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Маргарита Викторовна Черкунова
[Margarita V. Cherkunova],
Асия Рафаильевна Абушаева
[Asia R. Abushaeva],
Мадина Карипулловна Садыгова
[Madina K. Sadygova],
Никита Александрович Семилет
[Nikita A. Semilet]

Исследование реологических свойств полуфабрикатов для восточных кондитерских изделий на основе безглютенового сырья

Investigation of rheological properties of semi-finished products for oriental confectionery based on gluten-free raw materials

Саратовский государственный университет генетики, биотехнологии и инженерии им. Н.И. Вавилова, г. Саратов, Россия / Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, Saratov, Russia

Автор, ответственный за переписку: Никита Александрович Семилет, semiletna@yandex.ru / Corresponding author: Nikita A. Semilet, semiletna@yandex.ru

Аннотация. *Данная статья посвящена изучению реологических свойств готовых тестовых полуфабрикатов для восточных кондитерских изделий на основе безглютенового сырья. В качестве основного сырья использовали муку рисовую и кукурузную. Плотность пены определяли, как отношение определенной массы пены к объему сосуда, измеренному с помощью дистиллированной воды, пенообразующей способности – как отношение высоты столба пены к высоте столба раствора рецептурных компонентов, устойчивость пены – как отношения высоты пены после 3 часов к первоначальной. Органолептические показатели качества определяли в соответствии с ГОСТ Р 50228-92. Дегустационную оценку качества проводили по 10-бальной школе. Структурно-механические свойства образцов чак-чак были изучены на анализаторе текстуры «Структурометр СТ-3» методом определения усилия нагружения на инденторе при его внедрении в корпус образца при скорости движения (внедрения) 1,0 мм/с. В результате проведенных исследований пришли к выводу, что оптимальное соотношение муки рисовой и кукурузной составляет 1:1, в таком соотношение полуфабрикаты характеризуются высокими органолептическими и структурно-механическими показателями качества, не уступающими контрольному образцу полуфабрикатов. Использование муки рисовой и кукурузной в технологии чак-чак позволяет расширить ассортимент безглютеновых восточных мучных кондитерских изделий, пригодных для употребления людям страдающим таким заболеванием как целиакия.*

Ключевые слова: кукурузная мука, рисовая мука, чак-чак, органолептические показатели качества, пенообразующая способность, устойчивость пены, плотность пены, реологические свойства, анализатор текстуры «Структурометр СТ-3»

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Abstract. *This article is devoted to the study of rheological properties of finished dough semi-finished products for oriental confectionery based on gluten-free raw materials. Rice and corn flour were used as the main raw materials. Foam density was determined as the ratio of a certain foam mass to the volume of the vessel measured with distilled water, foaming ability – as the ratio of the height of the foam column to the height of the column of the solution of prescription components, foam stability – as the ratio of the height of the foam after 3 hours to the original. Organoleptic quality indicators were determined in accordance with GOST R 50228-92. The tasting quality assessment was carried out by a 10-point school. The structural and mechanical properties of the chak-chak samples were studied on the texture analyzer "Structurometer ST-3" by determining the loading force on the indenter when it is inserted into the sample body at a movement speed (insertion) of 1.0 mm/s. As a result of the conducted research, it was concluded that the optimal ratio of rice and corn flour is 1:1, in this ratio, semi-finished products are characterized by high organoleptic and structural-mechanical quality indicators that are not inferior to the control sample of semi-finished products. The use of rice and corn flour in the chak-chak technology makes it possible to expand the range of gluten-free oriental flour confectionery products suitable for consumption by people suffering from such a disease as celiac disease*

Keywords: corn flour, rice flour, chak-chak, organoleptic quality indicators, foaming ability, foam stability, foam density, rheological properties, texture analyzer "Structurometer ST-3"

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Introduction. An urgent problem today is improving the quality of flour confectionery products and expanding their range, in particular the development of technology for flour products with functional and dietary properties. The nutritional factor is important in the prevention of many diseases, which also include celiac disease - a disease associated with intolerance to the gluten protein, which impairs the functioning of the mucous membrane of the small intestine. To prevent and solve the problem associated with celiac enteropathy, it is advisable to use alternative raw materials that do not include gluten [18,19,20].

