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DEVELOPING MOCHI FROZEN DESSERTS TECHNOLOGY USING BY-PRODUCTS OF JUICE PRODUCTION

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The object of this study is the production of frozen Mochi desserts. A significant problem of our time is the spread of congenital food-borne diseases and the accumulation of waste and by-products of food production, which pollute the environment. These problems significantly reduce the list of products that can be consumed by humans and require additional solutions for the processing of by-products. Devising the recipe and technology of Mochi desserts could make it possible to solve these problems.

The effectiveness of using guar gum in the production of dessert dough in an amount of 10–30 % of the mass of rice flour has been proven. The guar gum solution has a viscosity of 0.34 Pa×s. Due to this, the dough is formed faster and has a stronger structure. Such a solution makes it possible to freeze and thaw products up to 7 times without loss of quality. When xanthan gum is added, the dough is not stable at freezing temperatures: after thawing, it becomes sticky and watery. This indicates an increase in the phenomenon of syneresis.

It has been found that the content of dry matter, fiber, and pectin substances in apple and blueberry juices is 22.3 %, 10.5 %, and 6.3 %, and 11.3 %, 16.2 %, and 1.6 %, respectively. The activity of lipase, lipoxygenase, and catalase enzymes in the specified raw materials is as follows: –0.26 conditional units, –0.004 ΔPV and 98.43 units of activity and –2.8 conditional units, –0.02 ΔPV and 1.43 units of activity. Such results are explained by the chemical composition of the raw materials and may indicate their antioxidant properties.

The results have practical significance for catering enterprises and those that manufacture frozen products. In addition, they could make it possible to increase the profitability of production through the use of by-products. The products devised have health benefits, can be consumed by people with celiac disease, and have added value due to the integrated processing of raw materials

Keywords: frozen desserts, gluten-free products, pomace, guar gum, xanthan gum

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1. Introduction

Mochi desserts are gaining wide popularity on the market. Their feature is the authenticity of Japanese traditions and the uniqueness of their composition and taste. However, the most important thing is that the dough for them is traditionally made from crushed rice or rice flour – gluten-free raw materials. In addition, an important aspect is that their production can use an original filling. This makes such products a potentially promising object for the production of gluten-free health products rich in proteins, dietary fiber, a wide range of vitamins and minerals.

The current task is to devise health products. This is due to the widespread spread of alimentary diseases. Such diseases include celiac disease, gluten intolerance, and wheat allergy. Celiac disease is a poorly studied autoimmune disease in which gluten can be "toxic" and have long-term clinical consequences [1]. People suffering from celiac disease or gluten intolerance must adhere to a gluten-free diet throughout their lives. Consumption of products containing wheat, other cereals, and their processed products should be completely excluded [2]. That is, baked goods, flour confectionery, and other products containing cereal flour are excluded from the diet. In addition, sausages, hot dogs, canned meat and fish, some types of ice cream, etc. may contain hidden gluten [3]. In general, 8.4 % of the world's population has nutritional problems related to wheat [2]. However, it is noted that the percentage of patients is increasing every year. According to medical reports, women are most affected by celiac disease, the incidence rate among men is much lower [4]. It has been established that such people suffer from mineral deficiencies and iron deficiency [5]. In this regard, it is important to find

raw materials for the manufacture of products that will satisfy the needs of celiac disease patients, gluten intolerance, and those who are allergic to wheat. Mochi desserts attract attention due to the use of rice flour for the dough and the possibility of variation in the selection of fillings. It is proposed to use by-products of juice production – pomace – as a component of the filling for desserts. They accumulate in large quantities at canneries during the production of juices and at restaurant establishments during the production of fresh juices. Most often, this waste is disposed of. However, it has a rich chemical composition, which makes it a promising raw material for fortifying other products. In combination with a cheese and cream component, gluten-free products with functional properties can be obtained.

Considering that Mochi desserts are planned to be produced frozen, it is advisable to find solutions to avoid the fragility of rice dough after defrosting. For this purpose, the possibility of using guar gum and xanthan gum as natural structure stabilizers should be considered.

Therefore, it is a relevant task to carry out studies on investigating the quality and processability of possible raw materials for frozen Mochi desserts, on devising the recipes and the technological process of production.

2. Literature review and problem statement

Given the market needs for products for patients with celiac disease, gluten intolerance, or those who are allergic to wheat, the share of research aimed at developing gluten-free products is significantly increasing. It should be noted that the products containing most gluten are bread, bakery products, confectionery, and desserts containing wheat flour. Therefore, a significant body of research is aimed specifically at developing gluten-free bread and confectionery products. According to data in [6], corn starch and wheat germ meal are promising raw materials for the production of gluten-free bread and pastries. In order to form the necessary structure of the products, it is proposed to use microbial polysaccharides – xanthan, enposan, and gellan. It has been proven that such a solution contributes to an increase in the specific volume of products, provides an elastic structure of baked goods and high organoleptic indicators. In addition, it was shown that the use of the listed microbial polysaccharides slows down the processes of staleness of bread from corn starch and pastries from wheat germ meal.

According to the data given in [7], an alternative way to obtain high-quality bread without using gluten as a structure-forming agent is to use modified starches, protein isolates, or concentrates from pseudocereals or nuts instead of wheat flour. In order to improve the quality of such bread, including during storage, it is proposed to use native starters or dry baking mixes based on amylase, transglutaminase, and other enzymes. These solutions make it possible to obtain bread with well-developed porosity. These data correlate with the results given in [6]. However, in the production of Mochi desserts, rice viscous dough will be used. Porosity in this case is not an important indicator, while the influence of components on the dough structure during freezing and thawing is of great importance. No such data were found when using starters with enzyme preparations. In addition, the issue of avoiding brittleness of gluten-free dough after defrosting in the production of frozen desserts remains unexplored.

The cited studies [6, 7] are aimed at the production of baked goods that undergo heat treatment. The properties of various structure-forming agents on the characteristics of gluten-free dough under the influence of high temperatures have been studied. However, the issue of the influence of freezing temperatures on the quality indicators of dough systems is poorly studied.

In [8], the influence of xanthan gum, guar gum, locust bean gum, and konjac-glucomannan on the structure of tapioca starch during freezing and thawing was studied. It was found that xanthan gum reduces starch retrogradation. Its introduction also reduces the phenomenon of syneresis. Guar gum does not slow down the retrogradation of tapioca starch gel, and the other mentioned hydrocolloids have an insignificant effect.

In [9], the possibility of using guar, xanthan, tara, and carboxymethylcellulose gums on the rheological characteristics of vegetable puree fortified with proteins was studied under the conditions of its cooling and freezing. The introduction of hydrocolloids made it possible to achieve the desired "pudding" viscosity of the fortified vegetable puree. It was proven that the introduction of these gums, in addition to tara gum, contributes to maintaining the stability of the puree after freezing and thawing. The best viscosity was observed in vegetable puree samples with the introduction of xanthan gum.

According to research data [10], the introduction of carboxymethyl cellulose or xanthan gum in an amount of 0.6 %, or gelatin in an amount of 6 % of the mass of strawberry puree makes it possible to get a high-quality dessert. The phenomenon of syneresis with such a solution is reduced. It is noted that strawberry desserts with the addition of the specified hydrocolloids in the specified quantities after defrosting have a higher viscosity compared to the sample without the addition of structure-forming agents. This effect of the additives is noted as positive, especially when xanthan gum and carboxymethyl cellulose are added to the strawberry mass.

The cited papers [9, 10] describe in detail the effect of gums on the structure of vegetable and berry systems after freezing and thawing. However, this can only to a certain extent characterize the behavior of xanthan and guar gums when they are added to rice dough, which will be frozen and thawed. This is due to the fact that the chemical composition of the systems studied in [8–10] and the proposed system is radically different. In addition, different quality requirements are imposed on the described products and rice dough. In this regard, studies aimed at investigating the effect of xanthan and guar gums on the quality of rice dough after freezing and thawing are relevant.

It should also be noted that an important component of Mochi desserts is their filling. Both the demand for products and the functionality of desserts will depend on its composition to a large extent.

