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THE INFLUENCE OF SUGAR ON THE STATE OF THE CARBOHYDRATE AMYLASE COMPLEX OF GLUTEN-FREE CAKES

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ВПЛИВ ЦУКРУ НА СТАН ВУГЛЕВОДНО-АМІЛАЗНОГО КОМПЛЕКСУ БЕЗГЛЮТЕНОВИХ КЕКСІВ

Objective. *Research into the influence of sugar content on organoleptic, physicochemical and rheological indicators, in particular on the parameters of starch gelatinization of a gluten flour mixture, the state of its carbohydrate-amylase complex, which determine the dough formation processes and the quality of finished gluten-free cakes.*

Methods. *To ensure the fulfillment of the tasks, standard generally accepted and special research methods were used. Samples were selected and prepared for research according to DSTU ISO 6498:2006. The mass fraction of dry substances was determined by the refractometric method; the mass fraction of carbohydrates - by the Bertrand-Bierry centrifugal method; the starch gelatinization temperature, the maximum viscosity index for various model systems - using the Brabender amylograph..*

Results. *The recipe and technology of gluten-free cakes with milk-protein concentrate of buttermilk have been developed. In the developed technology, a mixture of corn and rice flour was used as flour, and the structure-forming component was milk-protein concentrate of buttermilk. The influence of individual recipe components, in particular sugar, on the physicochemical, rheological and organoleptic parameters of model food systems of gluten-free cakes with MPC buttermilk was determined. The influence of sugar on the parameters of starch gelatinization of flour, the state of its carbohydrate-amylase complex, dough formation processes in the technology of gluten-free cakes and the quality of finished products were studied. It has been proven that in further studies it is advisable to reduce the sugar content by 10…15% in the recipe of gluten-free cakes as one of the effective ways of influencing the processes of protein swelling and starch gelatinization of the mixture of gluten flour in order to obtain products with certain physicochemical and organoleptic quality indicators.*

Keywords*: gluten, celiac disease, gluten flour, milk-protein concentrate, gluten-free muffins, sugar, starch, carbohydrate-amylase complex, quality indicators*

Formulation of the problem. Due to the rapid growth in the world and, in particular, in Ukraine, of food-related diseases, the number of people with excess body weight, fermentopathies, and the limitation of natural food resources, the problem of developing technologies for flour confectionery products (FCP) with a regulated nutrient composition, in particular gluten-free, as a group of products characterized by increased demand from the population, has become dominant.

Gluten-free food is currently a healthy eating trend. Millions of people around the world have started consuming gluten-free foods (cereal protein from wheat, rye, barley, oats) due to the general perception of health promotion and disease prevention, dissemination of information among consumers, intensification of marketing activities and improvement of sales channels for gluten-free products [1, 2].

Analysis of recent research and publications. The creation of scientific and practical principles for the production of gluten-free flour confectionery products is devoted to the works of domestic and foreign scientists: V.V. Dorokhovych, O.V. Nemyrich, A. V. Gavrisha, O.I. Shapovalenko, O.S. Pavlyuchenko, N.V. Chornoi, T. O. Lisovska, Camino M., Jeffrey L., Trif A., and others [3-9].

The scientific works of scientists are aimed at finding new technological solutions for the creation of flour confectionery products of increased biological value by involving certain types of gluten-free flour raw materials, non-traditional dairy raw materials on the principles of resource conservation, which determines the perspective and relevance of this scientific direction.

In the course of developing recipes for gluten-free flour confectionery products, in particular cupcakes, the most close attention, in our opinion, deserves the problem of imitating the structure-forming properties of gluten-containing raw materials. The absence of gluten in gluten-free flour raw materials and the need to create a porous, elastic structure of gluten-free dough and finished flour confectionery products requires solving the problem of forming rheological properties that provide a texture adequate to traditional products.

