

The object of research is the technology of creamy-whipped sweets with the addition of fruit and berry paste. Its addition solves the problem of improving sugar masses, namely structural characteristics and physiological value (enrichment with non-starch polysaccharides, vitamin C, polyphenols, and organic acids). In addition, a positive effect is achieved by providing the products with original organoleptic properties without the use of synthetic dyes and flavors. The proposed fruit and berry paste is obtained at gentle temperatures, which allows preserving the biological potential of raw materials and is characterized by a strong structure with a dynamic viscosity of 498 Pa•s.

It was found that the introduction of fruit and berry paste in the amount of up to 10 % by weight of formulation raw materials improves the foaming ability of protein mass in the process of whipping. Increasing the paste content to 20 % leads to a slight deterioration in this indicator, but its value is at the level of control. The stability of the whipped protein mass increases evenly by increasing the dosage of the additive. The positive effect of fruit and berry paste on the quality indicators of finished creamy-whipped candy masses was noted. Samples with the additive give less shrinkage during the structuring process, its duration is reduced, and strength increases. It is recommended to add fruit and berry paste to creamy-whipped candy masses in the amount of 15 % of the total amount of formulation raw materials and at the same time reduce the formulation dosage of agar by 40 %. Such products acquire an original lilac color, a pleasant yogurt flavor, and the aroma of red currant. The nutrient composition of products is significantly improved – the content of non-starch polysaccharides increases by 2 times; the product is enriched with vitamin C and polyphenolic compounds that are absent in the control sample

Keywords: technology of creamy-whipped candy masses, fruit and berry paste, viscosity, pectin, vitamins, phytosterols

UDC 664.14:664.858

DOI: 10.15587/1729-4061.2023.279287

SUBSTANTIATING THE TECHNOLOGY OF CREAM-WHIPPED CANDY MASSES WITH THE ADDITION OF BERRY AND FRUIT PASTE

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Received date 06.03.2023

Accepted date 16.05.2023

Published date 30.05.2023

How to Cite: Zagorulko, A., Shydakova-Kameniuka, O., Kasabova, K., Zahorulko, A., Budnyk, N., Kholobtseva, I., Kolianovska, L.,

Shklyaiiev, O. (2023). Substantiating the technology of cream-whipped candy masses with the addition of berry and fruit paste.

Eastern-European Journal of Enterprise Technologies, 3 (11 (123)), 50–59. doi: <https://doi.org/10.15587/1729-4061.2023.279287>

1. Introduction

Current trends in the global confectionery industry are largely focused on improving product safety for consumer

health [1, 2] and its enrichment with physiologically useful nutrients [3, 4]. Significantly popular in the confectionery group is the so-called soft products [5], which, in particular, include products with a foam-like structure (marsh-

mallow, pastille, creamy-whipped sweets, sweets such as “soufflé”, etc.). One of the ways to increase the safety level of such products is removal from its composition of synthetic food additives responsible for the formation of the structure, give the necessary taste, color, provide the necessary shelf life, etc. To replace such technological additives, products of processing plant raw materials are increasingly used. The composition of such products includes pectins (act as structure-forming agents), polyphenols (able to prolong the storage time due to antioxidant and antimicrobial properties, perform the function of a dye), organic acids (provide a preservative effect), etc. [6]. In view of the above, fruit and berry raw materials containing such substances deserve considerable attention. The advantage of using this raw material is its complex effect on the properties of the final product. On the one hand, as mentioned above, it consists of substances capable of regulating the structural-mechanical, physical-chemical, and organoleptic characteristics of products throughout the entire technological cycle of their production and storage. On the other hand, such raw materials are a source of vitamins, minerals, and other compounds that are in it mainly in a form with high bioavailability. This leads to the enrichment of confectionery products with its use with physiologically useful nutrients. The main disadvantage of fruit and berry raw materials is seasonality, so it is usually used in the form of pastes, purée, juices, or powders. The disadvantage of such forms of fruit and berry raw materials is that the technologies for their production involve the use of sufficiently stringent technological regimes (high temperatures, the introduction of preservatives, etc.). As a result, there is a destruction of the proportion of useful nutrients (for example, vitamin C), a change in some functional properties (the use of high temperatures, a change in pH affect the color of polyphenols), as well as contamination with undesirable substances (preservatives). The authors of works [7, 8] devised techniques for obtaining multicomponent fruit and berry pastes, involving the use of gentle technological regimes during their manufacture. The uniqueness of such pastes is the selection of raw ingredients and their ratio in terms of optimal organoleptic characteristics and high content of physiologically functional substances.

Therefore, research into the development of soft confectionery, in particular creamy-whipped candy masses, using such a multicomponent fruit and berry paste, is relevant.

