USE OF MULTICOMPONENT FRUIT AND BERRY PASTE IN THE TECHNOLOGY OF PASTILLES

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Abstract. Thanks to the wide assortment, excellent taste and bright appearance, confectionery products have become an integral part of the diet of a modern person. Along with this, these products are a source of easily digestible carbohydrates, the consumption of which in large quantities can contribute to the development of a number of diseases, in particular, weight gain, the occurrence of cardiovascular pathologies, and the like. It is very difficult and impractical to completely abandon sweets, because sugar is necessary for the brain to function, and other components of confectionery are effective and safe antidepressants. Therefore, a number of nutritionists are still advising to use a group of pastille-marmalade products (zefir, pastille, marmalade), since it is these sweets that have a lower energy value compared to cakes, chocolate and others.

Products such as marshmallows are obtained by whipping fruit and berry puree with sugar and egg white, followed by the addition of gelling agents. Food acids, essences, flavors, dyes, etc. are used as additives in the production of pastilles. The technology of these products uses fruit puree, most often sulphitized apple puree, which, during manufacture and storage, loses useful substances, which leads to the fact that the finished product has an insignificant content of vitamins, micro- and macroelements.

Therefore, it is possible to increase the content of functionally physiological nutrients by using blended fruit and berry paste obtained under gentle temperature conditions. This will give an attractive color and flavor to the pastille without the use of dyes and flavors.

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In this regard, the aim of the work is to improve the technology of pastille of increased nutritional value with the addition of multicomponent fruit and berry paste from apples, cranberries and blackberries. The new technology will expand the range of confectionery products with a high content of functionally physiological ingredients.

The structural and mechanical properties and quality indicators of multicomponent fruit and berry paste from apples, cranberries and blackberries have been studied. According to the results of determining the organoleptic and physicochemical quality indicators, it is established that the rational amount in the formulation of the pastille of multicomponent fruit and berry paste is 40% with the replacement of apple puree.

The changes that occur during storage of the pastille are set. Yes, there is less moisture loss in the pastille with the addition of the paste, which is due to the higher content of pectin in the products. An increase in shape-retaining properties and a decrease in adhesion have been determined, which will prevent them from sticking together during the entire shelf life.

The formulation and technological scheme of preparation of pastille products with multicomponent fruit and berry paste are developed, and also the complex indicator of quality of pastille with application of principles of qualimetry is defined.

The addition of a multicomponent fruit and berry paste to the recipe composition of the marshmallow increases the content of all biologically active substances in comparison with products without the addition of this paste. Thus, the content of low molecular weight polyphenolic compounds, vitamins, minerals increases, in particular the content of pectin increases 2.2 times, ascorbic acid is 4.2 times higher.

1. Introduction

Confectionery has significant advantages over other foods. They have a good pleasant taste and aroma, attractive appearance. It promotes digestion, better assimilation of these delicacies, in addition, sugar confectionery has a positive effect on the central nervous system, enhancing the efficiency of the whole organism.

The chemical composition of sugar confectionery is characterized by the predominance of mono- and disaccharides compared to other components. Also characteristic of the whole group of products is an

unbalanced content of substances, lack of dietary fiber, vitamins, micro- and macronutrients.

Pastilles, which are made on the basis of apple puree, pectin and other fruit and berry raw materials (zefir, pastille, marmalade, pat), are deficient or contain insignificant amounts of physiologically functional ingredients (vitamins, minerals, dietary fiber). This is due to the unstable quality of raw materials, the desire of manufacturers to reduce the cost of products by using improvers and structure-forming agents instead of traditional raw materials.

Therefore, the relevance of this topic is the improvement of existing technologies for the production of pastilles through the use of natural raw materials with a high content of physiologically functional ingredients. This will allow, on the one hand, to increase the nutritional value of products, and on the other hand, to reduce the cost of products by reducing the amount of gelling agents, since plant raw materials play a technological role in the formation of the structure of products. Such raw material can be a multicomponent paste from fruit and berry raw materials (apples, cranberries, blackberries) with a high content of physiologically functional ingredients, which is achieved by using low temperature processing modes (concentration).

2. Literature review

The group of pastilles includes confectionery products, which are obtained by whipping fruit and berry puree with sugar and egg white, followed by mixing the foam with a mixture of gelling agents. These products have a foam structure, which is stabilized by the structuring agent, as such use pectin, agar, gelatin and others. Organoleptic quality indicators and technological properties differ depending on the used hydrocolloid, final characteristics and type of confectionery.

To maintain good health, people should consume not only complete carbohydrates, proteins, fats, but also all the physiologically functional ingredients necessary for the successful functioning of the human body. Currently, the food industry is making extensive use of food fortification. This trend also applies to pastilles.

Alternative raw materials for pastille products have been developed. In [1, p. 14], glucose syrup was used to replace molasses with glucose.

The authors proved that replacement with glucose syrup has a positive effect on the viscosity, strength and organoleptic characteristics of finished products. The application of glucose syrup, which contains dextrins, leads to an increase in the viscosity of the gel-like mass. The results showed that the optimal dosage is the complete replacement of molasses and glucose with glucose syrup.

In [2, p. 40], research was conducted on the development of a new type of zefir of high nutritional value. As an additive, the use of pumpkin is proposed because it contains many physiologically functional ingredients – vitamins, minerals, macro-, micronutrients, fiber, in particular, pectin. According to the results of research, the authors found that with increasing the amount of pumpkin puree increases the density of products, they acquire a viscous consistency, while reducing the rate of moisture loss by 0.6… 0.8%. It is established that the optimal dosage is 30% of pumpkin puree to the weight of apple puree.

Known technology for the production of zefir in chocolate with beet powder as an additive. According to the results of research, the authors found that zefir have a pleasant pink color, taste and aroma. The chemical composition of beetroot powder allowed the authors to reduce the prescription amount of sugar in marshmallows. It has been determined that 100 g of this product contains the daily norm of dietary fiber, which makes it possible to increase the resistance of the human body to the negative effects of the environment and prevent a number of diseases such as diabetes mellitus, atherosclerosis, coronary heart disease, bowel disease, obesity [3, p. 31].

In work [4, p. 17], it is proposed to use a mixture of sweeteners (fructose, xylitol, sorbitol, isomalt) in the technology of zefir production. It was found that the joint use of sweeteners allows a synergistic effect in which the foaming capacity of the protein with the mixture is greater than when they are used separately. This combination of sweeteners gives the zefir a sweetness similar to that of sucrose. Thanks to the replacement of sugar in the zefir formulation with a sugar substitute, the authors obtained a unique therapeutic and prophylactic product. An improvement in physical and chemical quality indicators (moisture, density) and a decrease in the caloric content of the product have been established.

