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IMPROVING THE MARMALADE TECHNOLOGY BY ADDING A MULTICOMPONENT FRUIT-AND-BERRY PASTE

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The necessity to optimize the nutritional value of marmalade by using physiologically functional ingredients containing vitamins, dietary fiber, minerals, and other useful substances in its composition has been substantiated. Specifically, using the multicomponent fruit-and-berry paste from apples, quince, black currant has been proposed, which is obtained by an improved technique. The technique is characterized by the rapid dehydration (30...45 s, at 50 °C) of the blended paste in a rotor plant to 28...30 % of dry matter. When studying the dependences of the effective viscosity of paste compositions on the shear rate, it was found that the paste that demonstrated the best indicators contained apple in the amount of 40 %; quince – 50 %; black currant – 10 %.

It has been experimentally proven that the rational amount of fruit-and-berry paste is 30 % with a decrease in agar by 30 %. This makes it possible to obtain the jelly-fruit marmalade on agar with a mass fraction of moisture of 18 %, a total acidity of 10 degrees, and a mass fraction of reducing substances not more than 28 %. The products have a sweet-sour taste, with a pleasant aftertaste and the smell of black currant, rich purple color, jelly-like form, and non-tight consistency. The strength of the new samples of marmalade with a decrease in the amount of agar is 18.9 kPa, similar to that of control.

The improved technology makes it possible to expand the range of "healthy products", which is achieved by the partial replacement of raw materials with a fruit-and-berry paste, which contains a significant number of physiologically functional components. This allows for an increase in the nutritional value of marmalade, as well as a decrease in the formulation amount of agar, which is expensive, by 30 %.

In addition, gentle concentration modes improve the process of paste making

Keywords: fruit-and-jelly marmalade, fruit-and-berry paste, structural and mechanical properties, physiologically functional components, quality indicators, gelation

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1. Introduction

The current trend in the developed countries of the world is the formation of a healthy eating system, which necessitates the creation of modern confectionery products with high content of nutrients, low sugar content, and high-quality indicators. Creating such a range of confectionery products could shift the emphasis from the group of "risk" to the group of functional products for healthy eating. This confirms the feasibility of developing technologies to produce confectionery products with the introduction of plant-based raw materials that, as a consequence, would increase its nutritional value and would not affect the change in the quality of product characteristics.

Daily consumption of fruits and berries in the diet is an effective way to improve the nutritional status of humans because the body is provided with dietary fiber, vitamins, minerals, polyphenols, and other essential components.

Adjusting the chemical composition of products towards increasing nutrients has a beneficial effect on all systems of the human body. The limiting factor of fresh fruits and berries is seasonality and short shelf life. Therefore, most fruits and berries are not eaten in their natural form but in the processed form (frozen, dried, cooked, etc.) [1, 2]. Such treatment reduces the nutritional value of the products, the loss of the original taste and aroma. Therefore, the use of low-temperature processing helps preserve the natural properties of berries and fruits.

During the production of pastille-marmalade products, in particular marmalade, according to traditional technology, jelling agents and a large amount of sugar are used [3]. The products have a low content of vitamins, micro-, macronutrients, and contain synthetic flavoring ingredients [4].

To increase the nutritional value of the products, fruit and berry raw materials (purees, stews, supplies, juices, etc.) are added to the recipe. However, the shortcoming is the use of long-term heat treatment at high temperatures, which also contributes to nutrient loss.

Thus, the development of the production technology for jelly-and-fruit marmalade, enriched with physiologically functional ingredients, is relevant and timely. This can be achieved through the use of raw materials and semi-finished products that are treated under gentle temperature conditions.

2. Literature review and problem statement

Modern changes in the food structure have necessitated the production of confectionery products based on fruit, in particular, pastille and marmalade groups. Current changes in the structure of food have predetermined the production of confectionery products based on fruit raw materials, in particular, pastille-marmalade group, marshmallows [5], and pastilles [6]. However, the cited studies were limited to the indicators of uniform raw materials for the manufacture of pastes. In addition, the range of finished products in the pastille-marmalade group needs to be expanded by improving the technology of marmalade, pat, etc.