2. Literature review and problem statement

The formation of unique structural and mechanical properties of soft confectionery products with a foam-like structure is determined by the peculiarities of their technology. The first stage of the technology involves aeration of masses when the function of the foaming agent is performed mainly by protein [9]. At the second stage, the resulting foam mass is fixed to give it mechanical strength due to the introduction of gelatinous agents (agar, pectin, gelatin, etc.) [10]. The structure of such a mass has the form of a sponge, where the air cells are surrounded by sufficiently strong gel-like films. Films are cells that are formed by long and flexible gelatinizing molecules and filled with a concentrated aqueous solution of sugar, molasses, acid, and other components of the formulation. Thus, when using new raw ingredients in the technology of foam-like (whipped) confectionery masses (in particular, to improve their nutrient composition), it is nec-

essary to take into account the possible impact of the added additives on the structure of the finished product.

In view of this, the use of soft confectionery products with a foam-like structure of crop production in the technology is of considerable interest.

In [11], to improve the structural characteristics of creamy-whipped candy masses, it is proposed to use chia seeds. A feature of the technology is the use of whole chia seeds and in a crushed state. Whole seeds are applied at the stage of beating egg albumin, thus ensuring the stability of aeration of the mass. The crushed seed is introduced at the stage of preparation of the milk-fat mixture, which makes it possible to remove part of the fat component from the recipe and enrich the product with polyunsaturated fats.

High-tech is the use of plant materials in the technology of foam-like confectionery masses in the form of powders [12, 13]. The powdered state of the additives ensures the ease of their dosing, transportation, unpretentiousness during storage. In [14], the use of fruit and berry powders in the manufacture of whipped candy masses is recommended. It is noted that in the case of their dosage in an amount of up to 17 %, the structure of products improves. Suggestions for the use of artichoke powder [15] and Matcha green tea powder in whipped sweets [16] are given. The positive effect of plant-derived powders on foaming processes is due to the presence in their composition of high-molecular compounds (pectins), acting as stabilizers of the structure. It is also known that highly dispersed powders can act as solid stabilizers of dispersed systems. Particles of powders are wetted in different areas of the surface corresponding phase of the dispersed system, concentrate on the surface of the partition and protect air bubbles from destruction by the so-called armor shells [17]. In addition, the low humidity of powders and their high moisture retention capacity prevent staling of products during storage. The main problem of using vegetable raw materials in the form of powders is due to the difficulty of obtaining them in a fine state. Usually, the particle size of powders is more than 150 microns, which can be felt organoleptically in the finished product.

There are recommendations for the use of enriching plant ingredients in the form of liquid extracts or juices in the manufacture of whipped confectionery masses. In particular, the authors of [18] propose to replace molasses with concentrated Jerusalem artichoke juice in the recipe of whipped sweets such as “soufflé”, which not only has a positive effect on the consistency of the product but also yields diabetic products. In [19], it is proposed to replace corn molasses in marshmallow technology with concentrated fruit juices (pomegranate, grape, and cherry). This could reduce the sugar content in the recipe, give the products original taste characteristics, provide coloring without the use of synthetic dyes. There are also recommendations for the use of barberry fruit extract as a natural dye in marshmallow technology [20], which also increases the antioxidant activity of products. The problem of using plant components in the form of liquids is their high humidity. Therefore, their introduction into some technologies of whipped products (in particular, cream-whipped candy masses) is possible in two ways: either in small quantities, which will give the products the desired color, but at the same time enrichment with useful nutrients will be minimal; or in physiologically significant amounts, but this will require boiling with syrup to the required solids content, which will entail thermal destruction of some valuable components (in particular, vitamin C).

It is promising to use plant-derived components in whipped confectionery masses in the form of puree or pastes, which makes it possible to concentrate valuable nutrients of raw material derivatives [21]. In this form, products of processing fruits, vegetables, and berries are mainly produced. A distinctive feature of such raw materials is a high content of pectins, which positively affect the processes of structure formation of whipped confectionery products. In particular, it is recommended during the manufacture of marshmallows at the stage of whipping the protein mass to introduce mashed feijoa (20 %) or kiwi (15 %) [22]. Also, replace up to 30 % of applesauce with *Chaenomeles* puree [23], completely replace applesauce with black currant puree with the addition of paste, powder, or basil extract [24].

Of considerable interest is the experience of using blended multicomponent pastes in the technology of pastilles. In [25], a paste based on apples, cranberries, and hawthorn (ratio 50:40:10) was developed, which is proposed to be used in marshmallow technology instead of 75 % applesauce. Peculiarities of paste production provide for its concentration under gentle temperature conditions, which makes it possible to obtain a product with a high solids content and the level of preservation of derivatives of useful nutrients. This provides a significant increase in the physiological value of the developed marshmallow compared to the traditional one.

One of the ways to preserve the introduced physiologically functional ingredients in confectionery products is the use of modern equipment for the preparation of whipped masses [26]. However, the cited studies are limited due to the fact that testing was carried out only for the marshmallow mass without taking into account the technological features of other confectionery masses.

