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Exopolysaccharide Fermented Milk Ice Cream

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***Abstract*—Currently, there is an increasing interest in exopolysaccharides as effective biocorrector and auxiliary technological agents. Experimental studies were carried out to obtain fermented milk ice cream with a high content of exopolysaccharides. As a nutrient substrate for the cultivation of probiotic microorganisms, a mixture was used to obtain ice cream, including dairy and non-dairy components. The starter cultures included certain strains of microorganisms: Streptococcus thermophilus, Lactobacillus delbrueckii ssp. bulgaricus. It was experimentally established that ice-cream with the addition of a bacterial starter culture YO-PROX 777, including thermophilic lactic acid strains of the microorganisms Streptococcus thermophiles, Lactobacillus delbrueckii ssp, has the greatest ssp. bulgaricus. It was established that the highest concentration of exopolysaccharides is contained in ice cream using the starter culture «YO-PROX 777».**

Keywords— fermented milk ice cream, exopolysaccharides, starter cultures

I. Introduction

Exopolysaccharides synthesized by probiotic microorganisms during the fermentation of dairy or dairy-free systems have an important physiological and technological role. These bioobjects can act not only as an effective alternative to food additives that improve the consumer properties of products, but also act as a factor expanding the range of their functional properties, for example, increasing the adhesive activity of lacto- and bifidobacteria on the mucous surfaces of the gastrointestinal tract [1-3]. There is evidence of anticarcinogenic, antiviral, prebiotic, immunomodulating and hypocholesterolemic properties of exopolysaccharides [4-7]. As a result of the synthesis of microbial exopolysaccharides, they accumulate in the fermentable system simultaneously with the accumulation of acid, which is accompanied by additional moisture binding. One of the functions possessed by exopolysaccharides is the replacement of milk fat, which leads to a decrease in its amount and, as a consequence, the energy value of the finished product. Table I shows the functions of exopolysaccharides.

The formulation of new functional products from traditional types of raw materials is the main task facing the food industry. In this regard, one of the priority areas in the food industry is to expand the range of products for a healthy diet.

The creation of such products is currently carried out by using functional ingredients and regulating the composition of products intended for specific groups of the population. Thus, in the dairy industry, probiotic cultures and prebiotic components are mainly used, which are increasingly used in dairy desserts, in particular ice cream, produced in one of the largest and fastest growing segments of the food industry [8-10].

The purpose of the experimental studies is to assess the possibility of using bacterial starter cultures in fermented milk ice cream technology with improved consumer properties and a high content of exopolysaccharides.

II. Experimental

As a nutrient substrate for the cultivation of probiotic microorganisms, a mixture was used to obtain ice cream, including dairy and non-dairy components. Before introducing probiotic cultures, the experimental mixture was pasteurized at 85 °C, homogenized at a pressure of 12-12.5 MPa, cooled to 40-42 °C, followed by the introduction of probiotic cultures, fermented for 4.5 - 5 hours until the mixture reached pH = 4.6-4.7, cooling to 4-6 °C, milling at -5 °C and subsequent hardening. The fermentation process was carried out using lyophilized bacterial starter cultures of direct application of YF-L812, YO-PROX 501, YO-PROX 753, YO-PROX 777 and the stabilizer «Grindsted Pektin LC 710».

TABLE I. EXOPOLYSACCHARIDE FUNCTIONS

Product Features	Microbiological Functions
Intensify the process of fermentation of milk, reducing the time of clot formation	Stimulate the growth of a number of lactic acid bacteria and suppress the number of enteropathogenic Escherichia coli and staphylococci in the large intestine
Stimulate bacterial growth and their synthesis of other beneficial metabolites	Strengthen the immune status of the body
Improve rheological properties and texture of the finished product	Show antimicrobial action against saprophytic microflora
It is natural thickeners and stabilizers of the consistency of dairy products	They increase the number of beneficial bacteria and stimulate the production of their metabolites, increase the activity of food media

The starter cultures included certain strains of microorganisms: Streptococcus thermophilus, Lactobacillus delbrueckii ssp. bulgaricus. In the studied samples of ice cream, shape stability was determined by thermostating method. To determine it, the analyzed samples of the same form are placed on Petri dishes and, at a thermostat temperature of 20-25 °C, a change in the shape of the sample is observed. The experiment is completed when one of the samples melts completely. The degree of overrun of ice cream is determined by the difference in mass before and after the freezing process.