Scientists of the State University of Trade and Economics have developed a recipe and technology for gluten-free cakes with milk protein concentrate (MPC) of buttermilk [10]. The developed technology involves the use of flour, sugar, butter, milk protein component, melange, ammonium bicarbonate, sodium bicarbonate, which differs in that a mixture of corn and rice flour is used as flour, and milk protein concentrate of buttermilk as a structure-forming agent. The products are characterized by a beautiful appearance, a convex surface without breaks, a dense crumb of light brown color with a texture that is adequate to the traditional “Cheese” cake [11]. At the same time, the results of organoleptic evaluation revealed a very sweet taste of the products, which negatively affects the consumer properties of the finished cakes.

In the technology of gluten-free cakes using chemical leavening agents, up to 35% of sugar is used [11], which, in addition to shaping the taste of the products, also plays the role of a structure-forming and foaming stabilizer in the complex colloidal system of the cakes dough, increasing the viscosity of the system. The stabilizing effect of sugar is due to the dehydrating effect on the protein, which leads to the formation of a hard film that increases the stability of the foam system of the egg-sugar mass [12].

Sugar also has a significant effect on the parameters of starch gelatinization of flour. Considering that starch plays an important role in forming the structure of gluten-free cakes, even minor changes in the process of its gelatinization will have a significant effect on the quality of the finished products [13].

Objective of the article. The aim of this work is to study the influence of sugar content on organoleptic, physicochemical and rheological indicators, in particular on the parameters of starch gelatinization of a gluten flour mixture, the state of its carbohydrate-amylase complex, which determine the dough formation processes and the quality of finished gluten-free cakes.

Presentation of the main research material. The process of making cakes dough with and without chemical leavening agents consists of the following stages: whipping butter with sugar or melange with sugar; mixing the whipped mass with other recipe ingredients, except flour; then adding flour, preparing and forming the dough; baking and finishing. At the same time, the technological properties of the main raw materials have a significant impact on the quality of the cupcake dough and finished products.

The technological process of cakes production involves the use of short-term mixing with flour, therefore, the swelling of flour proteins does not occur to the full extent, in this case, the formation of the structure of the dough and baked cakes is significantly influenced by the properties of starch in the flour suspension. Therefore, during the heat treatment of products in the technological process, it is important to determine the temperature of starch gelatinization and the maximum viscosity of the water-flour suspension, which will become the basis for determining the recipe and parameters of heat treatment of gluten-free cakes.

The temperature of the beginning of starch gelatinization, the temperature at which the maximum viscosity was established, as well as the maximum viscosity index for various model systems were determined using a Brabender amylograph.

The results of decoding the amylograms obtained during the analysis of the control sample, samples of the model systems "FR:FC (60:40) - sugar - water" with a decrease in the amount of sugar by 5%, 10%, 15%, 20% relative to the sugar content in the control are given in Table 1.

Table 1 – The effect of sugar on the starch properties of a mixture of rice and corn flour

Model	Reducing the amount of sugar in the recipe, %	Indicator values			
		Time of beginning of gelatinization, τ·60 c	The temperature of the beginning of gelatinization, °C	Suspension temperature at maximum viscosity, °C	Maximum viscosity, units.a
Control 1 (FW-water)		8	55	72	620
Control 2 (FW-sugar-water)		5	60	78	690
Sample 1	5,0	6	72	82	720
Sample 2	10,0	5	72	82	780
Sample 3	15,0	4	71	80	920
Sample 4	20,0	3	68	78	≥ 1000

Analysis of the amylograms (Table 1) shows that for water-flour control models, the maximum gelatinization temperature (78°C) and maximum suspension viscosity (more than 690 units a) are similar to the “wheat flour-sugar-water” sample. This is due to the fact that the high concentration of sugar in the liquid phase slows down the diffusion rate during the swelling of proteins and starch in wheat flour, causing the formation of a more viscous system and reducing the competition between protein and starch for water [14].

As is known, sucrose (sugar) delays the swelling of starch grains in water by preventing free contact of water with them [15]. Analyzing the results of the studies, we can conclude that sugar increases the gelatinization temperature of starch. The gelatinization temperature, as can be seen from Table 1, for sample 1 “mixture of rice and corn flour-sugar-water” is 82°C, and reducing sugar to 20% in sample 4 affects the decrease in the gelatinization temperature to 78°C. The change in the gelatinization temperature is an important indicator that characterizes the subsequent process of starch

retrogradation during the storage of finished products, because it is known that the lower the gelatinization temperature, the longer the products retain their freshness during storage [15].