In [11] it is noted that the combination of a creamy component and fruit components such as pear, grapefruit, and figs, make it possible to obtain low-calorie desserts without the use of fat and sugar. The studies are aimed at investigating the possibility of various processing of the fruit component in order to use it as a sugar substitute. It should be noted that the work considers a promising solution for the production of low-calorie desserts, including frozen ones. However, the developed desserts do not contain dough in their composition and are proposed for sale at catering establishments and not for industrial production. In addition, the use of pre-pro-

cessed fruits is proposed as a fruit component. This does not solve the issue of comprehensive processing of raw materials because it is known that a significant amount of pomace accumulates at canneries after making juices. It is sent to feed production or to the production of pectin, but are mostly disposed of [12, 13]. The problem of significant accumulation of pomace is especially noticeable when processing fruits and berries with strong cytoplasmic membranes and a significant amount of dietary fiber in the composition. This complicates the juice yield, causes greater accumulation of by-products and, accordingly, requires additional technological solutions aimed at increasing the juice output [12]. However, even with the improvement of the pressing process and additional processing of pomace, the amount of waste in the processing of fruits and vegetables is 22 %. In numerical terms, this is from 15 to 32 million tons, which, of course, causes significant economic losses to business entities and negatively affects the environmental friendliness of production. At the same time, only 8 % of it is further processed while the rest is disposed of [13].

From the point of view of environmental issues and sustainable development, there is a growing interest in the use of by-products to create functional products with increased added value. This effect can be achieved due to the fact that pomace is rich in organic acids, anthocyanins, a wide range of vitamins and minerals, and dietary fiber. The composition of useful components depends on the raw materials from which pomace was formed in the technological process of juice production [12, 13].

It is known that the following is used for enrichment: in butter cookies – potato pomace; in pasta – apple pomace; in biscuit semi-finished products – papaya pomace; in whole grain bread – sea buckthorn berry pomace [13]. To fortify the listed products, pomace was used in native or dried form. However, a promising solution is to carry out extraction, which will make it possible to obtain liquid extracts rich in essential substances. This could expand the range of their use.

The method of extraction with a water-alcohol mixture from the pulp of sea buckthorn and cranberry berries was proposed in [14]. In this way, tinctures were obtained from the mentioned by-products and used for the production of mixed drinks – shots, with a reduced alcohol content. This solution makes it possible to reduce costs in the restaurant industry and at canneries, to increase the profitability of these enterprises.

The effectiveness of using an aqueous extract of Chaenomeles pomace as a substitute for citric acid solution in the production of pickled mushroom snacks has been proven. It has also been established that the introduction of an aqueous extract of Chaenomeles pomace to replace 40 % of water when kneading dough for yeast flour products makes it possible to reduce the duration of dough fermentation and increase its biological value [15]. According to the analyzed data, by-products of juice production such as pomace are used in the food industry to fortify bakery, pasta, confectionery products in native or dried form. Pomace extracts are used for the production of mixed drinks, bakery products, and to prevent darkening of pickled mushrooms. However, it should be noted that only a small number of studies considered the possibility of using such raw materials in the production of gluten-free products. In addition, no information was found on the use of pomace for the production of dessert products. All this indicates the feasibility of devising a technology for gluten-free dessert products using pomace as a functional component of the filling.

Therefore, based on data from the literature, it can be stated that the development of a recipe and technology for frozen Mochi desserts is a timely task. This will make it possible to expand the range of gluten-free dessert products and will contribute to the comprehensive processing of raw materials. Also, when developing new products, the proposed raw materials, their technological characteristics, and technological process parameters should be carefully studied. According to our review, in order to reduce the brittleness of rice dough after freezing and thawing, it is advisable to consider the possibility of using xanthan and guar gums. To give the products functionality, and the production – environmental friendliness, it is worth introducing by-products of juice production into the dessert recipe. Taking into account the raw material base and chemical composition of pomace, it is proposed to use apple and blueberry pomace as a fruit component of the Mochi dessert filling. Such a solution will not only expand the range of gluten-free products but will also meet the requirements of sustainable development and ensure comprehensive processing of raw materials.

Considering all of the above, devising a recipe and a technological scheme for a gluten-free frozen dessert Mochi is a promising task. The selection of raw materials for recipes for gluten-free desserts Mochi will make it possible to expand the range of products for patients with celiac disease and gluten intolerance. The establishment of the necessary technological process parameters will contribute to the easy adaptation of the proposed technology to industrial conditions.

3. The aim and objectives of the study

The aim of our study is to devise a technology for frozen Mochi desserts using apple and blueberry pomace as a fruit component of the filling. This will make it possible to correctly select raw materials and their ratios for the production of frozen Mochi desserts, as well as to expand the range of gluten-free products with functional properties, which corresponds to the concept of sustainable development.

To achieve this goal, the following tasks were formulated:

– to investigate the quality indicators of raw materials that will be used for the production of frozen Mochi desserts;

– to devise a recipe and technological scheme for frozen Mochi desserts;

– to study the quality indicators of semi-finished products and finished products.

4. Materials and methods of research

4. 1. Methods of research on the quality indicators of raw materials to be used for the production of frozen Mochi desserts

The object of research in our work is the production of frozen Mochi desserts using xanthan or guar gums in the dough and by-products of juice production as a fruit component of the filling. The hypothesis of the research suggests that the use of xanthan and guar gums in the rice dough recipe for frozen Mochi desserts should improve its structure immediately after production and after freezing and thawing. In addition, the introduction of hydrocolloids can contribute to the reduction of the technological process of dough production due to their stabilizing effect. The use of apple and blueberry pomace as a fruit component of the filling for des-

serts will make it possible to obtain functional products with added value. In combination with cottage cheese and cream, such a filling will have a positive effect on the human body, saturating it with proteins, fats, dietary fiber, and a wide range of vitamins and minerals.

In the studies we used rice flour according to TU 15.6-00952737-006-2002; cane sugar according to DSTU 4867:2007; corn starch according to DSTU 3976:2000; drinking water according to SanPiN 2.2.4-171-10 and DSTU 7525:2014; cream cheese according to DSTU 4395:2005; cream with a fat content of 33 % according to DSTU 7519:2014; guar gum according to TU 2458-019-57258729-2006; xanthan gum according to the current regulatory documentation and the manufacturer's quality certificate. Apple and blueberry pomace were used in accordance with the quality standards for by-products and had to meet sanitary and microbiological requirements. The technological process, during which the specified gums and by-products of juice production are obtained, is carried out in accordance with the international standards DSTU ISO 9001, DSTU ISO 22000 (HACCP), DSTU ISO 14001. It should be noted that all components considered for both the production of dough and filling do not contain gluten. Therefore, the resulting products can be consumed by people with gluten intolerance, wheat allergies, and celiac disease.

All of the above assumptions require scientific confirmation. For the development of a new product, it is important to understand the quality indicators and technological characteristics of the raw material. This is also important for the development of an effective technological process. In this regard, at the first stage of research, it is important to study the quality indicators of the proposed raw material. For this purpose, the following research methods were used: organoleptic assessment of the quality of the raw material that will be used for the development of Mochi desserts was carried out by tasting and visualization. The acidity of cream and cream cheese was determined according to standard procedures given in ISO/TS 11869. The acidity of apple and blueberry pomace was determined according to generally accepted procedures for determining acidity in fruit and vegetable products [26]. The acidity of rice flour, xanthan and guar gums was determined according to AOAS 943.02,981.12 and AACS 02-31.01. The dry matter content of the raw materials under study, which had a liquid or thick consistency, was determined by the refractometric method based on the light refraction index [16]. In powder systems (rice flour, xanthan, and guar gums), the moisture content was determined by the drying method according to the AACCI 44–15 procedure. After that, the dry matter content of the specified products was calculated.

The content of dietary fiber in the raw materials to be used is important for the creation of health-promoting products. Therefore, the content of fiber and pectin substances was determined in apple and blueberry juices, as well as in rice flour. It is these non-starch polysaccharides of the composition that will make it possible for us to understand not only the functionality of the proposed raw materials but also their processability. Fiber and pectin substances can have a significant impact on the technological process. The fiber content in the listed raw materials was determined by the modified Scharrer method according to ISO 6541:1981, the amount of pectin substances – according to the procedure given in [17].

