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IMPROVEMENT OF TURKISH DELIGHT PRODUCTION TECHNOLOGY USING A DEVELOPED MULTI-COMPONENT FRUIT AND VEGETABLE PASTE

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The object of this study is the technology of Turkish delight production based on fruit and vegetable paste with a high content of physiologically functional ingredients. The chemical composition of Turkish delight has been optimized by introducing physiologically functional ingredients. As a source of physiologically functional ingredients, it was proposed to use a multicomponent fruit and vegetable paste from apples, quince, pumpkins, made in an improved way. The technique is characterized by concentrating the paste in the rotary evaporator for 30…42 s at a temperature of 60…63 °C under conditions of preheating the purée to 50…52 °C. The dependence of the effective viscosity on the shear rate of samples of fruit and vegetable pastes was determined and it was found that the best indicators characterized the paste with a formulation ratio of raw materials: apple – 30 %; quince – 50 %; pumpkin – 20 %. The resulting paste has good organoleptic properties and a high content of dietary fiber, ascorbic acid, polyphenolic compounds.

It has been established that the production of Turkish delight with the addition of the developed fruit and vegetable paste provides the product with good organoleptic characteristics. Namely, it is characterized by a sweet-sour taste with a pleasant smell of quince, rich yellow-orange color, gelatinous, slightly viscous consistency, and the proper shape with a clear contour. Also, the addition of fruit and vegetable paste reduces the formulation amount of starch by 20 % while the resulting Turkish delight is characterized by a high strength value τ=38 kPa.

The improved technology of Turkish delight could expand the range of "healthy products" with increased nutritional value. In addition, the proposed technique and the modes of concentration make it possible to organize the process of paste production using energy-saving equipment

Keywords: Turkish delight, fruit and vegetable paste, structural and mechanical properties, physiologically functional ingredients, quality indicators

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1. Introduction

There is a growing number of health-conscious consumers around the world. Thus, when choosing food, buyers pay attention not only to shelf life, packaging, and labeling, but also to its composition. More often, different socio-economic groups of consumers in developed countries prefer healthy and functional products when choosing food.

Confectionery, despite its high caloric content due to the significant content of sugar and fat, is characterized by excellent consumer qualities and contributes to an increase in mood, which is now necessary for consumers. However, the demand for healthy food products is changing the direction towards sugar confectionery, which determines the prospects for the development of functional confectionery products, especially those related to the immune system [1].

It is known that the most common health problems are chronic diseases (diabetes, cardiovascular problems, etc.) and obesity. One of the causes is an increased refined food, animal fats, trans fatty acids, sugars, as well as reduced consumption of vegetables and fruits [2]. In this regard, an important task, along with increasing the consumption of biologically active substances from fruits and vegetables, is the production of affordable and nutritious plant-based foods. Fruit and berry and vegetable raw materials contain a significant amount of physiologically functional ingredients, such as dietary fiber, minerals, vitamins, phenolic compounds, which together have a positive effect on health. Trends in industrial production are the use of advanced non-thermal food processing technologies, namely food waste and by-products. New and environmentally friendly processing methods such as ultrasound, microwaves, and high-pressure technologies are also used [3]. One of the promising ways is the use of gentle processing temperatures of fruit and berry and vegetable raw materials, which makes it possible to obtain raw materials for sugar confectionery products with a high content of physiologically functional ingredients.

Along with marshmallow-marmalade products and sweets, oriental sweets, such as Turkish delight, are popular with consumers. This is due to the lower energy value and lack of fat compared to other confectionery. Thus, nutritionists and doctors recommend a moderate consumption of marshmallows, marmalade, and Turkish delight instead of cakes, pastries, and cookies. The raw materials for its production are fruit and berry raw materials, a large amount of sugar and starch. However, the products are characterized by a low content of physiologically functional ingredients. So, devising a low-temperature technique to produce fruit and vegetable paste and Turkish delight with its use is relevant and timely.