As is known, the components of the diet are influenced by both stable national traditions and the level of everyday culture of the people, as well as their awareness of the beneficial and harmful properties of various products [8]. More than 400 types of flour confectionery products are produced in the Russian Federation; one of the market sectors is occupied by oriental flour sweets, which have gained popularity thanks to the countries of the Near and Middle East and the richness of their assortment. The peculiarity of such flour confectionery products is that the art of their preparation is passed on from generation to generation and continues to be improved. Flour oriental sweets, in particular chak-chak, are characterized by a high content of fat and sugar and a small amount of dietary fiber and micronutrients, which becomes an obstacle to their consumption by people suffering from diabetes, obesity, and cardiovascular diseases. Therefore, it is necessary to improve the technology of national deep-fried flour confectionery products at the present time, implying the search for new technological solutions and the development of recipes that can

improve organoleptic characteristics, increase nutritional and biological value, maintain the quality of products, and also expand the range of gluten-free products [9,10].

Scientists of the Federal State Budgetary Educational Institution of Higher Education "Bashkir State Agrarian University" Bulyakova G.N. etc. developed the technology of chak-chak flour confectionery using rice flour in an amount of 10% by weight of flour, as well as chak-chak based on a mixture of flaxseed (4%) and rice flour (10%), added to increase the nutritional value finished product. The finished chak-chak is characterized by optimal physicochemical and organoleptic quality indicators [11,12].

Scientists of the Private Educational Institution of Higher Education “Kazan Innovation University named after. V.G. Timiryasova (IEUP)” (Tatarstan Republic, Kazan) Massarova A.F. And. Valeeva I.I. has developed a technology for preparing flour confectionery “chak-chak” using bird cherry and oat flour. It has been established that the energy value of “Chak-chak” containing oat flour decreased by 1% relative to the product produced according to the traditional recipe, and when 4 g of bird cherry flour is added to the recipe, the energy value decreases by 3% [13,14].

On the basis of the Federal State Budgetary Educational Institution of Higher Education "Bashkir State Agrarian University" by scientists Minyazova L.R. and Gaifullina D.T. A recipe has been developed for the national flour confectionery product “chak-chak” with increased nutritional value with the addition of corn flour and kumiss. The optimal amount of corn flour in chak-chak is 30% by weight of flour with 10% replacement of milk with kumis. As a result, the finished product is characterized by an increase in vitamins in its composition and a decrease in the calorie content of the finished product, compared to the control sample [15].

Scientists of the Federal State Budgetary Educational Institution of Higher Education "Bashkir State Agrarian University" Chernenkova A.A. and others developed a chak-chak recipe with increased biological value due to the addition of oat talkan, rich in vitamins: B1, B2, B6, D2, D3, E, A, K, carotene, nicotinic and pantothenic acids, macro- and microelements (potassium, magnesium, iron, chromium, manganese, zinc, nickel, fluorine, iodine, etc.), essential oils [16].

Scientist of the Mari State University Chilikova O.I. In order to increase the nutritional value and reduce the calorie content of chak-chak, premium flour was replaced by 50% with wheat flour [17].

The raw materials used and compliance with technological parameters for the production of bakery products are the main factors ensuring the quality of the finished product. When choosing gluten-free recipe components in the technology of flour confectionery products, attention should be paid to their influence on the rheological properties of the finished product, which depend on many factors: the chemical composition of the components, temperature, duration and intensity of thermal exposure, as well as the introduction of new recipe components into the chak-chak recipe entails a change in the behavior of dough pieces during the production of flour products [3,4,6].

Structural-mechanical (rheological) properties are properties that manifest themselves during deformation and destruction of any type of product during its mechanical loading, that is, the results of resistance to loads acting on the product are studied.

The study of the deformation of oriental flour confectionery products allows us to identify both the quantitative relationship between deformation and the rate of deformation, as well as molecular kinetic phenomena occurring during the deformation of finished products [5].

Therefore, the purpose of the work is to study the rheological properties of ready-made test semi-finished products for oriental confectionery products based on gluten-free raw materials.

Materials and research methods. The research was carried out in the educational laboratory for baking, confectionery and pasta production of the Department of Food Technology and in the UNIL for determining the quality of food and agricultural products of the Saratov State University of Genetics, Biotechnology and Engineering. N.I. Vavilova."

The experimental options differed in the type of flour and the amount of drinking milk; the research matrix is presented in Table 1.