When working with gums, which are natural stabilizers and thickeners, it is important to understand their rheological characteristics and technological properties. These values will be an important component in the development of technological process parameters. Therefore, it was considered appropriate to investigate the viscosity of guar and xanthan gums in comparison with the viscosity of rice flour. For this purpose, the Hepler apparatus was used [18]. The time of gelatinization in the gums was determined by preparing a 1 % solution of the corresponding gum and determining the time of the onset of gelatinization.

The activity of the enzymes lipase, lipoxygenase, and catalase was also determined in the studied raw materials as they can have a significant impact on the processes occurring during the storage of the finished product.

To determine the activity of lipase, 3 g of sunflower oil was mixed with 2 cm^3 of phosphate buffer (pH=7.4) and stirred. 1 g of the raw material under investigation (rice flour, guar or xanthan gum, apple and blueberry pomace), 3 cm^3 of distilled water were added to the resulting suspension, mixed thoroughly, the flask was corked and left to infuse for 1 hour. At the same time, the contents of the flask were periodically stirred. The infused mixture was quantitatively transferred to another conical flask. The residues from the infusion flask were washed with a mixture of alcohol and ether in a ratio of 1:1. The resulting solution was titrated with 0.05 N KOH solution; phenolphthalein was used as an indicator, titrated until a purple color appeared. A control experiment was carried out in parallel, in which the reaction mixture was boiled for 5 minutes before incubation to inactivate lipase. Lipase activity was calculated using formula (1):

$$LA = \frac{(a-b)}{g}, \quad (1)$$

where LA – lipase activity;

a – amount of KOH spent on titration in the working experiment, cm^3;

b – amount of KOH spent on titration in the control experiment, cm^3;

g – batch of material, g.

To determine the activity of lipoxygenase, 1 g of the test raw material was mixed with 50 cm^3 of distilled water, the temperature of which was 40 °C. 10 cm^3 of refined sunflower oil, the temperature of which was also 40 °C, was added. The resulting mixture was kept at room temperature for 20 min, shaking periodically. After that, it was centrifuged for 5 min at a speed of 3000 rpm. NaCl was added to the obtained first fugate to break the emulsion, repeated centrifugation was carried out, and the peroxide value was determined in the obtained oil sample. The effect of the test raw material on the activity of lipoxygenase was evidenced by the change in the peroxide value of the oil, which was processed under the specified conditions in the presence of the raw material compared to the peroxide value of the oil, which was not subject to the action of the raw material. The calculation of the activity of lipoxygenase was carried out according to formula (2):

$$PV_1 - PV_2, \quad (2)$$

where X is the activity of lipoxygenase;

PV_1 is the peroxide value of the oil with the addition of the test material;

PV_2 is the peroxide value of the oil without the addition of the test material to the sample.

In order to determine the activity of the catalase enzyme, it was necessary to prepare an extract from the raw material. For this purpose, 2 g of the test material was poured into 100 cm^3 of distilled water and kept for an hour at room temperature. The resulting extract was filtered. It should be noted that the extracts of guar and xanthan gums formed viscous colloidal solutions, so before filtering they were heated to destroy the structure. All extracts were filtered through a paper filter. 20 cm^3 of the filtrate was taken into 2 flasks. One of the flasks was boiled for 5 min – a control sample. 20 cm^3 of distilled water, 3 cm^3 of a 1 % solution of hydrogen peroxide, which was previously neutralized with a 0.1 N NaOH solution, were added to both flasks and left to stand for 30 min at room temperature. After settling, 5 cm^3 of 10 % H_2SO_4 solution was added, and the remaining amount of hydrogen peroxide was titrated with 0.1 N $KMnO_4$ solution. The activity of the catalase enzyme was judged by the amount of hydrogen peroxide destroyed within 30 min by the enzyme contained in 1 g of the tested raw material according to formula (3):

$$AK = \frac{(a-b)\times 1,7}{m}, \quad (3)$$

where AK is the activity of the catalase enzyme;

a is the amount of $KMnO_4$ solution used for titration in the control experiment, cm^3;

b is the amount of $KMnO_4$ solution used for titration in the working experiment, cm^3;

m is the batch of the material, g.

Taking into account the results obtained during our research, recipes for Mochi desserts were prepared and trial production was carried out. After analyzing the data obtained, the ratio of components was selected, which makes it possible to obtain high-quality products, and a principle and technological scheme of production was developed.

4. 2. Methods for researching the quality of semi-finished products and finished products

An important indicator for dessert products is the whipping of the filling. Therefore, it was considered advisable to study this indicator for the cheese-cream filling that will be used in the production of frozen Mochi desserts. For this purpose, the volume of the cheese-cream mixture before whipping and after whipping was weighed. The calculation is carried out according to (4):

$$S = \frac{M_1 - M_2}{M_2}\times 100, \quad (4)$$

where M_1 is the mass of the cylinder with the mixture before whipping, g;

M_2 is the mass of the cylinder with the mixture after whipping, g.

The value is satisfactory if it is not less than 80 %.

The effect of gums on the brittleness of rice dough was studied by repeatedly freezing and thawing the dough and visually assessing its brittleness after such treatment. In this way, the number of repeated freezing and thawing cycles that the dough can withstand was determined.

The acidity according to ISO/TS 11869 and the melting resistance of the finished Mochi were investigated. The melting resistance of Mochi was determined in samples of the dessert with and without a rice shell.

4. 3. Statistical processing of research results

The error for all studies was σ=3–5 %, the number of parallel experiments – n=5, probability – P≥0.95. Experimental data were treated statistically using the Fisher-Student method at a reliability level of 0.95. The results were calculated as the arithmetic mean of at least five experiments. The MS Office 2016 application package, including MS Excel (USA), was used to process experimental data.

5. Results of determining the quality and manufacturability of raw materials and semi-finished products for the production of frozen desserts

5. 1. Research on the quality indicators of raw materials that will be used for the production of frozen desserts Mochi

The organoleptic characteristics of the raw materials planned for use are of great importance for the development of new product recipes. This is important for assessing the possible perception of the developed product by the consumer. The results are given in Table 1.

Table 1

Organoleptic quality indicators of raw materials for the production of frozen Mochi desserts

Raw material	Indicator and its value		
	Color	Taste and aroma	Consistency and appearance
Rice flour	White	Neutral	Dry powdered product
Guar gum	Gray		
Xanthan gum	Cream		
Cream cheese	White	Salty, milky	Dense, plastic. The surface is smooth, oily
Cream	White with a cream tint	Pleasant, sweet, milky	Homogeneous, viscous liquid
Apple pomace	Yellow-green	Apple-like, no foreign aroma	Heterogeneous, not too wet mass. Contains peel inclusions
Blueberry pomace	Dark purple	Blueberry-like, no foreign aroma	Heterogeneous mass with the inclusion of berry particles

According to the data given in Table 1, all raw materials planned to be used in the work met the quality standards for organoleptic indicators.

An important aspect in the formation of the taste profile of the product being developed is the physicochemical quality indicators of the starting raw materials. These indicators will have an impact on the formation of the structure of the products by influencing the technological process. In this regard, the study of physicochemical quality indicators of raw materials is an important task at the first stages of the development of new products. The results of the research are given in Table 2.

According to the data given in Table 2, the acidity of rice flour is 36.4–45.6 % lower compared to the standard values for wheat flour [19].

Important for both the sensory perception of products by the consumer and for the technological process is the content of dry substances in the filling components. According to the data obtained, the highest content of dry substances is in cream cheese, which will serve as the basis of the cheese-cream component of

the dessert. Analyzing the content of dry substances in the fruit component of the future dessert, it was found that apple pomace contains 2 times more dry substances than blueberry pomace. This can significantly affect the planning of the technological process of dessert production. In addition, such a difference in the structure of by-products can have a significant impact on the organoleptic characteristics of finished products.