2. Literature review and problem statement

Turkish delight, as a traditional Turkish sweetie, quickly spread throughout the world and now are in demand in both European and Eastern countries. Turkish delight is made by mixing sugar, corn starch, and water in certain shares, as well as adding fruit or nuts to the mixture [4]. In a number of countries, according to regulatory documentation, fruit and berry puree is used, the industrial production of which leaves it impoverished in nutrients.

Fruit and berry and vegetable raw materials are known to be used as food and medicine because they have unique qualities and potential uses as functional ingredients. Among these, there are some species that are commercially grown in Australia, in particular vegetables (tomatoes), fruits (plums), citrus fruits (lime), berries (pepper berry), etc. [5]. Given the growing global demand for quality and functional natural products, Australian local vegetable raw materials have great opportunities for use as sources of flavors and dyes, natural preservatives, and functional ingredients. Along with this, there are objective difficulties associated with complex logistics during their delivery, and, as a result, shelf life. Therefore, the use of local plant materials is an effective way to solve this issue.

An important aspect in the production of healthy sugar confectionery products is compliance with consumer demands – on the one hand, to contain functional ingredients, and on the other – to meet high quality indicators [6]. This is due to the fact that the new ingredients that are included in the recipe and change during processing have a significant impact on the quality characteristics of soft confectionery.

Thus, in [7], changes in the qualitative characteristics of Turkish delight under the influence of different concentrations of cornel pulp were investigated. The addition of 4.4 and 12.2 % of dogwood pulp, which was obtained under industrial conditions, was proposed. Microbiological stability, intense color, pleasant fruity taste, and strength of the new Turkish delight with dogwood pulp have been established. However, the authors have not investigated changes in the chemical composition, which does not make it possible it to be positioned as a healthy product.

As a functional ingredient, the use of black plum peel for the production of Turkish delight, which contains a significant amount of fiber, Ca, P, Zn, ascorbic acid, is proposed [8]. In addition, black plum peels contain antioxidant and phenolic compounds. The research results indicate an increase in strength, a decrease in the adhesion of products, an improvement in organoleptic indicators of quality and chemical composition. However, these studies are limited to small volumes of processing of raw materials and locality of its cultivation.

Many studies have considered the use of pomegranate and its processed products in Turkish delight technologies [9]. Pomegranate, pomegranate juice [10], pomegranate seeds [11] have found their application due to the high content of antioxidants that are useful against cancer, cholesterol, diabetes, cardiovascular diseases. However, the conducted research is limited to difficulties due to the peculiarities of processing this raw material and additional technological stages under production conditions.

The use of quince as a food ingredient due to its aromatic nature and high nutritional value, primarily pectin substances, is proposed. Quince pulp was introduced in the amount of 10 and 15 %, which contributed to the preservation of physicochemical quality indicators, increased elasticity, acceptable organoleptic parameters. The use of quince makes it possible to make products without artificial colors and aromatic substances [12]. Along with this, the use of only one raw material, as a functional substance, limits the increase in the content of useful nutrients in the developed product.

Since the main ingredients for the production of Turkish delight are a mixture of starch, sugar, and water, which is brewed, the question arises of forming a stable structure of these products. Thus, the authors of [13] proposed the use of fungal polysaccharide pullulan with the replacement of 20 % starch in the ratio of 1:1. The resulting Turkish delight in structural and mechanical indicators was not inferior to the control sample. The ability to form a structure is inherent in many microbial polysaccharides and their use is justified in various confectionery technologies. [14]. However, along with the importance of textural characteristics, there should be an increase in the content of functional ingredients. The same partial replacement of starch polysaccharides with

non-starch polysaccharides is an actual direction, which will solve the problem of increasing nutritional value while ensuring high quality indicators [15].

A significant amount of research by scientists reported search for plant materials, which on the one hand is a functional ingredient, and on the other hand, makes it possible to provide high organoleptic indicators of product quality without the use of dyes and flavors. Thus, studies have been conducted on the use of black grapes in the technology of Turkish delight [16]. The authors added 2.5 %, 5.0 %, 7.5 % black grape syrup to the Turkish delight recipe. According to the results of color analysis, structural-mechanical and organoleptic quality indicators, it is recommended to add 2.5 % of black grape concentrate. As a natural dye in confectionery with a gelatinous structure, barberry extract is used [17]. Its use also makes it possible to improve the antioxidant and antiradical properties of confectionery. It is known about the addition of black carrot juice concentrate to traditional Turkish delight [18], which also contributes to an increase in the content of anthocyanins. However, the use of only one raw material does not completely solve the problem of increasing nutritional value.

