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SEMI-FINISHED PRODUCT TECHNOLOGY FOR FROZEN DESSERTS

Authors: Yaroslav Shelenkov, Oleksiy Haydaienko
Advisor: Alina Slashcheva
Donetsk National University of Economics and Trade
named after MykhailoTugan-Baranovsky (Ukraine)

Abstract. *The analysis of literary sources showed that the creation of products with reduced glycemic load and functional properties are new ways of improving the technologies of ice cream and frozen desserts. It has been proven that lowering the glycemic index is possible by replacing sugar with fructose or other sugar substitutes. Provision of functional (prebiotic) properties is expedient to be carried out at the expense of the introduction of lactulose. It has been proven that the rational formulation of the mixture from the point of view of the properties of the obtained semi-finished product should be considered formulations based on serum with the content of lactulose 1%, fructose 11%, stabilizer 0.4%, dry milk 8%. The optimal pasteurization process for the semi-finished product was determined - at a temperature of 80...82°C for (5.8...6.2)×60^{-1}s. The whipping ability was 70±1.8%, the ability to form stable foams was 80±2.0%. A technological scheme for obtaining a semi-finished product for frozen desserts based on whey with lactulose, fructose, stabilizer was developed. A set of data characterizing the quality of the developed semi-finished product was obtained, and its high nutritional and biological value was proven. Modes and terms of storage of semi-finished products are substantiated: temperature -4...6°C, no more than 3 months, in unsealed form – no more than 48 hours.*

Keywords: *semi-finished product, frozen desserts, prebiotic, fructose, lactulose, cheese whey.*

I. INTRODUCTION

Production of ice cream and frozen desserts is one of the most promising segments of the dairy industry. Ice cream is an affordable complete food product with high digestibility and a valuable source of important functional nutrients. The technologies of frozen dessert products allow adding additives that play the role of functional and technological components to their composition. This makes it possible to expand the range of targeted products for various types of food, taking into account age, individual needs, national and social requests [1].

The analysis of modern nutrition shows its inconsistency with the requirements of nutrition due to insufficient consumption of proteins, minerals, vitamins and an overload of saturated fats and easily digestible carbohydrates. The modern diet needs to improve the recipes of frozen products according to priority directions: increasing the content of functional ingredients (sulfur-containing amino acids, dietary fibers) against the background of reducing the content of fatty components and reducing the sugar content. The modern approach to the creation of food products is definitely related to the use of the concept of glycemic indices and glycemic load [2].

It is the presence of simple sugars in ice cream that determines its high glycemic index, which forces consumers to significantly limit its consumption, and patients with

diabetes, cardiovascular diseases or obesity to exclude ice cream from their diets altogether. Solving this problem is possible in two ways: making unsweetened ice cream or using sweeteners or fructose instead of sugar [3]. By the way, unsweetened ice cream is extremely popular in European countries and in Japan, where they make ice cream with the flavors of meat, seafood (shrimp, octopus, cuttlefish), seaweed, beer, as well as vegetable ice cream - tomato, pumpkin, carrot, garlic, onion, cucumber with spicy herbs, beet, potato, etc. However, such ice cream is not popular in Ukraine and is not produced by any manufacturer. Ukrainians perceive ice cream exclusively as a dessert. Therefore, today the problem of lowering the glycemic index of ice cream can only be solved by using sweeteners or fructose [4]. Thus, the scientific and practical task of creating a new generation of frozen desserts with reduced glycemic load, enriched with functional ingredients, is relevant and timely.

The purpose of this work is the scientific substantiation and development of the semi-finished product technology for frozen desserts based on whey with lactulose and fructose.

In accordance with the set goal, the following tasks were to be solved:

- determine the rational ratio of components in the semi-finished product;
- to study the complex of physico-chemical and technological properties, nutritional and biological value of the semi-finished product;
- draw up regulatory documentation, determine its consumer characteristics and main areas of use in the production of culinary products;
- to develop recipes and technologies of ice cream and dessert products.

II. LITERATURE ANALYSIS

2.1. Ways to improve the technologies of soft ice cream and frozen desserts

Today, the food industry is rapidly developing new product platforms and bringing new product categories to the market. The main goal of this activity is the economic growth of economic entities, therefore, most types of food products contain a large number of food additives that create the identical natural structure, taste, color of the product, etc. But the majority of food additives have either a synthetic origin or are subjected to deep physico-chemical influence during production, which determines their harmful effect on human health.

In the segment of frozen dessert products, the distinguishing feature of which is the multi-stage production process and the need to use special equipment, all modern technologies involve the use of foam and structure-forming food additives for the formation of a whipped and stable structure [5].

