass fraction of dry substances, %, including	29,0	29,5±0,3	30,9±0,5	29,8±0,2
Fat, %	4,0	4,3	4,3	4,3
DSMR, %	–	15,4	15,1	15,8
Sugar mass fraction, %	15,5	8,4	8,4	8,4
Water activity (a_w)	–	0,962±0,003	0,958±0,002	0,957±0,001
Cryoscopic temperature ($t_{кр}$), °C	–	–4,00±0,33	–4,42±0,16	–4,21±0,11
The amount of mesophilic aerobic and facultative anaerobic microorganisms, CFU in 1 g of ice cream	$1*10^5$	$4,5*10^4$	$5,0*10^4$	$4,0*10^4$
Bacteria of the coliform group in 0.1 g of ice cream	Not allowed	Not detected		
Yeasts and mold fungi	Not normalized	Not detected		

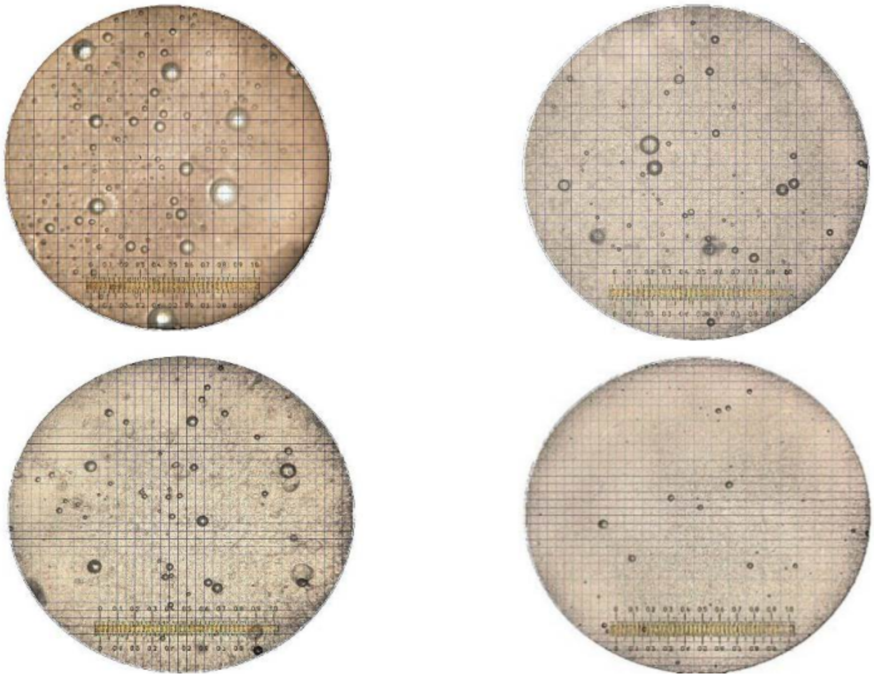

Fig. 2. **Microstructure of ice cream samples:** 1 – control; 2 – with apple powder and DWP; 3 – with sesame flour and DWP; 4 – with rice flour andWPC.

Study of the microstructure of control and experimental ice cream samples (Fig. 2) made it possible to conclude that the test samples are more saturated with air, and, therefore, their knockdown is higher compared to the control. The membranes of the air cells are not disturbed. The outer air bubbles are covered with a fat emulsion. Air bubbles in the test samples are homogeneous and evenly distributed over the entire surface of the ice cream. It should be noted that the weak stabilization of the fat globules of the control sample of ice cream due to the lower mass fraction of dry substances in the serum phase allows the liquid fat phase to penetrate into the space between them, forming clusters of milk fat (Fig. 2).

It is known that the size of air bubbles affects the consistency of ice cream [22]. It should be noted that the dimensions of the structural elements of ice cream are not directly regulated in regulatory documents. However, the size of air bubbles, in particular, is indirectly taken into account when evaluating the state of the structure and consistency of ice cream [20, 22]. However, the size of air bubbles, in particular, is indirectly taken into account when evaluating the state of the structure and consistency of ice cream [20, 22]. Therefore, the distribution of the air phase in the control and experimental ice cream samples was analyzed (Fig. 3).