The weakness of the studies analyzed above [14, 15, 22, 23] is that information is mainly provided on the use of mono additives, that is, products of processing of one type of plant raw materials, in whipped confectionery. This does not always make it possible to maximize the technological potential of raw materials. It is more expedient to use blended multicomponent pastes in the technology of whipped products, as proposed in [7, 8, 25]. The advantage of this paste is the optimized ratio of the initial components to balance the resulting product by chemical composition and the use of innovative approaches that make it possible to maximize the preservation of useful substances in the process of paste. The disadvantage of paste to be considered its development for a certain type of confectionery product and restrictions in colors, which requires adjusting the recipe of the paste itself. In addition, the main studies into the use of plant materials in the technology of whipped confectionery masses are focused on improving the technology of pastille masses. The issue of conducting such studies to improve the technology of creamy-whipped candy masses remains unresolved.

3. The aim and objectives of the study

The aim of this study is to substantiate the technology of creamy-whipped candy masses using fruit and berry paste based on apples, quinces, and black currants. This will improve their structural characteristics and physiological value (enrichment with non-starch polysaccharides, vitamin C, polyphenols, and organic acids). In addition, the problem of providing products with original organoleptic properties without the use of synthetic dyes and flavors is solved.

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

- to analyze the functional-technological and structural-mechanical properties of fruit and berry paste based on apples, quinces, and black currants;
- to investigate the influence of fruit and berry paste based on apples, quinces, and black currants on the quality indicators of semi-finished products for the manufacture of creamy-whipped candy masses (foaming ability and stability of whipped protein mass);
- to analyze the influence of fruit and berry paste on the quality of the finished candy masses (duration of structure formation, shrinkage, density, strength, organoleptic characteristics, and content of physiologically useful nutrients).

4. The study materials and methods

4.1. The object and hypothesis of the study

The object of research was the technology of creamy-whipped candy masses made with the addition of fruit and berry paste based on apples, quinces, and black currants, obtained under gentle technological regimes, which ensured maximum preservation of useful substances of derivative raw materials in it. The main hypothesis of the study is the possibility of obtaining creamy-whipped candy masses with consistently high structural and organoleptic properties. The introduction of the proposed fruit and berry paste could avoid the use of synthetic dyes and flavors in the manufacture of cream-whipped candy masses and would expand the range of sugar confectionery products of improved nutrient composition.

Experimental study was conducted at the research laboratories of the State Biotechnological University (Kharkiv, Ukraine).

4.2. Characteristics of study materials and description of procedures for preparing the study samples

The study materials:

- multicomponent fruit and berry paste obtained from apples, quinces, and black currants (40:50:10) by concentration in a rotary film evaporator at a temperature of 45...50 °C according to the technology described in [27];
- samples of whipped protein mass with different addition of fruit and berry paste;
- samples of structured creamy-whipped candy masses with different addition of fruit and berry paste.

The addition of fruit and berry paste was carried out during the whipping of egg albumin solution (obtaining whipped protein mass) in the amount of 5, 10, 15, and 20 % of the total amount of formulation raw materials. The preparation of the whipped protein mass was carried out according to the scheme shown in Fig. 1.

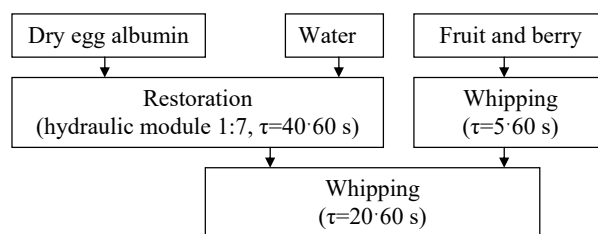


Fig. 1. Technological scheme for obtaining whipped protein mass

Samples of creamy-whipped candy masses (technology of sweets “Bird’s milk classic”) were chosen as control, which were made according to the schematic diagram below (Fig. 2).

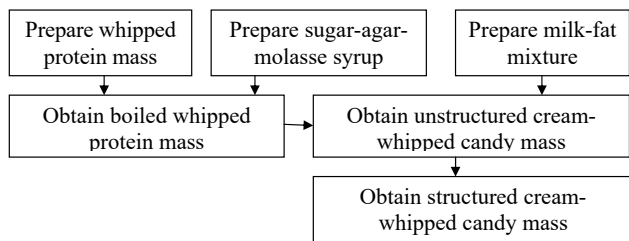


Fig. 2. Schematic diagram of obtaining creamy-whipped candy masses

For structuring, samples of creamy-whipped candy masses were poured into 40 ml chemical cups and kept for 60 minutes at a temperature of 19...21 °C.

4. 3. Methods of investigation of properties of fruit and berry pastes and cream-whipped sweets

Structural and mechanical characteristics of fruit and berry puree and pastes were determined on a rotary viscometer (Germany).

The foaming capacity of protein mass was calculated (in %) as the ratio of the volume of foam formed during whipping paste with egg albumin solution to the initial volume of albumin solution (Barilko-Pikielka procedure [28]). The stability of the whipped protein mass was calculated (in %) as the ratio of the volume of whipped mass after storage for 60 minutes to its initial volume.

The determination of the sample density of structured cream-whipped masses (finished product) was calculated (in kg/m³) as the ratio of the mass of the sample to its volume. The strength of such samples was established using the Valenta device by load (in grams) at which the structure is destroyed. The shrinkage of samples during structuring was calculated (in %) as the ratio of mass volumes after and before structuring.

