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DEFINING QUALITY INDICATORS FOR SUGAR PASTESWITH DEMINERALIZED WHEY DURING STORAGE

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This paper considers the changes in quality indicators of sugar pastes with dry demineralized whey and glycerin during storage in order to establish their technological shelf life.

Based on the results of studying changes in the mass fraction of moisture of sugar pastes over 30 days, a decrease in this indicator in the control sample was established, by 80 %, and in the experimental one – by 30 %.

Examining the sensory characteristics of consistency according to the devised descriptors has made it possible to establish that the control sample of sugar pastes onday 10 of storage is technologically unsuitable. Its consistency is characterized as too dense, hard, brittle, not uniform, with lumps. Accordingly, the molding ability, which received 3.45 points, decreases. The prototype, even on day 30 of storage, has acceptable consistency characteristics: moderately hard and dense, softish, homogeneous with the presence of barely perceptible small inclusions. A high molding ability is retained, which received 4.3 points.

Experimental studies of the fractional composition of the solid phase and the dispersion of sugar pastes are consistent with studies into the sensory characteristics of the consistency. It was established that on day 10 of storage, in the control sample the fractional composition of particles with a size of 21 to 30 μm prevails, the content of which is 62 %, which characterizes the structure as coarse crystalline. In the prototype on day 30 of storage, thecontent of particles the size of 11 to 20 μmwas 72 %, which preserves the quality of the paste and characterizes its structure as finely crystalline.

The results of the study made it possible to establish a tendency to slow down the build-up of solid particles of the developed sugar pastes, and their growth to a critical size of 22.6 μm.The data obtained have made it possible to establish the technological shelf life of the developed sugar pastes, which was 30 days, which is 3 times more than that of the control.

Consequently, the introduction into the formulation composition of sugar pastes of demineralized whey at a concentration of 50 % and glycerin at a concentration of 5 %makes it possible to extend their technological shelf life. This is important from a practical point of view and solves the problem set

Keywords: sugar paste, demineralized whey, glycerin, technological suitability, consistency, particle size

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1. Introduction

Confectionery production is one of the most developed branches of the food industry in most developed countries of the world. Therefore, under the conditions of market competition, the level of aesthetics of confectionery products is growing every year [1].

Modern finishing semi-finished products for confectionery are represented by a wide range of various creams, lipsticks, drawing masses, sprinkles, cast jewelry made of caramel, chocolate, etc. Among them,the most popular are plastic massessuch as marzipan, legumes, sugar pastes, which is justified by the multifunctionality of their use in various areas of confectionery industries. Plastic masses are usedfor coating confectionery, modeling figured products and decorative elements of varying complexity, for gluing cakes, pastries, cookies, as a layer for desserts, sweets, bars, etc. Thus, they can make up to 50 % by weight of confectionery products, so they can not only improve the appearance and give certain taste to confectionery products but also significantly affect their nutritional value and caloric content [2].

The high demand for finishing semi-finished products, in particular plastic masses (marzipan, legumes, sugar pastes), is explained by the intensive development of confectionery industries, however, it is satisfied mainly at the expense of imported products. The cost of imported finishing semi-finished products is quite high, the directions of their use in the decoration of confectionery products are limited, they have a low nutritional value. Under such conditions, the development of technology and the introduction into the domestic market of confectionery pastes of high nutritional value with the desired functional and technological properties in the context of the state policy on resource saving, increasing high-quality products of domestic production is a relevant task.

2. Literature review and problem statement

As a result of the review of scientific and patent sources, it was established that the improvement of existing technologies of marzipan pastes is aimed at the use of unconventional plant materials, in order to reduce the cost of finished products, as well as energy value and increase biological value. In particular, technologies of marzipan pastes using Mung beans and powdered soy milk [3] and canzhat flour with pumpkin have been developed [4]. In order to reduce calorie and glycemic content, sugar replacement and sweeteners were used, in particular erythrol, sucralose [3], and palatinose [5]. The main disadvantages of marzipan pastes with these additives are decreased sensory characteristics, in particular the loss of marzipan flavor and aroma.

Finishing semi-finished products made of bean paste have several advantages because they are resistant to changes in temperature and humidity; as a result, they do not deform and do not melt [6]. Legumes are characterized by high nutritional and biological value but have low sensory characteristics due to the inherent specific bean flavor and aroma. This problem can be partially solved by combining different types of legumes [7].