The trend of making confectionery products with reduced sugar content without deteriorating product quality is relevant. Thus, in [5, p. 270] studies

were conducted on the addition of dried acai powder (10.4 g / 100 g in dry form) to the finished product. According to certain organoleptic and physicochemical quality indicators, it is established that the addition of dried acai powder to sugar confectionery products based on isomalt and erythritol allows to obtain a product for consumers with diabetes.

The effect of betanin, which is obtained from molasses, which is a by-product during sugar beet processing, on the nutritional value, structure and shelf life of zefir has been studied. It is a biologically active supplement and can have a preventive effect on a number of body systems. The recommended daily intake of betanin is 3 g. Its effect on the organoleptic properties of zefir-pastille masses during addition in different amounts was studied. It is established that in the presence of betanin the accelerated process of moisture loss by products during storage takes place and changes of texture which are connected with loss of homogeneity of zefir mass are shown [6, p. 40].

In [7], biomodified products of oats and barley were developed, containing the following substances: fiber (9.44 and 4.63%), which has aerating properties; pectin (2.8 and 2.07%) and β-gucan (1.2 and 2.4%), which are surfactants; as well as proteins (9.37% and 9.35%). Replacement of 15% of sugar and pectin by biomodified products is proposed and the effect of this additive on physicochemical and structural-mechanical properties is studied. It was found that the plastic strength of zefir with the optimal dosage of biomodified products of oats and barley is higher by 45.3 and 43.2%. Marshmallows with additives have increased strength and decreased adhesion. As a result of research it was found that the introduction of biomodified products of oats and barley in zefir as a component that improves the structural and mechanical properties of products by replacing in the recipe pectin by 10%, sugar by 5% and egg white by 15% in terms of dry matter. Additives do not impair the physico-chemical and organoleptic quality of finished products.

Known formulation of pastilles using a mixture of polydextrose and fructose. Polydextrose is characterized by a low glycemic index, which does not affect blood glucose levels and is not absorbed. It is known that polydextrose stimulates the growth of bifidobacteria. The obtained results showed that the replacement of sugar by polydextrose and fructose in the formulation of pastilles expands the range of dietary and diabetic products. At the same time, there is

an improvement in structural-mechanical and organoleptic quality indicators. The resulting pastilles without excessive sweetness and viscosity and have a gel-like consistency that is easily broken [8, p. 36].

The authors [9, p. 24] developed a formulation for pastille with stevia extract and elamin. The use of elamin concentrate provides the body with macro- and microelements, is a means of prevention and treatment of goiter, due to the significant content of organically bound iodine. The use of elamin in the formulation of a new type of pastille is also due to the fact that it is a stabilizer of foams in the production of pastille products, a rational amount of which improves the consistency of pastille and is 0.45… 0.65%. The use of stevioside sweetener and aqueous stevia extract developed in the recipe pastille allowed to reduce the sugar content by 25…26% with simultaneous prevention of iodine deficiency.

It is proposed to develop a recipe for pastille products using non-traditional raw materials by modeling a recipe with full or partial replacement of sugar with simultaneous fortification of products with iodine [10, pp. 79–80].

Developed a pastille using banana puree, flax seeds and yogurt with prebiotics. The use of this method is that the resulting product is a confectionery product without the use of white crystalline sugar, enriched with prebiotic cultures of lactic acid bacteria of yogurt, proteins of plant origin and with improved organoleptic characteristics. Yogurt is a fermented milk product of therapeutic and prophylactic value, useful for human health. Banana puree contains proteins, fats and carbohydrates in the amount of 1.5, 0.5 and 21.0%, respectively. In addition, banana puree is a natural thickener, which allows you to use it as a gelling agent and stabilizer. Flax seeds contain proteins, fats and carbohydrates in the amount of 33.0, 38.0 and 4.5%, respectively. The high protein content in it allows you to use flax seeds as a foaming agent. Flax seeds contain water-soluble fiber, which is able to protect the walls of the stomach and all parts of the intestine from irritation.

Known pastilles technology with yacon tubers. The proposed method uses yacon tubers instead of apple puree, which allows the product to be used by people with diabetes. Yacon has the ability to accumulate in the tubers a large amount of inulin – a natural polysaccharide, which is 95% fructose. This important property allows you to recommend it as a dietary product, including people with diabetes and obesity.

Formulations of whipped products with non-traditional protein and carbohydrate components are developed: dietary zefir on the basis of Jerusalem artichoke puree and sugar substitutes; whipped confectionery based on soy and modified soy products, namely pastilles, Turkish delight and zefir containing probiotic bacteria. Creation of functional confectionery products, including probiotic component, is a new and promising direction in improving the structure of functional nutrition [11, p. 66].

Whipped confectionery successfully combines those nutrients that reduce the body's intake of radionuclides and increase the body's resistance to radiation. These include pectins, other substances that bind radionuclides and prevent them from being absorbed in the gut; potassium and calcium salts, which are antagonists of radioactive cesium and strontium; bioflavonoids that increase the body's resistance. The use of grain bioadditives in the composition of whipped confectionery products, containing cultures of bacteria – probiotics, enhances their functional properties.

Dietary fiber and polysaccharides of prescription components (apple puree and citrus pectin) perform an additional protective function for bifidobacteria. They adsorb bacteria, and acidic polysaccharides (pectin substances) form a layer on the surface of the complexes «dietary fiber – bacteria», which protects bifidobacteria during passage in the stomach. In the creation of functional zefir, pastilles, Turkish delight and whipped candies, use Jerusalem artichoke puree (zefir «White-pink» and pastille «White-pink»).

To give the products dietary properties, sugar is replaced by fructose and sorbitol (pastille and zefir). New confectionery products with artichoke processing products can be attributed to the products of functional direction, as fructooligosaccharides not only improve the taste and technological properties, but also have a positive effect on human health [12, p. 16].

Soy products (soy milk, soy concentrates and isolates, protein and fat fortifiers) can be a reserve in the production of confectionery products with a whipped foam structure, because, in addition to the ability to form foam, they contain biologically active substances and are relatively cheap. There is a growing interest in the use of soy milk, soy enrichment «Samson» and soy food concentrate «Odyssey», which have high nutritional value and contribute to the creation of functional products for mass, dietary and therapeutic nutrition [13, p. 25].

Technologies for the production of functional zefir with the use of eggshell powders, dry kelp and food adaptogenic additives and the provision of the product with therapeutic and prophylactic properties due to the complex of minerals that are part of the additives. Food adaptogenic supplement contains homeopathic medicines of mineral, plant and animal origin. Due to this, zefir include biologically active compounds of natural origin and the process of obtaining zefir mass is intensified. This reduces the process time by 25% and reduces the formulation amount of pectin by 1.5%. The optimal dosage of eggshell powder is – 2% of the total weight of zefir by dry matter, and dry kelp powder – 0.4%. During storage of zefir with the addition of dry kelp powder for 30 days, no iodine loss was found [14, p. 69].