Sugar, which is the main raw material for the manufacture of Turkish delight, forms the structure of finished products, as well as their taste [19]. However, scientists have proven the connection between excessive consumption of confectionery products with a significant glycemic index and the risk of a number of diseases [20]. Consequently, the change in sugar content in the direction of its decrease is an urgent trend. An alternative to partially or completely replace sucrose in the composition of Turkish delight is proposed to use isomaltose, which differs from other sugars in a low glycemic index [21].

During the development and improvement of confectionery technologies, aspects of product preservation and its microbiological safety are important. Studies were conducted on the influence of the environment and storage conditions of Turkish delight [22], which are determined by the indicators of changes in mass and density. They recommended storage of Turkish delight samples at a relative humidity of about 50 % and a temperature of 15 °C. The authors of work [23] conducted studies aimed at assessing the risk of aflatoxins in traditional confectionery products of Turkey, in particular Turkish delight.

Rational for a comprehensive solution to the problems of enrichment of confectionery products is the use of plant materials as a dye and flavoring and the use of resource-saving technologies. Thus, for this purpose, in the structured masses of marshmallow [24] and marmalade [25], the use of fruit and berry pastes, which are sources of physiologically functional ingredients and give the products original sensory properties, is proposed. Increasing the range of plant materials that are sources of useful nutrients expands the prospects for creating healthy confectionery products. This is possible due to the use of raw materials with a high content of physiologically functional ingredients, their combination, and the introduction of new methods for heat treatment on scraper heat exchangers [26]. Among them is also a technique for manufacturing multicomponent fruit and vegetable pasty semi-finished products using low-temperature modes of processing concentration on the designed resource-efficient equipment [27].

Resource-efficient processing of local fruit and vegetable raw materials under conditions of low-temperature gentle processing will ensure the preservation of natural properties minimizing the use of synthetic ingredients in formulations, replacing them with natural semi-finished products of a high degree of readiness. The use of natural semi-finished products in confectionery recipes will form an increase in the nutritional value of the products obtained, provide them with original organoleptic properties, and expand the range of functional health food products. So, it is expedient to improve the technology of Turkish delight using new types of pasty fruit and vegetable semi-finished products from fruit and vegetable raw materials.

3. The aim and objectives of the study

The aim of this study is to improve the technology of functional Turkish delight by introducing a developed multicomponent fruit and vegetable paste. This will expand the range of herbal supplements, which are a source of useful nutrients and Turkish delight of increased nutritional value.

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

– to substantiate the technique of production and establish the formulation ratio of raw materials in a multicomponent fruit and vegetable paste with the determination of its structural and mechanical properties and quality indicators;

– to determine the quality indicators of Turkish delight on the basis of the developed multicomponent fruit and vegetable paste.

4. The study materials and methods

The object of our study is the technology of production of Turkish delight based on fruit and vegetable paste with a high content of physiologically functional ingredients. The main research hypothesis is the production of fruit and vegetable pasty semi-finished products of a high degree of readiness and the content of physiologically functional ingredients under the conditions of using gentle low-temperature processing regimes with subsequent use in the production technology of Turkish delight. This approach will ensure the expansion of the range of confectionery products of high nutritional value, using raw materials of exclusively organic origin and high quality indicators.

Experimental and practical research for the implementation of the tasks was carried out at research laboratories of the State Biotechnological University (Kharkiv, Ukraine).

Experimental and practical research for the implementation of the tasks was carried out at two research laboratories: "Progressive processes and equipment of food production" and "Actual problems of technologies of bakery, confectionery, pasta, and food concentrates" of the State Biotechnological University (Kharkiv, Ukraine).

For the manufacture of a pasty semi-finished product of a high degree of readiness, the following fruit and vegetable raw materials were selected: Japanese quince (Henomeles Katayansky variety), apples (Antonovka ordinary variety), pumpkin (Vitamin variety).