To improve the quality of dough pieces and simplify the molding process, it was decided to increase the moisture content of the dough of samples 1-3 to 40.5% by additionally adding drinking

milk to the dough. The increased moisture content of the dough allows dough pieces to be molded using a pastry bag with a tip whose opening diameter is 5 mm into a preheated deep fryer with oil.

Table 1 – Research Matrix

Name of raw materials	Name of samples			
	Control sample	Sample 1	Sample 2	Sample 3
Premium grade wheat flour, %	100.0	-	-	-
Corn flour, %	-	100.0	-	50.0
Rice flour, %	-	-	100.0	50.0
Drinking milk, %	32.2	100.0	100.0	100.0

In the technology for producing chak-chak prototypes, an additional stage of beating the egg-sugar mixture is introduced to improve the structure of the dough, so it is advisable to determine the foaming ability and stability of the resulting foam.

The foaming ability of the egg-sugar mixture and the stability of the foam were determined by beating it until it increased in volume by 2.5-3 times. Foaming ability was determined by the formula:

$$П_с = \frac{hk*100}{hn}, (1)$$

where P_s - foaming ability; hk – height of the foam column after whipping, cm; hn – initial height of the mixture before beating, cm.

The stability of the whipped mass was determined by keeping it for three hours at room temperature and measuring its height. Stability of the whipped mass determined by the formula:

$$У_п = \frac{H*100}{hk}, (2)$$

where U_p is the stability of the whipped mass; H – foam height after curing, cm; hk is the height of the foam column after whipping, cm.

Foam density was determined as the ratio of a certain mass of foam to the volume of the vessel, measured using distilled water.

Organoleptic quality indicators were determined in accordance with GOST R 50228-92. Tasting quality assessment was carried out according to a 10-point school.

The structural and mechanical properties of chak-chak samples were studied using a texture analyzer "Structometer ST-3". The research method is based on determining the loading force on the indenter when it is inserted into the sample body at a movement (insertion) speed of 1.0 mm/s. The appearance of the device is shown in Figure 1.

Figure 1. Appearance of the device “Structometer ST-3”:
1 – body;
2 – control unit;
3 – table;
4 – replaceable indenter TA44;
5 – sample of a ready-made test semi-finished product for chak-chak

Research results and their discussion. The foaming ability, stability and density of the whipped mass were determined for two foam samples, since the work considered the introduction of a whipping stage before and after the introduction of drinking milk into the emulsion. The research results are presented in Figures 2-4. Research has shown (Fig. 2) that when whipping foam after the stage of introducing drinking milk, the foaming ability decreases by 1.45 times compared to sample 1. The introduction of drinking milk into the emulsion at various stages of whipping affects such an indicator as foam density (Fig. 4). The foam density of sample 1 is lower, which indicates that the mass is saturated with air bubbles. Whipping foam after the stage of introducing drinking milk leads to an increase in foam density by 0.11%.

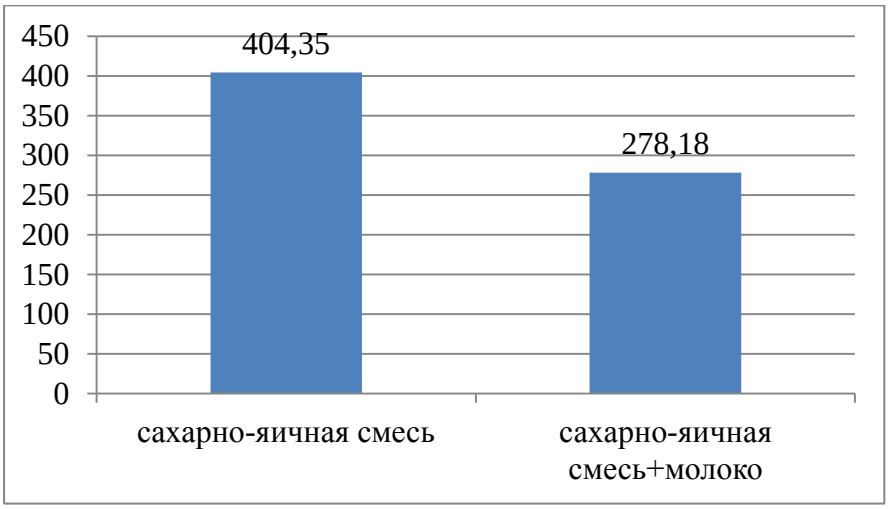

Figure 2. Dynamics of changes in foaming ability: sample 1 – sugar-egg mixture; sample 2 – sugar-egg mixture + milk