In [15] the technology of zefir production with the use of spicy-aromatic plants, in particular infusions of calamus, peppermint, nettle was developed. The use of wheat protein in the production of zefir, which can be used as a foaming agent for partial replacement of egg white in order to reduce production costs and reduce microbiological contamination. A method for the production of zefir «New» has been developed, which involves the preparation of zefir with the addition of agar-sugar-molasses syrup jam with pectin. This allowed to obtain zefir of dense mass, improved quality, increased taste.

A new type of zefir with the addition of royal jelly was developed, the chemical composition of the new type of zefir was studied and compared with zefir made according to a traditional recipe. The obtained results indicate a clear tendency to increase the nutritional and biological value of the new product in relation to amino acids and trace elements. Developed a new type of zefir has functional properties, so it can be attributed to the «useful sweets» and used for therapeutic and prophylactic purposes [16, p. 218].

Recently, there is a growing trend in the manufacture of products for use in health and prevention nutrition for both children and adults. In order to enrich pastilles with vitamins, macro-and micronutrients, prevent and eliminate iodine deficiency in the diet, formulations with dietary supplements Lamidan and Tsikorlakt were developed [17, p. 33].

In [18, p. 93–94], studies were conducted to improve the technology of jelly-fruit marmalade using fruit and vegetable cryoadditives. The authors

in the technology of jelly-fruit marmalade substantiate the use of fruit and vegetable additives (cryopasta from quince, apples, carrots, pumpkin, grapes and cryopowder from rose hips, sea buckthorn and grapes) to increase its nutritional value and expand the range. It is proved that the use of fruit and vegetable cryoadditives leads to marmalade with high organoleptic characteristics and high nutritional value, as well as physico-chemical and microbiological indicators that meet the requirements of regulatory documentation for this type of product. New products have significant antioxidant properties during the guaranteed shelf life.

Thus, the main areas of quality improvement and expansion of the range of pastille products include: expansion of types of natural additives and fillings; variety of taste and aromatic properties, appearance; increasing the nutritional value; production of functional products. The given tendencies of updating of the assortment of pastille products show wide possibilities of creation of new kinds. However, the main direction is still the development of products of high nutritional value, with dietary and health properties while maintaining its traditional appearance and naturalness.

3. The aim, objectives and methods

The object of research in this work is the technology of pastille with the addition of multicomponent fruit and berry paste.

The aim of the study is to improve the technology of production of pastille of high nutritional value with the addition of multicomponent fruit and berry paste from apples, cranberries and blackberries. The new technology will allow to expand the range of plant origin additions with a high content of functionally physiological ingredients and pastille of high nutritional value.

To achieve the goal, the following objectives were set:

– to investigate the structural and mechanical properties and quality indicators of multicomponent fruit and berry paste;

– determine the rational amount of multicomponent fruit and berry paste in the formulation of the pastille;

– establish changes in pastille with multicomponent apple, cranberry and blackberry paste that occur during storage;

– to develop the formulation and technological scheme of preparation of pastille products with multicomponent fruit and berry paste;

– determine a complexe indicator of the quality of pastille using the principles of qualimetry.

Apples (Antonovka variety), cranberries (Pilgrim variety), and blackberries with a high content of pectin were used as the main raw materials for the production of multicomponent fruit and berry paste. The structural and mechanical properties of apple, cranberry and blackberry paste and the obtained pastille with its addition of blends are determined. Structural and mechanical properties of the experimental samples were determined on a rotary viscometer «Reotest-2» (Germany). Determination of quality indicators of pastes was carried out in accordance with the requirements of DSTU 8010: 2015 Canned food. Fruit and berry pastes.

The study of the obtained organoleptic properties of the experimental samples was carried out by an expert commission consisting of 5 members on a 5-point scale.

The mass fraction of reducing substances in the pastille was determined by the ferrocyanide method, the acidity of the products – by titrimetric method, the mass fraction of dry matter – refractometric, to determine the strength of pastille used a Valentine's device.

To calculate the complex indicator of the quality of pastilles, we determined its chemical composition (the content of pectin substances, ascorbic acid, polyphenols, including anthocyanins, catechins and flavonols).

Quality indicators were determined by the following methods. The content of pectin substances was determined by the calcium-pectate method, low-molecular phenolic compounds – by the colorimetric method according to DSTU 4373: 2005. The content of catechins and flavonols was determined by the chromatographic method.

Quantitative determination of antioxidants was performed by spectrophotometric method. The spectra of cryoadditive extracts were recorded on a SF-46 spectrophotometer in the UV and visible regions. The thickness of the absorbing layer was 1 cm.

Quantitative content of the sum of oxidizable polyphenolic compounds was determined by permanganatometry by the method.

The error for all studies was $\sigma = 3…5\%$, the number of experiments was repeated – $n = 5$, the probability was – $P \geq 0,95$.

4. Research results

4.1 Determination of quality indicators of multicomponent fruit and berry paste

As a control was selected pastille «Vanilla» with the addition of apple puree, the test samples were pastille with fruit and berry multicomponent paste in the amount of 30, 40, 50% with the replacement of apple puree.

Multicomponent fruit and berry paste from apples, cranberries, blackberries was obtained by concentrating the puree by evaporation at low temperatures in a rotary film apparatus at a temperature of 60 ... 65ºC to a dry matter content of 30… 40%.

Multicomponent fruit and berry paste is a pasty, finely dispersed product of red-violet color, has a sour taste. Organoleptic indicators of the quality of fruit and berry paste were determined (Table 1).

Table 1

Organoleptic quality indicators of multicomponent fruit and berry paste

Indicator	According to regulatory documentation	Multi-component fruit and berry paste of apples, cranberries, blackberries
Taste	Sweet and sour with a specific pleasant taste of fruit and berry raw materials	Sweet and sour with a specific pleasant taste of cranberries and blackberries
Color	from burgundy to red-purple	red-purple
Smell	pleasant with a pronounced taste of fruit and berry raw materials	pleasant with a pronounced taste of cranberries and blackberries
Consistency	Pasty, soft, easy to form when placed on a flat surface does not spread	Pasty, soft, easy to form when placed on a flat surface does not spread
Appearance	Homogeneous, without impurities	Homogeneous, without impurities

As you can see from the table 1, multicomponent fruit and berry paste from apples, cranberries, blackberries, which was used for research, is homogeneous in appearance, without foreign inclusions, pasty, soft consistency, does not spread. The paste has a pleasant sweet and sour taste and smell of fruit and berry raw materials.

Physico-chemical and structural-mechanical quality indicators of fruit and berry paste are determined (Table 2). The rheological characteristics of

fruit and berry paste were investigated in order to determine the required consistency of the finished products. Studies of structural and mechanical properties of pastes were performed at 20°C.