Sugar pastes enjoy a steadily growing demand, which is explained in particular by low cost. However, sugar pastes are 90 % sugar, resulting in a high energy value, glycemic index, and sweetness coefficient. According to the results of the review of literary sources, a promising ingredient for new types of sugar finishing semi-finished products is dry demineralized whey (DDW) [8, 9]. This is due to its high nutritional [10] and biological value, low calorie content, acceptable sensory characteristics, and favorable functional andtechnological properties [11, 12].

In order to confirm the feasibility of using DDW in sugar paste technologies, a number of experimental studies have been conducted. According to the research results, the possibility of applying DDW at a concentration of 50 % of the total mass of dry components (powdered sugar) has been confirmed. The established concentration makes it possible to balance the nutrient composition of sugar pastes. Amino acid score improves, the total protein content increases by more than 7 times. The carbohydrate composition changes significantly, the sucrose content decreases by 65 %, the lactose content is 30 %, which helps reduce the energy value of sugar pastes by 25 %. The mineral composition of sugar pastes is improved by increasing the content of potassium, calcium, phosphorus, magnesium. In terms of vitamins, there is a significant increase in choline (B4), pantothenic acid (B5), biotin (B7) [13].

The positive effect of DDW on the structural, mechanical, and functional-technological properties of sugar pastes has also been established. It was investigated that DDW at a concentration of 50 % can significantly improve the molding capacity of sugar pastes. In particular, by reducing the plastic-elastic deformation characteristics and increasing the plastic ones [14]. At the same time, the adhesion-cohesive strength increases, which complicates the work with pastes [15]. According to the results of the review of literary and patent sources, it was established that the regulation of this indicator is possible through the use of food additives, in particular glycerin [16]. The rational concentration of glycerin was experimentally established, which amounted to 5 % of the total mass of the finished product. The determined concentration makes it possible to regulate the consistency and adhesion interaction within the right limits for sugar pastes [17].

At the same time, distilled glycerin in food production, in addition to reducing stickiness (adhesive interaction), performs a number of technological functions. It is used as a moisture-holding agent in confectionery and bakery products. It is proved that confectionery products lose 12 % of moisture per day, and with the use of glycerin – only 3 % [18]. Glycerin at a concentration of 2.5–4.7 % prevents drying and hardening of marmalade, marshmallows, soufflés, and other similar products[19]. When storing sugar pastes, the staling process also occurs, as a result of which the quality of sugar finishing semi-finished products deteriorates. Such a deterioration in quality is a consequence of the loss of moisture, as a result of which the balance between the liquid and solid phases is disturbed. This contributes to the fusion of sucrose particles, as a result of which sugar pastes become brittle, lose plasticity and technological suitability.

Thus, according to the results of our review of the scientific literature, the problem of extending the shelf life of sugar pastes remains unresolved. Therefore, it is advisable to conduct a study on the effect of DDW and glycerin at certain concentrations on the dynamics of changes in the quality indicators of the developed sugar pastes during storage.

3. The aim and objectives of the study

The aim of this study is to determine the dynamics of changes in the quality indicators of sugar pastes with dry demineralized whey and glycerin during storage. This will make it possible to establish the shelf life of the developed sugar pastesbased on reasonable technological shelf life.

To accomplish the aim, the following tasks have been set:

– to investigate the change in the mass fraction of moisture and sensory characteristics of the developed sugar paste duringstorage;

– to investigate changes in the fractional composition of solid phase particles and the dispersion of the developed sugar pastes during storage.

4. The study materials and methods

An object of our study: dry demineralized whey (TU U 15.5-00413890-089:2014), food glycerin (TU U 10.8-40570177-001:2016), model compositions of sugar pastes (Table 1). A subject of this research: the dynamics of changes in quality indicators of sugar pastes with dry demineralized whey and glycerin during storage.

Table 1

The formulation composition of sugar pastes, per 100 g

The name of the raw material	Control	Experiment
Powdered sugar	84.0	39.9
Maltose molasses	5.0	4.8
Gelatin	1.0	0.9
Water	10.0	9.5
DDW	–	39.9
Glycerin	–	5.0

The mass fraction of moisture was determined by the standardized method of DSTU 4910:2008.

The sensory analysis of control and prototype samples was carried out at the Department of Technology and Organization of Restaurant Management of the State National University of Trade and Economics (DTEU, Ukraine) by a tasting professional board consisting of 20 tasters.