The justification for the choice of the above fruit and vegetable raw materials is explained by the presence of a high content of physiologically functional ingredients of substances. Apple fruits contain: dry matter – 9.41...11.9 %, sugars – 7.11...9.9 %, organic acids – 0.72...1.06 %, vitamin C – 8.6...21.1 mg per 100 g [28]. The beneficial proper-

ties of Japanese quince are due to its chemical composition: the fruits have a delicate, delicate aroma and sour taste (with a viscous aftertaste), contain up to 7 % organic acids (on average 3.4...5.9 % for dry matter). Japanese quince fruits are rich in pectin substances (1.34...2.81 %), having good gelling properties. The content of vitamin C in quince is 180...230 mg per 100 g. Quince is of interest as a valuable source of phenolic compounds of capillary, anti-atherosclerotic, and anti-inflammatory action (total content of leucoanthocyanins and anthocyanins – 740 mg/100 g, catechins – 316) [28]. Pumpkin is a source of dietary fiber, carbohydrates, and beta-carotene (a powerful antioxidant that gives orange color to vegetables and fruits and turns into vitamin A in the body). Pumpkin contains: pectic substances 1,45 %, organic acids 0,15 % [29].

The structural and mechanical properties of purée made from quince, apples, and pumpkins, pastes obtained by mixing purée in different percentages and Turkish delights with the addition of fruit and vegetable paste were investigated. The effective viscosity of prototypes was determined on the rotational viscometer "Reotest-2" (Germany) [30].

As a control sample, the technology of Turkish delight was used [31].

The mass fraction of solids was determined by the refractometric method, the active acidity – by the electrometric method, the content of pectin substances – by the calcium-pectate method. For the quantitative content of polymeric phenolic compounds of the condensed series, a colorimetric method of analysis was used, namely: vanillin in the presence of chloride acid. The composition of polyphenols was studied by the photometric method according to calibration graphs, which established the dependence of the optical density of the solution on the concentration test substances.

The magnitude of the error for all studies was s=3...5 %, the number of repeatability of experiments – n=5, probability – $p \geq 0.95$. For data processing, the MS Office software package, including MS Excel (USA), as well as the standard Mathcad software package (USA) were used.

5. Improving the technological process of Turkish delight production by adding the developed fruit and vegetable paste to its recipe

5. 1. Establishment of the formulation ratio of raw materials of fruit and vegetable paste with the determination of its quality indicators

The technique of production of multicomponent fruit and vegetable pastes involved the recipes given in Table 1. Puree from the selected raw materials (apples, quinces, pumpkins) was made according to DSTU 4085-2001. Separately, the made purees were blended according to the recipes, taking into account the initial beneficial properties of each individual raw material. The blend was preheated (50...52 °C) followed by concentration at a temperature of 60...63 °C in the improved design of the rotary apparatus, which is characterized by a decrease in processing time (up to 30 s) and a high degree of agitation [28]. The concentration was carried out until we reached 28...30 % dry matter in the finished paste; the processing time was 30...42 s. This concentration technique, due to the short-term process and gentle temperatures, contributes to the preservation of nutrients in the resulting semi-finished product. The short duration of the process is explained by the fact that the dehydration of purée occurs under the action of centrifugal forces with a high degree of mixing by the working bodies of the apparatus in a thin layer of the product with an average thickness of 2...3 mm under vacuum.

Table 1

Formulation composition of mashed raw materials in prototypes (compositions) of fruit and vegetable semi-finished product

The composition of raw materials	Prototypes		
	I	II	III
Apple purée	50	30	40
Quince purée	40	50	30
Pumpkin purée	10	20	30

During the manufacture of multicomponent compositions, it is necessary to take into account the indicators of structural and mechanical properties at different stages of production. To determine the influence of individual raw materials on the structure formation of blended compositions, the shear characteristics of prototypes of mashed raw materials were established (Fig. 1), apple purée was selected as control.