The mass fraction of vitamin C was determined by the titrimetric method [29], the total content of dietary fiber – by the enzymatic method, the content of pectin substances – by the calcium-pectate method [30]. The determination of anthocyanins and catechins was carried out by spectrophotometric method [31], organic acids – by titration [32], phytosterols – by gas chromatography [33].

Evaluation of organoleptic characteristics of the studied samples was carried out by expert method with the involvement of 5 specialists from the State Biotechnological University (Kharkiv, Ukraine).

Statistical processing of research results was carried out for a series of parallel measurements (n=4–5, p<0.05).

The standard MS Office software packages were used for calculation.

5. Results of research into the properties of fruit and berry pastes and creamy-whipped sweets

5. 1. Determination of chemical composition and structural and mechanical properties of fruit and berry paste

A study of structural and mechanical characteristics of puree and pastes made from apples, quinces, and black currants was carried out. The particle size of the obtained puree was controlled at the rubbing stage within 0.3...0.5 m. The dependence of effective viscosity on the shear rate of puree and pastes (Fig. 3) made according to the recipe (apple 40 %; quince 50 %; black currant 10 %) was established. Apple puree (CP=11 %) and paste (CP=30 %) were chosen as the control sample. The viscosity (Pa·s) at the beginning of the application of shear force for apple puree (CP=11 %) and pureed prototype (CP=16 %) is 64 and 257, respectively. After boiling to a solids content of 30 %, apple paste (control) and prototype had the viscosity of 162 and 498, respectively. The chemical composition of the paste prototype was determined compared to control (Table 1).

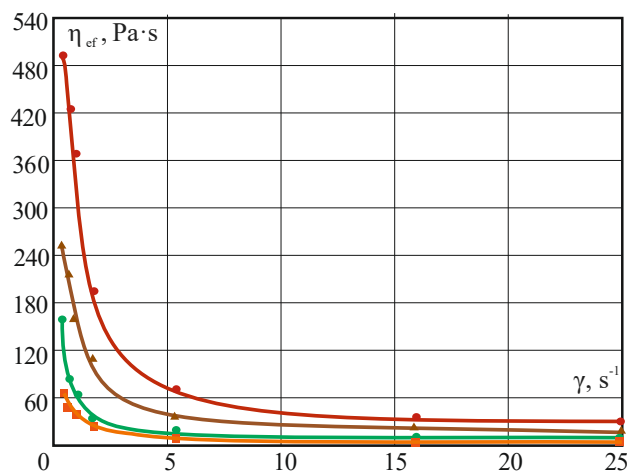


Fig. 3. Structural and mechanical properties at t=20 °C: ■ – applesauce (CP=11 %); ● – apple paste (CP=30 %); ▲ – puree (CP=16 %); ● – paste (CP=30 %)

It was found that the prototype of fruit and berry paste compared to the control (apple paste) contains more: 2.2 times non-starch polysaccharides; 3 times organic acids, 4.4 times vitamin C, 1.4 times catechins, and 2.6 times phytosterols. In addition, the proposed paste contains anthocyanins in the amount of 225.00 mg/100 g.

Table 1

Chemical composition of fruit and berry paste compared to control sample (n=4, P≥0.95, σ=4...4,2 %)

Paste	Substance content					
	Non-starch polysaccharides, %	Organic acids recalculated for malic acid, %	Vitamin C, mg/100 g	Anthocyanins, mg/100 g	Catechins, mg/100 g	Phytosterols, mg/100 g
Apple	1.69	0.55	8.00	–	68.90	12.00
Prototype	3.65	1.68	36.80	225.00	95.70	31.53

5.2. Results of investigating the effect of fruit and berry paste on the quality of whipped protein masses

The preparation of whipped protein masses was carried out according to the procedure described in chapter 4.2 (Fig. 1). The quality of whipped protein masses was assessed in terms of foaming capacity and foam stability. The arithmetic mean results of research are shown in Fig. 4. The relative error of measurements did not exceed 3.7 % (for $n=5$).

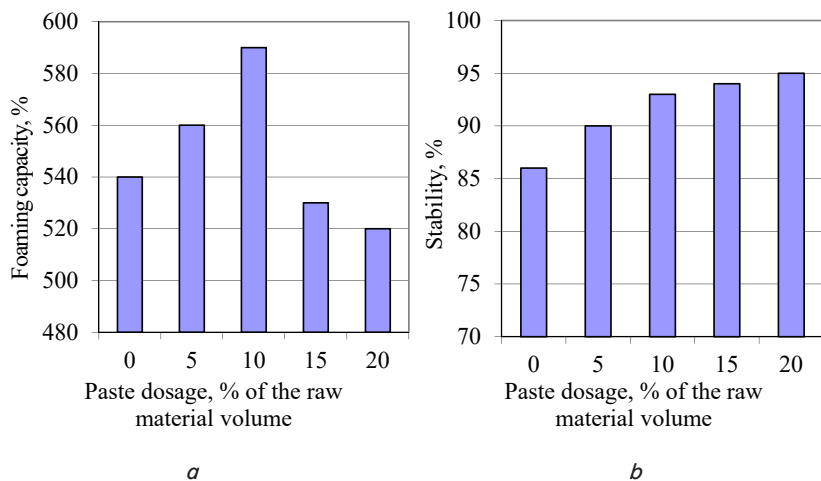


Fig. 4. Characteristics of whipped protein mass with the addition of fruit and berry paste: *a* – foaming capacity; *b* – stability

