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Development of the composition and technology of the frozen dessert without sugar, using sesame flour

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Abstract. The article presents the results of the analysis of the entry dose of stevioside, topinambur syrup, sesame flour and the type of stabilizer added to the milk ice cream formula, theoretically calculated, using solids according to GOST 31457-2012 for development of a functionally oriented dessert with low content of fat and without sugar. It has been established that the entry dose of the stevioside and the topinambur syrup in an amount of 0.03 and 5% respectively to the mixture mass of the frozen dessert allows us to get the product with pleasant flavor and scent. The use of the PGX-1 stabilizer (Germany) with an entry dose of 0.4 to the mixture mass allows us to get the product with the best indicators for whipping, thawing resistance, density and uniformity of consistency. It has been determined that the entry dose of sesame flour added to the mixture mass varies from 1.5 to 2%. It is expedient to put it into the normalize mixture after the process of homogenization before milling, pre-brewing with water in the ratio of 1:10 for 15–20 minutes to humidity (80 ± 1) %. It has been found that the expiration date of the frozen dessert without sugar with the use of sesame flour is 6 months at a temperature of – 18 °C.

Key words: frozen dessert, topinambur syrup, stevioside, stabilizer, sesame flour, prophylactic and functional products.

INTRODUCTION

A hot topic in the food industry is the creation of dietary, therapeutic food products of functional orientation with low content of fat, without sugar, with innovative useful additives to prevent the diseases connected with malnutrition of children and adults and to protect and promote the health of the population. The problem of diabetes is alarmingly increasing (Saad et al., 2013). According to preliminary data, there were 4,418,305 patients with diabetes in the Russian Federation in 2015 and every year the number increases. For this reason, the development of the technology of the frozen low-fat desserts without sugar, without sugar, with sesame flour for diabetics and people with obesity and calcium deficiency is a relevant and timely aim.

Stevioside is a glycoside from an extract of Stevia plants. In comparison with sucrose, stevioside is 250–300 times more sweet. As a result of a patent and information search, stevioside and topinambur syrup were chosen as a sugar substitute (Erashova &

Pavlova, 1997; Arseneva & Yakovleva, 2012; Ozdemir et al., 2015). Stevia extract contains over 70 chemical elements, providing its unique therapeutic and prophylactic properties, flavonoids, soluble chlorophyll and xanthophyll, oxycinnamic acids (coffee, chlorogenic, etc.), neutral water-soluble oligosaccharides, free sugar, 17 amino acids (including 8, which are indispensable), fiber, tannins, essential oil (containing 53 components), mineral compounds, vitamins A, B, C, D, E, K, P, PP, trace elements: iron, zinc, phosphorus, potassium, magnesium, calcium, selenium, sodium, iodine, emulsified fat, saponins and other components, including silver (0.0006 mg mL^{-1}), which ensures the antimicrobial properties of the Stevia extract (Arseneva, 2011a).

Stevioside is a harmless natural sugar substitute of low energy value without mutagenic and carcinogenic features, non-toxic, heat-resistant, stable in acid and alkalis. It does not require a large dosage and is harmless with a long-term use. Stevioside is used for the prevention and treatment of type 1 and type 2 diabetes.

Topinambur syrup has a sweet taste due to the fructans of rare polymers, which act on humans differently than glucose and fructose than usual glucose. Fructans are contained in a very small amount of plants. Tubers of topinambur are the absolute leaders in their concentration (Arseneva & Yakovleva, 2011). Polysaccharide inulin, which is contained in topinambur syrup, improves metabolism, maintains normal intestine microflora, reduces cholesterol; pectin and fiber clear toxins and wastes from the body; vitamins C, B1, B2 and PP and trace elements, especially biogenic silicon, iron, magnesium, potassium, etc. strengthen joints, bones, heart, contribute to the maintenance of immunity and health in general. Topinambur syrup glycemic index is only 13–16 gl, which is the lowest indicator among all known sweeteners. The natural topinambur syrup, obtained from the topinambur tubers, contains about 40% of the plant fiber, where the sweet polymer is concentrated. This fiber gives a lasting sense of saturation, because it does not decompose in stomach. The process of glucose releasing, so necessary for the full brain and other body organs function, begins only in intestine (Arsenyeva, 2002; Arsenyeva, 2011b).