Table 2

Physical-chemical quality indicators of raw materials for the production of frozen Mochi desserts (n=5, P≥0.95, σ=3–5 %)

Raw material	Indicator and its value			
	Titrated acidity		pH	Dry matter content
	degree	%		
Rice flour	2.2	0.15	5.7	86.0
Guar gum	2.0	0.14	6.0	80.4
Xanthan gum	0.4	0.03	7.4	80.2
Cream cheese, °T	68.0	4.76	4.9	58.0
Cream, °T	32.0	2.24	6.1	15.0
Apple pomace	4.0	0.28	3.1	22.3
Blueberry pomace	5.2	0.36	2.6	11.3

When forming the structure of the filling for desserts, the content of dietary fiber in its components will also be important. In addition, the content of dietary fiber will also have a functional effect on the human body. In this regard, the content of fiber and pectin substances in by-products of juice production and rice flour was determined (Table 3).

Table 3

The content of fiber and pectin substances in raw materials (*n*=5, *P*≥0.95, σ=3–5 %)

Raw material	Non-starch polysaccharides and their quantity, %	
	fiber	pectin substances
Apple pomace	10.5	6.3
Blueberry pomace	16.2	1.6
Rice flour	1.4	–

According to our data, the highest fiber content is found in blueberry pomace and compared to apple pomace, is 54.3 % higher, and compared to rice flour – 11.6 times higher. Comparing the data on the content of pectin substances, it was found that apple pomace is richer in this non-starch polysaccharide, and rice flour does not contain pectin substances. Thus, the content of pectin substances in apple pomace is 3.9 times higher compared to blueberry pomace. Such results should be taken into account when planning the technological process because they can significantly affect the structure of products and the parameters of technological processes during their production. In addition to the above, the viscosity of the solutions of the proposed gums in comparison with rice flour, and the time of gelatinization will have a significant impact on the technological process of dough formation (Fig. 1, *a*, *b*).

After conducting the experiment, it was found that the guar gum solution has the highest viscosity (Fig. 1, *a*). Also, a jelly-like structure is formed faster in the guar gum solution. These indicators will have a significant impact on the speed of the technological process.

An important indicator of raw materials that should be taken into account when developing new products is enzymatic activity. The value of the enzymatic activity of raw materials in the production of Mochi desserts can have a significant impact on the duration of storage of freshness of products in a thawed state. This is due to the fact that the activity of the enzymes lipase, lipoxygenase, and catalase can indicate the antioxidant properties of the raw materials. The results of calculations are given in Table 4.

Table 4

Enzyme activity of the experimental raw materials (n=5, P≥0.95, σ=3–5 %)

Enzyme name, unit of measurement	Enzymatic activity				
	rice flour	guar gum	xanthan gum	apple pomace	blueberry pomace
Lipoxygenase, Δ*PV* relative to the control sample	0.40	–1.00	3.00	–0.004	–0.02
Lipase, conditional units relative to the control sample	0.10	–0.01	–0.05	–0.26	–2.8
Catalase, units of activity/1 g raw materials	–19.0	1.7	–0.09	98.43	1.43

Analyzing data on our studies (Table 4), we can conclude about the potential antioxidant properties of apple, blueberry pomace, and guar gum. Such results indicate the possibility of prolonging the freshness of products using the specified raw materials. At the same time, it has been proven that the use of xanthan gum, on the contrary, can accelerate the spoilage processes of desserts in the thawed state.

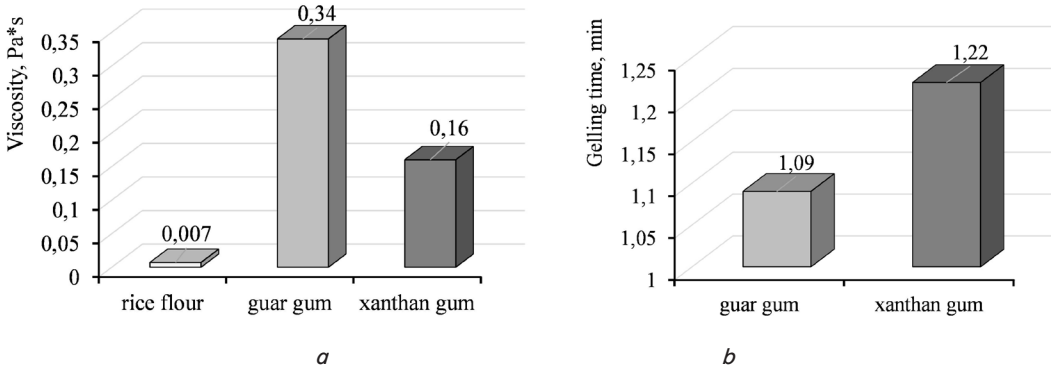

Fig. 1. Investigating the viscosity and gelation time of gums (n=5, P≥0.95, σ=3–5 %): *a* – viscosity of pastes compared to rice flour; *b* – gelation time

Based on the data on the quality indicators and technological characteristics of the raw materials, it is possible to compile recipes for frozen Mochi desserts to determine the best ratio of components. Also, taking into account the data, it becomes possible to develop technological process parameters.

5. 2. Development of the recipe and technological process for the production of frozen Mochi desserts

Considering the data given above, a number of Mochi dessert recipes were devised (Table 5).

As can be seen from Table 5, the dough with the addition of gums differs only in the amount of rice flour and, accordingly, the percentage of guar or xanthan gum. All other components of the dough do not change. The indicated components of the dough do not contain gluten. The filling components also do not contain gluten, so such products can be called gluten-free and contain the appropriate marking on the packaging.

According to the given recipes (Table 5) and taking into account the technological characteristics of the proposed raw materials (Fig. 1, *a, b*; Tables 2, 3), a principle and technological scheme for the production of frozen Mochi desserts was drawn up (Fig. 2).

It was found that preheating of the rice dough (Fig. 2, sector A) to form the necessary sticky structure should be carried out only for samples without the addition of gums. Thus, it was proven that the addition of guar or xanthan gum reduces the technological process of dough production for frozen Mochi desserts.

Table 5

Mochi dessert recipes

Name of raw materials	Recipe amount of raw materials for the preparation of Mochi
control sample dough	
Rice glue flour, g	100
Cane sugar, g	100
Cornstarch, g	5
Water, ml	220
Dough when adding gum guar or xanthan	
10 % by weight of flour	90 g rice flour+10 g polysaccharide
20 % by weight of flour	80 g rice flour+20 g polysaccharide
30 % by weight of flour	70 g rice flour+30 g polysaccharide
Dough when adding xanthan gum	
10 % by weight of flour	90 g rice flour+10 g polysaccharide
20 % by weight of flour	80 g rice flour+20 g polysaccharide
30 % by weight of flour	70 g rice flour+30 g polysaccharide
Stuffing	
Cream cheese, g	50
Cream, fat content 33 %, g	50
Apple or blueberry pomace, g	450
Icing sugar, g	40
Total:	1015