It was established that the maximum foaming capacity is inherent in the sample with the addition of 10 % paste. According to the value of this indicator, it exceeds the control by 9.3 %. When the dosage of the additive is increased to 15 and 20 %, the foaming capacity of the test system is sharply reduced – by 10.2 and 11.9 %, respectively, compared to a system with 10 % of the additive. It can be said that these samples are at the level of control in terms of foaming ability – the difference is 1.9 and 3.7 %, which is within the relative error of the experiment.

It was revealed that by increasing the dosage of the paste, the stability of the whipped protein mass increases. In particular, the stability of a sample with a 15 % additive is higher than that of a control by 9.3 %, and a sample with 20 % – by 10.5 %.

5.3. Results of investigating the influence of fruit and berry paste on the quality of creamy-whipped candy masses

The preparation of creamy-whipped candy mass involved boiling the whipped protein mass (with different contents of fruit and berry paste) with sugar-agar-molasses syrup and whipping the resulting mixture with the milk-fat component. The quality of the mass

was assessed by the duration of its structure formation and the percentage of shrinkage during structure formation (Table 2), as well as by indicators of density and strength (Fig. 5).

It was established (Table 2) that when the dosage of paste was increased to 20 %, the duration of mass structure formation was reduced by 23 minutes. Also, samples with an additive give less shrinkage during the structuring process. In particular, the shrinkage of masses from 15 and 20 % paste is less than in the sample without additives, by 12.1 and 18.2 %, respectively.

Table 2
Influence of fruit and berry paste on the quality indicators of creamy-whipped candy masses ($n=5, P \geq 0.95, \sigma = 3...4 \%$)

Quality indicator	Dosage of fruit and berry paste, % of the total amount of formulation raw materials				
	0	5	10	15	20
Duration of structure formation, $\times 60$ s	90	86	81	79	67
Mass shrinkage, %	3.3	3.2	3.1	2.9	2.7

A sample of creamy-whipped candy mass with the addition of 10 % fruit and berry paste is characterized by the lowest density – 4.2 % less compared to the control (Fig. 5, dependence 1). An increase in

paste content causes an increase in the mass density with a paste content of 15 and 20 % to 595 and 600 kg/m^3 , which corresponds to the level of the control sample.

A sample of creamy-whipped candy mass with the addition of 10 % fruit and berry paste is characterized by the lowest density – 4.2 % less compared to the control (Fig. 5, dependence 1). An increase in paste content causes an increase in the mass density with a paste content of 15 and 20 % to 595 and 600 kg/m^3 , which corresponds to the level of the control sample.

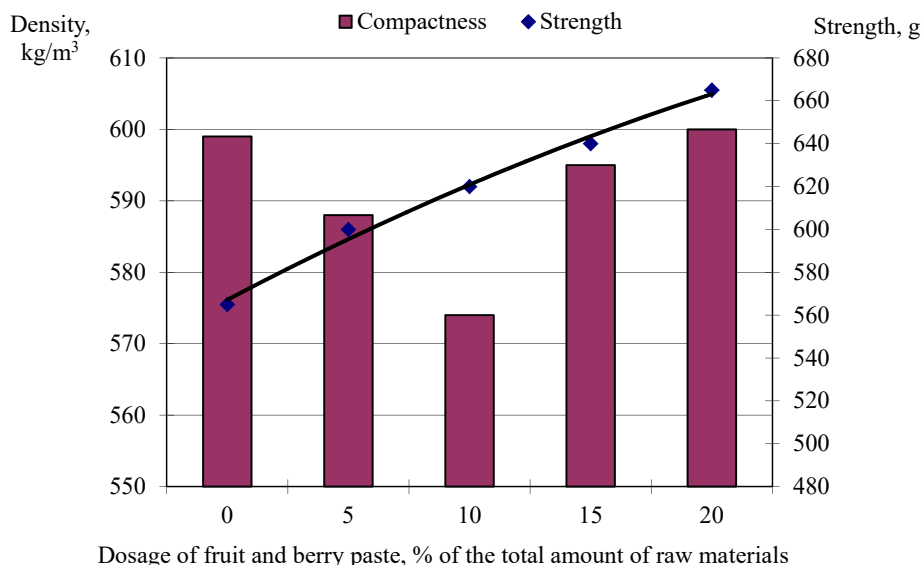


Fig. 5. The effect of fruit and berry paste on the density and strength of creamy-whipped candy mass

It was established that the introduction of pastes contributes to the increase in the strength of creamy-whipped candy masses (Fig. 5, dependence 2). In particular, the weight strength with the addition of 20 % paste is 665 g, which is 17.7 % higher than the strength of the control sample.