The sensory properties of control and prototypes were determined by the developed scales of sensory descriptors (Table 2). As a result of mathematical processing of sensory analysis data, the average value of quality indicators was established, taking into consideration the weight factor. The weight factor was determined by the expert method under the following conditions:

$$\sum_{i=1}^{n} m_{ij} = 1, \quad (1)$$

where m_{ij} is the coefficient of weight of the i-th indicator of the j-th group (m_i>0); n – the number of indicators of product quality.

The coefficient of weight m_{ij} was determined from the formula:

$$m_{ij} = \frac{m_{ij\text{mean}}}{\sum_{i=1}^{n} m_{ij\text{mean}}}, \quad (2)$$

where $m_{ij\text{mean}}$ is the arithmetic mean value of expert estimates of the i-th quality indicator of the j-th group.

The average value $m_{ij\text{mean}}$ was determined from the formula:

$$m_{ijcp} = \frac{1}{N}\sum_{z=1}^{N} m_{ijz} \ (z=1, 2, 3, ..., N), \quad (3)$$

where $N$is the number of experts; m_{ijz} – assessment of the$i$-thquality indicator of the j-thgroup given by the z-th expert (z=1, 2, 3, ..., N).

Evaluation of the dispersion of sugar pastes with DDW was carried out using optical microscopy [20]. The results of the study were recorded by micro photographing. The study used the CLPCcamera 4.5 (China) digital microscope, which has LED direct backlighting and a resolution of 3 to 5 megapixels. Connection to a personal computer (PC) was carried out through the USB interface. The calibration and properties of the digital camera matrix were performed on a Windows 7 PC. The analysis of variance of sugar paste samples was carried out using software provided by the microscope manufacturer.

Table 2

Point scale of sensory assessment of the quality of sugar pastes during storage

Comprehen-sive indicators	Weighting factor	Unit indicators	Weighting factor	Characteristics	Quality level, points
1	2	3	4	5	6
Appearance	0.1	Color, color intensity	0.1	Creamy, barely noticeable, close to white	5
				Creamy, slightly pronounced	4
				Creamy, noticeably expressed	3
				Creamy, strongly pronounced	2
				Yellow	1
			1.0	–	–
Taste and smell	0.1	Sweetness	0.5	Moderate	5
				Strong	4
				Weak	3
				Barely noticeable	2
				Absent	1
		Balance	0.5	Excellent	5
				Good	4
				Satisfactory	3
				Unsatisfactory	2
				Bad	1
		–	1.0	–	–

Continuation of Table 2

1	2	3	4	5	6
Consistency	0.5	Homogeneity	0.3	Uniform, without lumps	5
				Uniform, barely perceptible small inclusions	4
				Heterogeneous, visible small lumps	3
				Heterogeneous, lumps are present	2
				Heterogeneous lumpy	1
		Fragility	0.3	There is no friability	5
				Weakly expressed fragility	4
				Moderately pronounced fragility	3
				Strongly expressed fragility	2
				Fragile	1
		Density, strength	0.2	Moderately compacted	5
				Compacted	4
				Dense	3
				Very dense	2
				Solid	1
		Softness	0.2	Moderately soft	5
				Soft	4
				Moderately hard	3
				Solid	2
				Too hard	1
			1.0	–	–
Ability to form	0.3	Degree of detection	1.0	Perfect	5
				Fine	4
				Satisfactory	3
				Unsatisfactory	2
				Bad	1
		–	1.0	–	–
–	1.0	–	–	–	–

5. Results of studying the quality indicators of sugar pastes during storage

5. 1. Results of studying the changes in the mass fraction of moisture and sensory characteristics of sugar pastes during storage

The change in the mass fraction of moisture (Table 3) and sensory characteristics (Table 4) of sugar pastes, control and prototypes, was investigated for 30 days with an interval of 5 days.

Table 3

Moisture content in sugar pastes with DDW during storage, W (%)

Storage duration, day	Sugar paste (control)	Sugar paste with DDW (prototype)
1	10.0±0.3	12.0±0.3
5	7.0±0.3	11.0±0.3
10	4.0±0.3	10.0±0.3
15	3.5±0.3	10.5±0.3
20	3.2±0.3	9.0±0.3
25	2.6±0.3	8.8±0.3
30	2.0±0.3	8.5±0.3

Based on the results of our study of changes in the mass fraction of moisture in sugar pastes for 30 days, a decrease in this indicator in the control sample by 80 % was established, in the experimental one – by 30 %.