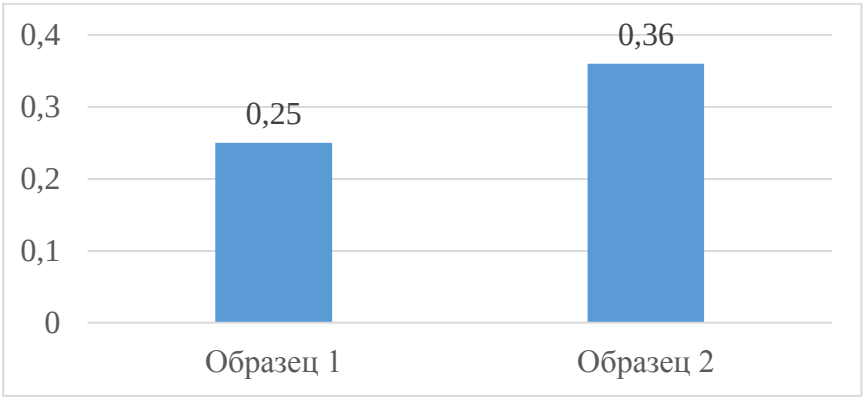

Figure 3. Dynamics of changes in foam density: sample 1 – sugar-egg mixture; sample 2 – sugar-egg mixture + milk

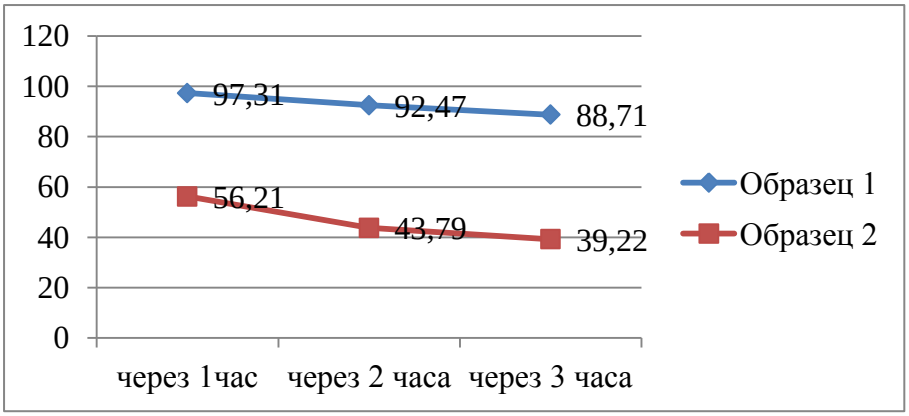

Figure 4. Dynamics of changes in foam stability: sample 1 – sugar-egg mixture; sample 2 – sugar-egg mixture + milk

Based on the results of determining the stability of the foam (Fig. 4), it follows that whipping the foam after the stage of introducing drinking milk led to a decrease in the stability of the foam by 44.21-57.76%. The foam structure remained most stable in sample 1, where whipping was carried out before adding milk. Organoleptic quality indicators of finished test semi-finished products are presented in Table 2.

Table 2. Organoleptic quality indicators of finished test semi-finished products

The name of indicators	Norm according to GOST R 50228-92	Name of samples			
		Control sample	Sample 1	Sample 2	Sample 3
					
Appearance	Specific to the product of this name	Sticks 25 mm long rounded, not blurry, without dents, swelling or damage			
Consistency	Baked product without traces of unkneading, with or without a layer, filling, depending on the recipe	Baked, without traces of unkneading	Heavily soaked in fat, baked, without traces of unmixed	Excessively hard, baked, without traces of unmixed	Baked, without traces of unkneading
Color	Characteristic of the product of this name, uniform with different shades	Yellow	Light yellow	Light yellow	Golden yellow
Taste	Characteristic of the product of this name, without any foreign taste	Peculiar, without foreign tastes	Characteristic of rice flour, without foreign flavors	Peculiar to corn flour, without foreign flavors	Characteristic of corn and rice flour, without foreign flavors
Smell	Characteristic of the product of this name, without foreign odor	Peculiar, without foreign odor			

A comprehensive assessment of the quality of finished products was assessed on a five-point scale according to the following quality indicators: taste, smell, color, appearance, consistency. The scoring of the quality of finished products is presented in Figure 5.