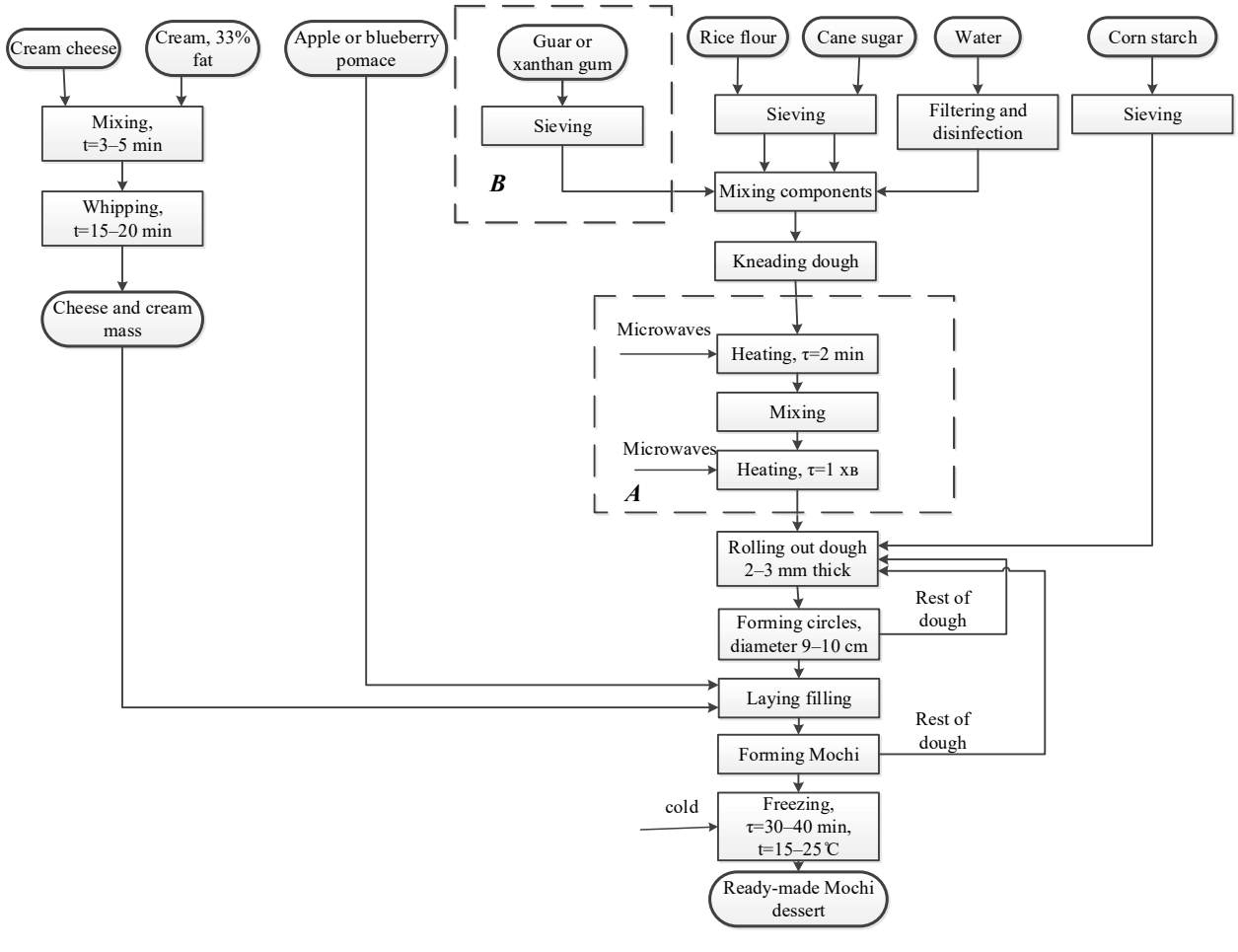

Fig. 2. Schematic diagram of the production of frozen dessert Mochi: sector A — operations used to make only dough from 100 % rice flour; sector B — operations used when using gums in percentage amounts

5. 3. Investigating the quality indicators of semi-finished products and finished products

According to the developed recipes (Table 5) and in accordance with the technological scheme (Fig. 2), test samples of Mochi desserts were produced.

A very important indicator for dessert products is the whipping of the filling or dessert mass. This indicator will indicate the "airiness" of the dessert. It depends on the raw materials from which the filling is made; for this work – on cream cheese and cream, and on the time of its whipping. The latter indicator will significantly affect the technological process, the operating time of the equipment. Therefore, it is important to determine the time required to whip the filling and obtain its maximum quality. The results are shown in Fig. 3.

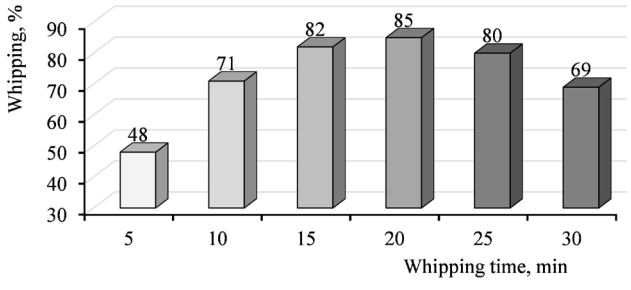

Fig. 3. Dependence of whipping of the cheese and cream filling on whipping time (n=5, P≥0.95, σ=3–5 %)

According to the data shown in Fig. 3, the whipping time has a significant impact on the whipping index of the cheese-cream filling. It was found that the filling can be either under-whisked or over-whisked, which will lead to a decrease in its quality. Thus, the whipping index must be carefully controlled.

The ability of rice dough to retain its structure after repeated freezing and thawing will be of great importance for the formation of a positive consumer opinion. The results of the determination are given in Table 6.

Table 6

Resistance of gluten-free dough to repeated freezing (n=5, P≥0.95, σ=3–5 %)

Dough sample	Brittleness after thawing							
	1 time	2 times	3 times	4 times	5 times	6 times	7 times	8 times
Control (100 % rice flour)	–	–	±	+	+	+	+	+
With added guar gum								
10 %	–	–	–	–	–	±	±	+
20 %	–	–	–	–	–	–	±	±
30 %	–	–	–	–	–	–	–	±
With added xanthan gum								
10 %	–	–	–	–	–	±	±	+
20 %	–	–	–	–	–	±	±	+
30 %	–	–	–	–	–	–	±	+

During the experiment, it was found that the introduction of both guar and xanthan gum in the entire dosage range contributes to greater resistance of rice dough to changes occurring during repeated freezing and thawing. However, these gums had different effects on the sensory perception of the dough after freezing and thawing.

At the next stage of the research, the physicochemical parameters of frozen Mochi desserts were studied (Table 7).

Table 7

Physicochemical parameters of frozen Mochi desserts (n=5, P≥0.95, σ=3–5 %)

Sample of finished Mochi	Indicator	
	Acidity, °T	Melting resistance, min
Without dough with apple pomace	25.0	1,080
Without dough with blueberry pomace	28.0	960
With dough with apple pomace	21.0	–
With dough with blueberry pomace	23.0	–

Analyzing the acidity of products with and without dough, it was noted that the former have a higher acidity compared to the latter. When using apple pomace as a fruit component, the acidity is higher by 19.0 %, when using blueberry pomace – by 21.7 %.

It was found that the resistance to melting of the developed desserts exceeds 12 hours and the fruit component does not significantly affect the specified indicator. When using blueberry pomace, the resistance to melting decreases by 12.5 % compared to products containing apple pomace. However, even this value exceeds 12 hours, which indicates the convenience of consuming such desserts for a long time after defrosting. In addition, it was found that Mochi in the dough does not melt at all.

A tasting evaluation of the developed products was carried out. It was found that the dough shell of Mochi desserts, which includes guar gum, acquired a grayish tint. The effect was enhanced by increasing the amount of gum in the dough recipe. In addition, the dough became harder with increasing the dosage of guar gum. Tasting analysis of dessert fillings revealed that the use of blueberry pomace as a fruit component causes its partial penetration into the cheese-cream component, while the consistency of the filling slightly deteriorates. At the same time, it was noted that the use of apple pomace does not cause mixing of the fruit and cheese-cream components of the filling. Such a solution makes it possible to obtain products whose fruit component does not penetrate into other layers of the filling and is clearly delimited.

Thus, it was established that the use of by-products of juice production – apple and blueberry pomace, in combination with cheese-cream cream makes it possible to obtain high-quality desserts. A promising solution for reducing the brittleness of rice dough after repeated freezing is the introduction of guar gum into its recipe.

6. Discussion of results based on research on the development of frozen Mochi desserts

It was found that the raw materials used for the production of Mochi dough differ significantly in color (Table 1). The color of xanthan gum has a creamy shade, and guar gum is gray. This is due to the origin of these gums and the technological process of their production [20, 21]. Such indicators of gums can significantly affect the color of the dough when they are used. In contrast to the data given in [6], the addition of guar gum negatively affects the color of rice dough, giving it a gray shade, and xanthan gum has no significant effect. This can be explained by the lack of heat treatment of rice dough for Mochi desserts, while bakery and pastry products in studies

[6] were baked. The effect of high temperature can affect the color change of the dough due to biochemical processes occurring during baking.