The control sample in terms of appearance (color) on the first day of storage received 5.0 points. The color is characterized close to white, barely noticeable cream shade. This is important when tinting the paste, and as a result of staining makes it possible to get the desired color scheme. At the same time, the prototype for this indicator received 4.2 points.This is due to the fact that the introduction of DDW increases the intensity of the color of sugar pastes before the appearance of cream color, which complicates the coloration process.

In terms of taste and smell (sweetness, balance), the control sample received 4.0 points, due to its high sweetness. The prototype for this indicator received 5.0 points since the introduction of DDW helps balance the sweetness and the appearance of a pleasant taste and aroma.

According to the results of our study, the indicators of color, taste, smell of control and prototypes almost do not change during storage for 30 days. However, significant changes are demonstrated in consistency indicators (uniformity, fragility, strength, density, softness), which have a great influence on the molding ability, and therefore technological suitability.

Table 4

Sensory characteristics of sugar pastes with DDW during storage

Indicator specification	Weighting factor	Characteristics	Weighting factor	Storage duration, day						
				1	5	10	15	20	25	30
Sugar paste (control)										
Appearance	0.1	Color, coloration intensity	1.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total score by descriptor				5.0	5.0	5.0	5.0	5.0	5.0	5.0
Taste and smell	0.1	Sweetness	0.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
		Balance	0.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Total score by descriptor				4.0	4.0	4.0	4.0	4.0	4.0	4.0
Consistency	0.5	Homogeneity	0.3	5.0	4.0	3.0	2.8	2.7	2.6	2.5
		Fragility	0.3	5.0	4.0	3.0	2.8	2.7	2.5	2.0
		Density, Strength	0.2	4.0	3.8	3.5	3.2	3.0	2.8	2.5
		Softness	0.2	5.0	4.5	4.0	3.5	3.0	2.5	2.2
Total score by descriptor				4.80	4.06	3.30	3.02	2.82	2.59	2.29
Ability to form	0.3	Detection degree	1.0	4.0	4.5	3.0	2.7	2.5	2.2	2.0
Total score by descriptor				4.0	4.5	3.0	2.7	2.5	2.2	2.0
Overall score				4.50	4.28	3.45	3.22	3.06	2.85	2.64
Sugar paste with DDW (prototype)										
Appearance	0.1	Color, coloration intensity	1.0	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Total score by descriptor				4.2	4.2	4.2	4.2	4.2	4.2	4.2
Taste and smell	0.1		0.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
		Sweetnessbalance	0.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Total score by descriptor				4.7	4.7	4.7	4.7	4.7	4.7	4.7
Consistency	0.5	Homogeneity	0.3	5.0	4.9	4.8	4.6	4.4	4.2	4.0
		Fragility	0.3	5.0	4.8	4.6	4.4	4.2	4.1	4.0
		Density, Strength	0.2	5.0	4.9	4.8	4.6	4.4	4.2	4.0
		Softness	0.2	5.0	4.8	4.6	4.4	4.2	4.1	4.0
Total score by descriptor				5.00	4.85	4.70	4.50	4.30	4.15	4.00
Ability to form	0.3	Detection degree	1.0	5.0	4.8	4.7	4.6	4.5	4.4	4.3
Total score by descriptor				5.0	4.8	4.7	4.6	4.5	4.4	4.3
Overall score				4.92	4.78	4.68	4.55	4.42	4.31	4.21

According to the results of the study, there is a significant deterioration in the consistency of the control sample on day 10 of storage. The total score for this indicator is 3.3. The consistency is characterized as too dense, hard, brittle, heterogeneous,there are lumps. Accordingly, the molding ability, estimated at 3.45 points according to the developed descriptors, deteriorates. Thus, the control sample on day 10 of storage is technologically unsuitable, the content of the mass fraction of moisture is 4.0 %. At the same time, the prototype on day 30 of storage has acceptable sensory characteristics of consistency. The total score for this indicator is 4.0. The consistency is moderately hard and dense, softish, homogeneous, with barely perceptible small blotches. Molding ability is estimated at 4.3 points according to the developed descriptors. The mass fraction of moisture content in the prototype on day 30 of storage is 8.5 %.

It is evident that the developed sugar pastes have significant advantages over the traditional ones.

5. 2. Results of studying the changes in the fractional composition of solid phase particles and the dispersity of sugar pastes during storage

For a more complete assessment of the quality of sugar pastes, the particle size constituting their solid phase was investigated. The dispersity assessment was carried out using optical microscopy. The results of the study were recorded by micro photographing (Fig. 1).