Currently, an important area of creating products with high nutritional value is the use of various additives based on natural plant-based raw materials: fruit, vegetable, and fruit-and-vegetable.

In order to increase the content of physiologically functional ingredients and provide attractive sensory characteristics of marmalade, various types of local vegetable raw materials are used. Thus, the use of black plum in the marmalade technology provides good organoleptic quality indicators [7]. However, questions remain regarding the improvement of the structural and mechanical properties of the obtained marmalade mass. The authors of [8] proposed the use of rosehip meal obtained after extracting valuable oil by CO_2 extraction in marmalade technology. The shortcoming of this technique is the low organoleptic characteristics of product quality and its significant cost. Various types of citrus fruits are used in marmalade technologies, including orange, lime, tangerine, lemon, etc. Citrus fruits have a high nutritional value but the differences in their biochemical and morphological characteristics limit their use in the technology of products with a jelly structure given the lack of additional research [9]. The authors of [10] proposed the use of rambutan fruits in the production of marmalades, jams, jellies, canned fruits, juices. Recently, the food industry has paid attention to the fruits of prickly pear [11], which are a source of phytochemicals such as polyphenols, vitamins, polysaccharides. Fruit jelly from this raw material is a source of dietary fiber, which helps normalize the action of the intestine and contains compounds that exhibit antioxidant, anticancer, anti-atherosclerotic, and hepatoprotective properties. At the same time, these products have a limited volume of production and distribution due to the local nature of cultivation of these raw materials. In addition, the use of local plant-based raw materials to enrich products with useful nutrients without the use of synthetic flavors has clear advantages. Thus, it is proposed to use sea buckthorn puree [12] and red currant as natural dyes [13] for the production of marmalade to improve the chemical composition, organoleptic, and physical-chemical parameters of finished products.

Important aspects of the fruit-and-berry raw materials used are the safety indicators of the original plant raw materials [14] and innovative equipment for its processing [15].

Of considerable interest is the use of vegetable raw materials in the development of marmalade technology. This is due to the presence of a number of healthy substances contained in it, as well as the color stability of the finished products, which provide the available polyphenolic compounds [16]. The authors of [17] proposed the use of black carrots, the interest in which is due to the stability of the color of marmalade due to the high content of anthocyanins and other biologically active compounds. The use of tomato pomace [18] in the technology of sugar confectionery makes it possible to obtain high rheological characteristics of marmalade mass. In order to receive a functional product, the use of red beets has been proposed [19]. Its biologically active compounds, in particular polyphenols, flavonoids, and betanin, are well preserved during the processing of marmalade mass and are characterized by a higher level of bioavailability. However, questions about the taste and sugar content of marmalade products remain uncertain, necessitating the need to expand the range of the utilized raw materials towards the use of fruit raw materials.

In [20], the technology of jelly-fruit marmalade with the use of processed products from beets, cranberries, sea buckthorn is substantiated to increase the biological value. Their optimal amount in the marmalade recipe was determined: 100 % cranberry and 48 % sea buckthorn puree to the total weight of gelatin and beet juice. However, in terms of industrial production, obtaining such semi-finished products requires additional equipment, which complicates the technology of the target product.

The authors of [21] used fruit and vegetable additives (cryopastes and cryopowders from fruit and vegetable raw materials) to expand the range and increase the nutritional value of marmalade. However, the application of these additives is limited due to the complexity and high cost of obtaining them.

The authors of [22] developed a technique to produce fruit and berry marmalade with the addition of kelp in an amount of 5 %, which allows improving its quality and expanding the range. Worth noting is the technology of functional marmalade, the implementation of which employs dietary fiber preparations from apples, bamboo, and wheat [23]. The use of only isolated dietary fiber does not make it possible to comprehensively solve the issue of product enrichment with essential substances.