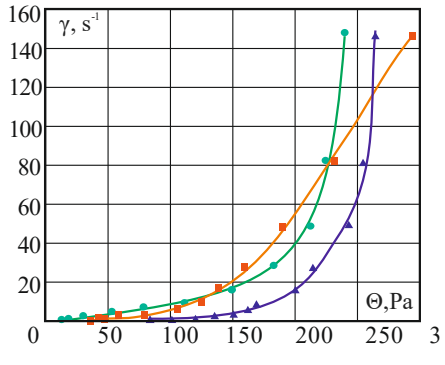

Fig. 1. Limiting shear stress at a temperature of 18...20 °C: ● – apple purée; ▲ – quince puree; ■ – pumpkin puree

The established indicators of the limiting shear stress (LSS) indicate higher rates of quince at 8.3 and pumpkin 3.8 times, respectively, compared with the control (apple purée – 10 Pa). All prototypes have LSS, that is, they begin to flow only after applying a shear force, which indicates their belonging to imperfectly plastic solid-like bodies. The dependence of the effective viscosity on the shear rate of multicomponent pastes in accordance with the formulation ratios (Table 1), made from fruit and vegetable raw materials, is shown in Fig. 2.

Comparing the maximum indicators of effective viscosity (for a non-destroyed structure) of manufactured prototypes of pastes with control (apple paste, 165 Pa·s), it can be seen that samples I–III have higher values, namely 486; 578; and 455 Pa·s, respectively.

To establish the optimal formulation of prototypes of pastes I–III, their organoleptic evaluation was carried out. The results obtained are summarized in Table 2.

To confirm the selected paste formulation, it is necessary to assess the physicochemical properties and chemical composition of prototypes of fruit and vegetable pastes (Table 3).

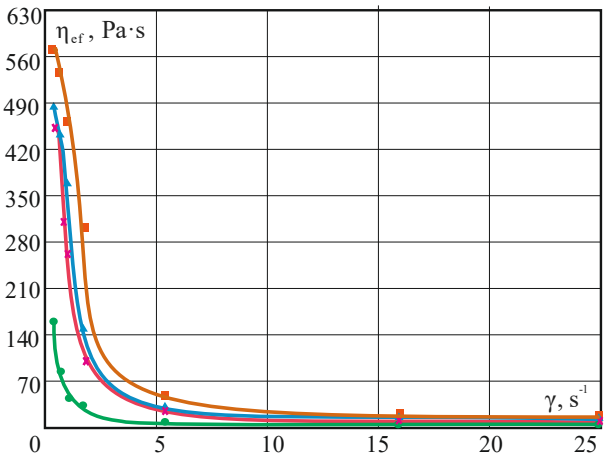

Fig. 2. Rheological viscosity curve at a temperature of 18...20 °C: ● – apple paste; ▲ – sample I; ■ – sample II; ✕ – sample III

Table 2

Comparative data on the evaluation of prototypes of fruit and vegetable pastes by organoleptic properties

Evaluation Indicator	Sample I	Sample II	Sample III
Appearance	Pasty mass		
Taste and smell	Pleasant harmonious taste of quince, barely felt apples	Pronounced taste and smell of quince, pumpkin is almost not felt	Pronounced smell and taste of quince; pronounced pumpkin
Color	Yellow-orange	Rich yellow-orange	Light yellow-orange
Consistency	Homogeneous viscous smearing mass, does not dissect when placed on a flat surface		

Table 3

Chemical composition of the resulting fruit and vegetable pastes (per 100 g of product)

Substance	Unit of measure	Control, apple paste	Sample I	Sample II	Sample III
Mass fraction of solids	%	30.00±1.00	30.00±1.00	30.00±1.00	30.00±1.00
Pectic substances	%	1.73±0.05	2.40±0.07	3.38±0.10	3.19±0.09
Sum of sugars		8.15±0.24	8.51±0.25	8.92±0.26	8.64±0.25
Organic acids, calculated for malic acid		0.54±0.02	1.03±0.03	1.15±0.03	0.89±0.03
Condensed polymeric phenolic compounds	%	0.04±0.01	0.65±0.02	0.81±0.02	0.57±0.02
Vitamin C	mg/100 g	8.07±0.24	35.8±1.07	37.8±1.13	33.5±1.00
β-carotene		–	0.18±0.01	0.19±0.01	0.17±0.01
Polyphenols:					
Anthocyanins	mg/100 g	–	225.00±6.75	237.00±7.11	227.00±6.81
Catechins		69.30±2.07	97.80±2.93	95.50±2.91	94.70±2.87
Active acidity	–	3.11±0.09	3.08±0.09	2.98±0.09	3.20±0.09