In order to automate the calculation of the particle size of the solid phase of sugar pastes, the results of all prototypes were exported to a tabular processor. According to the results of our study, the curves of differential distribution of particles (crystals) of the solid phase of sugar pastes during storage were constructed (Fig. 2–5).

It was established that on day 1 of storage both in the control and in the prototype, the fractional composition of the particles of the solid phase (crystals) with a size of 10 to 20 μm prevails, the content of which is 85–95 %. The obtained data testify to the high quality of the pastes and characterize the structure as fine-crystalline (Fig. 2).

On day10 of storage in the control sample, the fractional composition of particles with a size of 21 to 30 μm prevails, the content of which is 62 %. This degrades the quality of pastes and characterizes the structure as coarsely crystalline, and therefore technologically unsuitable. In the prototype, there were no significant changes in the percentage of the fractional composition of the particles of the solid phase (Fig. 3).

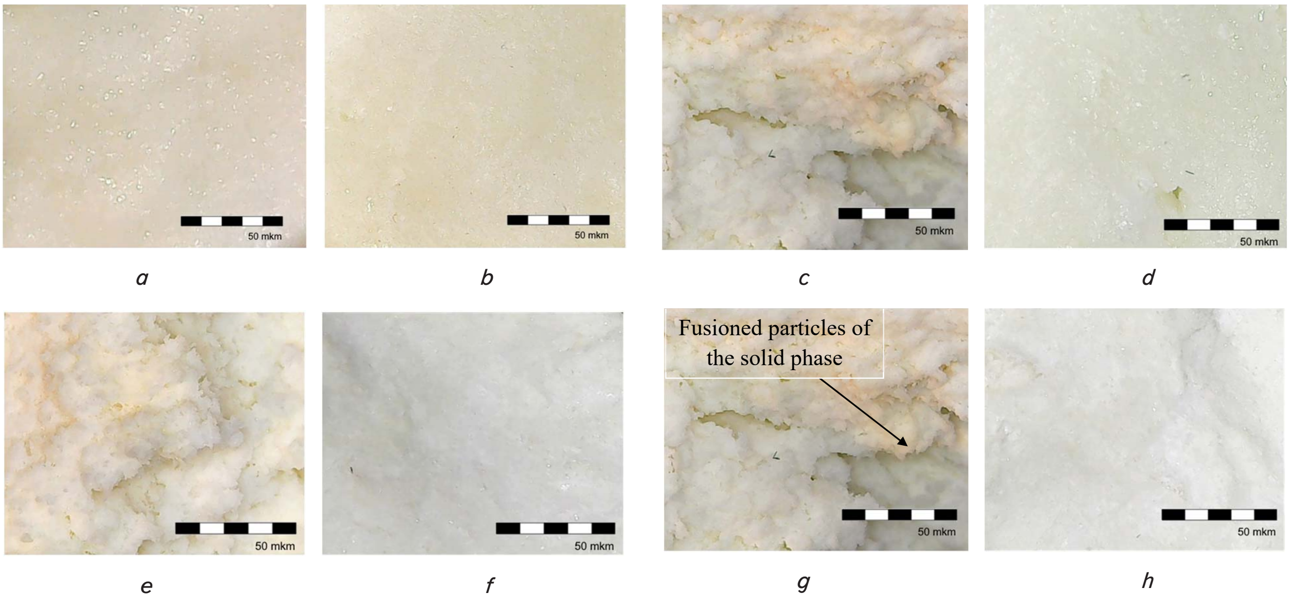

Fig. 1. Microstructure of sugar pastes (magnification, 600 times): on day 1 of storage:*a* – control; *b* – experiment; on day 10 of storage;*c* – control;*d* – experiment;on day 20 of storage;*e* – control*; f* – experiment;on day 30 of storage; *g* – control; *h* – experiment