Along with the enrichment of the chemical composition with useful nutrients, it is important to ensure the stability of the structural and mechanical properties of products. It is known that a wide range of gelling agents is used as structuring agents in marmalade recipes, along with natural polysaccharides of fruit raw materials. Thus, the use of gelatin in different concentrations [24] allows obtaining marmalade with different structural and rheological properties to expand the range of products. The application of pectin [25] as a gelling agent has undeniable advantages for increasing the nutritional value. However, there are some technological difficulties associated with the formation of jelly masses, which depend on the amount of sugar, pectin, and acid in the recipe. The desire to increase the strength of pectin mesh leads to stronger products, which impairs their organoleptic quality.

The technology of jelly-and-fruit marmalade uses a combination of gelling agents, which consists of agar, k-carrageenan, H- and L-pectin [26]. This makes it possible to improve the rheological characteristics of the products and reduce their sugar content [27]. The use of jelly products of microbial polysaccharides such as xampan, polymixan, gelan in the technology is of interest [28]. Their application makes it possible to obtain products with reduced consumption of gelling agents, with stable structural and mechanical characteristics, as well as ensure their longer storage [29]. It is the gelling substances that have a high cost, which affects the cost of production, and, as a consequence, reduces its range and quality. Due to the use of fruit and berry raw materials, which contain a significant amount of pectin, it is possible to improve both the nutritional value and technological properties of products, as well as reduce their cost.

Specifically, gelling substances have a high cost, which affects the cost of production, and, therefore, leads to a decrease in its range and quality. Due to the use of fruit and berry raw materials, which contain a significant amount of pectin, it is possible to improve both the nutritional value and technological properties of products, as well as reduce their cost.

The main types of raw materials used in the production of marmalade include sugar, which is involved, on the one hand, in the formation of taste, and, on the other hand, affects the texture of products [30]. In addition, there is a relationship between the consumption of sugar and sweets with a high glycemic index and the risk of so-called "diseases of civilization" [31].

Therefore, changing the product recipe composition by partial or complete replacement of sugar is one of the strategies in a significant number of studies. The gradual decrease in sugar content in recipes has led to an interest in low-calorie foods. A range of sweeteners has recently appeared in the range of marmalade products [32].

Work [33] proposed a technique for making jelly-fruit marmalade on agar and fructose using sea buckthorn juice, which is formed by "injection" into a barrier film. The authors established a decrease in the plastic strength and effective viscosity of the products. They have pleasant organoleptic quality indicators and high content of minerals and vitamins. At the same time, the issues of forming the proper structure of products and the stability of their sensory and rheological properties during storage remain unresolved.

Thus, it is possible to state that marmalade is one of the most consumed and affordable confectionery. Much of the range of jelly marmalade in the market is characterized by a low content of nutrients. Therefore, the need to adjust the nutritional value of marmalade is a relevant task. Increasing the biological value of marmalade is possible by using physiologically functional ingredients containing vitamins, dietary fiber, minerals, as well as other nutrients in the composition. The source of these substances can be a multicomponent fruit and berry paste from apples, quinces, black currants, which is obtained by concentrating at gentle temperatures. The application of low processing temperature during concentration makes it possible to save all the nutrients of the starting raw materials.

3. The aim and objectives of the study

The study aims to improve the technology of marmalade with high nutritional value through the introduction of multicomponent fruit-and-berry paste. This will provide an opportunity to expand the range of plant-based supplements, which are a source of physiologically functional ingredients, for marmalade of high nutritional value.

To achieve the aim, the following tasks are set:

– to determine the functional-technological properties of the multicomponent fruit-and-berry paste from apples, quinces, and black currants;

– to establish the organoleptic, physical-chemical, and structural-mechanical indicators of marmalade quality when adding the multicomponent fruit-and-berry paste.

4. The study materials and methods

Apples (Antonivka variety), quince (Muscat variety), and black currants (Sofiyivska variety) were selected as the basic raw materials for the production of a multicomponent fruit-and-berry paste. These varieties have a high content of pectin. The structural and mechanical properties of apple, quince, and black currant puree, their blends of pastes with different percentages of raw materials, and the resulting marmalade with the addition of blends of fruit-and-berry pastes were determined. The structural and mechanical properties of the experimental samples were determined at the rotary viscometer "Reotest-2" (Germany). The mass fraction of dry matter in pastes was determined by a refractometric method, active acidity – by an electrometric method, the pectin content – by a calcium-pectate method, the content of low-molecular phenolic compounds was determined by a colorimetric method according to DSTU 4373:2005.