III. Results and Discussion

An important indicator of the quality of ice cream, both for the producer and for the consumer, is its resistance to melting. As described above, exopolysaccharides synthesized by starter microorganisms have stabilizing properties, that is, they affect the resistance to melting of the finished product. The results of experimental studies are presented in Fig. 1.

Sample №1 Sample №2

Sample №3 Sample №4

Fig. 1. Resistance to thawing of samples of fermented milk ice cream enriched with exopolysaccharides: № 1 - starter culture YF-L812, stabilizer – «Grindsted Pektin LC 710»; № 2 - starter culture YO-PROX 501, stabilizer – «Grindsted Pektin LC 710»; starter culture YO-PROX 753, stabilizer – «Grindsted Pektin LC 710»; starter culture YO-PROX 777, stabilizer – «Grindsted Pektin LC 710».

The study revealed that the sample with the addition of starter culture YO-PROX 753 has the least stabilizing properties, and the best result was shown by the product with the addition of starter culture YO-PROX 777. One of the indicators of the quality of ice cream is its degree of overrun. For analysis, soft ice cream was used, the measurement results are presented in Table II.

In order to determine the efficiency of the freezing process, in addition to calculating the degree of overrun, the study studied the microstructure of ice cream. The presence of a uniform distribution and size of air bubbles in the mixture indicates that the mixture has the necessary physical indicators: viscosity, surface tension, condition of the ingredients of the mixture. Fig. 2 shows the microstructure of prototypes № 1-4 of fermented milk ice cream. It was found that the microstructure of samples containing starter cultures YF-L812, YO-PROX 501, YO-PROX 753 is uneven, air bubbles vary significantly in size, which adversely affects the organoleptic evaluation of ice cream. The most uniform distribution and the same size of air bubbles is observed in fermented milk ice cream using the starter culture YO-PROX 777.

To determine the amount of exopolysaccharides produced by microorganisms of starter cultures, the phenol-sulfur method was used. In the course of the research, experimental data on the optical density of solutions were obtained (Table III).

Based on the data on the optical density and concentration of the glucose solution, a calibration graph was obtained (Fig. 3), which allows to identify the concentration of polysaccharides in the solution, according to which the concentration of exopolysaccharides in fermented milk ice cream was determined (Table IV).

TABLE II. Exopolysaccharide Functions

Starter culture	Overrun B,%
YF-L812	33,94
YO-PROX 501	52,41
YO-PROX 753	34,67
YO-PROX 777	68,50

TABLE III. Optical Density

Starter culture	Optical density, A			
	Sample № 1	*Sample № 2*	*Sample № 3*	*Sample № 4*
YO-PROX 777	640	640	643	644
YO-PROX 501	474	473	476	475
YF-L 812	450	448	451	448
YO-PROX 753	561	560	557	561

TABLE IV. The Content of Exopolysaccharides in Fermented Milk Ice Cream

Starter culture	Exopolysaccharides concentration, µg / ml
YO-PROX 777	89
YO-PROX 501	64
YF-L 812	61
YO-PROX 753	75