Increasing the strength of the studied systems is the basis for reducing the formulation amount of gelatinous agent.

The possibility of reducing the formulation amount of agar by 10–40 % was investigated. Arithmetic mean research results are shown in Fig. 6. The relative error of measurements did not exceed 3.9 % (for $n=4$).

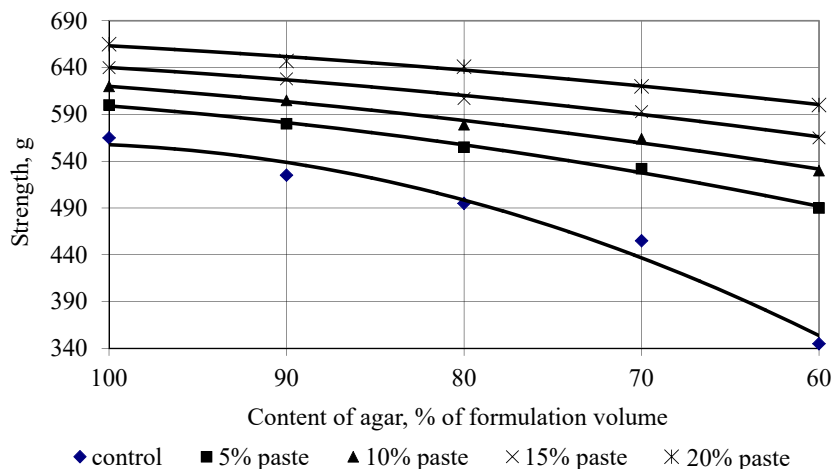


Fig. 6. The effect of the amount of gelatinous agent on the strength of creamy-whipped candy masses with different dosages of fruit and berry paste

It was found that in case of reduction of the formulation amount of agar, the strength of all samples of creamy-whipped candy masses decreases unequally. The most pronounced is a decrease in the strength of the control sample – by 38.9 % when 40 % agar is removed from the formulation. For masses with the same dosage of agar and the addition of fruit and berry paste, the reduction in the strength index is: 18.3 % for a sample with 5 % paste, 14.5 % – with 10 %, 11.7 % – with 15 % and 9.8 % – with 20 % additive.

In view of the results shown in Fig. 6, we note the following. The introduction of 5 % paste to creamy-whipped candy masses will reduce the formulation dosage of

agar by almost 20 %, the introduction of 10 % paste – by 30 %, 15 % – by 40 %. These samples will have a strength index at the control level with 100 % formulation agar content. Taking into account the results obtained, samples of creamy-whipped candy masses with a certain reduction in the amount of agar were made and their organoleptic quality indicators were evaluated (Table 3).

It was established that with the introduction of fruit and berry paste, the color of the samples under study changes from pale pink to rich lilac. The taste and smell of the sample with 5 % paste almost do not differ from the control. Candy masses containing an additive of 10–20 % acquire a pleasant yogurt flavor and aroma, notes of red currant are felt. The structure of samples with paste content up to 15 % is lush, fine-porous. However, for a mass with the addition of 20 % of the additive, there is an acquisition of uncharacteristic ductility for such products, the consistency becomes rubber-like, more characteristic of sweets such as “nougat”, porosity is uneven, with large cavities. The taste of such a mass acquires excessive acid. Therefore, for the technology of creamy-whipped sweets, it is recommended to use fruit and berry paste in the amount of 15 % of the total amount of formulation raw materials and at the same time reduce the formulation dosage of agar by 40 %.

An analysis of changes in the content of some physiological and functional ingredients in the proposed creamy-whipped candy mass (with the addition of 15 % fruit and berry paste) compared to the control sample (Table 4) was carried out.

Table 3

Organoleptic quality indicators of creamy-whipped candy masses with the addition of fruit and berry paste and a decrease in agar content

Indicator	Dosage of fruit and berry paste, % of the total amount of formulation raw materials				
	0	5	10	15	20
Color	White	Pale pink	Pink	Lilac	Rich lilac
Structure	Fine-porous, lush, porosity uniform			Lush, there is a slight unevenness of porosity	Compacted, viscous, porosity uneven, with large cavities
Smell	Inherent in this product, expressed, without extraneous			With a slight aroma of red currant	
Taste	Inherent in the product, without extraneous		Inherent in the product, with a slight taste of black currant and pleasant sourness, yogurt		The taste of currants is enhanced, becomes excessively acidic

Table 4

Analysis of changes in the content of physiological and functional ingredients in creamy-whipped candy mass with the addition of 15 % fruit and berry paste compared to the control sample ($n=4$, $P \geq 0.95$, $\sigma=4...4,2$ %)

Sample of creamy-whipped candy mass	Substance content					
	Non-starch polysaccharides, %	Organic acids recalculated for malic acid, %	Vitamin C, mg/100 g	Anthocyanins, mg/100 g	Catechins, mg/100 g	Phytosterols, mg/100 g
control	0.43	0.15	0.01	0.00	0.00	0.00
15 % additive	0.86	0.40	5.56	34.06	14.42	4.71

It was found that the developed product, compared to the control, contains 2 times more non-starch polysaccharides and 2.7 times more organic acids. Also, the creamy-whipped candy mass with fruit and berry paste includes vitamin C, anthocyanins, and catechins in the amount of 5.56, 34.6, and 14.42 mg/100 g, respectively. In addition, the developed product contains phytosterols, 4.71 mg/100 g.