In dietotherapy topinambur is recommended for diabetics, as it has a sugar-reducing property, a beneficial effect on the pancreas. It also reduces blood pressure and increases hemoglobin (Vozhdaeva & Sorochkina, 2000; Suhas et al., 2015). Topinambur syrup contains prebiotics, specific substances necessary for nutrition and healthy activity of intestinal cultures (probiotics). Biologically active topinambur substances also stimulate heart, reduce blood pressure and level of 'bad' cholesterol in blood (Yakovleva, 2012).

The benefit of sesame flour is primarily due to the vitamin-mineral product structure, which contains a wide amount of calcium and other useful compounds of natural origin. Percent of consumption (based on 100 g of sesame per day): Food fiber – 28%; Vitamin B1 (thiamin) – 80%; Vitamin B2 – 20%; Vitamin E – 15%; Vitamin PP – 55%; Potassium – 20%; Calcium – 140%; Magnesium – 135%; Phosphorus – 90%; Iron – 90%. Sesame helps to strengthen the entire bone system. It contributes to the blood vessels purification (including brain), relieves spasms, cramps and muscle pain. It also strengthens immunity, removes toxins and gently cleanses intestine. Sesame is recommended in case of high cholesterol level (Zhukovsky, 1997).

MATERIALS AND METHODS

In this research the entry dose of stevioside, topinambur syrup, sesame flour and the type of stabilizer added to the milk ice cream formula, theoretically calculated using solids according to GOST 31457-2012 was determined in order to obtain a sugar-free ice cream formula using sesame flour(Onopriyko et al., 2004; Arseneva, 2009).

The experimental samples of the frozen dessert mixture were prepared in a laboratory in the following way: pre-mixed dry components were added to water heated to a temperature of 35–40 °C, and were mixed until their almost complete dissolution. The mixture was subjected to a thermal treatment at a temperature of 85 °C with 60 second extract time. Homogenization was carried out at the same temperature, the homogenization pressure was about 10–12 MPa (Olenev et al., 2004).

Sesame flour was added to the homogenized mixture, cooled to a temperature of 4–6 °C, and left in a freezer for ripening the mixture for 4–12 hours. A batch freezer was used without forced air supplying for freezing. Upon the completion of this process, the temperature of the frozen dessert was about -4–-6 °C.

Standard techniques were used in this research to determine physico-chemical parameters, and a score system of the organoleptic parameters presented in Tables 1, 2 and 3 was developed.

The characteristics of the sweetness and scent of the frozen dessert are presented in Table 1 in points.

Table 2 shows the characteristics of organoleptic indicators (sweetness and color) of the frozen dessert samples in points.

Table 1. The characteristics of the sweetness and scent of the frozen dessert

Sweetnes and scent characteristics	Number of points
Unsweetened, without stevia scent	1
Lack of sweetness, without stevia scent	2
Not enough sweetened, stevia scent	3
Excessively sweetened, stevia scent	4
Sweetened, stevia scent	5

Table 2. The characteristics of organoleptic indicators (sweetness and color) of the frozen dessert samples in points

Flavor and color characteristics	Number of points
Excessively sweetened, coffee color	1
Highly sweetened, light coffee color	2
Sugary, beige color	3
Not sweetened enough, milk color	4
Pleasantly sweetened, milk color	5

The characteristic of the quality indicators was developed according to the 5-point scale to make an organoleptic assessment of the frozen dessert samples (Table 3).