It should be noted that the salty taste of cream cheese gives a specific taste to the finished products. Also, the increased humidity of blueberry pomace negatively affects the formation of layering of the product. In this case, the fruit component seeps into the cheese-cream component of the filling, mixing with it, and also to some extent leaks to the outside of the dessert itself. At the same time, the low humidity of apple pomace ensures the structuring of the fruit component of the filling and prevents it from spreading. Data on the consistency of pomace are consistent with the determination of the dry matter content in it (Table 2).

The advantage of using pomace as a fruit component of the filling is the comprehensive processing of raw materials. This will reduce the amount of by-products and waste from canning and catering enterprises, in contrast to the solution proposed in [11] to combine fruit and dairy raw materials for the production of low-calorie desserts. In addition to influencing the quality of products and the integrated processing of raw materials in their production, the use of by-products of juice production can have a functional effect. Products with such a solution can have a preventive value. Along with the use of gluten-free rice flour for the production of dough, this makes it possible to devise recipes and technology for health-improving desserts (Table 5, Fig. 2).

The functionality of the developed Mochi desserts is indicated by the significant content of fiber and pectin substances in the juices (Table 3). Both fiber and pectin substances stimulate intestinal motility, contribute to the elimination of toxins, heavy metals, and radionuclides. Therefore, products whose components are rich in fiber and pectin substances can be used to prevent constipation and hemorrhoids. In addition, fiber contributes to rapid satiety. All this is very important for people with digestive disorders and for those who watch their weight. In addition to the positive effect on intestinal motility and the sorption effect, fiber saturates the human body with vitamins and trace elements. Along with a wide range of vitamins and minerals in apple and blueberry juices, this will have a positive effect on the nutritional profile of the products.

However, it should be noted that a significant content of fiber and pectin substances in raw materials can also significantly affect the technological process of production. In addition, it is possible to influence the formation of the filling structure since pectin substances are a known structure-forming agent. Their insignificant amount in blueberry pomace compared to apple pomace (Table 3) correlates with the data on the more fluid consistency of blueberry pomace (Table 1) and the results of organoleptic evaluation of finished products.

Since Mochi dessert is a complex product, made using various raw materials and semi-finished products, not only the filling components but also the dough components have an important impact on its quality. Xanthan and guar gum, used in the work, are system stabilizers, thickeners. Therefore, it is important for the development of the technological process to study the rheological characteristics of these gums in comparison with the main raw material – rice flour. It was found that the guar gum solution has the highest viscosity (Fig. 1, *a*). This indicator exceeds the similar one by 2.1 times compared to the xanthan gum indicator and by 48.5 times compared to the rice flour indicator. Such results may indicate a greater strength of the dough structure with gums, its faster formation. It was also found that when using guar gum, the jelly-like structure of the solution is formed 11.9 % faster than when using xanthan gum (Fig. 1, *b*). Such results may indicate an acceleration of dough formation, the need for more intensive kneading. It should be noted that according to the data obtained (Fig. 1, *b*), when using guar gum, the intensity of kneading rice dough should be greater than when using xanthan gum. At the same time, on the contrary, the time should be shorter. In addition, it is important to note that when using both proposed gums, the technological process does not require additional heating of the dough, which is mandatory for the control sample (Fig. 2). Dough made exclusively from rice flour should be heated to increase its viscosity by gelatinization of starch. In the case of using gums, the viscosity of the system increases significantly and does not require heating. This will make it possible to shorten the technological process and reduce electricity consumption.

It should be noted that Mochi desserts will be produced frozen. If we take into account the filling components, the cheese-cream cream and the fruit component, freezing and thawing affect them to a small extent [22, 23]. The presence of a covering layer is especially important for preserving the structure during freezing and thawing [23]. In our studies, rice dough will serve as such a covering layer. Unlike work [6], which investigated the effect of heat treatment on the formation of the structure of gluten-free dough with gums, rice dough in our work is exposed to low temperatures. Therefore, the effect of gums on the structure differs from that proven in work [6]. Of great importance during freezing and thawing of gluten-free dough systems is the retrogradation of starch under the influence of low temperatures and the susceptibility of the system to the phenomenon of syneresis. In contrast to the data given in [8], rice dough used for the manufacture of Mochi desserts is a more complex system. However, the results reported in [8] on the effect of hydrocolloids on the retrogradation of tapioca starch may be useful for the above studies. The purpose of adding xanthan and guar gums to rice dough is to make it able to maintain an elastic structure during repeated freezing and thawing, in contrast to their ability to provide a viscous "pudding" structure of vegetable puree [9]. It has been established (Table 6) that adding xanthan or guar gum to the rice dough recipe in the entire dosage range helps increase its resistance to freezing temperatures. It has been proven that adding both gums even in the smallest (10 %) amount helps avoid dough brittleness up to 5 times. At the 6th and 7th times, the dough loses its characteristic stickiness, acquires slight brittleness, but does not crumble. The dough begins to crumble after the introduction of gums in the specified amount after 8 freezing. This correlates with the data presented in [8] and confirms the slowing down of rice flour starch retrogradation in the presence of xanthan and guar gums. However, it should be noted that the addition of xanthan gum in the entire dosage range caused the rice dough to become watery and sticky after thawing. The effect increased with increasing dosage of the gum in the system. In this regard, it is not recommended to use xanthan gum to stabilize dough systems that will be frozen.

Given the possibility of long-term sale of Mochi desserts after defrosting, it is important to study the enzymatic activity of the raw materials used for production. According to the results of enzymatic activity studies (Table 4), it was found that apple and blueberry pomace and guar gum inhibit hydrolytic and oxidative processes. This is evidenced by the negative value of lipase and lipoxygenase activity. The high

value of catalase activity in the listed raw materials indicates its potentially possible antioxidant properties. This is especially pronounced in apple pomace. Such results indicate the possibility of prolonging the freshness of products in the thawed state using the specified raw materials. It was also found that xanthan gum inhibits the action of hydrolytic processes but intensifies oxidative ones. This, in turn, can accelerate the processes of product spoilage. On the other hand, rice flour intensifies both hydrolytic and oxidative processes. At the same time, the value of catalase activity in xanthan gum and rice flour is negative. Thus, the use of xanthan gum in the recipe will accelerate the spoilage processes of rice dough. This once again indicates the inexpediency of using xanthan gum in the new technology.

An important aspect in the development of new recipes and technologies is how the product devised will be perceived by the consumer. Given the characteristics of Mochi desserts, the whipping of the cheese-cream component of the filling will have a significant impact on consumer properties. In addition to consumer properties, this indicator also has technological significance. The time and intensity of whipping directly depend on it. This, in turn, affects the duration of operation of technological equipment. According to the results of research (Fig. 3), the regulated whipping value of 80 % can be achieved by whipping the filling for 15–25 minutes. However, it should be noted that when whipping the filling for 25 minutes, the whipping indicator is lower by 6.3 % compared to the similar value for whipping for 20 minutes. Comparing it with the whipping of the filling that was whipped for 15 minutes, it can be noted that the value is lower by 2.5 %. In addition, increasing the whipping time to 30 min leads to a decrease in the whipping index by 18.8 %, 23.2 % and 15.9 % compared to the indicators for whipping for 15 min, 20 min, and 25 min, respectively. The data obtained indicate that the filling can be either under-whisked or over-whisked, which will lead to a decrease in its quality.

During the research, it was noted that the best whipping index is the filling that was whipped for 20 min. Further whipping causes a decrease in the index by 6.5 % compared to that for whipping for 20 min. Probably, the decrease in the whipping index with an increase in whipping time is associated with the stratification of the cheese-cream component into components. Considering the slight difference in the whipping rate between 15 min and 20 min, which is 3.7 %, we can recommend whipping the filling for Mochi desserts for 15 min. This will reduce the equipment operating time, speed up the technological process, and at the same time will not have a negative impact on the quality of the filling.