Black currant marmalade was chosen as a control sample [34].

The resulting organoleptic properties of the marmalade test samples were estimated by an expert board consisting of 5 employees from the Kharkiv State University of Food and Trade (Kharkiv, Ukraine) using a 5-point scale.

The mass fraction of moisture in marmalade was determined by a refractometric method, acidity – by a titrimetric method, the content of reducing substances – by a ferricyanide method, the shear stress – by using the penetrometer "Labor".

The value of error for all studies was s=3...5 %; the experiments were repeated n=5; the probability was p≥0.95. For data processing, we used the MS Office software package, including MS Excel (USA), as well as the standard Mathcad software package (USA).

5. Results of studying the quality indicators of the fruit-and-berry paste and marmalade during its introduction

5. 1. Determining the functional and technological properties of the multicomponent fruit-and-berry paste

Apples, quinces, and black currants in different quantities were used to prepare the fruit-and-berry paste. The rationale for the choice of such raw materials is based on the presence of pectin substances in it, which would create a jelly-forming effect, color compatibility of each type of fruit, as well as a significant content of important physiologically functional ingredients.

The compositions of the fruit-and-berry pastes made from apples, quinces, and black currants were prepared according to the recipes given in Table 1.

To make a puree of apples, quinces, and black currants, primary mechanical treatment was performed. To remove mechanical contaminants and stabilize polyphenols, quince fruits were kept in 9...10 % of NaCl solution at a temperature of 20...25 °C for 35...40 minutes. At the same time, 1.0 % citric acid was added to the NaCl solution for quince fruit treatment to inactivate enzymes. The apples and quince shredded on a crusher were alternately blanched by steam at a temperature of 100...110 °C. The duration of apple blanching is 3 minutes, quinces – 5 minutes. The blanching of black currants was performed with water at a temperature of 85...90 °C for 3 minutes.

Table 1

The content of components in the compositions of fruit-and-berry puree

Component	Composition		
	1	2	3
Apple	50	40	60
Quince	35	50	35
Black currant	15	10	5

After preliminary heat treatment, fruits and berries were ground to a particle size of 0.3...0.5 mm. The resulting pomace was sent for drying. The puree of apples, quinces, and black currants was blended according to the recipes given in Table 1.

The blended compositions of fruit-and-berry raw materials were concentrated in a rotary film plant to a dry matter content of 28...30 % for 30...45 s [6], provided that the puree is preheated to 48...50 °C.

When devising technologies for marmalade products, it is necessary to consider and control the structural and mechanical characteristics of raw materials, semi-finished products, and manufactured products. Therefore, we studied the change in the viscosity of pastes in the temperature range of 30...80 °C at the rotary viscometer "Reotest-2". The viscosity of the initial compositions of fruit and berry raw materials was determined by the degree of the destruction of the structure, which corresponds to the shear strain rate of 3 s^{-1}. The dependences of the viscosity of the fruit-and-berry puree on the temperature at a shear rate of 3 s^{-1} are shown in Fig. 1.

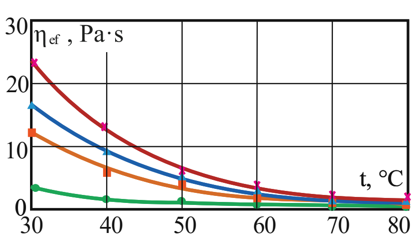

Fig. 1. Viscosity dependences (η_{ef}) of fruit-and-berry puree on temperature (t) at a shear rate 3 s^{-1}:
● – control (apple paste); ■ – composition 1;
✕ – composition 2; ▲ – composition 3

As the temperature increases, the viscosity of all puree samples in the range from 20 to 70 °C decreases approximately by 6 times and, at 70 °C, is 1.5...3.5 Pa·s.

To ensure maximum preservation of the raw material quality, the puree should be concentrated under a vacuum of 13...15 kPa at a temperature of 60...65 °C in the field of action of centrifugal forces with a rotor blade speed of 3 s^{-1}.