Table 3. The characteristic of the quality indicators was developed according to the 5-point scale to make an organoleptic assessment of the frozen dessert samples

Indicator	Product organoleptic characteristics	Points
Consistency	Homogeneous, moderately dense	5
	Homogeneous, not dense	4
	Heterogeneous, slightly liquid	3
	Heterogeneous, excessively dense	2
	Heterogeneous throughout the mass, excessively liquid	1

Table 3 (continued)

Color	Uniform, white, barely visible particles of sesame flour are allowed	5
	Uniform, white, with visible particles of sesame flour	4
	Uneven, white-gray, with visible particles of sesame flour	3
	Uneven, white-gray, with significant particles of sesame flour	2
	Uneven, taupe, with large particles of sesame flour	1
Sweetness	Pure, with pronounced sweetness, without foreign flavor	5
	Moderately sweet, insufficiently pronounced	4
	Unpronounced flavor	3
	Unpronounced, with foreign flavor	2
	Pronounced foreign flavor	1
Scent	Pure, with pronounced aroma, without foreign odor	5
	Pure, without foreign odor	4
	Unpronounced	3
	Unpronounced odor of foreign filler	2
	With pronounced unpleasant foreign odor	1

RESULTS AND DISCUSSION

At the first stage of the research the concentration of stevioside was selected. It varied from 0.03 to 0.07% to the mixture mass within 0.005%.

Organoleptic features of the frozen dessert samples were assessed on a five-point scale. It is noted that the concentration of stevioside did not influence the consistency of the final product, the color remained unchanged, therefore all the samples received 5 points for consistency and color.

Fig. 1 presents the profilograms of the organoleptic assessment of the frozen dessert samples with a sweetener dose, % to the mixture mass: from 0.030 to 0.050 (a) and from 0.055 to 0.070 (b).

As seen from the profilograms (Fig. 1), the highest score for the organoleptic indicators was obtained by an experimental sample with the entry dose of stevioside of 0.05%. However, a frozen dessert with this concentration had a pronounced unpleasant specific flavor of stevioside. At a concentration of 0.03% there was no flavor, but it was not sweetened enough. Therefore, further research was devoted to the selection of the topinambur syrup concentration, which varied from 1 to 9% to the mixture mass within 1%. Products consistency did not change even at various topinambur syrup concentration and scored five points.

As seen from the profilogram (Fig. 2), the highest score for the organoleptic indicators was obtained by the experimental sample with the entry dose of stevioside of 5% to the mixture mass.

It is established that the frozen dessert sample had the highest score (5 points according to flavor characteristics) when adding 5% topinambur syrup and 0.03% stevioside to the mixture mass.

The selection of stabilizer entry dose and type was done at the following stage (Vzor & Nikitkov, 1998; Arseneva, 2011b). PGX-1 (Germany), Kremodan SE 334 VEG (USA), Denyse 805 R (Russia) at a concentration of 0.4% recommended by the producer were used as stabilizers. The quality indicators of the frozen dessert experimental samples with the researched stabilizers are presented in Table 4.

