zymase activity by 30 % and maltase — by 22 %, which accelerates the time of the first raising of the dough and ultimately reduces the time of the dough proofing process by 30–35 %. The ability of DPA to influence the state of proteins was determined, which, in turn, improves the structural-mechanical and rheological properties of the dough. If the amount of dry potato additive increases to 5 % by weight of flour, there is a proportional increase in elasticity to 7 %, the rate of dough thinning decreases by 10 %, and the indicators of elasticity and stability increase by 8 % and 1.5 %, respectively.

***Key words**: yeast semi-finished products, dry potato additive, the activity of amylase and zymase, gas formation.*

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GLUTEN-FREE CAKES WITH CEREAL FLOUR

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БЕЗГЛЮТЕНОВІ КЕКСИ З БОРОШНОМ КРУП'ЯНИХ КУЛЬТУР

***Objective**. To substantiate the composition and ratio of flour raw materials in the technology of gluten-free cupcakes using milk protein concentrate.*

***Methods**. Sampling and preparation for the study were performed according to DSTU ISO 6498:2006. Studies of the viscosity of the dough for the cupcakes was carried out on a rotary viscometer «Reotest-2» in the range of shear rates from 0.167 to 4.5 s^{-1}. Measurements were taken immediately after mixing at room temperature 20±2°C. Organoleptic evaluation of ready-made cupcakes is determined by the five-point system. Each organoleptic quality index is assigned a weighting factor: 0.20 for appearance, 0.15 for color, 0.25 for consistency, 0.15 for smell, 0.25 for taste.*

***Results**. The expediency and possibility of using corn and rice flour mixes in the ratio of 60...70 % and 40...30 %, respectively, of the total amount of gluten flour of cereals according to the recipe are substantiated. The technology of gluten-free cupcake using milk protein concentrate scallops was developed. The method of obtaining a new flour confectionery product — gluten-free cupcake — is as follows: softened butter and sugar are beaten for (12...18) • 60 s, combined with pre-rubbed milk protein concentrate cracks and continue whisking until smooth. Then add the mélange, baking soda, ammonium, mix thoroughly, pour in a mixture of corn and rice flour and knead the dough for (5...7) • 60 seconds. The dough is spread into prepared forms and baked at 160...170°C for (20...25) • 60 sec. Ready-made cupcakes are sprinkled with refined powder and sold. The proposed technology allows to expand the range of gluten-free pastry products with high nutritional value.*

***Keywords**: gluten-free muffins, rice flour, corn flour, structural and mechanical properties, nutritional value, technological scheme.*

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Formulation of the problem. To date, food genomics has proven not only the relationship of nutrition with the human genome but also the possibility of preventing diseases induced by improper nutrition. Among the diseases associated with poor nutrition, the treatment of which can be modified by the introduction of personalized nutrition is celiac disease — a chronic, genetically determined disease that manifests itself in persistent gluten intolerance (cereal protein of wheat, rye, barley, oats) with the development of atrophy of the small intestine mucosa and associated malabsorption syndrome [1].

According to the all-Ukrainian society of celiac disease, 450 thousand Ukrainians suffer from this disease every year. The most common disease is detected among children in the age group from six months to two years, who develop permanent gluten intolerance. In recent years, the average age of patients diagnosed with celiac disease is 45 years, and 25 % of celiac disease is detected in the age group over 60 years [2].

The only way to treat this disease and prevent all its severe complications is strict and lifelong adherence to a gluten-free diet. At the same time, all products from wheat and rye flour, oats, and barley are excluded from the diet. Among cereals, it is allowed to use buckwheat, corn, rice. Milk and dairy products are excluded since celiac disease is often accompanied by lactose intolerance. Use fresh cottage cheese in its natural form and in products, butter [3, 4].

Unfortunately, in Ukraine, the production of gluten-free products is not effective, the needs of the population in gluten-free products are provided by products of foreign origin. Along with finished products, mixtures for the preparation of bakery, confectionery, and pasta are supplied to Ukraine.