Experts in the dairy industry note that the direction of creating low-calorie ice cream through the use of vegetable fat substitutes is quite developed, however, numerous medical studies have proven the harm of such products to health, so more and more consumers refuse such a dessert and prefer more healthy products. However, unlike the countries of Europe, America and Asia, this segment of the frozen products market is unfilled in Ukraine. Therefore, technologists face the urgent problem of developing new technologies and adjusting the recipe composition of ice cream and frozen desserts in order to increase the content of protein and dietary fiber [6] against

the background of reducing the amount of fat and sugar [7].

A promising way to solve this problem is to use low-fat dairy secondary raw materials as a basis for ice cream, such as casein, whey, sour milk cheese, low-fat goat milk, concentrated milk protein, etc. [8].

One of the ways to increase the dietary fiber content is the use of vegetable (pumpkin, carrot, tomato), fruit (apple, quince, etc.) and berry purees as a filler for dairy products or as a base for ice cream [9]. At the same time, the researchers note that due to the content of pectin substances and fiber, fruit and berry and vegetable purees play the role of a moisture-retaining and emulsifying component in food systems, and the presence of easily digestible sugars (mainly fructose and glucose) allow to exclude or limit the amount of sugar [10].

A new approach to the use of unused natural properties of raw materials can make it possible to maximize their functional properties, which will increase the economic efficiency of technologies by reducing the use of food additives and sugar, as well as increase the nutritional and biological value of finished products.

2.2. Analysis of modern ice cream technologies

The analysis of the diet of Ukrainian citizens shows its non-compliance with the requirements of nutrition due to insufficient consumption of proteins, minerals, vitamins and an overload of simple carbohydrates. The modern diet requires improvement in the production of products in priority directions: functional and low-fat food products, with reduced sugar content or without sugar and with a low glycemic index [11]. The assortment of ice cream with sugar substitutes in Ukraine is insignificant, production volumes are limited to the production of ice cream with xylitol and sorbitol. The modern approach to the creation of food products is connected, in particular, with the use of the concept of glycemic indices and glycemic load.

Consumer demand for healthier products is driving down the sugar content in dairy products. Sugar plays an important role in ice cream not only for flavor, but also for texture, color and viscosity. There are natural and artificial sweeteners designed to reduce sugar levels [12]. However, there is little information on the effect of high-intensity sweeteners and fat substitutes on the perception of sensory properties of ice cream [13].

In recent years, in many scientific works of Ukrainian and foreign scientists (A.M. Dorohovych, V.F. Dotsenko, N.A. Didukh, D. Richarda), considerable attention has been paid to the production of food products with sugar substitutes.

It is proposed to solve the problem of reducing the glycemic index of ice cream by using sugar substitutes (stevia, lactite, sorbitol, aspartame) [14] and fructose [15].

The technology of ice cream with fructose, prebiotic and sour milk cheese was developed, which ensure the production of high-quality ice cream with reduced glycemia and improved nutritional and biological value [16]. It was found that the introduction of sugar substitutes – fructose and sorbitol into ice cream increases the content of bound moisture by 4.2%, which improves the structure and consistency of ice cream and reduces the glycemic index of the finished product by 8.75%.

At the current stage, many researchers will develop ice cream with prebiotics (usually inulin or other non-starch oligosaccharides) [17] or probiotics [18, 19].

The effect of adding probiotics on the quality indicators of ice cream was studied [20]. According to the authors, the whipped texture of ice cream was found to improve the gastrointestinal tolerance of probiotics compared to natural yogurts and fruit yogurts, as evidenced by an in vitro stomach survival study of probiotics (B. animalis). In addition, it was determined that the addition of B. animalis decreased the pH, but did not affect the physicochemical properties and melting of ice cream, and obtained good sensory evaluations and satisfactory probiotic viability [21].

Currently, a promising direction is the use of dairy processing products in the production of ice cream - buttermilk, whey, sour milk cheese, yogurt [22, 23], which is expedient from the point of view of manufacturability, high nutritional value, and rational use of by-products of dairy production.

Conclusions: Considering the above, it can be concluded that dairy technologists are conducting quite intensive scientific work to find new ways to improve recipes and technologies of ice cream and frozen desserts in the direction of creating products with a reduced glycemic index. Thus, the scientific substantiation and development of the technology of frozen dessert products with a low glycemic index based on low-fat dairy raw materials is relevant today.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of research is the technology of a semi-finished product for frozen desserts based on whey with lactulose and fructose.

The subject of the study is whey, fructose, lactulose, model food systems containing whey, fructose and lactose, semi-finished products for frozen desserts.

Research methods are physicochemical, organoleptic, microbiological, mathematical and statistical, methods of system analysis, planning and processing of experimental data using modern computer programs.