The dependences of the effective viscosity of fruit-and-berry paste compositions on the shear rate have been studied (Fig. 2). The obtained nature of the curves indicates that all samples belong to pseudoplastic, the viscosity of which is a property of the equilibrium state between the process of destruction and recovery. The derived dependences of pseudoplastic fluids are described by the following equation [35]:

$$\eta_{ef}=B\cdot\gamma^{-m}, \tag{1}$$

where B is the effective viscosity at a single value of the velocity gradient, Pa·s;

γ is the share rate, s^{-1};

m is the rate of structure destruction.

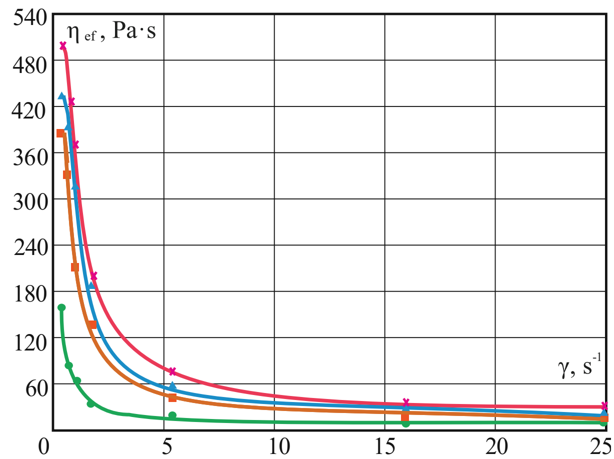

Fig. 2. Viscosity dependences of fruit-and-berry pastes on the shear rate at t=20 °C:
● – control (apple paste); ■ – composition 1;
✕ – composition 2; ▲ – composition 3

The maximum value of the effective viscosity η_{ef} (Pa·s) of the studied samples in the compositions: 1 – 388; 2 – 549; 3 – 507, and control – 160, respectively. These data indicate an increase in the effective viscosity indicator compared to control (apple paste), which is positive for strengthening the resulting structure. To identify the optimal formulation of the composition among the selected samples, their organoleptic evaluation was performed (Table 2).

According to the established organoleptic parameters, composition 3 differs by a barely felt smell and taste of black currant, pleasant quince; composition 1 has a more pronounced taste, and 2 – a pleasant harmonious taste.

The color of composition 3 is not as bright as that of 1 and 2. A larger proportion of black currants gives a specific sweet-sour taste while a reduced amount leads to a deterioration of the color scheme of the paste. Given the further use of paste in the marmalade technology, the best indicators are demonstrated by composition 2 with the following recipe ratio of components: apple – 40 %; quince – 50 %; black currant – 10 %, compared to compositions 1 and 3.

Table 2

Organoleptic evaluation of compositions of fruit-and-berry pastes

Indicator	Characteristics		
	Composition 1	Composition 2	Composition 3
Appearance	Homogeneous mashed puree without seeds and mashed skin particles		
Taste and smell	The pronounced smell and taste of black currants, pleasant quince, apple is almost not felt	Pleasant harmonious taste of quince and black currant, apple is almost not felt	Barely felt smell and taste of black currant, pleasant quince, apple is practically not felt
Color	Bright red-purple	Red-purple	Purple
Consistency	Pasty, easy to spread and mold		

The physical and chemical quality indicators of fruit-and-berry pastes are given in Table 3. The mass fraction of dry matter of all compositions is 30±1.15 %, and the active acidity is almost the same.

Table 3

Physical and chemical quality indicators of fruit-and-berry pastes (per 100 g of product)

Substance	Unit	Control, apple paste	Composition 1	Composition 2	Composition 3
Mass fraction of dry matter	%	30±1.15	30±1.15	30±1.15	30±1.15
Active acidity	–	3.2±0.15	2.96±0.15	3.05±0.15	3.11±0.15

Table 4 gives the characteristics of the content of the physiologically functional ingredients of the paste samples compared to the control.