The perception of frozen products also depends significantly on their resistance to melting. This indicator indicates how long the dessert can be stored in an unfrozen state before losing its shape and structure. The resistance to melting of the developed Mochi desserts without dough is 960–1080 min (Table 7). When using dough, the products did not melt and did not lose their shape, unlike the frozen desserts presented in [24], which began to melt after 25–80 min. This difference in results is probably due to the composition of the developed desserts and the technology of their production. That is, the advantage of the developed recipe and technology will be the production of high-quality frozen desserts that do not lose their shape and structure even when thawed.

According to the results of our work, it is recommended not to use xanthan gum as a structure-forming agent in the rice dough recipe, and to use guar gum in an amount of 10 % of the mass of rice flour. It is proposed to use apple and blueberry pomace as a fruit component of the filling for Mochi desserts. This will improve the nutritional profile of the finished product by fortifying it with a wide range of vitamins, minerals, fiber, and pectin substances. Also, products using the specified by-products of juice production in combination with the use of guar gum in the dough will have antioxidant properties. This is possible due to the activity indicators of the enzymes lipase, lipoxygenase, and catalase in the specified raw materials (Table 4). When kneading rice dough, which will contain 10 % guar gum, it is recommended to remove the heating stage (Fig. 2), which is used to increase the viscosity of the system.

When implementing the results in production, one should strictly adhere to the results described in our work. This will make it possible to obtain high-quality products. It should be noted that when introducing guar gum into the rice dough recipe, it is not recommended to sell products after five times of freezing and thawing, and products without adding hydrocolloid – after two times. The developed technological scheme (Fig. 2) regarding dough mixing should be strictly adhered to. This will make it possible to reduce equipment operation and electricity consumption for the technological process. When accepting raw materials for the production of the filling, the quality indicators of apple and blueberry pomace should be carefully monitored. Deviation of the parameters from those given in the work by more than 3.5 % may cause deviations in the quality indicators of the finished products.

The disadvantages of our study include the fact that when determining the whipping index of the cheese-cream filling, only the whipping time was taken into account, and the intensity was not taken into account. This could lead to over-whipping of the filling at a more intensive mode, or to under-whipping – at a less intensive one at the same time. However, the identified drawback was technologically eliminated, a range of whipping times was proposed and the need for process control was emphasized.

Further research will be aimed at studying the microbiological stability of the developed desserts during storage both in the frozen and thawed state. The possibility of improving the color of the dough using natural ingredients will also be studied. Research will be conducted to study the possibility of using by-products of oil production in the recipe of gluten-free dough. An assortment of fillings for Mochi desserts will be devised.

The above areas of further research are important because, firstly, the developed desserts and their components do not undergo heat treatment. This can significantly affect the formation of pathogenic microflora during storage. It is also necessary to confirm or refute the antioxidant properties of the raw material, based on the values of its enzymatic activity. Secondly, guar gum, which is recommended to be used to reduce the brittleness of rice dough after repeated freezing and thawing, has a gray color. This negatively affects the color of rice dough, making it unattractive to consumers. It is known that the introduction of any additional non-traditional components, especially of natural origin, into the dough recipe can significantly affect its quality. In this regard, research aimed at finding natural raw materials that would improve the color of the dough and studying the impact on quality indicators is an important task. Thirdly, the oil industry currently produces a significant number of “niche” oils using envi-

ronmentally friendly technologies. In such technological processes, a significant amount of by-products with high nutritional and biological value accumulate. In order to comprehensively process raw materials and create products with added value, studying the possibility of using such by-products in the technology of Mochi desserts is a promising task. Fourth, a feature and characteristic attribute of Mochi desserts is the possibility of using original fillings for their production. This will make it possible to expand the range of these products, including gluten-free ones, and will make it possible to adapt the products to the preferences of a wider audience.

7. Conclusions

1. It has been established that all the raw materials proposed for the production of frozen Mochi desserts meet the established requirements. However, it is necessary to take into account the gray color of guar gum, which negatively affects the color of rice dough and, thus, reduces the attractiveness of the product for the consumer. In addition to changing the organoleptic indicators of the dough, the introduction of guar and xanthan gums also has a technological effect since these additives are known structure-forming agents. It was established that the guar gum solution has a viscosity 2.1 times higher than that of xanthan gum solution and 48.5 times higher than that of rice flour. Also, a jelly-like structure is formed in the guar gum solution 11.9 % faster than that of xanthan gum solution. These results indicate the possibility of forming a stronger dough structure in a short time. This, of course, affects the technological process by reducing it.

The use of by-products of juice production in the technology makes it possible to increase the added value of the product due to the integrated processing of raw materials, to give the developed dessert functional properties due to the rich chemical composition of the pomace. It was found that blueberry pomace contains 54.3 % more fiber than apple pomace and 11.6 times more than rice flour. However, apple pomace has a 3.9 times higher content of pectin substances compared to blueberry pomace. This has a significant impact on the consistency of the by-products and, as a result, on their technological characteristics. Blueberry pomace has a more fluid consistency, while apple pomace does not spread. It was found that apple, blueberry pomace, and guar gum have a negative value of the activity of lipase and lipoxygenase enzymes: –0.26; –2.8; and –0.01 conditional units and –0.004; –0.02; and –1.00 ΔPV, respectively. This indicates the ability of the listed raw materials to inhibit hydrolytic and oxidative processes. It was also found that apple, blueberry pomace, and guar gum have a high activity index of the catalase enzyme, units of activity/1 g of raw materials: 98.43; 1.43; and 1.7, respectively. Such results indicate the potentially possible antioxidant properties of the specified raw materials and, as a result, the extension of the shelf life of desserts in thawed form. It was also found that xanthan gum inhibits only the action of hydrolytic processes, and, on the contrary, intensifies oxidative ones. Rice flour intensifies both hydrolytic and oxidative processes. This may indicate the rapid spoilage of thawed desserts during their use.

2. Based on the results of our research into the quality and technological characteristics of raw materials, the recipes and a technological scheme for the production of frozen Mochi desserts were developed. The differences in the proposed recipes are that either guar gum or xanthan gum is added to rice flour when kneading the dough in an amount of 10.0 %, 20.0 %, or 30.0 % to replace flour. It should be noted that the filling in the developed products differs in the fruit component. Either apple pomace or blueberry pomace was used as the fruit component. The fruit components were not mixed together. This solution makes it possible to solve the problem of accumulation of by-products and waste at canning and catering enterprises. It makes production environmentally friendly. It should be noted that both the dough components and the fillings do not contain gluten. This makes it possible to consume such products by people who are allergic to wheat, with gluten intolerance and celiac disease. Considering the rheological properties of gums, it was found that heating to form a sticky structure is not required for dough using them since the necessary dough structure is formed immediately after mixing. This reduces the technological process, electricity costs for its passage, and increases the profitability of production.

3. The main components that shape the quality of ready-made frozen Mochi desserts are rice dough and filling. The established rheological characteristics of the gums make it possible to resolve the issue of rice dough fragility during freezing and thawing. It was found that the use of xanthan and guar gums in an amount of 10.0–30.0 % by weight of rice flour provides greater resistance of the dough to low temperatures compared to control. Fragility in rice dough without the use of gums appears after the third freezing, while the introduction of gums in the entire dosage range makes it possible to freeze the dough up to 6–7 times without destroying the structure. This indicates a slowdown in starch retrogradation in systems with the introduction of gums. However, the acquisition of wateriness and stickiness by the dough when using xanthan gum indicates an increase in the phenomenon of syneresis. It was found that the introduction of guar gum, on the contrary, contributes to an increased ability of the system to retain moisture, the phenomenon of syneresis is absent. The results obtained indicate the inexpediency of using xanthan gum as a stabilizer of the structure of rice dough that will be subjected to freezing. For this purpose, the use of guar gum is effective.