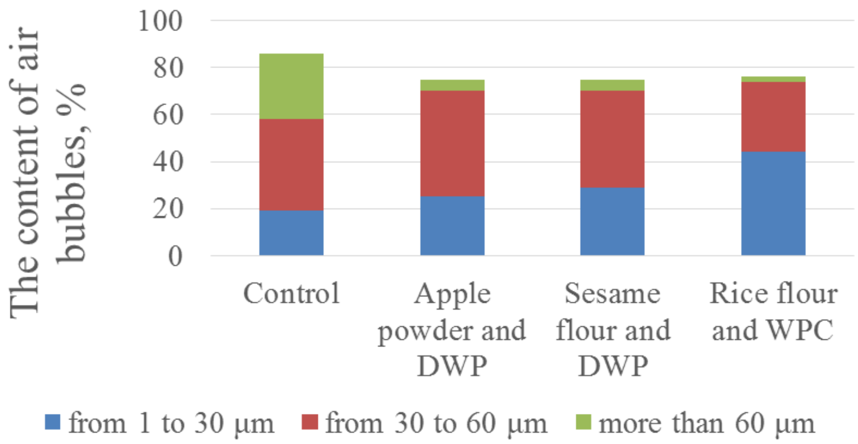

Fig. 3. **Air phase distribution in ice cream.**

Figure 3 shows that the content of finely dispersed air bubbles in samples of ice cream with rice flour and WPC, with sizes from 1 to 30 μm reaches 60 %, and bubbles with sizes larger than 60 μm are absent in the field of the studied microphotographs. Moreover, in experimental samples of ice cream with DWP and vegetable components (apple powder or sesame flour), the content of air bubbles with sizes from 30 to 60 μmis within 50–55 %, from 1 to 30 μm – within 40–45 %, At the same time, in the control sample of ice cream, the share of coarsely dispersed bubbles (D>60 μm) is about 30 %, finely dispersed bubbles (up to 30 μm) is only 25 %.

Therefore, the replacement of traditional stabilizers with WPC, DWP, rice flour and inulin in low-calorie milk ice cream does not increase the value of the water activity indicator, but, on the contrary, lowers this indicator. Moreover, the new components of low-calorie ice cream are good moisture-binding components, due to the use of which the amount of sugar has been reduced by a third in comparison with the traditional composition of ice cream. Based on the results of the microstructural analysis of low-calorie milk ice cream using milk processing products and vegetable ingredients, it can be stated that there is a tendency to increase the dispersion of the air phase in it.

Conclusion. The composition of low-calorie milk ice cream with the usage of protein and vegetable components was substantiated, and the organoleptic, physical, chemical and microbiological parameters were examined throughout the research. The expediency of using protein and plant components in recipes of low-calorie milk ice cream has been proven. It was established that the indicators of flavor, color and consistency of low-calorie milk ice cream, as well as mass fractions of dry substances and dry defatted substances, titrated and active acidity, the number of mesophilic aerobic and facultative-anaerobic microorganisms and the coliform bacteria were within the acceptable range according to DSTU 4733:2007. Studies of the low-calorie milk ice cream microstructure showed that its samples are more saturated with air, the membranes of air cells are not disturbed, the air bubbles are homogeneous and evenly distributed over the entire surface of the ice cream, and they are covered with a fat emulsion on the outside.

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Дослідження якості низькокалорійного молочного морозива

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Сучасний підхід до харчування передбачає необхідність створення нових видів морозива, корисніших для здоров'я, ніж традиційні. Вирішенням цього питання є створення морозива, що має низьку калорійність внаслідок зниження вмісту жиру та цукру і додавання різноманітних функціональних компонентів.

Метою роботи було дослідження впливу продуктів переробки молока та рослинних інгредієнтів на якість низькокалорійного молочного морозива.

Досліджено органолептичні, фізико-хімічні і мікробіологічні показники низькокалорійного молочного морозива. Встановлено, що за смаковими профілями дослідні зразки морозива мали гарні показники запаху і кольору за відсутності сторонніх запахів. За фізико-хімічними і мікробіологічними показниками зразки низькокалорійного молочного морозива відповідали вимогам ДСТУ 4733:2007. Дослідження мікроструктури низькокалорійного молочного морозива показали, що існує тенденція до підвищення дисперсності повітряної фази в його зразках. Показано, що нові складники низькокалорійного морозива є гарними вологозв'язувальними компонентами, за рахунок використання яких, зменшено на третину кількість цукру у порівнянні із традиційним складом морозива.

Обгрунтовано склад низькокалорійного молочного морозива з використанням білкових і рослинних компонентів та досліджено органолептичні, фізико-хімічні і мікробіологічні показники. Доведено доцільність використання білкових та рослинних компонентів у рецептурах низькокалорійного молочного морозива.

Ключові слова: низькокалорійне молочне морозиво, якість, органолептичні показники, фізико-хімічні показники, мікробіологічні показники, мікроструктура, продукти перероблення сироватки.