During theoretical and experimental work, the technology of semi-finished products for frozen desserts in the form of a liquid mixture for soft ice cream based on whey, fructose and lactulose was considered as the main object of research.

The following main materials were used within the specified object: whey according to DSTU 7515:2014, dry milk according to DSTU 4273:2003, stabilization system for the production of ice cream CREMODAN SI 320, containing alginate, locust bean gum, guaran, carrageenan, according to certificate of the manufacturer ("Danisco A/S", Denmark); lactulose (crystalline lactulose "Lactulose" manufacturing company "ServaFeinbio Chemica", Germany) and fructose, which were purchased from "Altex" LLC, Dnipro.

The organizational aspects of the scientific work consisted in conducting a number of studies aimed at studying the characteristics of the initial components, the selection of rational ratios of recipe components, organoleptic, physico-chemical, structural-mechanical properties, technological indicators of products, their shelf life, establishing the possibility of practical use of the developed technology in production conditions.

Research of organoleptic, physico-chemical and microbiological characteristics of model systems, semi-finished products and culinary products was carried out by modern methods according to standard methods, using appropriate devices. The

selection of samples and their preparation for research was carried out according to standard methods.

The stability of the foam structure of the systems was determined after a 15-minute proofing of the whipped mixture according to the formula:

$$УП = \frac{B_n^{15}}{B_n} \times 100\%$$

where УП – foam stability, %;

B_n^{15} – foam height after proofing, m;

B_n – initial foam height, m.

Determination of the heat resistance of the mixtures was carried out according to the method developed by V. M. Polishchuk. The samples of the mixtures in glass chemical cups were mixed in a water bath, with the help of which it was possible to carry out different modes of heat treatment, in the range from 78 to 95°C and with different durations of exposure at a given temperature The heating of the mixtures was carried out with their continuous mixing, which prevented local overheating. Heat treatment was carried out at 4 temperature regimes – (80±2)°C, (85±2)°C, (90±2)°C, 95°C. For each regime, the mixture was processed until the moment of coagulation of milk proteins was established. The duration (in minutes) during which the mixture was kept at the specified temperature regime until the visible coagulation of the proteins in it began was chosen as a criterion for heat resistance of the mixtures.

The quality of mixtures and ready-made ice cream was determined by physico-chemical parameters (mass fraction of moisture – DSTU 5867, mass fraction of fat – DSTU 5867, mass fraction of sucrose – DSTU 3628). The selection of samples and their preparation for research were guided by the requirements of the current DSTU.

IV. RESULTS

4.1. Study of the influence of recipe components on the technological indicators of mixes for frozen desserts

The further aim of our work was to study the effect of different concentrations of stabilizer and fructose on the foaming ability and foam stability of the control and whey-based mixture. To do this, a certain amount of stabilizer and fructose was measured, introduced into the serum and the mixture was mixed until the stabilizer was completely dissolved. In a water bath, the system was brought to a temperature of 70...75°C and held for (10...15)·60s^{-1}. Cooled to room temperature. Model mixtures based on whey with a fructose content of 10-12% and a stabilizer content of 0.1...0.6% were subject to research. The study of the foaming ability and foam stability of the samples was carried out according to the methods described in section 2. The results of the studies are presented in fig. 1-3.