Some of these substances, in addition to the physiological role, are characterized by certain functional and technological properties (Table 5).

Pectins are structured into monomolecular layers on each side of the film that surrounds the air cells in the foam mass. This reduces the surface tension at the interface of the phase separation, slows down the decrease in the thickness of the films, they acquire high viscosity and strength. In addition, pectins are anionic polysaccharides that are capable of forming complexes with proteins. The formation of such complexes occurs due to the interaction of positively charged protein groups with negatively charged groups of the pectin molecule [38]. It is known that protein–anion

Table 5

Physiological and functional-technological properties of some substances in the composition of creamy-whipped candy mass with the addition of fruit and berry paste

Substance	Physiological role	Functional and technological properties
Pectins	Adsorbents of heavy metals and other toxic substances of food [34]	High moisture-retaining capacity→slowing down the processes of moisture loss by food products during storage→prolongation of shelf life
Organic acids	Improvement of digestive processes, suppression of the development of pathogenic microorganisms in the intestine, anti-inflammatory and antioxidant properties [35]	Antimicrobial and antioxidant properties→inhibition of microorganisms development and inhibition of fat oxidation in food products during storage→prolongation of shelf life
Polyphenols	antioxidant, antimicrobial and immunostimulating effects on the human body [36]	
Phytosterols	Reducing the absorption of cholesterol from food, absorption of cholesterol in the large intestine and the risk of stomach cancer [37]	Emulsifying and antioxidant properties→inhibition of microorganisms development and inhibition of fat oxidation in food products during storage→prolongation of shelf life

polysaccharide complexes have higher surface-active properties than an individual protein. Also, organic acids are introduced along with the paste, which in small quantities have a positive effect on the foaming process [28]. This is due to the fact that the pH of egg white is about 9.0 while the optimal pH value for maximum foaming properties is in the range of 5.8...6.5 [22]. Therefore, the introduction of fruit and berry paste in an amount of up to 10 % brings the pH of the protein mass closer to the optimal for the formation of foam.

Increasing the amount of paste to 15 and 20 % excessively reduces the pH of the system. As a result, the charge of the protein macromolecule changes, which affects its conformation and the interactions

6. Discussion of results of investigating the technology of creamy-whipped candy masses with the addition of fruit and berry paste

The components of fruit and berry raw materials for creating a paste were chosen by studying the content of vitamins, minerals, phytosterols, pectins, etc. for the presence of their maximum ratio during blending. The main attention was paid to the content of pectin substances, which will help strengthen the structure of the resulting semi-finished product and, accordingly, creamy-whipped candy masses. The main raw materials are quince and apple; black currants are chosen for a beautiful color paste. Useful substances available in the selected raw materials will provide semi-finished products and products with their addition of immunomodulatory action, and the presence of phytosterols will contribute to the cholesterol-destroying effect. The rheological properties of fruit and berry paste indicate a strengthening of its structure compared to the control by 3 times (Fig. 3). This increase in effective viscosity is due to the presence of more pectins. The determined indicators of the chemical composition of the proposed paste also show a greater content of all constituent indicators (Table 1): non-starch polysaccharides 3.65 %; organic acids recalculated for malic acid 1.68 %; vitamin C 36.80 mg/100 g; phytosterols, mg/100 g.

The improvement of the foaming capacity of protein masses with the addition of 10 % paste (Fig. 1, a) is explained by the presence in the additive of a significant amount of pectins (more than 3.5 %), which are surfactants.

that determine the equilibrium of the film surrounding the air cells in the foam mass [28]. As a result, the foaming capacity begins to decrease. The deterioration of foaming capacity can also be explained by the following. First, the surfactant content in the system increases excessively. As a result, the rate of diffusion of their molecules into the surface layer decreases, the surface tension increases, which leads to a deterioration in the foaming ability of such samples. Secondly, the paste contains a significant amount of sugars (about 8 %), which somewhat slow down the process of foaming. On the other hand, sugars increase the viscosity of the interfilm fluid, thus improving the stability of the whipped protein mass (Fig. 4, b) [39].

Due to the fact that the introduction of fruit and berry paste contributes to an increase in the stability of whipped protein masses, there is a decrease in the percentage of shrinkage of the creamy-whipped candy mass during the structuring process (Table 2).

The results of assessing the density of the finished candy masses (Fig. 5, dependence 1) correlate with the results obtained regarding the ability to foam during whipping of the protein mass (Fig. 4, a).