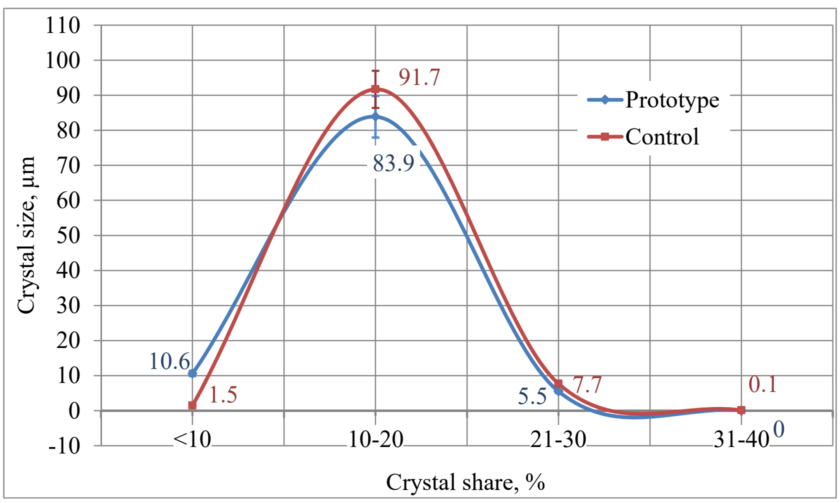

Fig. 2. Differential curves of the numerical distribution of particles (crystals) of the solid phase of sugar pastes on day 1 of storage, n=3, P≥0.95

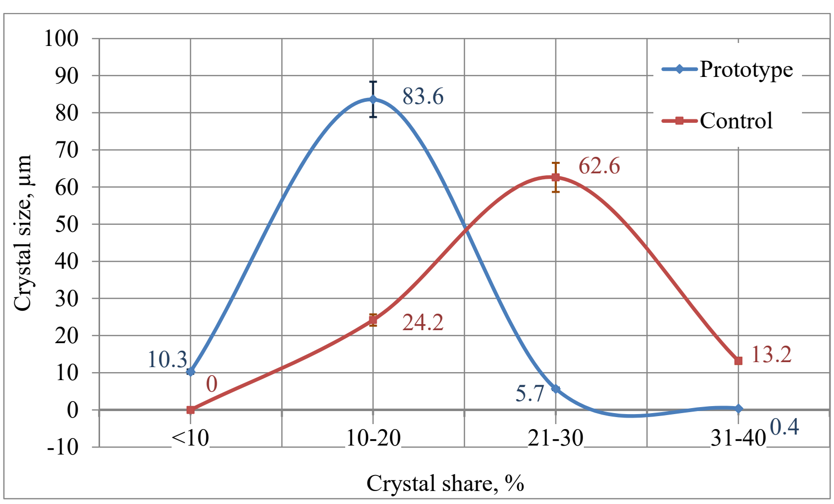

Fig. 3. Differential curves of the numerical distribution of particles (crystals) of the solid phase of sugar pastes on day10 of storage, n=3, P≥0.95

On day 20of storage in the experimental sample, the content of the fractional composition of particles with a size of 11 to 20 μm is reduced by 7 %, and, accordingly, the content of particles with a size of 21 to 30 μm increases. However, this does not have a significant impact on the quality of the developed pastes. In the control sample, respectively, particles with a size of 21 to 30 μm continue to increase, the content of which reached 51 % (Fig. 4).

On day 30 of storage of sugar pastes, in a prototype the particle content of 11 to 20 μm in size was 72 %, which preserves the quality of the paste and characterizes the structure as finely crystalline. In the control sample, the content of particles ranging in size from 31 to 40 μm reached 48 %, which characterizes the structure as heterogeneous, lumpy, coarse crystalline (Fig. 5).

According to the results of our study, the dynamics of the average particle sizes (crystals) of the solid phase of sugar pastes during storage were determined (Fig. 6).

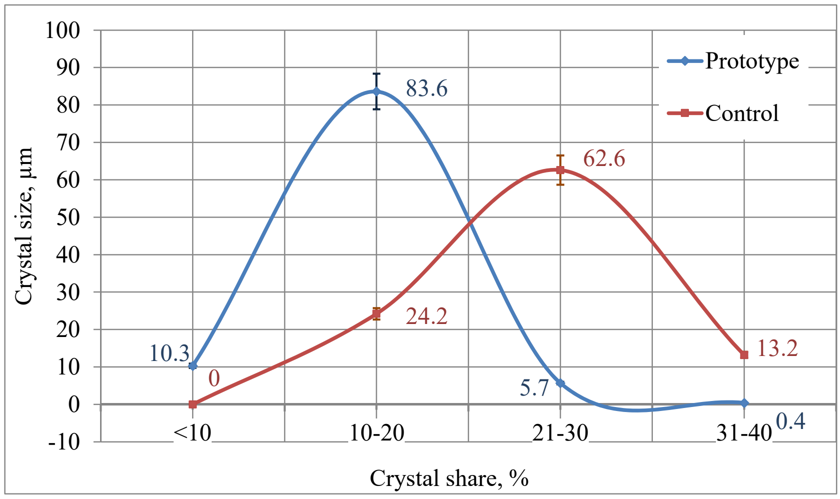

Fig. 4. Differential curves of the numerical distribution of particles (crystals) of the solid phase of sugar pastes on day 20of storage, n=3, $P \geq 0.95$