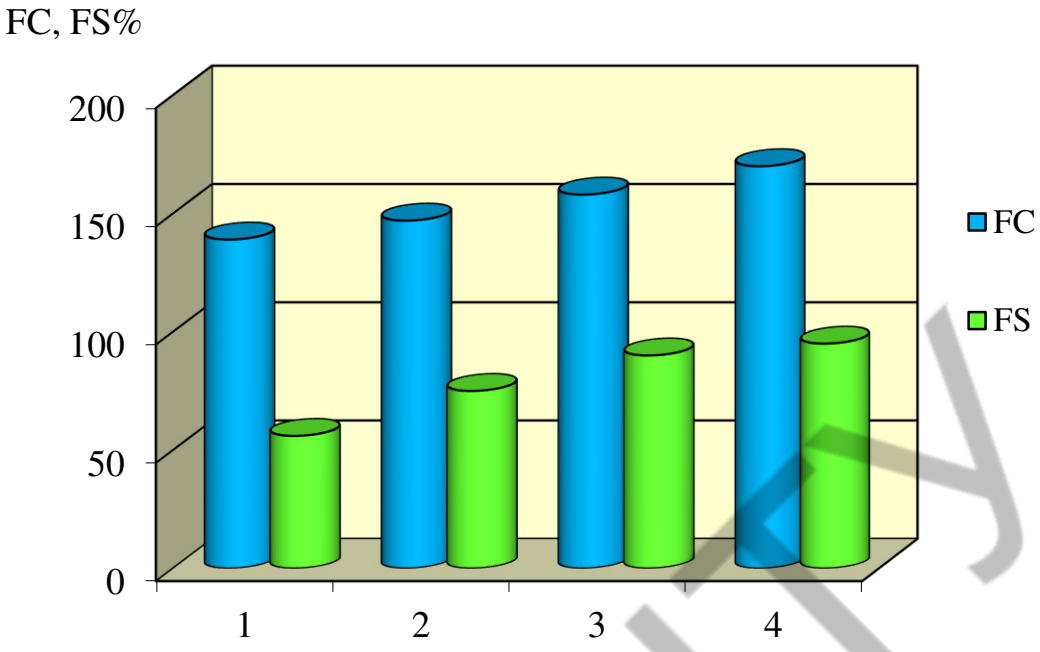

Fig.. 1. Foaming capacity (FC) and foam stability (FS) of control (1) and mixtures based on serum with a stabilizer content of 0.2; 0.4; 0.5 and 0.6% with a fructose content of 10%.

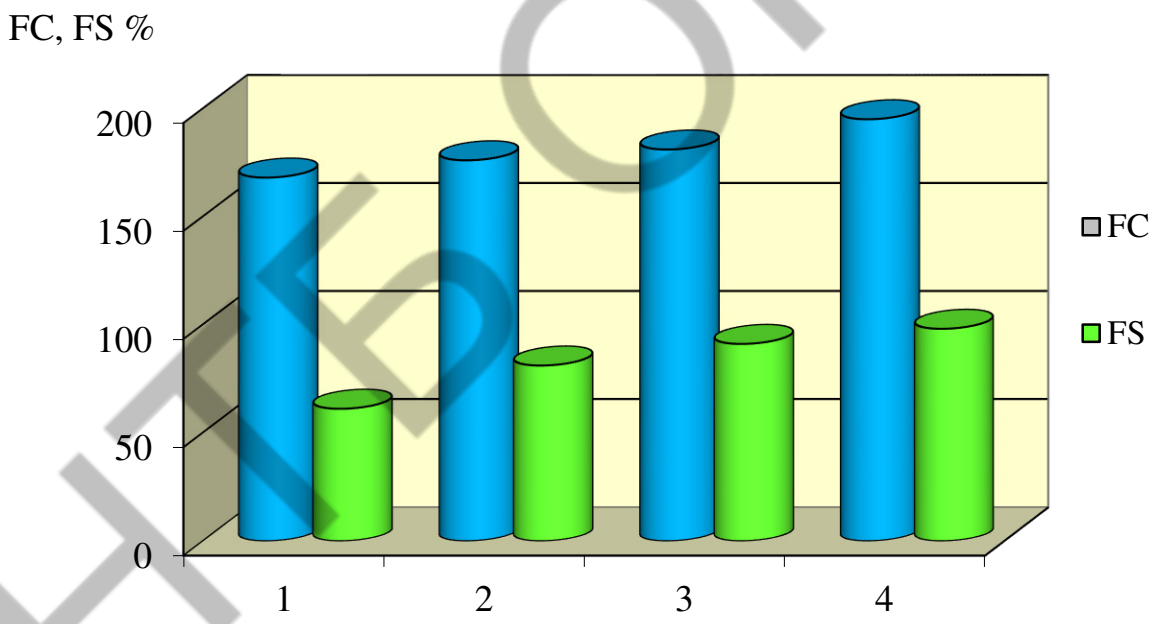

Fig. 2. Foaming capacity (FC) and foam stability (FS) of control (1) and mixtures based on serum with a stabilizer content of 0.2; 0.4; 0.5 and 0.6% with a fructose content of 11%.

The analysis of the obtained results allows us to draw the following conclusions. With an increase in the concentration of the stabilizer in the system, its foaming ability first increases to a maximum value, and then gradually decreases. This regularity is characteristic of all nonionic surface-active substances, which, in our opinion, can be explained as follows.

In the stabilizer concentration range of 0.4%, the foaming ability increases and

reaches maximum values. This interval corresponds to the critical concentration of micelle formation, at which the formation of an adsorption layer with maximum mechanical strength is completed, which prevents the coalescence of bubbles of the gaseous dispersion phase. The decrease in the critical concentration of micelle formation is explained by the presence of a synergistic effect during the interaction of the stabilizer we have chosen with milk protein, the amount of which increases with the increase in the concentration factor.