Table 2

Physical, chemical and structural-mechanical quality indicators of multicomponent fruit and berry paste

Indicator	According to regulatory documentation	Multi-component fruit and berry paste of apples, cranberries, blackberries
Physical and chemical quality indicators		
Mass fraction of dry matter, %, not more	30–40	33,0
Active acidity, pH, not less	3,3±0,5	3,25
Structural-mechanical quality indicators		
Ultimate shear stress, Pa	100…165	132
Dynamic viscosity, Pa·s	600…800	615

As can be seen from table. 2, multicomponent fruit and berry paste has a mass fraction of dry matter of 33.0% and an active acidity of 3.25. The value of the shear stress for fruit and berry paste is 615 Pa.

Because the multicomponent paste has high quality indicators and contains more physiologically functional ingredients compared to apple puree, their use in the technology of pastille products has been proposed. To do this, the effect of multicomponent fruit and berry paste on the quality of the pastille was determined.

4.2 Determination of the rational amount of multicomponent fruit and berry paste in the pastille formulation

Multicomponent pastes were introduced at the stage of preparation of the pastille mass together with apple puree. The control sample was made using the same technology, but without the addition of paste.

At the first stage of research, the rheological properties of pastilles with fruit and berry pastes were determined. The studies were performed on a viscometer «Reotest-2» in the range of shear rates of 0.3… 27s^{-1}. The equipment of the viscometer allowed to set up to 24 fixed values of shear rates.

Cylinders H1 were used for measurements, which are included in the instrument kit and provide an error of no more than 3%.

Analysis of the shear curves of the displacement of the pastille using a multicomponent fruit and berry paste with the replacement of the mass of apple puree (Figure 1) shows that almost all samples have the ultimate shear stress Θ (USS) and do not begin to flow immediately after an increase in the shear stress. That is, they belong to non-ideally plastic solid-like bodies. An increase in the content of fruit paste in the pastille affects the value of the ultimate shear stress.

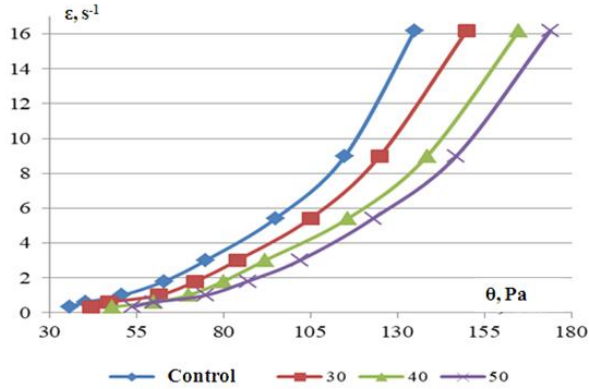

Figure 1. Dependence of the shear characteristics of the pastille with the addition of a paste with the replacement of apple puree

Thus, with increasing percentage of the paste increases the shear stress. That is, the increase of the multicomponent paste in the lozenge leads to the strengthening of the structure of the obtained product.

The dependence of the effective viscosity on the shear rate for the pastille with the addition of the paste is shown in Figure 2.

Figure 2 it can be seen that the maximum value of the effective viscosity has a pastille with a multicomponent fruit and berry paste in an amount of 50% with replacement of apple puree and is equal to 165 Pa · s, which is almost 1.5 times more than that of the control sample.

Thus, the introduction of a multicomponent paste into the pastille leads to the strengthening of the structure of the resulting product. In our opinion,

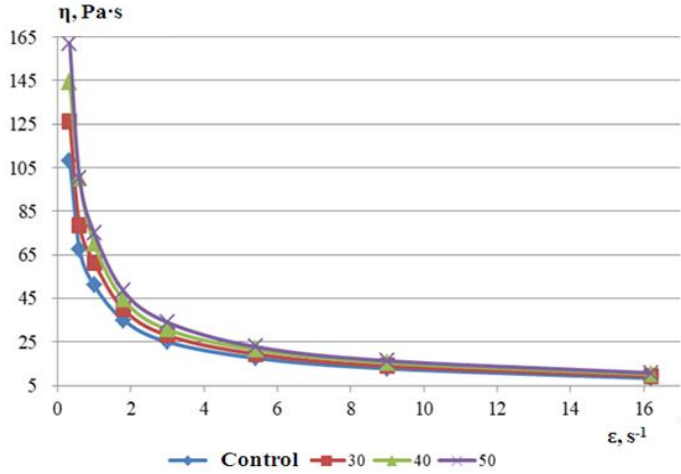

Figure 2. Complete rheological curves of pastilles with the addition of fruit and berry paste with the replacement of apple puree

this is due to the chemical composition of the paste, which contains a greater amount of dietary fiber, namely pectin substances (3.3 g per 100 g) compared to applesauce (1.3 g per 100 g). It is known that it is pectin that tends to form a gel. The property of pectin to gelation is used in cooking in the preparation of sweet dishes, namely in the production of marmalade, jam, preserves, pastilles, etc.

At the next stage of our studies, we determined the effect of the additive on the organoleptic quality of the pastille (Table 3).

From the given organoleptic indicators it is possible to draw a conclusion that introduction of multicomponent paste in the amount of 30,0… 40,0% with replacement of apple puree leads to receiving finished products with high organoleptic indicators of quality. Increasing the dosage of the additive to 50.0% slightly reduces these quality indicators, namely: the taste of the pastille acquires a pronounced taste of the additive, the color of the surface is intensely colored, the structure of the pastille becomes uneven.

The influence of multicomponent paste on physicochemical quality indicators was evaluated by such indicators as mass fraction of reducing substances and total acidity of table 4.

Table 3

Organoleptic quality indicators of pastille with multicomponent fruit and berry paste

Indicator	The amount of fruit and berry paste, % replacement of apple puree			
	control	30,0	40,0	50,0
Taste and smell	Sweet and sour, without a pronounced taste and smell of cranberries		Sweet and sour, pronounced taste and smell of cranberries	Strong taste and smell of cranberries
Color	White	Pink	Pink with a shade of red	Red with a shade of purple
Consistence	Soft, easily broken			Soft
Structure	Foamy, uniform			Foamy, uneven texture
Form	Rectangular			
Appearance	Inherent to this product, without coarse hardening on the side faces			

Table 4

Physical and chemical quality indicators of pastille with multicomponent fruit and berry paste

Indicator	The amount of fruit and berry paste, % replacement of apple puree			
	conrol	30,0	40,0	50,0
Mass fraction of reducing substances, %	8,0	8,7	9,0	9,5
Total acidity, deg	5,1	6,0	7,1	8,0
Density, kg/m^3	607	590	580	570

As a result of physical and chemical research, it can be concluded that the introduction of a multicomponent paste in an amount of 20 ... 40% with the replacement of the mass of apple puree leads to the production of pastilles with high quality indicators.