It was found that the paste of composition 2, when compared with the control sample, has a higher content of pectin substances, by approximately 2 times, and ascorbic acid – 4.5 times (Table 4). The content of polyphenolic compounds in the fruit-and-berry paste (anthocyanins, catechins, and tannins) is superior to apple paste.

The resulting paste has a significant amount of physiologically functional ingredients and has better structural and mechanical characteristics, which allows it to be recommended for use in jelly-fruit marmalade.

5. 2. Determining the rational quantity of the developed multicomponent fruit-and-berry paste in the marmalade technology

Jelly-and-fruit marmalade "Black currant" was chosen as a control sample [34]. The recipe composition of this marmalade involves the introduction of the berry part – black currant additive, and, as a structuring agent – agar. We can assume a decrease in the recipe amount of agar due to the content in the multicomponent paste of not only black currants but also such fruit components as quince and apples. These fruits contain a significant amount of pectin, which is a well-known fact.

In the experimental studies, it is proposed to replace black currant additive with multicomponent fruit-and-berry paste in the amount of 10 %, 20 %, 30 %, or 40 % of the total weight. The paste was added to the finished sugar-molasses-agar syrup and the mixture was boiled to a dry matter content of 82.0 %.

To determine the rational amount of a multicomponent paste in the marmalade technology, the organoleptic and physical-chemical parameters (Table 5) and the strength of the samples at the limit shear stress were studied (Fig. 3).

It was found that in terms of the physical and chemical parameters, all samples meet the requirements of regulatory documentation for jelly-fruit marmalade on agar. Specifically: the mass fraction of moisture is within 15.0...24.0 %; total acidity, 7.5...22.5 degrees; the mass fraction of reducing substances is not more than 28.0 %. According to organoleptic parameters, the best samples were those with the addition of 20 and 30 % of the multicomponent fruit and berry paste.

These products had a sour-sweet taste, with a pleasant aftertaste and smell of black currants, rich purple color, jelly-like non-tight consistency, and the proper shape with a clear contour.

Fig. 3 shows that a marmalade sample with the addition of the multicomponent paste in the amount of 30 % has the highest value of shear strength. The strength indicator of this sample is 26.2 kPa, which exceeds the strength of the control sample (18.3 kPa) by almost 30 %. Therefore, it was considered appropriate to reduce the recipe amount of agar in the samples with the addition of 30 % of the paste. To this end, we determined the shear strength of the marmalade samples with a decrease in agar by 10...40 % (Fig. 4).

Table 4

Comparison of the content of the pastes' physiologically functional components (per 100 g of product)

Substance	Unit	Control, Apple paste	Composition 1	Composition 2	Composition 3
Pectin substances	%	1.76±0.02	3.28±0.03	3.51±0.03	3.37±0.03
Total sugars		8.1±0.20	7.5±0.20	7.9±0.20	7.6±0.20
Organic acids are converted per malic acid		0.52±0.01	1.75±0.05	1.68±0.05	1.53±0.05
Ascorbic acid	mg/100 g	8.03±0.11	37.3±0.02	36.8±0.02	34.7±0.02
Anthocyanins		–	232±2.50	226±2.50	215±2.50
Catechins		68.9±1.55	97.7±2.15	95.7±2.15	94.5±2.15
Tannins	%	0.05±0.01	0.45±0.01	0.61±0.01	0.37±0.01
β-carotene	mg/100 g	–	0.08±0.02	0.12±0.02	0.07±0.02

Table 5

The organoleptic and physical-chemical quality parameters of marmalade samples made from a fruit-and-berry paste

Parameter	Parameter characteristics (% of paste from the total mass of the system)				
	Control (marmalade «Black currant»)	10	20	30	40
Taste and smell	Inherent in this product, without foreign taste and smell	Inherent in this product, with a faint taste and smell of black currants	Inherent in this product, sweet-sour, with a pleasant taste and smell of black currants		Sour, with a pronounced taste and smell of apples and black currants
Color	Dark purple	Light purple	Purple	Intense purple	Dark purple with red
Consistency	Jelly-like, not tight				Jelly-like, brittle
Shape	Proper, with a clear outline				
Surface	Evenly sprinkled with white crystalline sugar, elastic				
Moisture mass fraction, %	18.0±0.9	18.0±0.9	18.0±0.9	18.0±0.9	18.0±0.9
Titrated acidity, degree	10.2±0.3	8.8±0.3	9.5±0.3	10.0±0.3	11.5±0.3
Mass fraction of reducing substances, %	10.0±0.2	10.7±0.2	11.3±0.2	11.1±0.2	12.0±0.2