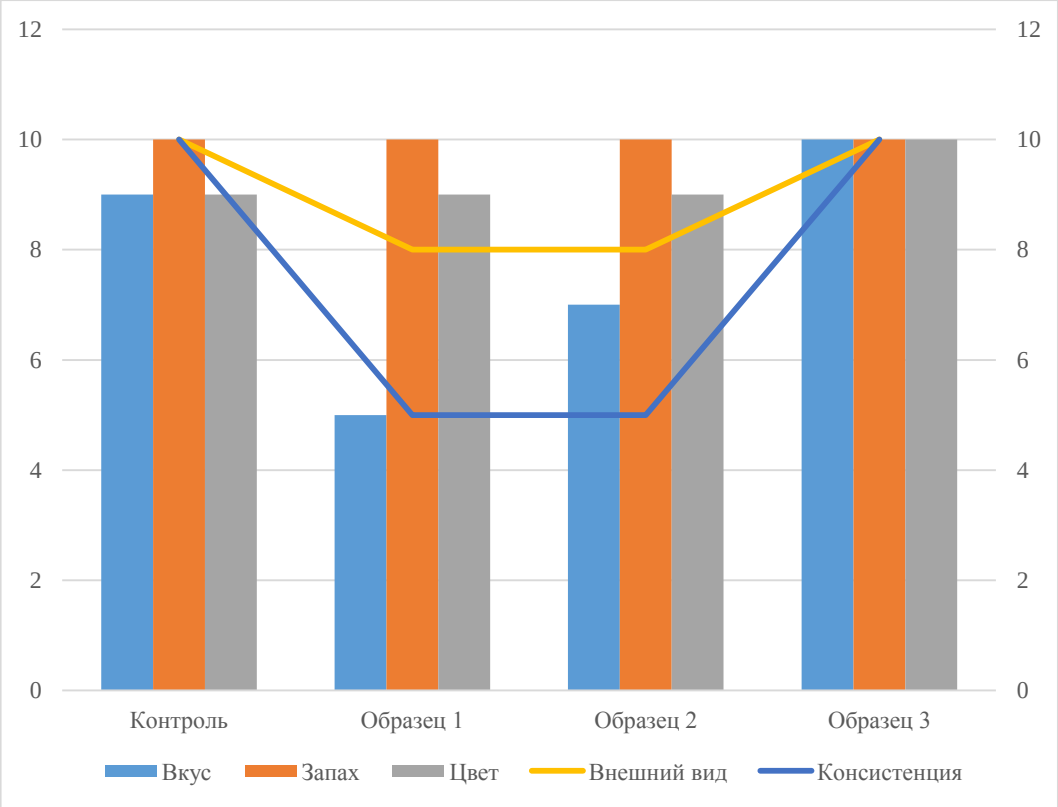

Figure 5. Comprehensive assessment of the quality of finished products

From the organoleptic quality indicators (Table 2) it follows that the control and No. 3 chak-chak samples meet the requirements of regulatory and technical documentation, for them the taste and smell are characteristic of ready-made test semi-finished products, without foreign taste and smell, in the test sample it is mildly present pronounced taste of corn and rice flour. Sample 1, due to its excessively soft consistency, absorbed too much frying fat, which is why when chewing the sample its taste is felt, which does not attract consumers. Sample 2, containing only corn flour, is very hard, which makes it difficult to chew the sample; accordingly, this sample will receive a similarly low rating from consumers. The color in all samples, characteristic of this product name, in sample 3 is more saturated golden, due to the addition of corn flour. Appearance - sticks 25 mm long, round in shape, not blurry, without dents, swelling or damage. The consistency of samples control and No. 3 is baked, without traces of unkneading, while in sample 1 excess frying fat is visible, and sample 2 is excessively hard when broken.

From a comprehensive assessment of the quality of finished products (Fig. 5), sample 3 stands out, as it is characterized by improved taste and color, which was appreciated by tasters. It is worth noting the improvement in the appearance and consistency of sample 3, since thanks to the addition of rice flour, the semi-finished products acquire an airy consistency.

Figure 6-9 shows the results of measurements of the structural and mechanical properties of samples of finished test semi-finished products.