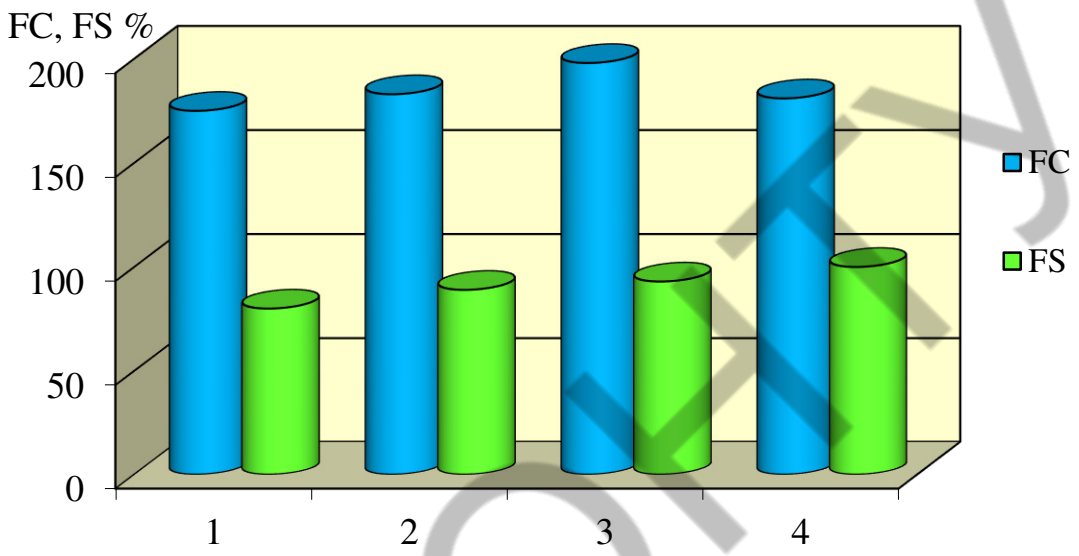

Fig. 3. Foaming capacity (FC) and foam stability (FS) of control (1) and mixtures based on serum with a stabilizer content of 0.2; 0.4; 0.5 and 0.6% with a fructose content of 12%.

A further increase in the concentration of the stabilizer (0.6%) above the critical concentration of micelle formation leads to the fact that the rate of diffusion of molecules to the surface layer decreases due to the increase in the micellar concentration of the components of the stabilization system. At the same time, the surface tension of the mixture practically does not change, and the foaming ability gradually decreases.

Thus, the most rational formulation of the mixture should be considered formulations based on serum with a fructose content of 11.0%, stabilizer 0.4.

4.2. Study of heat resistance of mixes for frozen desserts

Pasteurization is one of the most important operations in the production of mixes for soft ice cream and frozen desserts. The defining parameters of this treatment are the temperature and duration of its effect on the mixture, which determine its effectiveness.

The heat resistance of model mixtures is influenced by individual recipe components. Therefore, in order to develop the necessary modes of heat treatment of liquid semi-finished products for frozen desserts, a study of their heat resistance was conducted. Research on thermal stability was carried out in the temperature range of 80...95ºC.

Table 1. Heat resistance of model mixtures for sweet dishes

The name of the sample	Heat resistance of mixtures during heat treatment, $\cdot 60^{-1}$sec			
	80±2ºC	85±2ºC	90±2ºC	95±2ºC
Control [8]	12±0,3	6±0,2	4±0,3	2±0,2
A mixture based on whey with lactulose and fructose	6±0,2	4±0,2	3±0,15	0

The results of the conducted research confirm that the composition of mixtures for frozen desserts affects their heat resistance. It was established that the addition of recipe components significantly reduces heat resistance: at a processing temperature of 80...82ºC, the heat resistance of the mixture [8] decreases by 1.7 times, and that of the developed 1% mixture by 2 times. With a further increase in temperature, the heat resistance of the above-mentioned mixtures decreased. The decrease in the level of heat resistance of the latter can be explained by the fact that with an increase in dry substances in the mixtures, the content of mineral elements increases, which leads to a change in the ionic balance in the system and affects the stability of milk proteins, as well as due to an increase in the acidity of the mixtures. Thus, it is rational to carry out the pasteurization process for the semi-finished product – at a temperature of 80...82ºC for $(5.8...6.2)\cdot 60^{-1}$s.

Thus, on the basis of the set of researches, the most rational formulation of the mixture from the point of view of the properties of the obtained semi-finished product should be considered the formulation based on whey with the content of lactulose 1%, fructose 11.0%, stabilizer 0.4%, milk powder 8%. All the results obtained in this section were taken into account in subsequent studies, namely during the development of technological schemes of semi-finished products for frozen desserts.