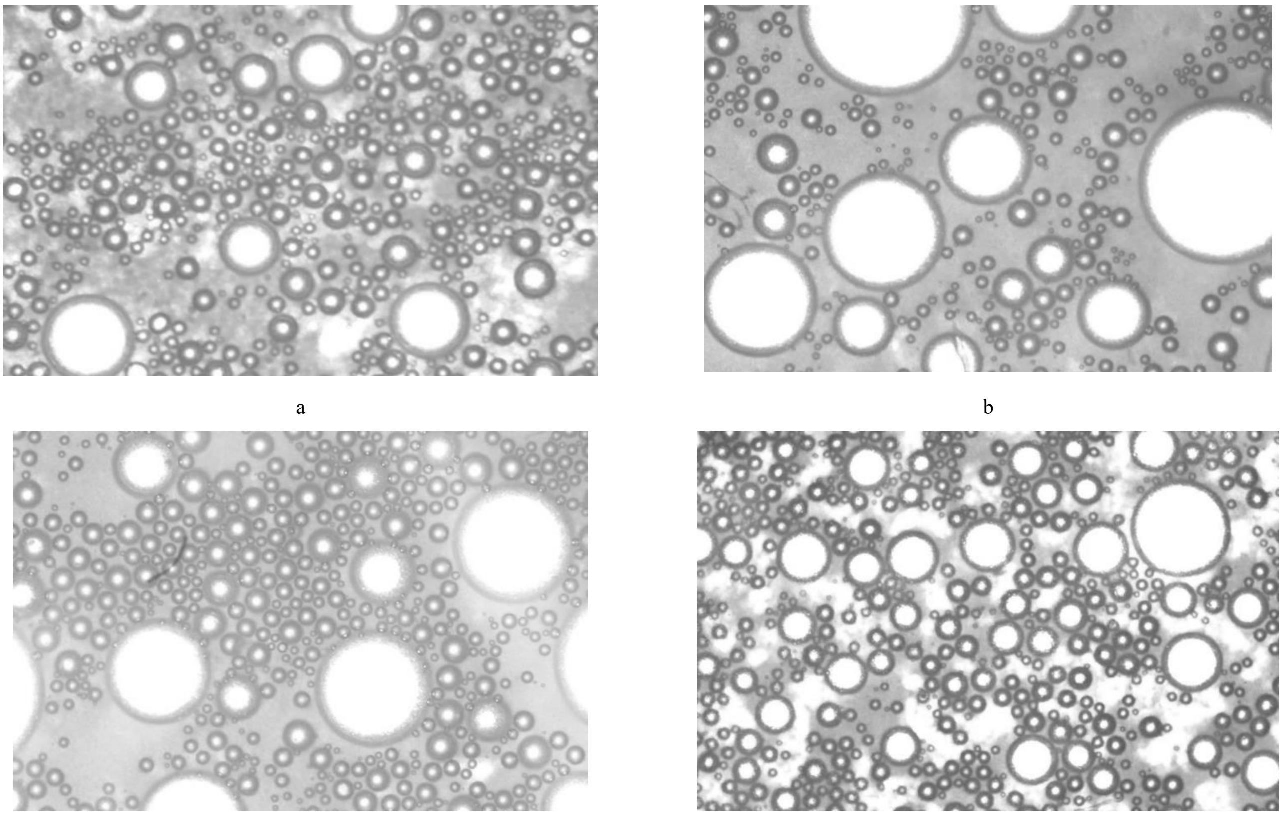

Fig. 2. Microstructure of sour milk ice cream with the addition of starter cultures (60 times increase): a - YF-L812; b - YO-PROX 501; c - YO-PROX 753; d - YO-PROX 777.

It was found that the highest concentration of exopolysaccharides is contained in ice cream using the starter culture «YO-PROX 777» - 89 µg / ml. According to the proposed recipe, ice cream was produced, which includes Grindsted Pektin LC 710 pectin with a mass fraction of 0.3% of the total mixture and a starter culture of direct application of YO-PROX 777.

Tables V and VI show the organoleptic and physico-chemical characteristics of fermented milk ice cream with exopolysaccharides. In accordance with these indicators, we can conclude that sour milk ice cream meets all the established requirements for this type of product. Fig. 4 presents a diagram of the technological process for the production of sour milk ice cream.