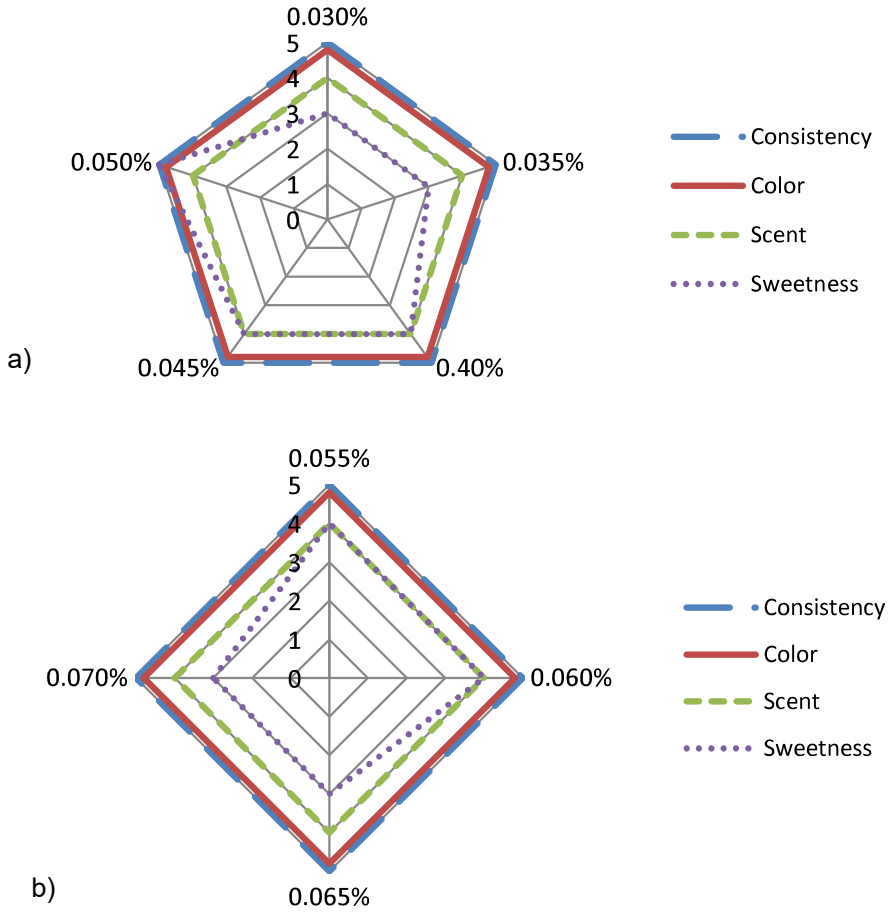

Figure 1. profilograms of the organoleptic assessment of the frozen dessert samples with a sweetener dose, % to the mixture mass: from 0.030 to 0.050 (a) and from 0.055 to 0.070 (b).

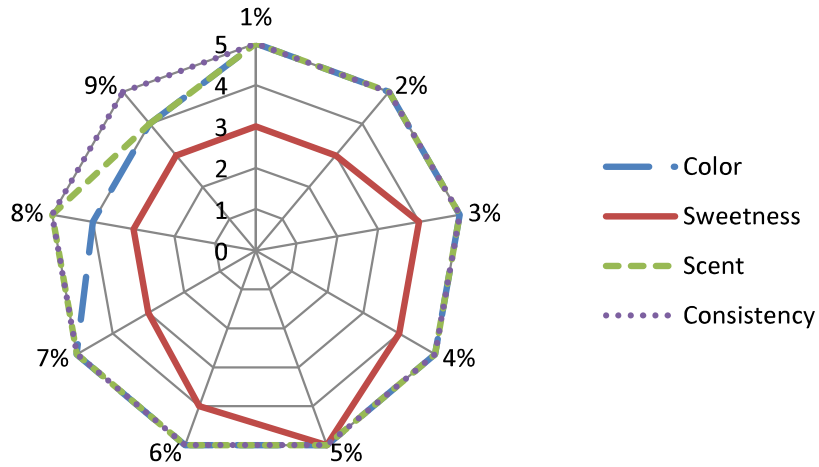

Figure 2. The profilogram of organoleptic assessment of the frozen dessert samples with various concentration of topinambur syrup in points.

As seen from the data presented in Table 4, the experimental samples, regardless of the stabilizer entry, had a creamy, sweet flavor, sufficiently dense, homogeneous consistency without any visible ice crystals, according to the organoleptic characteristics. When using the PGX-1 stabilizer, the experimental samples had higher whipping and thawing resistance indicators, therefore the PGX-1 stabilizer was used in further research.

Table 4. The quality indicators of the frozen dessert experimental samples with the researched stabilizers

Indicators	Stabilizer entry type		
	PGX-1 (Germany)	Kremodan SE 334 VEG (USA)	Denyse 805 R (Russia)
Organoleptic:	Creamy	Creamy	Creamy
Sweetness	Sweet	Sweet	Sweet
Scent	Gentle and moderately	Sufficiently dense	Moderately dense
Consistency	dense consistency, homogeneous without any visible ice crystals	consistency, homogeneous without any visible ice crystals	consistency, homogeneous without any visible ice crystals
Whipping, %	36 ± 2	34 ± 2	32 ± 2
Thawing resistance, min	43 ± 2	40 ± 1	40 ± 1
Temperature after freezing, °C	-4…-6	-4…-6	-4…-6

It is generally accepted that it is recommended to use no more than 7 g sesame flour per day. A portion of the final product weighing 100 g corresponds to 7% of frozen dessert mixture mass. In this proportion, the consistency became excessively thick when adding sesame flour to the mixture. Therefore, the amount of flour varied from 1 to 5% to the mixture mass within 0.5%.