The reduction in the duration of structure formation of candy masses with an additive (Table 2) can be explained by an increase in the total amount of gelatin-forming substances in the system – pectin paste is added to the formulation agar. As a result, creamy-whipped candy masses with fruit and berry paste after structuring have a higher value of strength index (Fig. 5), compared to the mass without addi-

tives, which is the basis for reducing the amount of agar in the formulation.

The results of assessing the strength of creamy-whipped masses with a decrease of 10–40 % of the formulation amount of agar (Fig. 6) showed that the larger the dosage of the paste, the slower the decrease in strength. The different dynamics of reducing the strength of the test samples in case of reducing the dosage of agar can be explained by the synergism of the action of agar and pectin [40].

Organoleptic analysis of ready-made creamy-whipped candy masses (Table 3) showed that the sample with the addition of 20 % fruit and berry paste has a viscous rubber-like consistency, not characteristic of candy masses of this type. The excessively acidic taste of such a mass is explained by a significant proportion in the addition of organic acids and vitamin C, the source of which in the paste is black currant and quince. Therefore, it is recommended to add fruit and berry paste in the amount of 15 % of the total mass of formulation raw materials during the manufacture of creamy-whipped candy masses.

Our results indicate that the use of such an amount of additive will reduce the dosage of agar by 40 % and obtain products with original taste characteristics. Products acquire a pleasant lilac color and taste and aroma of black currant without the use of synthetic dyes and flavors. In addition, the finished product is characterized by a high content of physiologically useful nutrients (Table 4). In particular, it is characterized by the presence of pectin substances (0.86 %), organic acids (0.4 %), vitamin C (5.56 mg/100 g), and polyphenolic compounds (34.06 mg/100 g anthocyanins and 14.42 mg/100 g catechins). In addition, the developed product contains phytosterols 4.71 mg/100 g. Some of these substances, in addition to the physiological role, are characterized by certain functional and technological properties (Table 5).

The peculiarity of the proposed technology of creamy-whipped candy masses compared to existing ones is the use of fruit and berry paste in the amount of 15 % of the total mass of formulation raw materials. This makes it possible to intensify the process of making sweets while maintaining high quality products. In addition, the use of paste makes it possible to enrich the products with a number of useful substances and give original sensory properties without the use of dyes and flavors.

These data are limited exclusively to creamy-whipped candy masses since additional research is needed for other technologies and formulations.

The disadvantage of the above data is the use of fruit and berry paste with certain types of raw materials. The choice of other formulation components for paste will contribute to changes in the properties of semi-finished products and finished products. It is promising to model formulations from various raw materials for fruit and berry pastes with stable properties and content of useful components. One way is to use mathematical modeling of formulations to this end. In this case, difficulties may arise associated with the peculiarities of the parameters of the technological process and the available equipment for production.

Further development of research is to expand the range of pastes and confectionery products based on them to create “healthy products”.

In view of this, it is promising to continue research into determining the antioxidant activity of the developed products and assessing their quality during storage (microbiological and oxidative stability, drying processes).

7. Conclusions

1. The proposed fruit and berry paste obtained by concentration at gentle temperatures up to a CP content of 30 % is characterized by a strong structure with a dynamic viscosity of 498 Pa·s, which is 3 times more than that of the control (apple paste). In the paste, compared to the control, there are more non-starch polysaccharides, 3.65 % (2.2 times); vitamin C, 36.80 mg/100g (4.4 times); phytosterols, 31,53 mg/100g (2,6 times); anthocyanins, 225.00 mg/100g (not in control). Due to these properties, the proposed paste can be recommended as a semi-finished product of a high degree of readiness of immunomodulatory action for the production of various confectionery products.

2. It was found that the introduction of fruit and berry paste in the amount of up to 10 % by weight of formulation raw materials improves the foaming ability of protein mass in the process of whipping. Increasing the paste content to 20 % leads to a slight deterioration in this indicator, but its value is at the level of control. The stability of the whipped protein mass by increasing the dosage of the additive increases evenly.

3. A positive impact of fruit and berry paste on the quality indicators of finished creamy-whipped candy masses was noted. Samples with an additive give less shrinkage during the structuring process, the duration of structure formation is reduced, and their strength increases. It is recommended to add fruit and berry paste to creamy-whipped candy masses in the amount of 15 % of the total amount of formulation raw materials and at the same time reduce the formulation dosage of agar by 40 %. Such products acquire an original lilac color, a pleasant yogurt flavor, and the aroma of red currant. The nutrient composition of products is significantly improved – the content of non-starch polysaccharides increases by 2 times; the product is enriched with vitamin C and polyphenolic compounds that are absent in the control sample. The developed technology makes it possible to obtain a product with original organoleptic characteristics without the use of synthetic dyes and flavors.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

Funding

The work was carried out within the state budget theme No 4-22-23 BO “Innovative technologies for the preservation and processing of plant raw materials into safe special-purpose products”.

Data availability

All data are available in the main text of the manuscript.

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