4.3. Research of functional and technological properties of the semi-finished product

In order to determine the objective assessment of quality, the functional and technological properties of the developed semi-finished products were investigated: the ability to whip, the ability to form stable foams, the degree of dispersion of the fat phase. As a control, a mixture for soft ice cream was used [8]. The degree of dispersity of the fat phase was assessed by determining the average diameter of fat globules of control and developed semi-finished products. The obtained data are given in table. 2.

Table 2. Functional and technological indicators of the semi-finished product

Indicators	Control	Semi-finished product
Beating ability, %	60±1,5	70±1,8
The ability to form stable foams, %	65±1,5	80±2,0
The degree of dispersion of the fat phase, μm	110±2,8	90±2,3

The analysis of research results showed that the semi-finished product has a higher whipping capacity (by 9.8...10.2%) compared to the control sample. The developed semi-finished product is able to form more stable foams - 1.3 times more

than the control sample. The degree of dispersion of the fat phase of the semi-finished product is 1.2 times higher than that of the control sample. The obtained data were used during the development of the semi-finished product quality model.

4.4. Study of the nutritional value of the semi-finished product

Since the developed semi-finished products are new, non-traditional products planned for further use in the production of culinary products, it was necessary to investigate their nutritional value.

The concept of quality of food products is understood as a wide set of properties characterizing nutritional and biological value, organoleptic, structural-mechanical, functional-technological, sanitary-hygienic and other properties of the product, as well as the degree of their expressiveness. From the point of view of quality indicators, a food product must contain components necessary for the human body for normal metabolism.

The content of the main food substances in the developed semi-finished product, as well as its energy value are presented in the table. 3.

Table 3. Chemical composition of the semi-finished product

Product names	Content, g per 100 g					Energetic value, kcal
	Dry substances	Proteins	Lipids	Carbo-hydrates	Ash	
Control [8]	29,0±0,5	3,78±0,1	8,0±0,2	15,0±0,3	0,7	147,0
Semi-finished product	19,75	3,85±0,1	3,10±0,2	12,0±0,3	0,8	91,3

On the basis of the results, which are presented in Table 3.3, it is possible to produce biscuits, which the disintegration of the finished product is enriched with a high content of all nutrients, and it is possible to use vikoristany for processing in the product of eating without reducing the nutritional value. In addition, the disintegration of the finished product against lactulose in the amount of 1 ± 0.02 g / 100 g.

It is important to characterize the protein speeches of the napivfabrikativ, that the stench can be brought up to the high-bility, high-yield and sufficient balance for the amino acid warehouse of the produktiv. Advances in protein allow recommending the inclusion of dietary supplements on the basis of dispersed beverages in the consumption of protein diets.

In this manner, we carried out an investigation about the high biological value of the dispersed beverages.

4.5. Basic technological diagram of semi-finished product production

Based on a series of preliminary studies, a basic technological scheme for the production of semi-finished products for frozen desserts was developed (fig. 4).