For Mochi desserts, a two-component filling is proposed: cheese-cream cream and apple or blueberry pomace. It was found that to obtain an “airy” structure, it is advisable to whip the cheese-cream cream for 15.0 min, 20.0 min, or 25 min. This makes it possible to obtain a cream with a whipping index of 82.0 %, 85.0 %, or 80.0 %, respectively. It was found that the optimal time over which the highest quality cheese-cream component of the filling is formed is 20 min. However, it was found that the whipping index for whipping for 15 min is only 3.7 % lower than the optimal one. This indicates the possibility of carrying out the operation for both 20 min and 15 min. The technological characteristics of each component are important in shaping the quality of multilayer fillings. It was found that blueberry pomace, due to its low dry matter content (11.3 %) and, as a result, a fluid consistency, is mixed with a layer of curd and cream component. At the same time, apple pomace is more structured due to its higher dry matter content (22.3 %) and pectin substances (6.3 %). This makes

it possible to obtain a fruit component of the filling, which has a clear separation from the curd and cream component. The developed recipes and technological scheme make it possible to obtain desserts that retain their structure and shape even when defrosted. It was found that desserts without dough have a melting resistance of more than 12 hours, and the fruit component does not significantly affect this indicator, and they do not melt in the dough at all. Thus, it was found that by-products of juice production – apple or blueberry pomace – are promising raw materials for filling in the development of frozen Mochi desserts. A promising solution to avoid brittleness of rice dough after repeated freezing and thawing is to use guar gum in its recipe in an amount of 10 % by weight of rice flour.

Conflicts of interest

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

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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References

1. Caio, G., Riegler, G., Patturelli, M., Facchiano, A., De Magistris, L., Sapone, A. (2017). Pathophysiology of non-celiac gluten sensitivity: where are we now? Minerva Gastroenterology, 63 (1). https://doi.org/10.23736/s1121-421x.16.02346-1
2. Sharma, N., Bhatia, S., Chunduri, V., Kaur, S., Sharma, S., Kapoor, P. et al. (2020). Pathogenesis of Celiac Disease and Other Gluten Related Disorders in Wheat and Strategies for Mitigating Them. Frontiers in Nutrition, 7. https://doi.org/10.3389/fnut.2020.00006
3. Senatorova, G., Omelchenko, O., Teslenko, T., Muratov, G., Orlova, N., Chatykian, K. (2023). Challenges in differential diagnosis of coeliac disease and gluten intolerance in children. Neonatology, Surgery and Perinatal Medicine, 13 (2 (48)), 61–70. https://doi.org/10.24061/2413-4260.xiii.2.48.2023.9
4. Afanasiuk, O., Shmaliy, V., Yakovets, O. (2022). Klinichnyi vypadok tseliakiyi u doroslykh. Grail of Science, 14-15, 584–589. https://doi.org/10.36074/grail-of-science.27.05.2022.105
5. Hubska, O. Yu. (2019). Oberezhno – hliuten! Shcho neobkhidno znaty pro tseliakiyu? Available at: https://health-ua.com/article/41194-oberezhnoglyuten--sho-neobhdno-znati-pro-tcelakyu
6. Samokhvalova, O., Kucheruk, Z., Kasabova, K., Oliinyk, S., Shmatchenko, N. (2021). Effect of microbial polysaccharides on the quality indicators of protein-free and gluten-free products during storage. Eastern-European Journal of Enterprise Technologies, 1 (11 (109)), 61–68. https://doi.org/10.15587/1729-4061.2021.225003
7. Šmídová, Z., Rysová, J. (2022). Gluten-Free Bread and Bakery Products Technology. Foods, 11 (3), 480. https://doi.org/10.3390/foods11030480
8. Muadklay, J., Charoenrein, S. (2008). Effects of hydrocolloids and freezing rates on freeze–thaw stability of tapioca starch gels. Food Hydrocolloids, 22 (7), 1268–1272. https://doi.org/10.1016/j.foodhyd.2007.06.008
9. Giura, L., Urtasun, L., Ansorena, D., Astiasarán, I. (2022). Effect of freezing on the rheological characteristics of protein enriched vegetable puree containing different hydrocolloids for dysphagia diets. LWT, 169, 114029. https://doi.org/10.1016/j.lwt.2022.114029
10. Boča, S., Galoburda, R., Skrupskis, I., Skrupska, D. (2014). The Effect of Freezing and Hydrocolloids on the Physical Parameters of Strawberry Mass-Based Desserts. Proceedings of the Latvia University of Agriculture, 31 (1), 12–24. https://doi.org/10.2478/plua-2014-0002
11. Alija, J., Talens, C. (2012). New concept of desserts with no added sugar. International Journal of Gastronomy and Food Science, 1 (2), 116–122. https://doi.org/10.1016/j.ijgfs.2013.06.002
12. Lapytska, N., Syza, O., Gorodyska, O., Savchenko, O., Rebenok, E. (2023). Improving the jelly plum juice technology by using secondary products of oil production. Eastern-European Journal of Enterprise Technologies, 3 (11 (123)), 68–77. https://doi.org/10.15587/1729-4061.2023.281929
13. Kowalski, S., Gumul, D. (2024). The Use of Waste Products from the Food Industry to Obtain High Value-Added Products. Foods, 13 (6), 847. https://doi.org/10.3390/foods13060847
14. Lapytska, H., Biloborodko, A. (2024). Development of shot technology using by-products of juice production. Biota. Human. Technology, 3, 160–169. https://doi.org/10.58407/bht.3.24.9
15. Khomych, G. P., Nakonechna, Yu. G., Oliynyk, L. B., Gaivoronska, Z. M., Nakonechnyy, K. R. (2024). Use of juice production waste in food technology. Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies, 26 (101), 127–134. https://doi.org/10.32718/nvlvet-f10119

16. Manual of methods of analysis of foods. Fruit and vegetable products (2015). Food safety and standards authority of India Ministry of health and family welfare government of India. New Delhi. Available at: https://fssai.gov.in/upload/uploadfiles/files/FRUITS_AND_VEGETABLE.pdf
17. Shelukhina, N. P., Fedichkina, L. G. (1994). A rapid method for quantitative determination of pectic substances. Acta Botanica Neerlandica, 43 (2), 205–207. https://doi.org/10.1111/j.1438-8677.1994.tb00745.x
18. Horalchuk, A. B., Pyvovarov, P. P., Hrynchenko, O. O., Pohozhykh, M. I., Polevych, V. V., Hurskyi, P. V. (2006). Reolohichni metody doslidzhennia syrovyny i kharchovykh produktiv ta avtomatyzatsiya rozrakhunkiv reolohichnykh kharakterystyk. Kharkiv, 63. Available at: https://www.researchgate.net/profile/Andrii-Goralchuk/publication/282649472_Rheological_methods_of_raw_foods_and_automation_of_payments_rheological_characteristics/links/5615678208ae4ce3cc6533c3/Rheological-methods-of-raw-foods-and-automation-of-payments-rheological-characteristics.pdf
19. Drobot, V. I. (2019). Dovidnyk z tekhnolohiyi khlibopekarskoho vyrobnytstva. Kyiv, 580.
20. Vozhegova, R. A., Borovik, V. O., Grabovsky, M. B., Marchenko, T. Yu., Grabovskaya, T. O. (2022). Niche cultures – new opportunities for the agro-industrial complex of Ukraine. Agrarian innovations, 13, 181–189. https://doi.org/10.32848/agrar.innov.2022.13.27
21. Demchenko, V. G., Konyk, A. V., Khomenko, M. (2022). Mobile technology complex for the preparation of water-soluble polymers. Scientific Works, 86 (1), 125–132. https://doi.org/10.15673/swonaft.v86i1.2414
22. Simkova, K., Grohar, M. C., Pelacci, M., Veberic, R., Jakopic, J., Hudina, M. (2024). The Effect of Freezing, Frozen Storage and Thawing on the Strawberry Fruit Composition. International Journal of Fruit Science, 24 (1), 186–199. https://doi.org/10.1080/15538362.2024.2355920
23. Alinovi, M., Mucchetti, G. (2020). Effect of freezing and thawing processes on high-moisture Mozzarella cheese rheological and physical properties. LWT, 124, 109137. https://doi.org/10.1016/j.lwt.2020.109137
24. Sawano, M., Masuda, H., Iyota, H., Shimoyamada, M. (2021). Melting Characteristics of Ice Cream Prepared with Various Agitation Speeds in Batch Freezer. Chemical Engineering Transactions, 87, 337–342. http://doi.org/10.3303/CET2187057