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GLUTEN-FREE BAKERY PRODUCTS OF HIGH NUTRITIONAL VALUE

БЕЗГЛЮТЕНОВІ ХЛІБОБУЛОЧНІ ВИРОБИ ПІДВИЩЕНОЇ ХАРЧОВОЇ ЦІННОСТІ

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Abstract. *The problem of the need to produce gluten-free bread of high nutritional value was considered in the paper. The current state of production of these products and raw materials for ensuring its quality and nutritional value were considered. Attention was paid to the chemical composition of sorghum flour, meal of pumpkin seed kernels, micellar casein and whey, as raw materials that can increase the nutritional value of bread.*

It was established that the use of these raw materials as sources of physiologically functional substances improved the organoleptic properties of products, their aroma, preservation of freshness. The nutritional value of protein, dietary fiber, minerals and vitamins increased. The digestibility of these products improved.

Based on the research results, recipes and technological instructions for three types of bakery products with high consumer properties and nutritional value were developed and approved in accordance with the established procedure.

Key words: *gluten-free bread, raw materials, consumer properties, nutritional value.*

Introduction.

Nowadays the urgent problem is to develop technology for the production of qualitatively new food products with targeted changes in biochemical composition that meet the needs of the body, the requirements of medicine and food hygiene, providing all groups with sufficient health products and a wide range.

The question of expanding the range of products of special dietary direction for patients with diabetes and celiac disease-disorders of protein metabolism in the body was of great importance.

Patients with celiac disease are contraindicated in the use of bakery products from wheat and rye flour because the protein of cereal gliadins causes an allergic reaction in the body of these patients, irritates the small intestine.

Bread for people with this disease is prepared mainly from gluten-free starches with the addition of gluten-free cereal flour: rice, corn, buckwheat with the use of guar gum and xanthan as a thickener.

The gluten content in gluten-free products should not exceed 20 mg per 1 kg of dry matter of the product.

To improve the nutritional value of gluten-free products, butter, dairy products, oil, sugar and other raw materials containing physiologically valuable ingredients are used.

Scientists from the National University of Food Technologies (Kyiv, Ukraine) developed a technology of gluten-free bread from a mixture of potato and corn

starches and buckwheat, corn or rice flour with the addition of white sugar and oil. However, the nutritional value of bread from this raw material was low. This indicated the need for research on the use in the technology of gluten-free raw materials, enriching them with physiologically functional substances [1].

The aim of the research was to increase the consumer properties and nutritional value of gluten-free products using raw materials containing physiologically functional ingredients in the technology of their preparation.

Our research established the feasibility of using starches and sorghum flour, sour whey, micellar casein, meal from pumpkin seed kernels and citrates of Ca and Mg for this purpose.

The main text. ***Input data and methods***.

During the study, corn and potato starches (DSTU 3976: 2000 and DSTU 4286: 2004), whole grain sorghum flour of LLC. "Asparagus-LTR", (TU U 10.6-40031186-001:2016), micellar casein of TM "Ostrovit", "Ingredia" (France), meal of pumpkin seed kernels of PE "Piroil" (TU U.15.8-38667335-002-2014), citrates of Ca and Mg (TUU 15.8.-35291116-0,14: 2011), glucose-fructose syrup (TU U 15.6-32616426-009: 2005), guar gum (E 412) and hydroxypropylmethylcellulose-HPMC (464), salt, compressed yeast, white crystalline sugar, corn oil were used. A mixture of guar gum and HPMC was used as a structure-forming agent.

The dough was prepared by method without fermentation.

The parameters of the technological process and the quality of bread were determined by general methods [2]. The degree of freshness of the bread was assessed by determining the deformation of the crumb on an automated penetrometer, and the water absorption capacity of the crumb. The aroma of bread was evaluated by the content of bisulfite-binding compounds by the method of R. Tokareva and V. Kretovych. Digestibility of proteins *in Vitro* was performed by the method of O. Pokrovsky and I. Yertakov. The digestibility of carbohydrates was investigated by determining the amount of reducing sugars formed by enzymatic hydrolysis. The chemical composition of the products was determined according to the software package "Optima" and instructions of Ukrhlibprom: "Calculation of nutritional and energy value of bakery products" [3].