5. 2. Determination of Turkish delight quality indicators based on the developed multicomponent fruit and vegetable paste

The technology of Turkish delight [32], which is made from sugar, starch, purée (berry, fruit, or citrus fruits) with the addition of citric acid, dye, and flavoring, was chosen as the control sample. A complete replacement of purée (berry, fruit, or citrus fruits) with a developed multicomponent fruit and vegetable paste of apples, quince, and pumpkin is proposed. Starch is the structure forming agent during cooking, and due to the high content of pectin substances in fruit and vegetable paste, we can assume reducing its formulation quantity in the system. Sugar syrup and paste are gradually introduced into the starch paste until a homogeneous consistency is formed and it is boiled down to the 70 % mass fraction of solids.

An important indicator of Turkish delight, which affects its quality, is the strength of the finished product (Fig. 3) since it will affect the quality indicators, shelf life, and safety during transportation.

A sample of Turkish delight with a complete replacement of purée with fruit and vegetable paste has the highest strength index according to the maximum shear stress, which increases by 41.5 % (Fig. 3). This confirms the expediency of reducing the formulation amount of starch, so it was proposed to reduce its content in the system by 10 %, 20 %, 30 %.

Important characteristics of the quality of finished products are organoleptic and physical-chemical indicators (Table 4). When determining the quality, excluding from the formulation of the dye and flavoring is proposed.

Table 4

Quality indicators of the prototype of Turkish delight σ=3 %, *n*=5

Indicator	Control (Turkish delight)	Turkish delight with fruit and vegetable paste and starch content 80 %
Taste	Inherent in Turkish delight, without foreign taste	Inherent in Turkish delight, sour-sweet with a good taste of quince
Smell	Inherent in Turkish delight, without foreign smell	Inherent in Turkish delight, with a noticeable aroma of quince
Color	Light yellow	Rich yellow-orange
Consistency	Gelatinous, slightly viscous, viscous	
Surface shape and condition	Regular shape, with a distinct contour and evenly sprinkled icing sugar	
Mass fraction of solids, %	83.00±2.50	83.50±2.50
Titrated acidity, degree	1.00±0.03	1.20±0.03
Mass fraction of reducing substances, %	22.00±0.68	22.80±0.68

As can be seen from Table 4, according to physicochemical indicators, control and prototypes of Turkish delight are correlated with the requirements of regulatory documents for oriental sweets such as soft sweets and have an

increased nutritional value [32]. Thus, the mass fraction of moisture is 83.0...83.5 %, titrated acidity – 1.0...1.8 degrees, mass fraction of reducing substances – 22.0...22,8 %. Sensory characteristics of Turkish delight with fruit and vegetable paste and starch content of 80 % were determined.

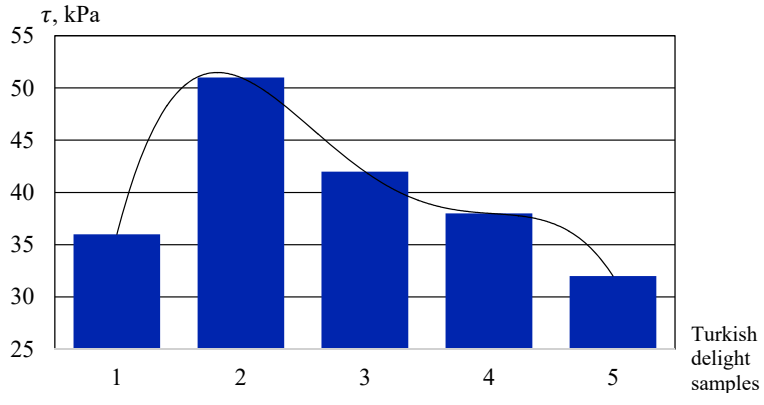

Fig. 3. Strength of Turkish delight samples in terms of limiting shear stress: 1 – control (Turkish delight); Turkish delight with complete replacement of purée with fruit and vegetable paste and the content of the formulation amount of starch, %: 2 – 100, 3 – 90, 4 – 80, 5 – 70