Increasing the dosage of the additive to 50.0% slightly worsens these quality indicators. So, the mass fraction of dry (Figure 3) substances exceeds the indicator specified in the regulatory documentation. This indicates that for the storage of such pastilles, special conditions must be developed to extend the shelf life, as a result, this will lead to an increase in the cost of products.

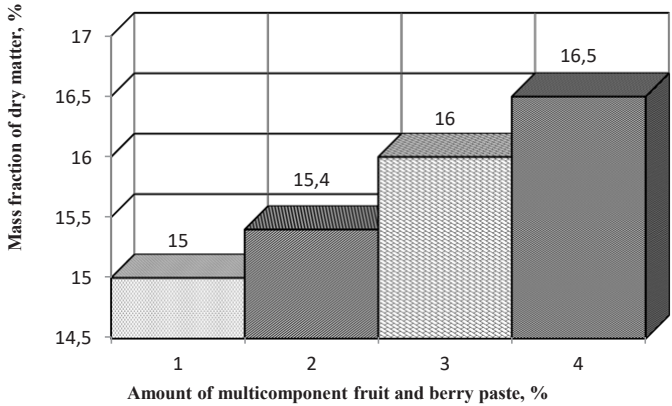

Figure 3. Mass fraction of dry matter in the pastilles: 1 – without additives (control), with multicomponent fruit and berry paste in the amount of 2 – 30.0%, 3 – 40.0%, 4 – 50.0%

Thus, the addition of paste in the amount of 30… 50% increases the dry matter content by 2.6… 9.1% compared to the control sample. This is due to the increase in the amount of pectin in the paste compared to apple puree, which probably binds free moisture and holds it firmly.

Increasing the dosage of the additive to 50% of the paste exceeds the mass fraction of dry matter in the regulatory documentation.

The addition of paste in the amount of 30… 50% increases the content of reducing substances by 8.0… 15.8% compared to the control sample. This is due to the presence of reducing substances in the paste.

The addition of multicomponent paste in the amount of 30… 50% increases the acidity of the pastille by 15.0… 36.2% compared to the control sample. This is due to the high acidity of the paste. Therefore, we proposed to reduce the prescribed amount of acid by 30%.

At the next stage of our research, we determined such structural and mechanical properties of the pastille as strength (Figure 4) and adhesion (Figure 5).

The introduction of a multicomponent paste in the amount of 30… 50% increases the strength of the pastille by 5.0… 13.0% compared to the control sample. This is due to the increase in pectin in the pastille as the amount of additive increases.

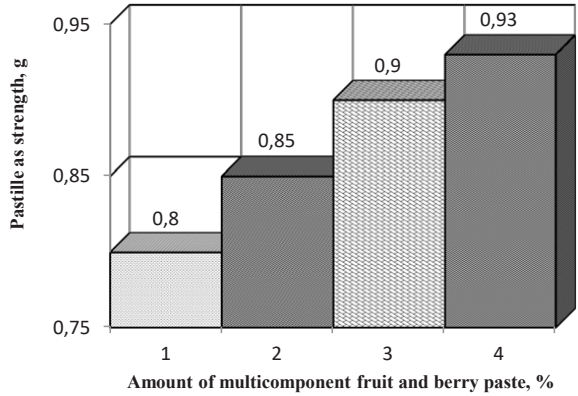

Figure 4. Strength of pastille: 1 – without additives (control), with multicomponent fruit and berry paste in the amount of 2 – 30.0%, 3 – 40.0%, 4 – 50.0%

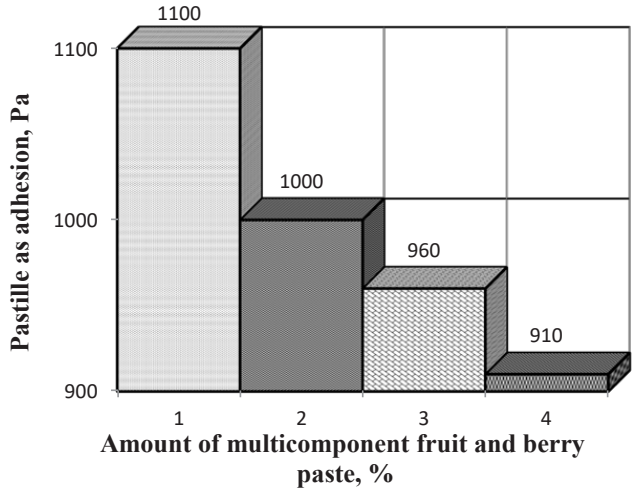

Figure 5. Adhesion of pastille 1 – without additives (control), with multicomponent fruit and berry paste in the amount of 2 – 30.0%, 3 – 40.0%, 4 – 50.0%

The adhesion of the pastille with the addition of a multicomponent paste in the amount of 30.0… 50.0% is reduced by 11.1… 17.3% compared to the control sample. This is due to the increase in bound water in the pastille. These changes in the conditions of the enterprises will only improve the quality of the products, as the adhesion of the pastille to the casting equipment will be less.

Thus, as a result of research, it was found that to obtain pastille with high quality, it is advisable to use 30… 40% multicomponent fruit and berry paste with the replacement of apple puree.

4.3 Establishing pastille changes with a multi-component paste of apples, cranberries and blackberries that occur during storage

Pastille products, like most confectionery products, lose their consumer properties during the shelf life (15… 30 days), which is the result of drying and microbiological spoilage.

The control sample was pastille without additives. Test samples of products were stored in plastic bags at a temperature of 18 ± 3oC and relative humidity not exceeding 75% for 30 days. Indicators such as mass fraction of moisture and adhesion were determined.

It was found that during storage the control sample of pastille loses moisture more intensively than products with the addition of multicomponent fruit and berry paste during the entire shelf life (Figure 6).

Thus, during 1…30 days of storage, the moisture content in pastille without additives is reduced by 4.0…10.0%, in products with multicomponent fruit and berry paste – not significantly.

Less moisture loss in pastille with the addition of multi-component fruit and berry paste from apples, cranberries, blackberries, due to the higher content of pectin in the products, which is able to absorb and bind water.

During storage of confectionery there are changes in their physical properties and chemical composition. This is due to the insignificant compaction of the structure due to the regrouping and ordering of the elements of the structure.

The addition of multicomponent fruit and berry paste (which contains more pectin substances that retain water) has a positive effect on the formation of the structure of the pastille.

Determined the adhesive properties of new pastille during storage (Figure 7).