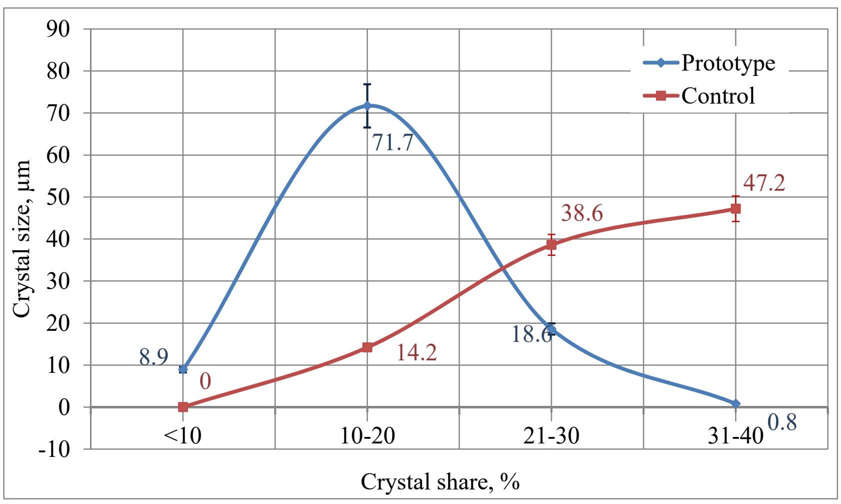

Fig. 5. Differential curves of the numerical distribution of particles (crystals) of the solid phase of sugar pastes on day 30 of storage, n=3, $P \geq 0.95$

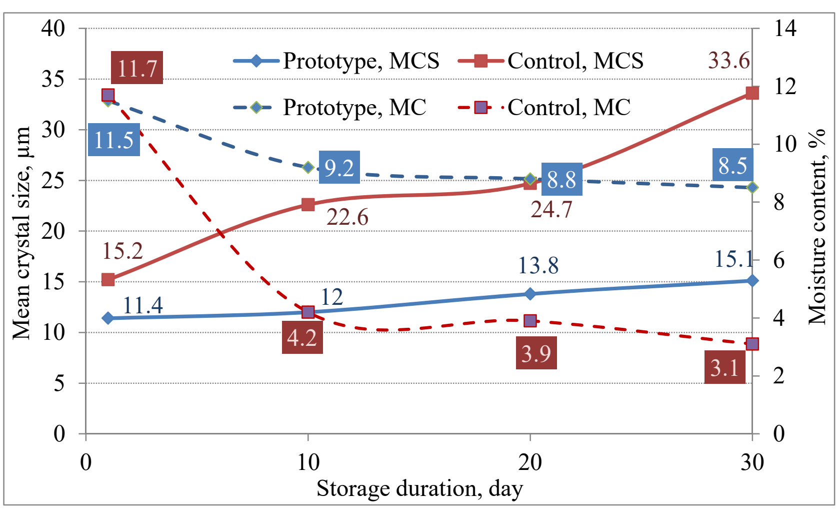

Fig. 6. Changes in the size of particles (crystals) of the solid phase of sugar pastes (average crystal sizes n=3, $P \geq 0.95$, moisture content n=5, $P \geq 0.95$)

The technological shelf life of the developed sugar pastes was 30 days, which is 3 times more than the control (Fig. 6).

6. Justification of the shelf life of sugar pastes with demineralized whey

The main problem of sugar pastes during storage is the loss of moisture, as a result of which the balance between the liquid and solid phases is disturbed. This contributes to the fusion of sucrose particles, as a result of which sugar pastes become brittle, lose plasticity and technological suitability.

In order to establish the terms of technological shelf life of the developed sugar pastes, changes in quality indicators during storage over 30 days were investigated. In particular, we investigated the change in the mass fraction of moisture, sensory characteristics, fractional composition, and dispersion of particles of the solid phase of sugar pastes.

According to the results of studying the changes in the quality indicators of sugar pastes during storage, it was found that on day 30 of storage the mass fraction of moisture in the control sample decreased by 80 %, in the experimental – by 30 % (Table 3). According to our studies of sensory characteristics, a significant deterioration in the consistency of the control sample on day 10 of storage was established. The total score for this indicator was 3.3, which, according to the developed descriptors, characterizes the consistency as too dense, hard, fragile, with the presence of lumps. Accordingly, this leads to a loss of molding ability, and therefore technological suitability (Table 4).