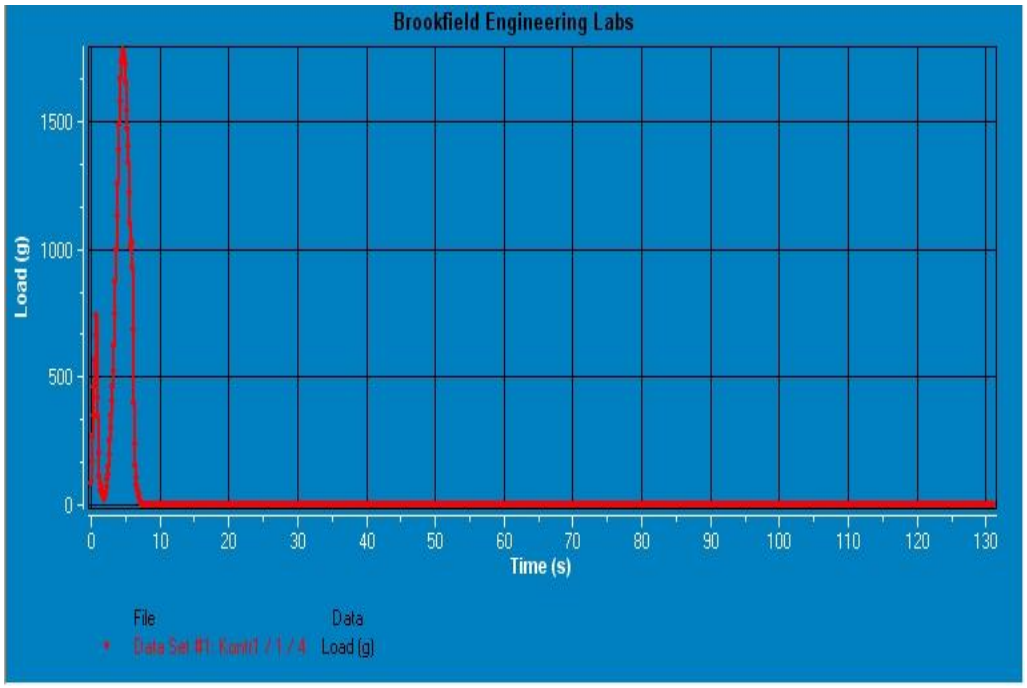

Figure 6. Change in the loading force on the indenter depending on the depth of its penetration into the body of the finished test semi-finished product (control sample)

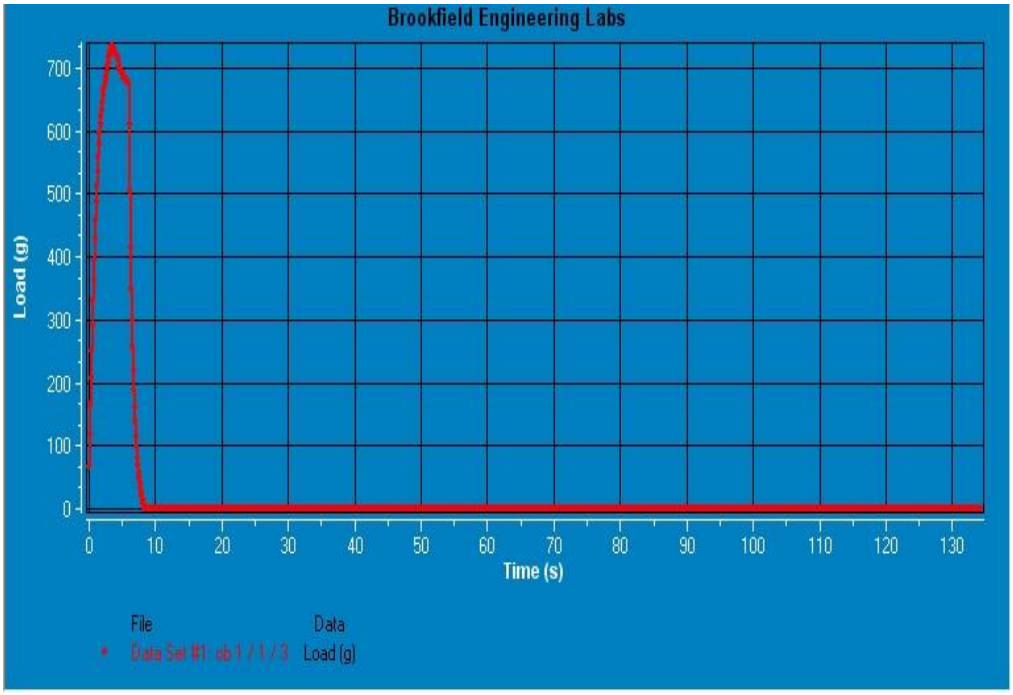

Figure. 7. Change in the loading force on the indenter depending on the depth of its penetration into the body of the finished test semi-finished product (sample 1)