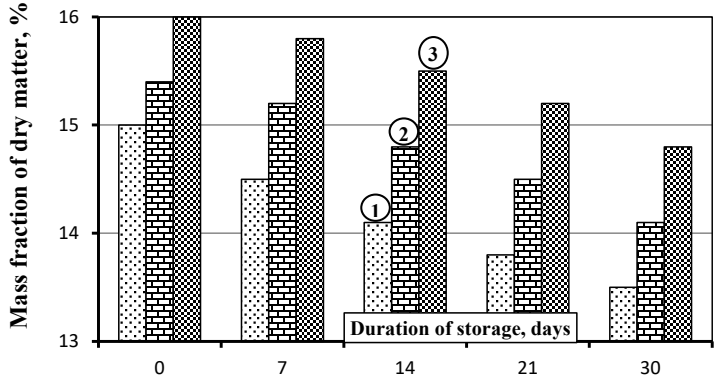

Figure 6. Mass fraction of pastille moisture during storage: 1 – without additives (control), with multicomponent fruit and berry paste in the amount of 2 – 30.0%, 3 – 40.0%

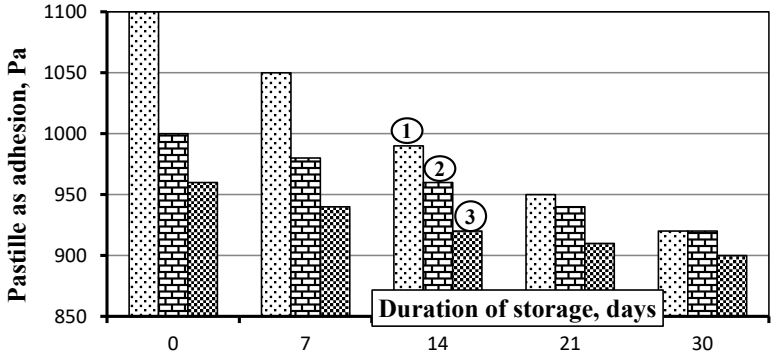

Figure 7. Adhesion of pastille during storage: 1 – without additives (control), with multicomponent fruit and berry paste in the amount of 2 – 30.0%, 3 – 40.0%

As you can see, during storage, the structure of the pastille mass of new products is more highly concentrated, which is the main reason for reducing moisture loss due to the introduction of multicomponent fruit and berry paste. As a result, the shape-retaining properties increase and the stickiness for their bonding decreases during a long shelf life.

Therefore, on the basis of the conducted researches it is possible to state that new pastille products get positive changes of indicators during storage within 30 days.

4.4 Development of formulation and technological scheme of preparation of pastille products with multicomponent fruit and berry paste

It is established that the optimal amount is 30…40% of multicomponent fruit and berry paste with apple puree replacement. Since the main goal is to increase the physiologically functional ingredients in pastille, we choose 40% of multi-component fruit and berry paste.

In view of this, formulation for pastille «Berry» using a multi-component fruit and berry paste of apples, cranberries, blackberries (Table 5).

Table 5

Formulation of pastille «Berry» with the addition of multicomponent fruit and berry paste

Name of raw materials and semi-finished products	Mass fraction of dry matter, %	Pastille «Berry» (per 1 ton of finished product)	
		mass of the recipe ingredient	in dry matter
White sugar	99,85	686,0	685,0
Powdered sugar	99,85	4,5	44,9
Syrup	78,0	107	83,5
Apple puree	10,0	366,0	36,6
Egg white	12,0	23,3	2,8
Agar	85,0	6,0	5,1
Lactic acid	40,0	4,2	1,7
Multicomponent paste of apples, cranberries, blackberries	33,0	184,8	54,9
Total	-	148,31	92,03
Product yield	85,0	1000,0	850,0

Using the formulation, the technology of making pastille with the addition of multi-component fruit and berry paste from apples, cranberries, blackberries was developed (Figure 8).

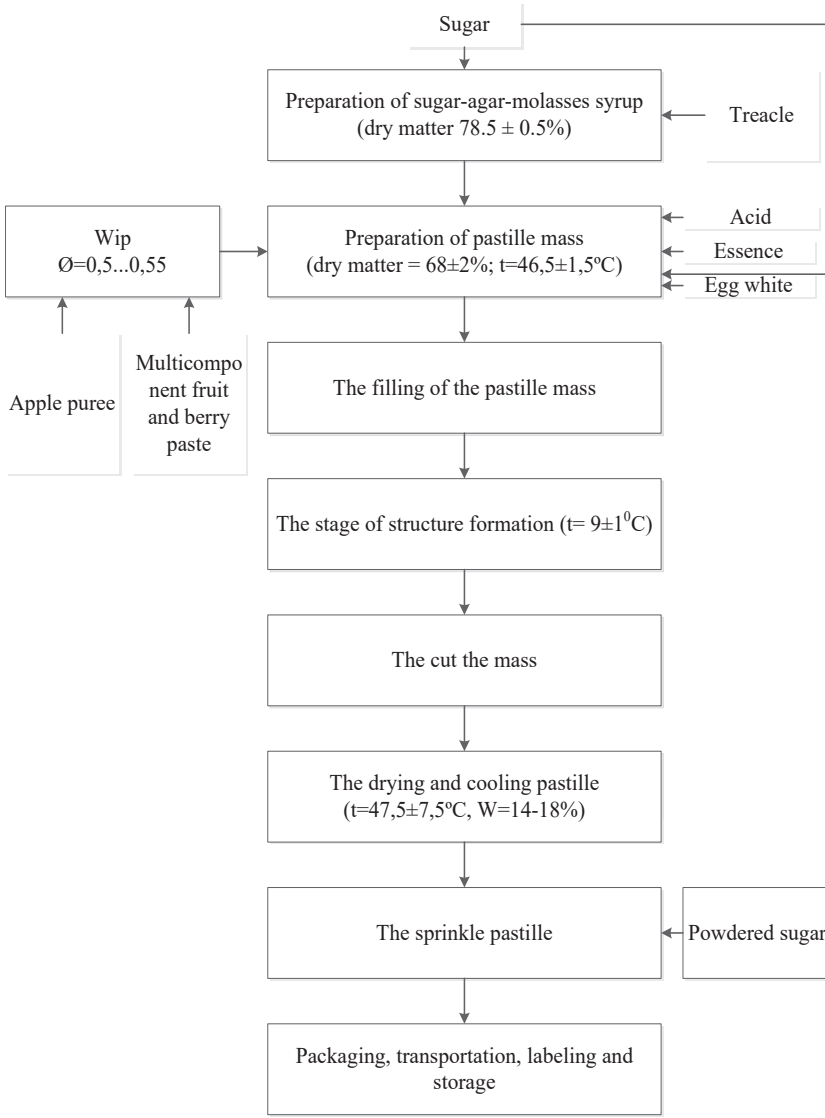

Figure 8. Technological scheme of production of pastille «Berry» with the addition of multicomponent fruit and berry paste

Before the start of production, the preparation of raw materials is carried out. Apple puree and multicomponent fruit and berry paste from the barrels are pumped into the pulverizers and wiped to get rid of the remnants of the peels, seeds and impurities, and desulphitation is carried out. After that, compaction is carried out in a vacuum apparatus and pumped into an intermediate container. Egg white, if fresh, is filtered through a sieve with a pore size of 2 mm. If the egg white is dry, it is released from the packaging, sieved through a sieve and reconstituted with water based on dry matter, then sent to an intermediate container. Agar is sieved to remove ferro-impurities and washed, then poured with cold water for swelling for 1...2 hours, to improve the properties of gelation. The sugar is released from the container and sieved to remove ferrous impurities and impurities and pumped into an intermediate container. Flavors and essences are stored in separate containers and the required amount is measured before production. Lactic acid is stored in containers that do not oxidize, before production, the acid is filtered and the required amount is measured.