At the same time, the content of the mass fraction of moisture is 4.0 **%** (Table 3). According to the results of sensory studies, the prototype, even on day 30 of storage, in terms of consistency received a total score of 4.0. According to the developed descriptors, this characterizes the consistency as moderately hard and dense, homogeneous, soft; there are barely perceptible small blotches. There is a high formative ability, estimated at 4.3 points (Table 4). The content of the mass fraction of moisture is 8.5 % (Table 3). The total score on sensory characteristics on day 30 of storage in the control sample was 2.64 points, in the experimental – 4.21.In order to confirm the results of our studies of sensory characteristics, experimental studies were conducted on changes in the fractional composition of solid phase particles and the dispersion of sugar pastes during storage.

According to the results of the study, it was found that on day 10 of storage, in the control sample the fractional composition of solid phase particles with a size of 21 to 30 μm prevails, the content of which is 62 % (Fig. 3). This characterizes the structure as coarse-crystalline and significantly degrades the quality of the paste. At the same time, the developed sugar pastes, even on day 30 of storage, have acceptable characteristics. The fractional composition of solid phase particles with a size of 11 to 20 μm was 72 %, which preserves the quality of the paste and characterizes the structure as finely crystalline (Fig. 5). Accordingly, the results of the study (Fig. 6) have made it possible to establish a tendency to slow down the growth of solid phase particles of the developed sugar pastes, and their growth to a critical size (22.6 μm). Thatallowed us to establish the technological shelf life of the developed sugar pastes, which amounted to 30 days, which is 3 times more than the control.

The obtained results described above are all interrelated and have one explanation, which is justified by the change in the formulation composition of sugar pastes and the functional and technological properties of the formulation components. The developed sugar pastes, unlike traditional ones, contain demineralized whey (DDW) at a concentration of 50 % and glycerin at a concentration of 5 %. In the developed sugar pastes, the total protein content increases by 7 times, sucrose – decreases by 65 %, the lactose content is 30 **%** [13].

The functional and technological properties of the protein component of demineralized whey (DDW) have an impact not only on the consistency and structure of the finished product but also on the duration of storage. This is due to the ability of proteins to hydrate. Due to this property, proteins are characterized by a moisture-retaining ability, which makes it possible to retain the moisture content of the dispersion medium of sugar pastes, which for demineralized whey is 70 % [8, 9]. Lactose, which is a hygroscopic reducing substance, also prevents the rapid loss of moisture. Since lactose, compared to sucrose, is a reducing disaccharide, it has a free hemiacetal hydroxyl, which determines the reducing properties and contributes to the appropriate preservation of moisture [10, 11]. The moisture-retaining agent in the developed sugar pastes is also glycerin [16].

Accordingly, the use of demineralized whey (DDW) and glycerin in sugar paste technologies makes it possible not only to obtain finishing semi-finished products with the desired functional and technological properties but also extend their technological shelf life. This means that the obtained scientific result in the form of a kinetic description of the process of increasing particles of the solid phase of the developed sugar pastes is interesting from a theoretical point of view.From a practical point of view, the identified mechanism makes it possible to extend the technological shelf life of sugar pastes, which solves the problem set.

The disadvantage of studies into the quality of sugar pastes during storage is that they are carried out in natural conditions, at room temperature, which determines the appropriate restrictions. This, accordingly, does not take into consideration the effect of temperature on the consistency of sugar pastes during storage, which can be determined in the subsequent stages of the study.

7. Conclusions

1. Based on the results of studying the changes in the quality indicators of sugar pastes during storage, it was found that on day 30 of storage the mass fraction of moisture in the control sample decreased by 80 %, in the experimental – by 30 %. The total score on sensory characteristics in the control sample was 2.64 points, in the experimental – 4.21.

2. It was investigated that on day 30 of storage, in the control sample, the fractional composition of solid phase particles with a size of 31–40 μm prevails, which is 48 % and characterizes the structure as coarse crystalline. The experimental one is dominated by a fractional composition measuring 11–20 μm, which is 72 % and characterizes the structure as fine-crystalline.

The tendency of slowing down the growth of solid phase particles of the developed sugar pastes and their growth to a critical size (22.6 μm) has been established. The technological shelf life of the developed sugar pastes was 30 days, which is 3 times more than the control.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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