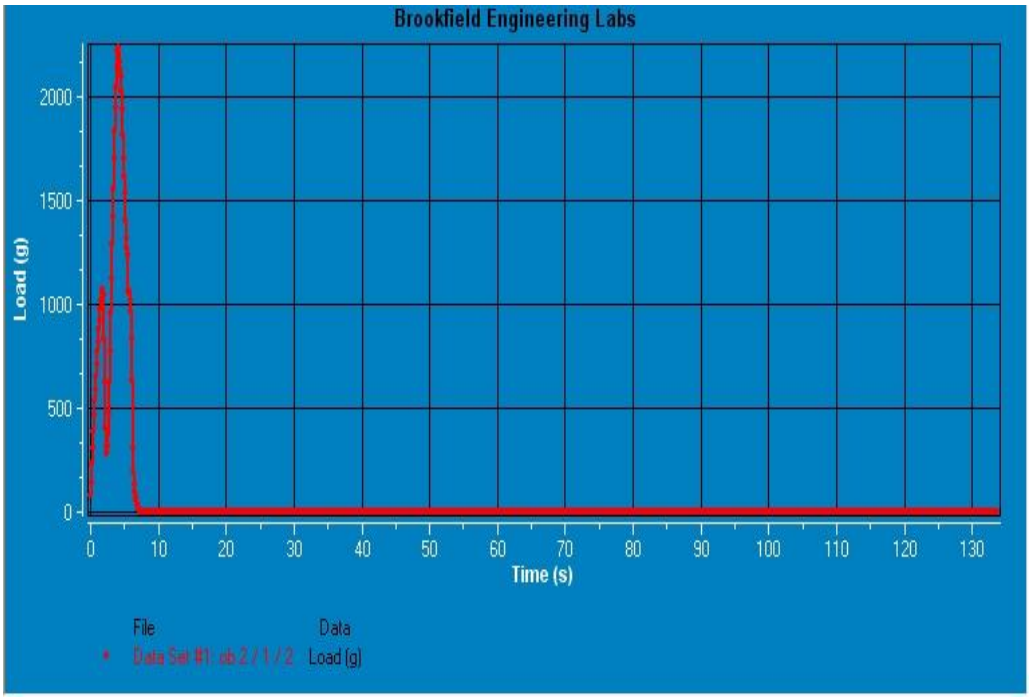

Figure 8. Change in the loading force on the indenter depending on the depth of its penetration into the body of the finished test semi-finished product (sample 2)