Preparation of sugar-agar-molasses syrup involves mixing sugar, molasses and swollen agar in the boiler and boiling the syrup under the pressure of heating steam 0.3 ± 0.1 MPa to a dry matter content of 78.5 ± 0.5%. After boiling, the syrup is sent by pump to the intermediate tank to the stage of preparation of the pastille mass.

Preparation of pastille mass involves beating continuously egg white, agar-molasses-sugar syrup, acid, essence, apple puree, multicomponent fruit and berry paste to a dry content of 68 ± 2% at a temperature of 46.5 ± 1.5°C, after the pastille is sent to stage of filling.

The filling of the pastille mass is carried out in a continuous way with the help of a forming head with heating on the lines of non-slotless filling of pastille. Or in a periodic way, filling in trays, pre-covered with plastic wrap. The pastille trays are leveled with knives. Finished trays are placed on racks and sent to the stage of structure formation.

The stage of structure formation takes place in cooling cabinets at a temperature of 9±1°C for 15...20 minutes. To form a crystalline crust, the marshmallow layers are sent to the convection chamber, where air heated to a temperature of 39 ± 1°C is supplied from the air heater with the help of a fan. The finished pastille mass is sent to the cutting.

To cut the pastille mass, put the crust down and cut with special disc knives or by hand. The resulting raw pastille is placed on a rack and sent to the oven for further release of moisture.

At the stage of drying and cooling pastille, racks with pastille are moved to a drying chamber for 4.5 hours, where air heated to a temperature of 47.5 ± 7.5 degrees is circulated. Then pastille is completely cooled for 1-1.5 hours in the workshop premises.

After drying, the pastille is sprinkled with powdered sugar. At this stage, the pastille is sprinkled with powder mechanically or manually. To do this, use either a vibrating sieve or sieves with holes with a diameter of 1.2 mm. After sprinkling, the pastille is sent for packaging and packed in boxes or plastic bags. Packing takes place by means of the automatic machine.

The developed technology differs from the traditional one by the presence of multicomponent fruit and berry pastes, the operation of their preparation and the introduction of these additives at the stage of preparation of pastille mass.

Pastille using a multi-component fruit and berry paste contains an increased amount of physiologically functional ingredients compared to traditional. The chemical composition of pastille is given in table 6.

As can be seen from the above data, the introduction of multicomponent fruit and berry paste can significantly increase the content of dietary fiber, organic acids, vitamins (groups B, PP, C, E), low molecular weight phenolic compounds and minerals (magnesium, potassium, phosphorus, iron, calcium).

In addition, when adding a multi-component fruit and berry paste, the samples acquire the inherent product of a pronounced taste and aroma, which allows not to use in the recipe flavor and dye.

In the course of our research we theoretically substantiated and experimentally proved the prospects of multicomponent fruit and berry paste (from apples, cranberries, blackberries) in the pastille technology.

4.5 Determination of a complex quality indicator of pastille with multicomponent fruit and berry paste

The addition of multicomponent fruit and berry paste to the prescription composition of the pastille increases the content of all biologically active substances compared to the control sample. It was considered expedient

Table 6

Nutritional value of pastille with the addition of multicomponent fruit and berry paste

Substance	Pastille «Vanilla»	Pastille «Berry»
Caloric content, kcal	324,0	210,0
Proteins, g/kg	0,5	0,55
Fat, g	0,5	0,5
Carbohydrates, g	80,0	54,5
Pectic substances, g	0,8	1,95
Ascorbic acid, mg	1,07	14,5
Vitamins		
Vitamins of group B, mg	0,01	0,03
Vitamin PP, mg	0,02	–
Vitamin C, mg	-	3,0
Vitamin E, mg	-	0,98
Minerals		
Sodium, mg	16,0	18,5
Potassium, mg	55,0	127,4
Calcium, mg	21,0	18,0
Magnesium, mg	7,0	11,5
Phosphorus, mg	11,0	15,3
Iron, mg	1,6	1,6
Polyphenolic compounds		
Total amount, mg:	91,0	297,5
Anthocyanins, mg	-	91,4
Catechins, mg	42,0	53,4
Flavonols, mg	4,27	43,2

to determine a complex indicator of product quality using the qualimetric method. For this purpose, a structure of pastille quality indicators was developed – a «tree of properties», which more fully reveals the properties of products. To construct it, we chose the following groups (A, B, C) of properties. Group A includes organoleptic properties: structure, color, smell, taste, texture and surface. Group B – physical and chemical properties: mass fraction of dry substances, mass fraction of reducing substances, density and total acidity. Group C included indicators of the content of pectin substances, ascorbic acid, vitamins, minerals and polyphenols. Despite the

fact that the properties that are included in the trees are not the same in importance, the expert group determined the weight coefficients of single and group quality indicators (Table 7).

Table 7

«Tree of properties» pastilles with multicomponent fruit and berry paste

Pastille quality (P_o=1,00)	Organoleptic properties (P_A=0,30)	Structure	P_{A1}	0,2
		Taste and smell	P_{A2}	0,2
		Color	P_{A3}	0,2
		Consistence	P_{A4}	0,2
		Surface	P_{A5}	0,2
	Physico-chemical properties (P_B=0,25)	Mass fraction of dry matter	P_{B1}	0,25
		Mass fraction of reducing substances	P_{B2}	0,25
		Density	P_{B3}	0,25
		Total acidity	P_{B4}	0,25
	Biological and nutritional value (P_C=0,45)	Pectic substances	P_{C1}	0,40
		Ascorbic acid	P_{C2}	0,15
		Vitamins	P_{C3}	0,15
		Minerals	P_{C4}	0,15
		Polyphenols	P_{C5}	0,15

For pastilles, as well as other confectioneries, the most important thing is to improve the organoleptic characteristics and increase the nutritional value. Physico-chemical parameters are important, but their compliance with quality requirements according to regulatory documentation is of paramount importance. Therefore, we selected the following group weights: 0.30 – for organoleptic, 0.25 – for physicochemical properties and 0.45 – for biological and nutritional value.