For an organoleptic assessment which results are presented in Table 5, 9 frozen dessert samples with various dosage of sesame flour, % to the mixture mass (sample 1–1; 2–1.5; 3–2; 4–2.5; 5–3; 6–3.5; 7–4; 8–4.5; 9–5), were offered to a group of 8 people aged 23–26 (graduate students in the 1st and 2nd years of studies).

Table 5. Results of organoleptic assessment of 9 frozen dessert samples with various dosage of sesame flour, % to the mixture mass (sample 1–1; 2–1.5; 3–2; 4–2.5; 5–3; 6–3.5; 7–4; 8–4.5; 9–5)

Sample number	Assessment (points)				Points in total
	Color	Scent	Consistency	Flavor	
№ 1	4.9	4.8	4.8	4.9	19.4
№ 2	4.9	5.0	4.9	4.9	19.7
№ 3	4.9	4.9	4.9	5	19.7
№ 4	4.8	4.8	4.5	4.8	18.9
№ 5	4.8	4.8	4.3	4.8	18.7
№ 6	4.8	4.0	4.3	4.8	17.9
№ 7	4.6	4.0	3.5	4.3	16.4
№ 8	4.6	4.0	3.4	4.3	16.3
№ 9	4.5	4.0	3.4	4.3	16.2

As seen from the data presented, samples 2 and 3 with 1.5 and 2% sesame flour addition respectively received the highest assessment.

Since sesame flour does not dissolve during pasteurization, it is not possible to add it into the mixture before pasteurization as the homogenization comes immediately after pasteurization (Olenev, 2001). Sesame flour was brewed with water in the ratio 1:10 for 15–20 minutes to a humidity of (80 ± 1)% and was added directly to the normalized mixture after the homogenization process before maturing the mixture. Organoleptic and physico-chemical indicators of the frozen dessert sample without sugar with the use of sesame flour are presented in Table 6.

Table 6. Organoleptic and physico-chemical indicators of the sample

Indicator	Characterictics and description
Flavor and scent	Pure, creamy with a pleasant sesame flavor
Consistency	Moderately dense, with barely visible sesame particles
Structure	Homogeneous, without visible fat globules, protein, lactose, with barely visible sesame particles
Acidity, 0 T	22 ± 0.5
Fat mass fraction, %	5 ± 0.1
Whipping, %	48 ± 2
Thawing resistance, min	45 ± 2
Average diameter of air bubbles, μm	62 ± 0.1
Average diameter of fat globules, μm	1.8 ± 0.1

Research on the establishment of expiration dates of the frozen dessert were conducted in the laboratory of the Department of Applied Biotechnology. The frozen dessert sample was stored at -18 °C and all the changes of quality indicators were examined monthly within 8 months (results are presented in Table 7).

Table 7. The changes of quality indicators frozen dessert samples examined monthly within 8 months

Indicator	Storage time, months								
	0	1	2	3	4	5	6	7	8
Flavor and scent	Pure, creamy with a pleasant sesame flavor								
Consistency	Moderately dense, with barely visible sesame particles								
Structure	Homogeneous, without visible fat globules, protein, lactose.								
Average diameter of air bubbles, μm	63 ± 1	63 ± 1	63 ± 1	63 ± 1	62 ± 1	62 ± 1	62 ± 1	62 ± 1	62 ± 1
Average diameter of lactose crystals, μm	No more than 10								
Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms (QMAFAnM), CFU g^{-1}	No more than $1*10^5$								
Amount of yeast, CFU g^{-1}	No more than 50								
Amount of mold, CFU g^{-1}	No more than 50								
Coliform bacteria per $0.01cm^3$	No coliform bacteria								

The results of the research show that during the storage period there were no changes in quality indicators in the sample of frozen dessert with sesame flour. However, according to the technique (Gapparov et al., 1999), an expiration date for the products is 6 months.

CONCLUSIONS

1. The entry dose of the stevioside and the topinambur syrup in an amount of 0.03 and 5% respectively added to the mixture mass of the frozen dessert allows us to get the product with pleasant flavor and scent.