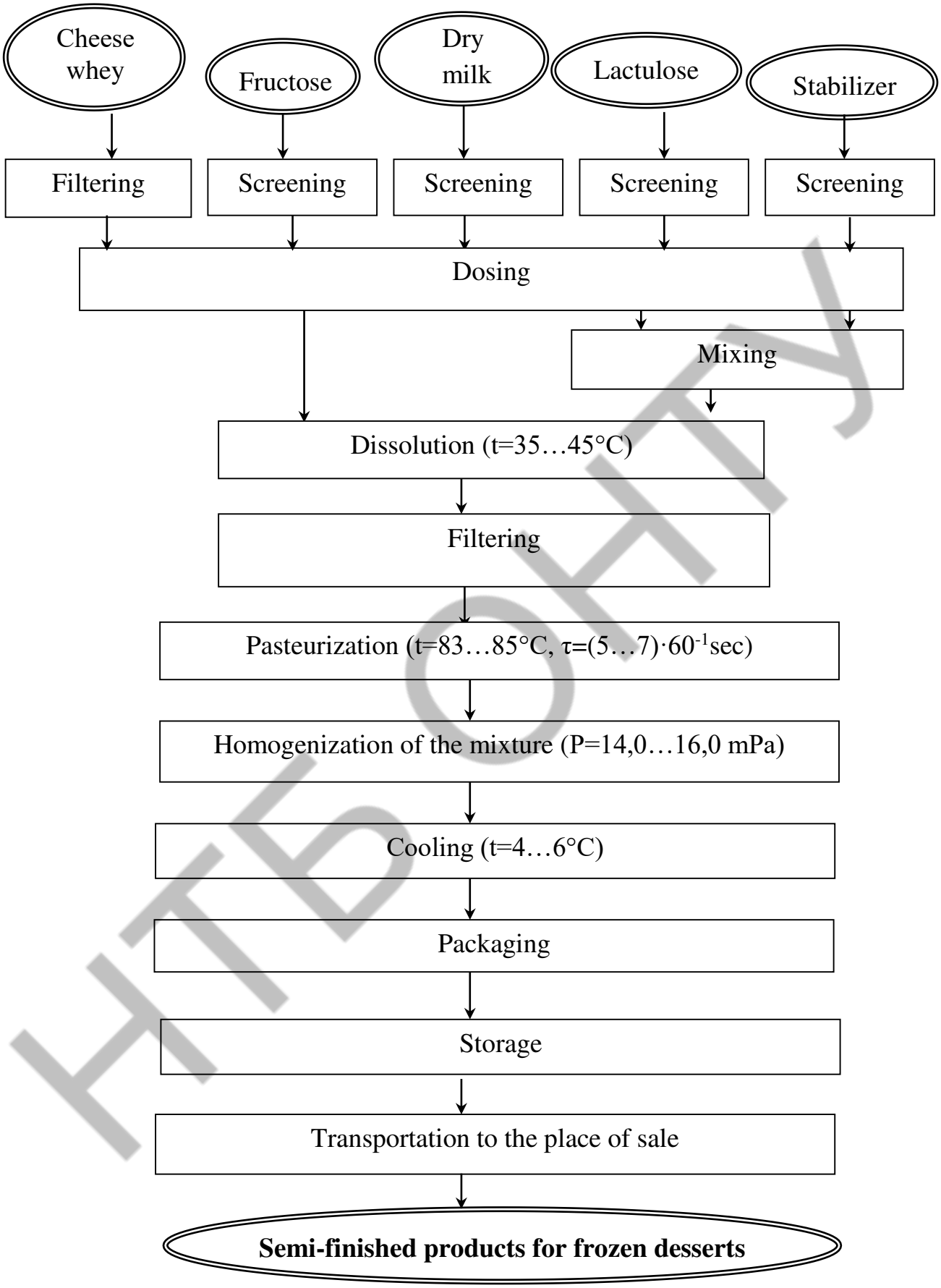

Fig. 4. Basic technological diagram of a semi-finished product for frozen desserts

4.6. The main areas of use of semi-finished products in the production of frozen desserts

The semi-finished product technology substantiated in the previous sections is low-waste, resource-saving and easy to implement. The production of the developed semi-finished product can be carried out both at the enterprises of the dairy industry and at the enterprises of the restaurant industry. However, since the main raw material of the developed semi-finished product is inexpensive whey, its transportation from dairy plants to restaurant enterprises can significantly increase the cost of the semi-finished product. In connection with this, it is advisable to produce the developed product at dairy plants, and then use it as a semi-finished product with a high degree of readiness at restaurant enterprises.

During the study of the process of freezing desserts from a semi-finished product, as well as those made according to traditional technology (a control sample), it was found that during the preparation of soft ice cream based on a semi-finished product, it is rational to carry out the freezing process for $(6...7)\cdot 60^{-1}$s. The obtained data were used during the development of a technological scheme for the preparation of soft ice cream and frozen desserts based on semi-finished products (Fig. 5).