The complex indicator of pastille quality with multicomponent fruit and berry paste began with the definition of group complex indicators at the first level. Calculations of organoleptic properties (P_A) were performed within the expert group on a 50-point system. Absolute values of organoleptic characteristics were translated into relative dimensionless values using a graph of the Harrington desirability function. For groups B and C, the maximum allowable value was taken according to the regulatory

documentation or the best value from the point of view of content maximization, or as in the control sample (Table 8).

Table 8

Baseline indicators for properties of groups B and C

Property group	Indicator	Unit of measurement	The value of the baseline
B	Pb_1^3	%	85,0
	Pb_2^2	%	9,9
	Pb_3^1	kg/m^3	700,0
	Pb_4^2	degrees	6,4
C	Pc_1^2	g/100 g	1,95
	Pc_2^2	mg/100 g	14,5
	Pc_3^2	g/100 g	4,01
	Pc_4^2	mg/100 g	192,3
	Pc_5^2	mg/100 g	297,5

Notes: 1 – the maximum allowable value according to regulatory documentation; 2 – taken in terms of content maximization; 3 – as in the control sample

The results of the translation of absolute quality indicators into relative dimensionless quantities are given in table 9.

The evaluation of group properties was performed taking into account the relative values of quality indicators within the group and their weighting factors (Table 7). Based on the calculation, a model of pastille quality was built according to group properties (Figure 9) and its complex quality assessment was calculated (Table 10).

From the given data it is visible that the developed pastille with multicomponent fruit and berry paste for each group has the improved properties.

To understand the evaluation scale, the indicators are distributed according to this scale: very good – 1.00…0.80; good – 0.80…0.60; satisfactory – 0.60…0.40; bad – 0.40…0.20.

Thus, the table shows that the complex assessment of the quality of the control sample corresponds to the indicator «good» (0.74), while the complex assessment of the pastille with a multicomponent paste corresponds to the indicator «very good» (0.98).

It is established that the complex quality index of pastille with multicomponent paste taking into account group indicators (organoleptic,

Table 9

Determination of relative quality indicators of pastille samples

Unit of measurement	K_i-T_i quality indicators			Relative quality indicators		
	Code	Control	Pastille with multicomponent paste	Code	Control	Pastille with multicomponent paste
Points	P_{A1}	48	48	KA_1	0,96	0,96
Points	P_{A2}	46	50	KA_2	0,92	1,00
Points	P_{A3}	46	50	KA_3	0,92	1,00
Points	P_{A4}	45	48	KA_4	0,90	0,96
Points	P_{A5}	47	49	KA_5	0,94	0,98
%	P_{B1}	85,0	84,0	KB_1	1,00	0,99
%	P_{B2}	8,0	9,0	KB_2	0,88	1,0
kg/m^3	P_{B3}	607,0	580,0	KB_3	0,86	0,82
Degrees	P_{B4}	5,10	7,1	KB_4	0,79	1,00
g/100g	P_{C1}	0,8	1,95	KC_1	0,41	1,00
mg/100g	P_{C2}	1,07	14,5	KC_2	0,73	1,00
g/100g	P_{C3}	0,03	4,01	KC_3	0,00	1,00
mg/100g	P_{C4}	111,6	192,3	KC_4	0,58	1,00
mg/100g	P_{C5}	137,30	297,5	KC_5	0,95	1,00

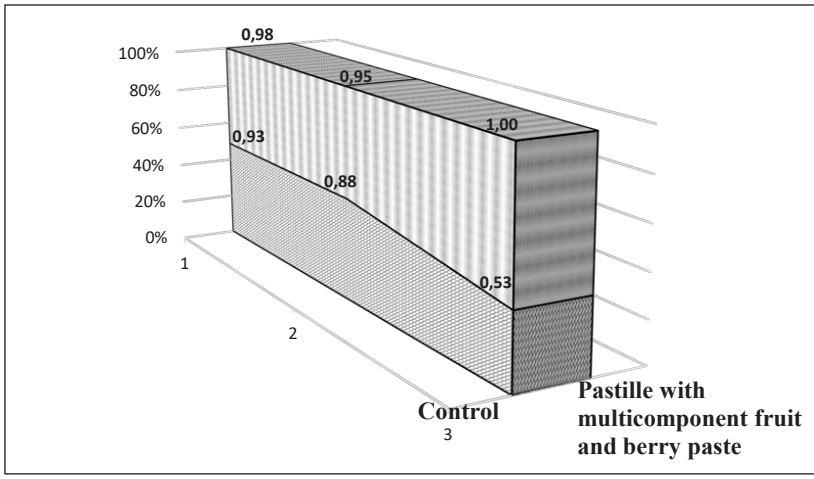

Figure 9. Quality model of the studied samples of pastille by group properties: 1 – organoleptic; 2 – physico-chemical; 3 – biological and nutritional value

Table 10

Complex assessment of pastille quality

Sample	Quality assessment by properties			Complex indicator
	Organoleptic	Physico-chemical	Biological and nutritional value	$К_0$
Pastille (control sample)	0,3·0,93	0,25·0,88	0,45·0,53	0,74
Pastille with multicomponent paste	0,3·0,98	0,25·0,95	0,45·1,00	0,98

physicochemical, biological and nutritional value) exceeds the corresponding sample made by classical technology by 24.5%. Thus, the advanced pastille technology is competitive.

5. Conclusions

The technology of pastille of high nutritional value has been improved with the addition of multicomponent fruit and berry paste made of apples, cranberries and blackberries, which expands the range of products of high nutritional value.

The quality indicators of multicomponent fruit and berry paste (mass fraction of dry matter 33.0%, active acidity 3.25, shear stress 615 PA), which contains more physiologically functional ingredients compared to apple puree, due to its production at gentle temperatures, were determined.

A rational amount of multicomponent paste in the pastille formulation has been established, which is 40% with the replacement of apple puree. This strengthens the structure of the resulting product, gives the products a pleasant taste, cranberry smell and a uniform red color. The consistency and structure of the products becomes somewhat protracted, which is allowed by regulatory documentation. According to physico-chemical quality indicators, the obtained pastille with paste is not inferior to the control sample. New pastilles maintain their high quality for 30 days. The developed technology differs from the traditional presence of multicomponent fruit and berry paste, the operation of their preparation and the introduction of the specified enrichment raw materials at the stage of pastille mass preparation.

Pastille using a multi-component fruit and berry paste (apples, cranberries, blackberries) has an increased number of physiologically

functional ingredients compared to traditional. It is established that the complex quality indicator of pastille with multicomponent paste taking into account group indicators (organoleptic, physicochemical, biological and nutritional value) exceeds the corresponding sample made by classical technology by 24.5%.

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