2. The frozen dessert samples were got with the best indicators for whipping, thawing resistance, density and uniformity of consistency when using the PGX-1 stabilizer with an entry dose of 0.4 to the mixture mass.

3. The entry dose of sesame flour that is needed to be pre-brewed with water in the ratio 1:10 for 15–20 minutes to a humidity of (80 ± 1)%, varies from 1.5% to 2% to the mixture mass.

4. It is expedient to add brewed sesame flour before freezing.

5. An expiration date of the frozen dessert without sugar with the use of sesame flour is 6 months at a temperature of – 18 °C.

REFERENCES

Arsenyeva, T.P. 2002. *Handbook of the technologist of dairy production. Technology and recipes*, GIORD, SPb., pp. 180 (in Russian).

Arseneva, T.P. 2011a. Selection of components of plant origin for diabetic ice cream. *The science* **176**, 50–52 (in Russian).

Arsenyeva, T.P. 2011b. Development of ice cream with plant components for diabetic nutrition. *Low-Temperature and Food Technologies in the 21st Century: Sat. scientific works of the V international. scientific-practical. Conf.* **425,** 304–305 (in Russian).

Arseneva, T.P. 2009 Development of theoretical bases and elaboration of technologies low-lactose dairy products and adjustable fatty acid composition, *Pishchevaya tekhnologiya* **192**, 22–31 (in Russian).

Arseneva, T.P. & Yakovleva, Y.A. 2012. Formulation of ice cream with plant ingredients. *Pishchevaya tekhnologiya* **215**, 75–78 (in Russian).

Arseneva, T.P. & Yakovleva, Y.A. 2011. Jerusalem artichoke as a means of treating the prevention of various diseases. *Processes and devices of food production* **86**, 1–6 (in Russian).

Erashova, L.D. & Pavlova, G.N. 1997. Source of natural sweetener food. *Food industry* **98**, 9 (in Russian).

Gapparov, M.M., Panchenko, S.N. & Ugreninov, V.G. 1999. Natural products - food of the 21st century. *Food industry* **85**, pp. 12 (in Russian).

Olenev, Y.A., Tvorogova, A.A., Kazakova, N.V & Soloveva, L.N. 2004. *Reference book on production of ice cream*. DeLiprint, Moscow, 798 pp. (in Russian).

Olenev, Y.A. 2001 *Technology and equipment for production of ice cream*, DeLi, Moscow, 323 pp. (in Russian).

Onopriyko, A.V., Khramtsov, A.G. & Onopriyko, V.A. 2004. *Production of dairy products*. March, Rostov-on-Don, 411 pp. (in Russian).

Ozdemir, C., Arslaner, A., Ozdemir, S. & Allahuari, M. 2015. The production of ice cream using stevia as a sweetener. *J. Food Sci. Technol.* **842**, 246–264.

Saad, N., Delattre, C., Urdaci, M., Schmitter, J. & Bressollier, P. 2013. An overview of the last advances in probiotic and prebiotic field. *LWT – Food Science and Technology* **50**, 1–16.

Suhas, M.G., Preeti, M. & Rahul, R.G. 2015. Analytical hierarchy process to recommend an ice cream to a diabetic patient based on sugar content in it, *Procedia Computer Science* **264**, 64–72.

Vozhdaeva, L.I. & Sorochkina, I.G. 2000. About the functional properties of Jerusalem artichoke. *Problems and prospects of healthy food* **197**, p. 43 (in Russian).

Vzor, A.L. & Nikitkov, V.A. 1998. The use of stabilizers and emulsifiers in modern ice cream production. *Food industry* **118**, 40–43 (in Russian).

Yakovleva, Y.A. 2012. Development of the composition and technology of low-lactose cream ice cream for people suffering from diabetes mellitus *Collected works of young scientists. Part I: Proceedings of the Conference (65th\\Student Scientific and Practical Conference)* **222**, 22–24 (in Russian).

Zhukovsky, P.M, 1997. *Cultivated plants and their relatives*. VNIIMSa, Uglich, 751 pp. (in Russian).