Saturation of the market with gluten-free food products is one of the problems posed by life to scientists and industry in the country. Special attention, in our opinion, should be paid to bakery products and flour confectionery products (FCP), which are the most commonly used and are the main source of gluten, because they include wheat flour as the main raw material resource.

Analysis of recent research and publications. In the overall structure of the FCP market, cakes occupy up to 15 % of total production. These products have a pleasant appearance and taste, are well absorbed by the human body and therefore are popular with the population.

Analysis of the literature indicates that the use of gluten-free flour in the production of pastry, including cakes on chemical baking powder, causes a number of technological problems and requires a variety of tools to improve the structure of the gluten-free dough. The fact is that gluten wheat flour (gluten) has unique technological properties that play an important role in the formation of structural and mechanical properties of flour dough and the texture of finished products. After moistening and mixing, the proteins of non-gluten flour varieties do not develop into a visco-elastic network, like wheat proteins [5].

The steps for regulating the structural and mechanical properties of gluten-free dough are defined. First, it is the use of flour mixtures, rather than individual types of gluten-free flour, which allows to significantly improve the nutritional and biological value, the structure of products; expand the raw material base, and the range of finished products [6].

According to modern scientific ideas, in the absence of a hydrated gluten network, one of the important factors in optimizing and stabilizing the process of gas content formed in a gluten-free test is a sufficient amount of water to hydrate the biopolymers of the dough and obtain the desired viscosity. To increase the hydration capacity of a gluten-free test, you can add protein substances [7].

Therefore, the scientific and practical interest is in milk and protein concentrates, in particular, milk and protein concentrate (MPC) of buttermilk — the source of a unique protein system, which is represented by proteins of high nutritional value. In addition to enhancing the nutritional capacity of the dough, this step allows you to combine animal proteins with vegetable flour proteins, creates prerequisites for expanding the range of gluten-free cakes with increased biological value.

Purpose of the article. The purpose of this work is to scientifically substantiate the composition and ratio of flour raw materials in the technology of gluten-free cakes using a milk-protein concentrate (MPC) of buttermilk.

According to this goal, according to the selected research areas, the following tasks had to be solved in the course of work:

— determine the technological feasibility of using non-gluten flour of cereals in the technology of gluten-free cakes;

— to justify the ratio of gluten-free flour types in the technology of gluten-free cakes using milk-protein buttermilk concentrate;

— to develop a technological scheme of obtaining of gluten-free cakes using a milk-protein concentrate, buttermilk.

Presenting main material. Classic recipes for gluten-free FCP are based on the use of economically available types of non-gluten flour — rice and corn, less often buckwheat. The main disadvantage of such products is their low nutritional value, due to the high content of starch in non-gluten flour raw materials, low content of proteins, dietary fibers, vitamins, and mineral nutrients [3].

Each type of agglutinated cereal flour has specific features of its chemical composition and functional properties. Thus, the average protein content in buckwheat flour is 12.6 %, rice flour — 7 %, corn flour — 8 % [8].

The protein of buckwheat flour is well balanced in amino acid composition, in terms of lysine content, it exceeds the protein of wheat and rye. Buckwheat flour has more calcium and iron in comparison with flour of other cultures, it contains vitamins B_1, B_2, PP, and E. The Rutin of this flour increase the strength of capillaries, lecithin and arginine reduce the content of cholesterol in the blood. It is dominated by albumins and globulins, which are easily digested by the body. The fiber in buckwheat flour is 1.5–2 times more than in oatmeal and rice. It contains the enzyme lipoxygenase.

The amino acid composition of rice protein is close to buckwheat. Rice processing products are rich in vitamins B_1 and B_2, phosphorus, phytinum, and lecithin. Rice flour contains silicon, which contributes to the processes of metabolism in the human body, Biotin, as well as other vitamins and trace elements of important medical and biological significance.

Corn flour contains more lipids, sugars, and hemicellulose than wheat flour. This flour is rich in K, Ca, Md and F, vitamins E and B_2, and Biotin. The composition of its fats is dominated by polyunsaturated (linoleic and linolenic). The proteins of cornflour swell slightly. Flour does not contain gluten, does not form gluten, but has a great gas-forming ability.