6. Discussion of results of the development of a multicomponent fruit and vegetable paste, indicators of its quality, and Turkish delight with its use

The technique of production of multicomponent fruit and vegetable paste has been improved by substantiating the recipe composition of raw materials: Japanese quince (Henomeles Katayansky variety), apples (Antonovka ordinary variety), pumpkin (Vitamin variety). The selected raw materials in the compositions of prototypes of pastes are selected taking into account their initial content of functionally physiological ingredients, organoleptic, and structural-mechanical properties. The presence of a larger amount of pectic substances in the fruit and vegetable raw materials makes it possible to reduce the number of gelling agents according to the recipes of the obtained products based on paste, and significantly reduce the cost of the product.

The optimal ratio of fruit and vegetable raw materials for the production of multicomponent paste based on organoleptic parameters, effective viscosity, and chemical composition of the proposed prototypes of compositions was determined (Table 1). It was found that the maximum effective viscosity η_{ef} (Pa·s) of all paste compositions is: 1–486; 2–578; 3–455, and control – 165, respectively (Fig. 2). The presence of a greater shear characteristic for quince and pumpkin puree compared to apple puree is due to the higher content of pectin substances in them and the difference in the initial dry matter content. In general, the manufactured recipe compositions exceed the control sample by 2.7...3.5 times, which indicates a significant strengthening of their structure. This effect is due to the presence of a higher content of dietary fiber in quince and pumpkin compared to apple. Overall, this effect of strengthening the structure is a positive phenomenon special during the formation and structure formation of various confectionery products, for example, pastel-marmalade, soft sweets, etc.

An organoleptic assessment of the quality indicators of paste samples showed that all samples have a pasty structure, but the second sample, which has a rich bright yellow-orange range, has an advantage in color. A lower percentage of quince leads to a deterioration in the color range of the paste. According to the indicators of evaluation by taste and aroma, the second sample also has the most pleasant quality with an inherent quince taste and smell, in contrast to the first and second samples. The presence of more pumpkin gives the sample an unpleasant specific vegetable flavor. All samples have a homogeneous viscous structure with good performance and do not spread when placed on a flat surface but, according to the structural-mechanical indicator, the second sample with a viscosity of 578 Pa·s also has an advantage (Fig. 2). Based on the assessment, for further research, sample II with the percentage of formulation content of raw materials was chosen: apple – 30 %; quince – 50 %; pumpkin – 20 %. This multicomponent paste has a pleasant taste and aroma of quince, bright yellow-orange color, and the highest rate of effective viscosity.

The analysis of the characteristics of fruit and vegetable pastes (Table 3) shows that by the number of physiologically functional ingredients, the percentage of components of the raw materials of sample II exceeds other samples. Compared to the control sample, sample II has 4.7 times more vitamin C, pectin substances almost 2 times, and the content of anthocyanins and catechins is much higher. An active acidity of 3...3.2 of all samples will contribute to less development of anaerobic bacteria and, accordingly, less damage to the finished semi-finished product. It will also make it possible during pasteurization of the paste to use a gentle temperature regime, which will contribute to the preservation of nutrients.

The proposed technique of production of fruit and vegetable paste according to the chosen recipe will make it possible to obtain a semi-finished product of a high degree of readiness with increased indicators of physiologically functional ingredients, due to the use of low-temperature modes of concentration and pasteurization. The paste obtained by this method can be used in various branches of food production, restaurant industry, and in everyday life. The increased rates of structure formation make it possible it to be introduced for the manufacture of various functional products, including confectionery.