The dependence of the maximum viscosity of the suspension on the sugar content (Table 1) allows us to characterize the properties of gluten-free cakes with MPC of buttermilk during baking. The porous structure of the product is fixed as a result of the coagulation of flour proteins and the transformation of starch into a thick paste. With a 20% decrease in sugar in the muffin recipe, the amylogram shows a high maximum viscosity, which indicates the binding of starch during the gelatinization of a large amount of water. As a result, a low-stretch starch paste and a muffin with an excessively brittle crumb are formed.

The results of rheological studies of dough samples for gluten-free cakes with MPC of buttermilk with different sugar contents are shown in Figure 1.

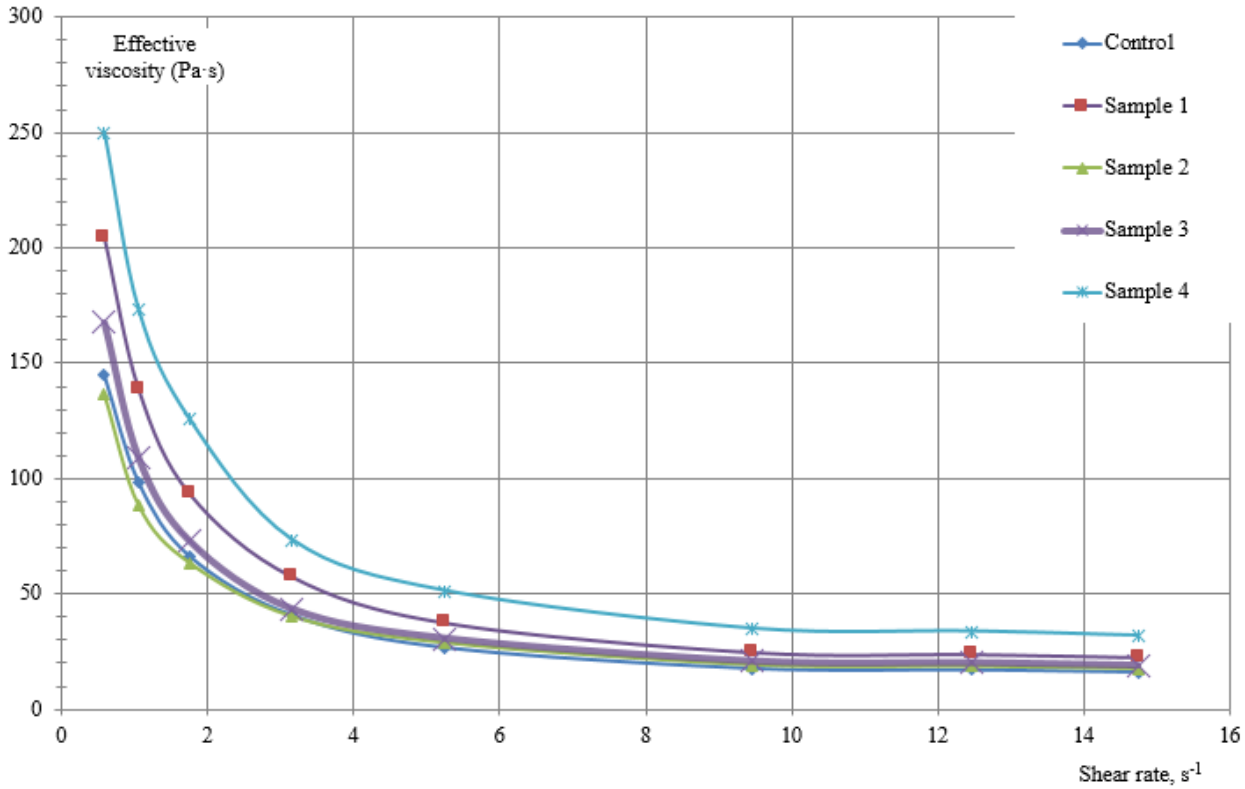


Figure 1 – Rheological curves of the dependence of effective viscosity (Pa·s) on shear rate (s^{-1}) in dough for gluten-free cakes with MPC of buttermilk with different sugar contents:
control – sugar content 27.6 wt. %;
sample 1 (-5%) – sugar content 26.2 wt.%;
sample 2 (-10%) – sugar content 24.8 wt.%;
sample 3 (-15%) – sugar content 23.4 wt.%;
sample 4 (-20%) – sugar content 22.0 wt.%.

Reducing the amount of sugar by 5% leads to a decrease in the effective viscosity by 27…29%. Further, with a decrease in the sugar content from 15 to 20%, the viscosity of the samples increases. Thus, with a decrease in the sugar content by 20%, the effective viscosity increases by 32…37% over the entire range of shear rates. The destruction of the dough structure of sample 4 occurs at a shear rate of 9.4 s^{-1}, while the rest of the samples at 10.2 s^{-1}.

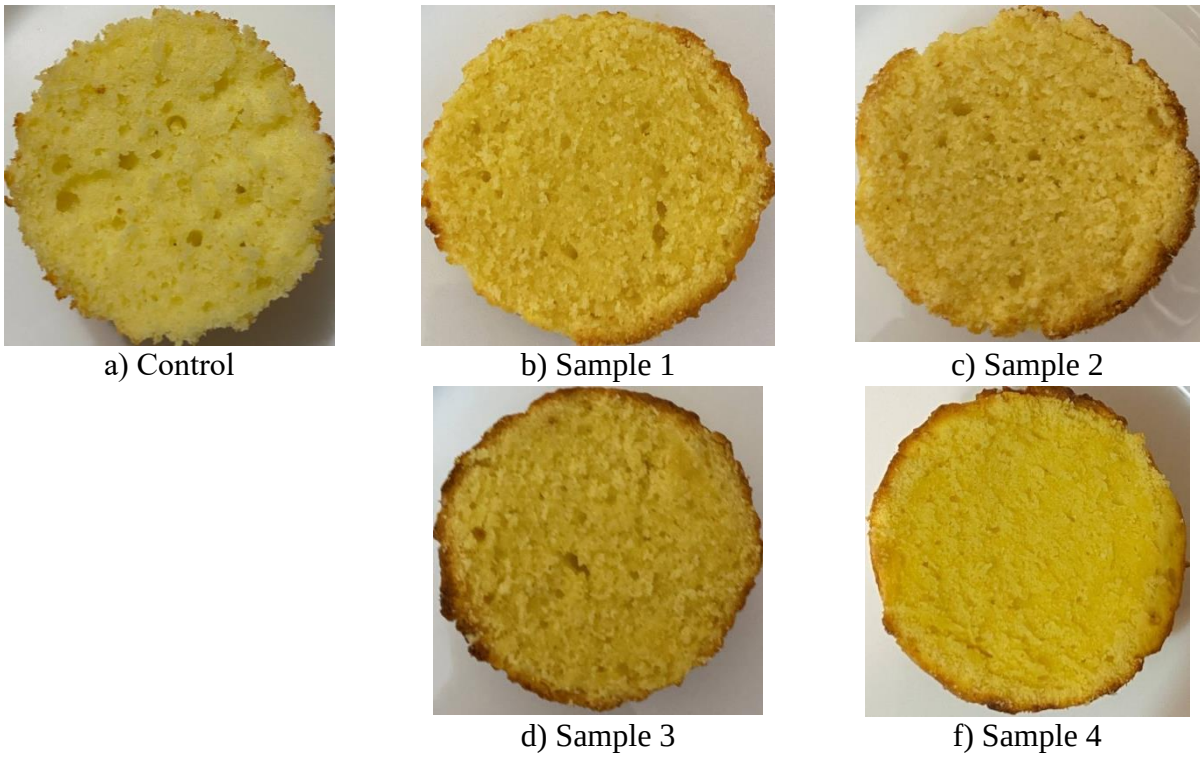
The presented results of the study of the viscosity of dough samples correlate well with the results obtained above.