An important technological property of the flour understudy, on which the humidity and rheological properties of the dough depend, is its water-absorbing ability (WAA). According to some researchers [6–8], the WAA of gluten-free dough from rice, buckwheat, and cornflour is very different due to different chemical composition and granulometric characteristics.

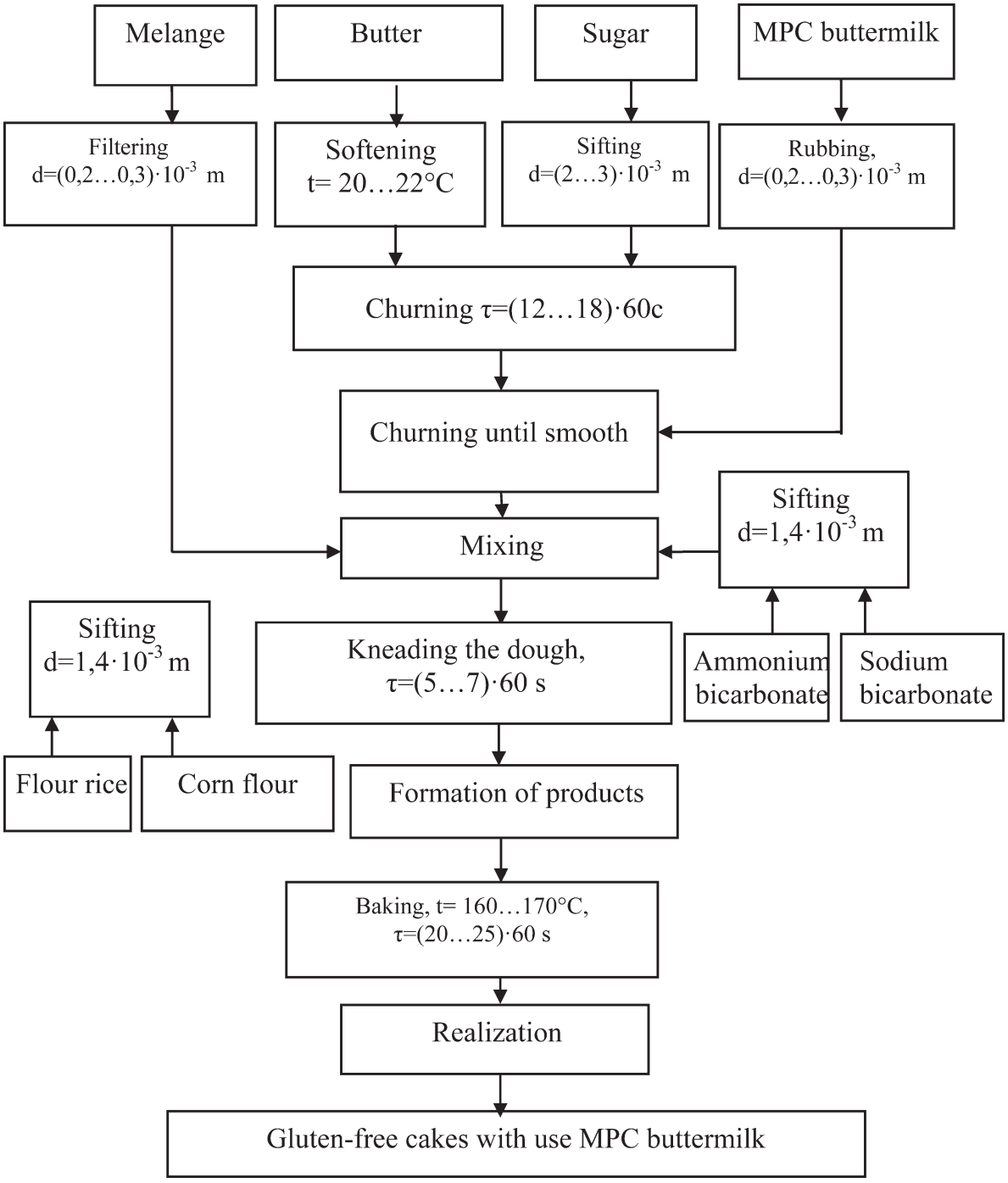
Thus, varying the quantitative composition of the composite mixture of the designated types of gluten-free flour will not only eliminate the existing disadvantages of their chemical composition but also correct the rheological properties of dough and flour confectionery products.