The influence of the developed multicomponent fruit and vegetable paste from apples, quince, and pumpkin on the quality of Turkish delight has been established. To this end, a paste was added to the starch paste mixed with boiled sugar syrup with a complete replacement of traditional puree (berry, fruit, or citrus). Taking into account the chemical composition of the developed fruit and vegetable paste, namely the higher content of pectin substances (Table 3), and improved structural performance (Fig. 2), it was assumed the possibility of reducing the formulation amount of starch in the system. Determination of strength by limiting shear stress in Turkish delight samples with a decrease in starch content by 10...30 % showed that it is advisable to reduce starch by 20 %. This contributes to the approximation of the strength index to the control sample, which is

38 kPa in the prototype. At the same time, it is important to maintain good structural indicators for changes in the quantitative ratio of starch and non-starch polysaccharides since this ensures an increase in the number of non-starchy polysaccharides, primarily pectin substances, which, as is known, have a beneficial effect on systems and the human body [15, 24]. So, according to the results of determining the indicators of Turkish delight mass (Fig. 3) and finished products, we consider it rational to completely replace purée with fruit and vegetable paste and reduce the formulation amount of starch by 20 %.

Organoleptic indicators of the quality of fruit and vegetable paste (Table 2) and trial laboratory preparations of Turkish delight with its use, namely the rich aroma and color, made it possible to exclude dye and flavor from the recipe. Thus, Turkish delight with fruit and vegetable paste is characterized by a sweet-sour taste with a pleasant smell of quince, rich yellow-orange color, gelatinous, slightly viscous consistency, and the proper shape with a clear contour (Table 4). According to the physical and chemical indicators, the prototype of Turkish delight is not inferior to the control one and meets the requirements of regulatory documentation for oriental sweets such as soft sweets.

Thus, the improved technology of Turkish delight expands the range of "healthy products" due to the significant number of physiologically functional ingredients in fruit and vegetable paste. Among them are pectin substances, ascorbic acid, the content of polyphenols (anthocyanins, catechins) and polymeric phenolic compounds of condensed matter. The presence of a significant content of polyphenols makes it possible to exclude dye and flavoring from the recipe since Turkish delight with paste has a rich, pleasant aroma and taste. In addition, it is possible to assume a reduction in production costs due to a decrease in the formulation amount of starch and the exclusion of other ingredients. An improved method of production of fruit and vegetable paste and Turkish delight technology can be introduced in the canning and confectionery industries, respectively. To determine the resource efficiency of improved technologies using plant materials, simulation is used [33], however, the theoretical data obtained requires industrial testing of the hardware and technological adaptation of the lines. One of the limitations of research is compliance with hardware and technological recommendations, the change of which will lead to changes in the structural and mechanical properties of products and the final quality obtained. One of the drawbacks is the approbation of the proposed fruit and vegetable paste obtained according to the recommended method and the subsequent introduction into the technological process of making Turkish delights without determining the possibility and efficiency of using multicomponent pasty semi-finished products. It is planned to pay attention to the determination of the chemical composition and quality indicators of Turkish delight during storage in subsequent studies.

7. Conclusions

1. The rational formulation ratio of multicomponent fruit and vegetable paste has been established, which is: apple – 30 %; quince – 50 %; pumpkin – 20 %. The new technique is characterized by the use of short-term concentration of pastes for 30...42 s at a temperature of 60...63 °C in a rotary evaporator under conditions of preheating of purée to 50...52 °C. Such gentle temperature conditions contribute to the production of a semi-finished product with pleasant organoleptic quality indicators and increased chemical composition. The selected formulation ratio of fruit and vegetable paste has a 3.5-fold greater indicator of effective viscosity (578 Pa·s) compared to the control (apple paste), which, when created on its basis, will contribute to a better structure of the formation of the products obtained.

2. Turkish delight with the addition of the developed fruit and vegetable paste is characterized by good organoleptic characteristics: sweet and sour taste with a pleasant smell of quince, yellow-orange color, gelatinous, slightly viscous consistency, and has a clear contour. Also, the addition of fruit and vegetable paste reduces the formulation amount of starch by 20 % while the resulting Turkish delight is characterized by a high strength value, τ=38 kPa. The improved technology of making Turkish delight expands the range of "healthy products" with increased nutritional value due to the significant amount of physiologically functional ingredients in fruit and vegetable paste.

Conflicts of interest

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

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Data availability

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

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