During laboratory baking, it was found (table 2, figure 2) that a decrease in the sugar content by 10…15% of the recipe amount does not worsen the quality of the baked product.

A decrease in the sugar content in the recipe by more than 20% leads to a decrease in the porosity and specific volume of the products. The organoleptic properties of finished cupcakes also deteriorate [14].

Table 2 - Quality indicators of gluten-free cakes made from MPC of buttermilk with different sugar contents

Indicators	Control	Sample 1 (- 5,0%)	Sample 2 (- 10,0%)	Sample 3 (- 15,0%)	Sample 4 (- 20,0%)
Specific volume, cm^3/g	1,36	1,4	1,35	1,3	1,25
Porosity, %	16,67	18,2	15,97	14,8	10,43
Appearance	The shape is round, typical of the form in which the products are baked, without cracks; the surface is convex, with the presence of minor cracks and tears that do not change the product's appearance.				
Crust color	Light brown, bottom and lateral surface lighter				Brown
View of the break-in	Well baked, without tempering and traces of non-promis, light yellow in color.				Undercooked, yellow in color
Taste and smell	Pronounced, balanced, typical of this type of cake	Pronounced, typical of this type of cupcake, very sweet	Pronounced, balanced, typical of this type of cupcake, without any foreign aftertaste		



a) Control b) Sample 1 c) Sample 2 d) Sample 3 f) Sample 4

Figure 2 – Appearance of gluten-free cakes with different sugar contents when broken

Conclusions. One of the effective ways to influence the processes of protein swelling and starch gelatinization of flour in order to obtain products with certain physicochemical and organoleptic quality indicators is to change the recipe amount of sugar. Based on the conducted studies and recommendations of scientists [13, 15], we predict in further studies a reduction in the sugar content in the recipe of gluten-free cakes by 10...15%. This will not affect the deterioration of the quality of finished products [14].

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Мета. *Дослідження впливу вмісту цукру на органолептичні, фізико-хімічні та реологічні показники, зокрема, на параметри клейстеризації крохмалю суміші аглютенового борошна, стан його вуглеводно-амілазного комплексу, що обумовлюють процеси тістоутворення та якість готових безглютенових кексів.*

Методи. *Для забезпечення виконання поставлених завдань використано стандартні загальноприйняті та спеціальні методи досліджень. Відбір проб і підготовку їх до дослідження здійснювали за ДСТУ ISO 6498:2006. Масову частку сухих речовин визначали рефрактометричним методом; масову частку вуглеводів – центрифужним методом*

Бертрана-Б'єррі; температуру клейстеризації крохмалю, показник максимальної в'язкості для різних модельних систем – за допомогою амілографа Brabender.

Результати. *Розроблено рецептуру та технологію безглютенових кексів з молочно-білковим концентратом сколотин. У розробленій технології в якості борошна використано суміш кукурудзяного та рисового борошна, структуроутворюючого компонента – молочно-білковий концентрат сколотин. Визначено вплив окремих рецептурних компонентів, зокрема, цукру, на фізико-хімічні, реологічні та органолептичні показники модельних харчових систем безглютенових кексів з МБК сколотин. Досліджено вплив цукру на параметри клейтеризації крохмалю борошна, стан його вуглеводно-амілазного комплексу, процеси тістоутворення у технології безглютенових кексів та якість готових виробів. Доведено, що у подальших дослідженнях є доцільним зменшення вмісту цукру на 10…15%, у рецептурі безглютенових кексів, як один з ефективних способів впливу на процеси набрякання білків та клейстеризацію крохмалю суміші аглютенового борошна з метою отримання виробів з певними фізико-хімічними та органолептичними показниками якості*

Ключові слова: *глютен, целіакія, аглютенове борошно, молочно-білковий концентрат, безглютенові кекси, цукор, крохмаль, вуглеводно-амілазний комплекс, показники якості.*

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