A promising raw material for the production of gluten-free cakes is also the MPC of buttermilk, which is obtained from dairy raw materials by the joint precipitation of casein and whey proteins. It has a biological value significantly higher than cottage cheese since whey proteins have an advantage over casein fractions in terms of the content of essential amino acids. The increased nutritional value of buttermilk MPC is caused by the content of 20.8 % protein, 1.34 % fat, 0.16 % calcium, 0.24 % phosphorus, and trace elements and water-soluble vitamins [9].

Based on a series of preliminary experiments and taking into account the information contained in the scientific and technical literature, a technological scheme for obtaining a gluten-free cake using milk-protein buttermilk concentrate was developed (picture 1).

The developed technology provides for the introduction of a certain ratio of corn and rice flour, as well as milk and protein concentrate of buttermilk into the dough.

The method for obtaining a new flour pastry — gluten-free cakes — is as follows: softened butter and sugar whipped for (12...18) * 60 s, combined with pre-rubbed MPC buttermilk and continue whipping until smooth. Then add melange, soda, and ammonium, mix thoroughly, add a mixture of corn and rice flour and knead the dough for (5...7)*60 seconds. The dough is laid out in prepared forms and baked at a temperature of 160...170 °C for (20...25)*60 seconds. Ready-made cakes are sprinkled with refined powder and sold.



Picture 1 — Technological scheme for obtaining gluten-free cake using buttermilk concentrate

In order to determine the rational amount of gluten-free flour raw materials, model food compositions were constructed (table. 1)and the study of their structural-mechanical and organoleptic indicators. For control, we choose the «cheese» cakes made using traditional technology was selected [10].

Samples of products made of different types of flour and flour mixtures were examined, in which the amount of each type of flour in the mixture varied from 20 to 80 %. In the course of laboratory baking, the inexpediency of using any one type of flour was revealed due to the low quality of organoleptic indicators.

The study of the viscosity of the dough for the cakes was carried out on a rotary viscometer «Reotest-2» in the range of shear rates from 0.167 to 4.5 s^{-1}, since it is known that the structure of the cakes dough is destroyed at higher shear rates [11]. Measurements were taken immediately after mixing at room temperature of 20 ± 2 °C. The results of the studies are given in Table. 2.

Table 1 — Model food compositions of gluten-free cake using MPC buttermilk

№	Indicator	The ratio of raw materials, %					
		Control	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
1	Wheat flour	23,9	—	—	—	—	—
2	Flour rice	—	19,1	14,3	9,6	7,2	4,8
3	Corn flour	—	4,8	9,6	14,3	16,7	19,1
4	Sugar	27,3	27,3	27,3	27,3	27,3	27,3
5	Butter	12,8	12,8	12,8	12,8	12,8	12,8
6	Cottage cheese 18 % fat	21,3	—	—	—	—	—
7	MPC buttermilk	—	21,3	21,3	21,3	21,3	21,3
8	Melange	13,6	13,6	13,6	13,6	13,6	13,6
9	Ammonium bicarbonate	0,7	0,7	0,7	0,7	0,7	0,7
10	Sodium bicarbonate	0,4	0,4	0,4	0,4	0,4	0,4

Table 2 — Gluten free cakes dough test quality using MPC buttermilk

Indicator	Control	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Effective viscosity, Pa·s, γ=0, 9 c^{-1}	168,78	198,60	187,20	175,4	168,9	135,7

The presented data shows that compared to the control sample viscosity in experiments 1 and 2 increases. This is due to the high humidity of rice flour and buttermilk MPC. The closest values of viscosity relative to the control have experience № 3 and № 4.

The organoleptic rating of ready-made cakes is determined by a five-point system. Each organoleptic quality indicator is assigned a weighting coefficient: for appearance — 0.20, for colour — 0.15, for consistency — 0.25, for flavour — 0.15, for taste — 0.25. The results of the study are shown in table 3.