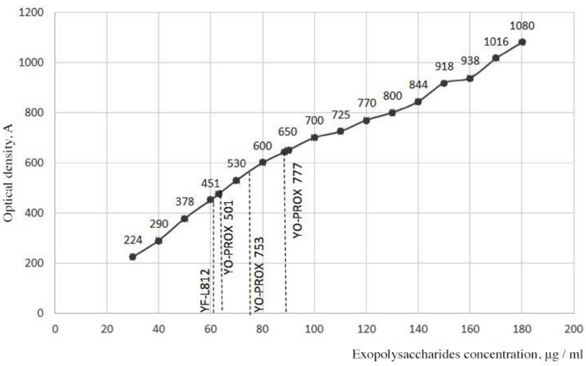

Fig. 3. Glucose Calibration Curve.

TABLE V. ORGANOLEPTIC INDICATORS OF SOUR MILK ICE CREAM

Indicator	Characteristic
Appearance	The shape due to the geometry of the forming device, without glaze
Taste and smell	Pure sweet and sour, characteristic of dairy products, without extraneous smacks and smells
Structure	Homogeneous, with organoleptically imperceptible ice crystals, without noticeable lumps of stabilizer
Consistency	Dense
Color	Uniform throughout the mass, white

TABLE VI. PHYSICO-CHEMICAL CHARACTERISTICS OF SOUR MILK ICE CREAM

Indicator	Value
Mass fraction of milk fat, %	5,3
Mass fraction of SOMO, %	11,3
Mass fraction of sucrose, %	17,1
Total solids, %	37
Acidity, °T	38
Temperature, °C	-18,0

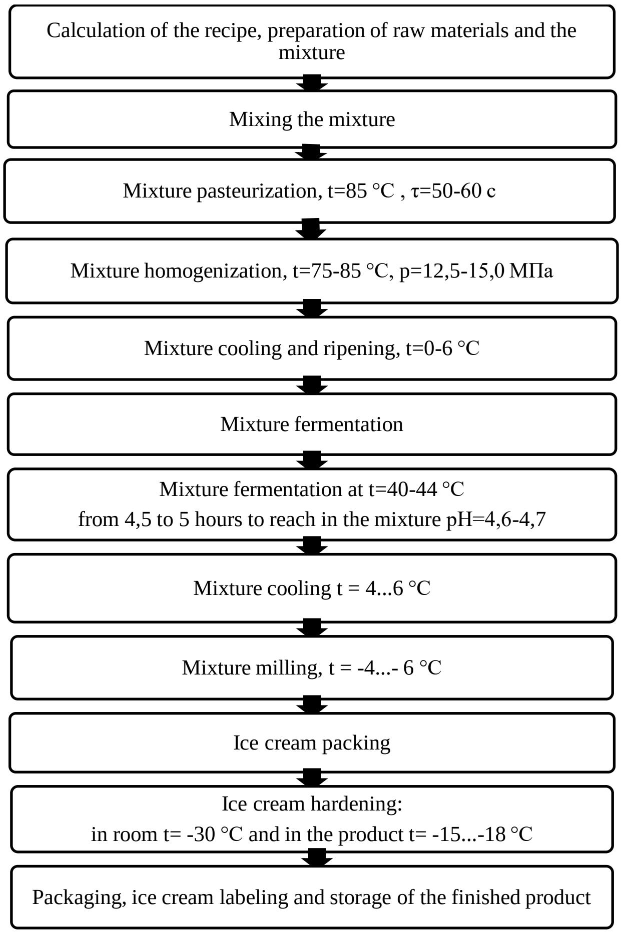

Fig. 4. General scheme of the technological process for the production of sour milk ice cream

IV. CONCLUSION

Thus, the possibility of using bacterial starter cultures "YO-PROX 777" in functional fermented milk technology has been shown. It was found that the introduction of starter cultures made it possible to increase the melting time by 1.5 times, increase the degree of overrun by 2.1 times and the concentration of exopolysaccharides by 1.2 times. The data obtained confirm the prospect of including the developed fermented milk ice cream in the diets of biocorrective, prophylactic and therapeutic actions for various population groups.

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