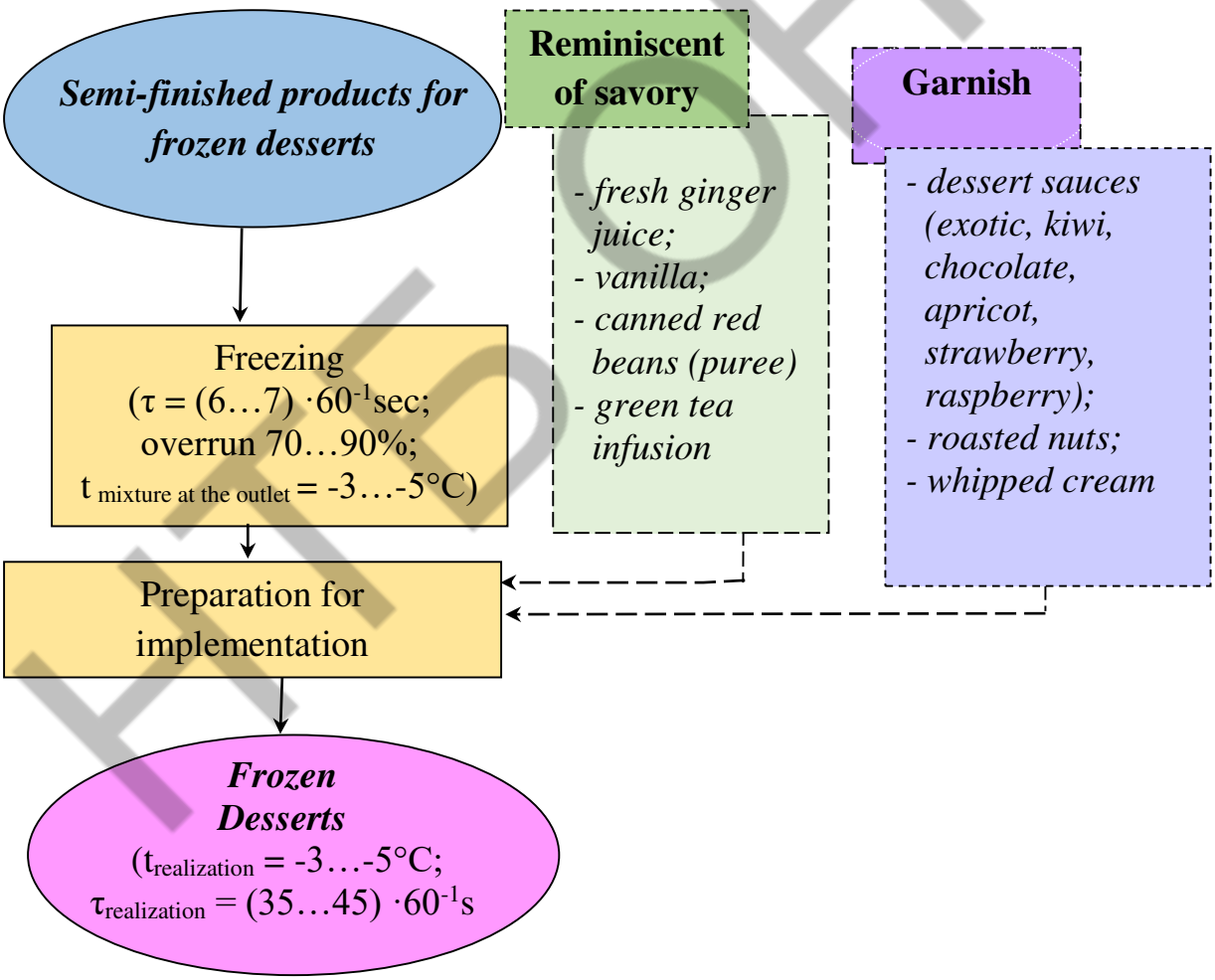

Fig. 5. Schematic diagram of the production of frozen desserts from semi-finished product

The semi-briquettes supplied to the restaurant industry must comply with the draft technical conditions in terms of quality requirements. Products are received in batches. Each batch must be accompanied by a document of the prescribed form certifying its quality and safety. The semi-finished product is delivered to the catering industry vacuum-packed in bags made of polyethylene or polymer materials with a capacity of 1...5 liters. The semi-finished product is stored at a temperature of 4...6°C for no more than 3 months, in unpacked form - no more than 48 hours. Before use, the bags are opened, then the semi-finished product is used in accordance with the recommendations for preparing dessert dishes.

We developed original technologies of frozen (soft) ice cream "Ginger", "Fasoleve", "Green tea" and original desserts.

Prospects for further research in this direction are the determination of the nutritional value of the developed frozen desserts and their functional properties (physiological action) and their glycemic index.

Thus, the basic technological scheme of the semi-finished product was developed and substantiated, the rational ratio of components in the semi-finished product based on milk whey was determined (lactulose 1%, fructose 11.0%, stabilizer 0.4%); its consumer characteristics and main directions of use in the production of culinary products are determined; recipes and technologies of ice cream and frozen desserts based on semi-finished products have been developed.

V. CONCLUSIONS

The analysis of literary sources showed that the creation of products with reduced glycemic load and functional properties are new ways of improving the technologies of ice cream and frozen desserts.

It has been proven that lowering the glycemic index is possible by replacing sugar with fructose or other sugar substitutes.

Provision of functional (prebiotic) properties is expedient to be carried out at the expense of the introduction of lactulose.

It has been proven that the rational formulation of the mixture from the point of view of the properties of the obtained semi-finished product should be considered formulations based on serum with the content of lactulose 1%, fructose 11%, stabilizer 0.4%, dry milk 8%.

The optimal pasteurization process for the semi-finished product was determined - at a temperature of 80...82°C for $(5.8...6.2)\times60^{-1}$s.

The whipping ability was 70±1.8%, the ability to form stable foams was 80±2.0%.

A technological scheme for obtaining a semi-finished product for frozen desserts based on whey with lactulose, fructose, stabilizer was developed.

A set of data characterizing the quality of the developed semi-finished product was obtained, and its high nutritional and biological value was proven.

Modes and terms of storage of semi-finished products are substantiated: temperature -4...6°C, no more than 3 months, in unsealed form – no more than 48 hours.

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TABLE OF CONTENTS