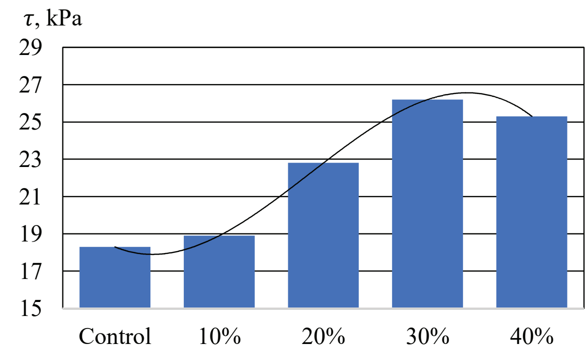

Fig. 3. Dependences of strength on the ultimate shear stress (τ) of marmalade samples: control; % of the introduced paste of the total weight of the system: 10; 20; 30; 40

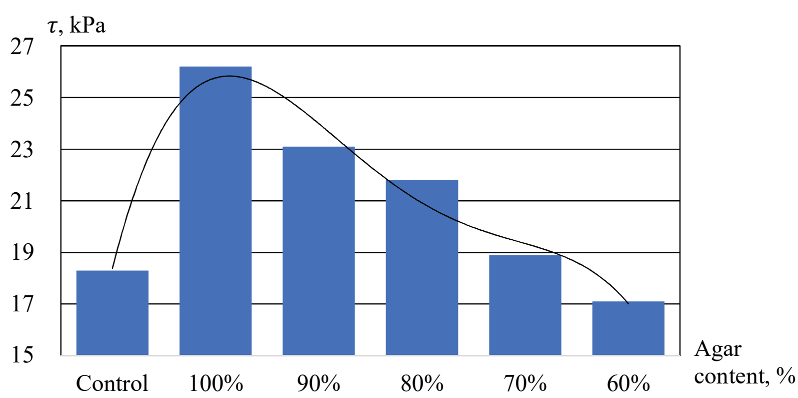

Fig. 4. Dependences of the marmalade samples' strength in terms of shear stress on the recipe amount of agar: control; with the addition of the multicomponent paste in the amount of 30 % of the total weight of the system containing the formulation amount of agar, %: 100, 90, 80, 70, 60

The strength dependence of the experimental samples of marmalade on the content of the recipe amount of agar was determined. Fig. 4 shows that the strength of the samples decreases with a decrease in the amount of agar. Thus, in the sample with the addition of 70 % of agar, i.e. with a decrease by 30 %, the strength is approximately at the level of the control sample and is 18.9 kPa. Further reduction of the amount of agar by 40 % is not advisable as the strength becomes less than that of the control sample.

It was found that the addition of 30 % of the multicomponent paste of apples, quinces, and black currants can reduce the formulation amount of agar by 30 %, without adversely affecting the organoleptic and physical-chemical parameters.

6. Discussion of results of the development of the multicomponent fruit-and-berry paste, its quality indicators, as well as marmalade containing it

A multicomponent fruit-and-berry paste has been developed, which includes apples of the Antonivka variety, quince of the Muscat variety, and black currants of the Sofiyivska variety. This composition is justified by the significant content of vitamins, macro-and microelements, and, especially, the high content of pectin. It is the presence of the latter in the plant-based raw materials that makes it possible to reduce the number of gelling agents in the recipe and significantly reduce the cost of the product.