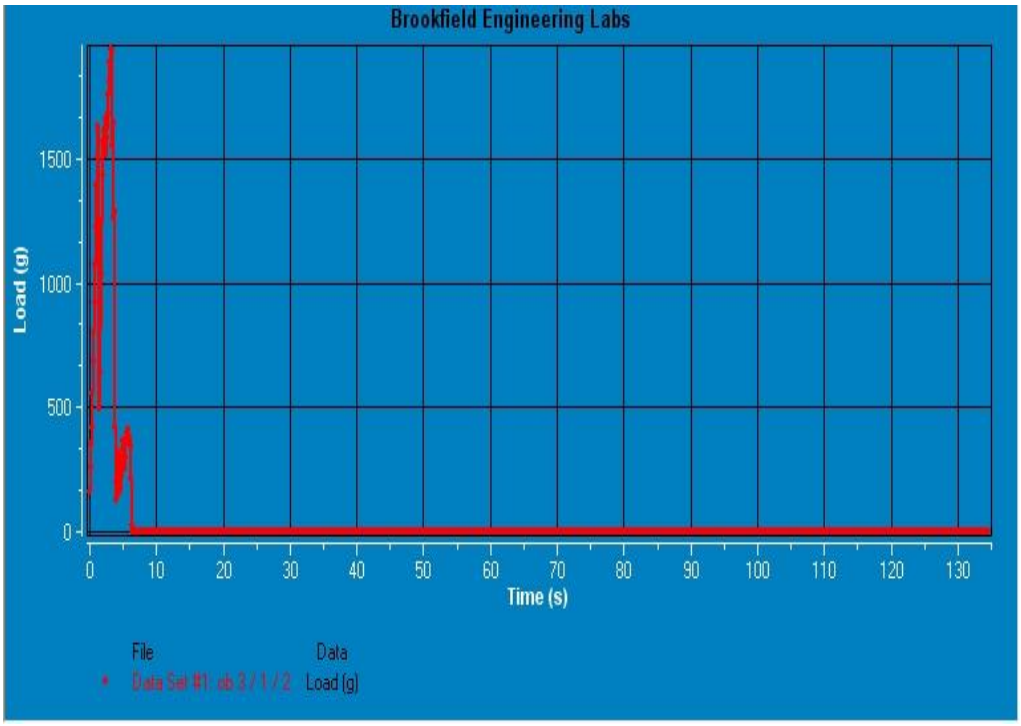

Figure 9. Change in the loading force on the indenter depending on the depth of its penetration into the body of the finished test semi-finished product (sample 3)

As can be seen from Figures 6-9, addition, the structural and mechanical properties of the finished test semi-finished products in the control and samples No. 3 do not differ. The deformation force in sample 1 is less than 2.13 times, and in sample 2 it is 1.41 times greater than in the control sample and sample 3. From Figures 6-9 we can conclude that complete replacement of wheat flour with a mixture of corn flour and rice, taken in a 1:1 ratio, does not affect the strength characteristics of the finished test semi-finished products, which proves the balance of the recipe components.

Conclusion. Based on the results of a study of the foaming ability, stability and density of the whipped mass, it was established that the whipping stage must be carried out before the stage

of introducing drinking milk into the emulsion. Based on the results of the study, we can conclude that rice and corn flour have a positive effect on the organoleptic quality indicators of finished test semi-finished products for the production of chak-chak. Semi-finished products are characterized by a mild taste that is attractive to the consumer. It has been established that the optimal ratio of rice and corn flour is 1:1, since the resulting semi-finished products are characterized by an improved consistency, close to the control sample, which is also confirmed by the results of structural and mechanical quality indicators. The production of test semi-finished products only from rice or only from corn flour is not recommended, since the finished test semi-finished products do not meet the requirements of regulatory documentation for organoleptic and structural-mechanical quality indicators.

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ИНФОРМАЦИЯ ОБ АВТОРАХ

Маргарита Викторовна Черкунова – студент 4 курса направления подготовки 19.03.02 Продукты питания из растительного сырья, Саратовский государственный университет генетики, биотехнологии и инженерии им. Н.И. Вавилова, г. Саратов, Россия, ritcher.777@gmail.com

Асия Рафаильевна Абушаева – ассистент кафедры технологии продуктов питания, Саратовский государственный университет генетики, биотехнологии и инженерии им. Н.И. Вавилова, г. Саратов, Россия, asiyatugush@mail.ru

Мадина Карипулловна Садыгова – доктор технических наук, профессор, доцент кафедры технологии продуктов питания, Саратовский государственный университет генетики, биотехнологии и инженерии им. Н.И. Вавилова, г. Саратов, Россия, sadigova.madina@yandex.ru

Никита Александрович Семилет – кандидат технических наук, доцент кафедры технологии продуктов питания, Саратовский государственный университет генетики, биотехнологии и инженерии им. Н.И. Вавилова, г. Саратов, Россия

INFORMATION ABOUT THE AUTHORS

Margarita V. Cherkunova – 4th year student of the direction of preparation 19.03.02 Food from Vegetable Raw Materials, Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, Saratov, Russia, ritcher.777@gmail.com

Asiya R. Abushayeva – Assistant of the Department of Food Technology, Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, Saratov, Russia, asiyatugush@mail.ru

Madina K. Sadygova – Dr. Sci. (Tech.), Professor, Associate Professor of the Department of Food Technology, Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, Saratov, Russia, sadigova.madina@yandex.ru

Nikita A. Semilet – Cand. Sci. (Tech.), Associate Professor of the Department of Food Technology, Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, Saratov, Russia

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