As shown by the results of test laboratory bakery, an increase in the amount of rice flour in the recipe of the mixture of more than 40 % leads to a decrease in the specific volume of ready-made cakes by 23 %, the formation of a dense crumb with low porosity due to the high volumetric capacity of rice flour. And an increase in the amount of cornflour in the recipe of the mixture of more than 70 % leads to the production of finished products with an unsatisfactory crumb-like consistency.

Results of organoleptic evaluation (table. 3) indicate that the best indicators have experiments 3 and 4 with a ratio of corn and rice flour 60...70 % and 30...40 %, respectively, of the total amount of flour mixture according to the recipe.

The resulting products are characterized by a good appearance, a convex surface without breaks, a dense yellow flesh with a texture that is adequate for the traditional «Cheese» cakes.

Conclusion. The expediency and possibility of using corn and rice flour in the ratio of 60–70 % and 30–40 % respectively of the total amount of flour mixture according to the recipe in the technology of gluten-free cakes are proved. The proposed technology of gluten-free cakes using

Table 3 — Organoleptic quality assessment of gluten-free cakes using MPC buttermilk

Indicator	Weighting factor	control	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Outer appearance	0,20	5,0	4,8	5,0	5,0	5,0	5,0
Colour	0,15	5,0	4,9	5,0	5,0	4,9	4,9
Taste	0,25	5,0	4,9	4,9	4,8	4,8	4,7
Smell	0,15	4,9	5,0	4,9	5,0	5,0	4,9
Texture	0,25	4,9	4,5	4,7	4,9	4,9	4,7
Base score	1,0	24,8	24,1	24,5	24,7	24,6	24,2

MPC buttermilk allows you to expand the range of gluten-free flour confectionery products with increased nutritional value.

The prospect of further research in this direction provides for the study of the influence of prescription components on the processes of dough-making in the production of gluten-free cakes with a different sugar, fat, egg products.

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***Мета** — обґрунтувати склад та співвідношення борошняної сировини у технології безглютенових кексів з використанням молочно-білкового концентрату сколотин.*

***Методи**. Відбір проб і підготовку їх до дослідження здійснювали за ДСТУ ISO 6498:2006. Дослідження в'язкості тіста для кексів виконували на ротаційному віскозиметрі «Реотест-2» у діапазоні швидкостей зсуву від 0,167 до 4,5 с $^{-1}$. Вимірювання проводили одразу після замісу за кімнатної температури 20 ± 2 °С. Органолептичну оцінку готових кексів визначено за п'ятибальною системою. Кожному органолептичному показнику якості присвоєно коефіцієнт вагомості: для зовнішнього вигляду — 0,20, для кольору — 0,15, для консистенції — 0,25, для запаху — 0,15, для смаку — 0,25.*

***Результати**. Обґрунтовано доцільність та можливість використання у технології безглютенових кексів суміші кукурудзяного та рисового борошна у співвідношенні 60...70 % і 40...30 % відповідно, від загальної кількості глютенового борошна круп'яних культур за рецептурою. Розроблено технологію безглютенового кексу з використанням молочно-білкового концентрату сколотин (МБК). Спосіб одержання нового борошняного кондитерського виробу — безглютенового кексу — здійснюється так: розм'якшене вершкове масло і цукор-пісок збивають протягом (12...18)·60 с, з'єднують із попередньо протертим МБК сколотин і продовжують збивання до однорідної маси. Потім додають меланж, соду, амоній, ретельно перемішують, всипають суміш кукурудзяного та рисового борошна і замішують тісто протягом (5...7)·60 с. Тісто розкладають у підготовлені форми і випікають за температури 160...170 °С протягом (20...25)·60 с. Готові кекси посипають рафінадною пудрою і реалізують. Запропонована технологія дозволяє розширити асортимент безглютенових борошняних кондитерських виробів з підвищеною харчовою цінністю.*

***Ключові слова**: безглютенові кекси, рисове борошно, кукурудзяне борошно, структурно-механічні властивості, харчова цінність.*