The best ratio of the fruit and berry raw materials for the manufacture of a multicomponent paste was determined on the basis of the organoleptic characteristics, viscosity, and chemical formulation of the proposed compositions (Table 1). It was found that the viscosity of all paste samples at elevated temperatures in the range from 20 to 70 °C decreases approximately by 6 times and, at 70 °C, is 1.5...3.5 Pa·s (Fig. 1). Whereas the maximum value of the effective viscosity ηef (Pa·s) of the studied compositions is: 1 – 388; 2 – 549; 3 – 507; and control – 160, respectively (Fig. 2). Based on our research, the best ratio of the fruit and berry raw materials is demonstrated by composition 2 that contains 40 % apples, 50 % quince, and 10 % black currant. This multicomponent paste has a pleasant taste of quince and black currant, red-purple color, and the highest viscosity (Table 2). Also, this composition has the highest content of pectin – 3.51 %, tannins – 0.61 %, and β-carotene – 0.12±0.02 mg/100 g (Table 4).

The influence of the selected multicomponent paste on the quality of jelly-fruit marmalade on agar was determined. For this purpose, the paste was added to the finished sugar-molasses-agar syrup in the amount of 10...40 % instead of the black-currant additive specified in the recipe. The sample with the addition of 10 % of the paste has a light unsaturated color and almost imperceptible taste and smell of black currants while the sample with the addition of 40 % is too sour and dark in color (Ta ble 5). The addition of 20 and 30 % of the paste gives the products a pleasant sweet-sour taste and smell of black currants, as well as rich purple color. It was found that the marmalade with the addition of the multicomponent paste in the amount of 30 % has the highest value of the shear strength index – 26.2 kPa, which exceeds the control sample by almost 30 % (Fig. 3).

The resulting data (Fig. 3) indicated the expediency of reducing the recipe amount of the jelling agent in the finished products. Determining the shear strength of marmalade samples with a decrease of agar by 10...30 % showed that it is advisable to reduce agar by 30 % (Fig. 4). This makes it possible to bring the strength index, 18.9 kPa, to the value of this indicator in the control sample.

Thus, the improved technology of jelly-fruit marmalade on agar makes it possible to expand the range of "healthy products" and reduce the cost of the product by reducing the recipe amount of the jelling agent by adding a multicomponent fruit-and-berry paste.

It is planned to pay attention to determining the chemical composition and quality indicators of marmalade products during storage in future studies.

The technique of paste making is more energy-efficient than traditional due to the use of low temperatures of the concentration process. The use of non-traditional raw materials – quince in combination with other recipe components of the paste, makes it possible not only to expand the range of raw materials used but also involve all available plant-based resources.

Reducing the recipe amount of agar can reduce the cost of marmalade by up to 20 %. In addition, the use of a multicomponent fruit-and-berry paste makes it possible to expand the range of "healthy products".

A limitation of our research is the incomplete detection of the influence of temperature modes of processing at all stages of production of a fruit-and-berry paste. Namely, the establishment of quality indicators for the fruit and berry raw materials at all stages of production during their processing by the low-temperature method compared to traditional technique.

Our data on the marmalade strength when applying the paste form the preconditions for the development of dietary confectionery products with low sugar content. This determines the further area of research aimed at reducing the sugar content in pastille and marmalade products.

7. Conclusions

1. A composition of the multicomponent fruit-and-berry paste with the following recipe ratio of components has been developed: apple – 40 %; quince – 50 %; black currant – 10 %. Due to the short-term boiling of pastes for 30...45 s with preheating the puree to 48...50 °C, they demonstrate pleasant organoleptic quality indicators and high content of pectin, polyphenolic compounds, and ascorbic acid.

The selected paste composition has the highest indicator of effective viscosity compared to the apple paste and other compositions, which helps strengthen its structure and has a positive effect on the marmalade structure.

2. The rational amount of the developed fruit-and-berry paste was determined – 30 % with the exclusion from the recipe composition of jelly-fruit marmalade on agar of the black-currant additive. This quantity gives the products a pleasant taste and smell, rich purple color, as well as the physical-chemical quality indicators that meet the requirements of regulatory documentation for marmalade. Also, the addition of the paste can reduce the formulation amount of agar by 30 %; at the same time, the new samples of marmalade are characterized by a high value of strength, τ=18.9 kPa.

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