The nutritional value of the developed bread was calculated by determining the chemical composition and the degree of daily requirement for the main components of substances and energy under the condition of daily consumption - 227 g of bread. The calculation was performed based on the norms of physiological needs of the population in basic nutrients [4].

Results of the research and analysis.

Analysis of the chemical composition of raw materials used in the study (table 1) showed that these raw materials can increase the consumer properties and nutritional value of gluten-free products, because sorghum flour in its composition exceeded the most used rice and corn flour in terms of protein, dietary fiber and fat. The source of protein was also casein and meal of pumpkin seed kernels, which contained a significant amount of dietary fiber. Whey contained 50% of milk solids, 90% of milk sugar, more than 20% of proteins, about 80% of minerals, vitamins and organic acids.

Table 1

Chemical composition of gluten-free raw materials

Ingredients,%	Flour			Whey	micellar casein	Meal of pumpkin seed kernels
	rice	corn	sorghum			
Protein	7.4	7.2	10.8	1.0	85.0	43.7
Fat	0.6	1.5	3.1	0.2	1.4	9.8
Carbohydrates	82.1	75.8	76.2	3.5	1.0	38.9
Including dietary fiber	0.4	0.7	6.5	-	-	33.1
Ash	0.5	0.8	1.8	0.8	2.5	1.2

Author's development

Laboratory and industrial research showed that technologically appropriate amount of raw materials, which along with the enrichment of products with functionally active substances provided high quality bread, was 60% of corn, 10% of potato starch and 30% of sorghum flour to prepare gluten-free products from starch-sorghum mixture. To increase the nutritional value of products from this mixture it was necessary to add micellar casein in the amount of 5-7%, meal of pumpkin seed kernels - 4-6%, whey - 10-15%, as well as citrates of Ca and Mg in the amount of 0.70 and 0.45% (50% of the daily requirement for these minerals).

With this dosage of raw materials, the bread had a proper volume, smooth, sometimes with small cracks, intensely colored surface, well-fluffed, elastic crumb, pleasant taste and aroma.

Based on the results of the research, formulations and technological instructions for three gluten-free products were developed and approved in accordance with the procedure established in Ukraine: starch-sorghum bread with whey, starch-sorghum dairy bread (with casein) and starch-sorghum pumpkin bread (with meal of pumpkin seed kernels). Calcium and magnesium citrates were also included in the recipes of these types of bread.

Expert evaluation of the developed products was conducted with the participation of experts. The obtained results, processed by the method of mathematical statistics, are shown in table 2.

The results of expert evaluation indicated the high quality of the developed gluten-free products enriched with the components of the raw materials. An important indicator of the consumer properties of bread was its aroma. The aroma stimulated the appetite and promoted better digestion of food. The aroma of bread was formed by fermentation products, but the decisive role in the accumulation of aromatic compounds belonged to the carbonyl compounds formed during baking and were products of the melanoidin formation reaction.

Studies showed (table 3) that in gluten-free starch products the content of carbonyl substances was insignificant due to the low protein content in starches.

After four hours after baking, in starch - sorghum bread with whey there was increase in crumbs by 15% and increase in crust by 25% compared to control sample.

This was due to the content of water-soluble substances of sorghum flour and whey, which actively reacted in melanoidin formation. There were significantly increase of these substances in starch-sorghum dairy bread: by 21% in crumb, by 33% in crust, and in starch-sorghum pumpkin bread - by 18% and by 29%, respectively. This was due to the protein content of casein and components of the meal kernels of pumpkin seeds.

Table 2

Average score organoleptic evaluation

Sample	Surface condition	Crust color	Crumb elasticity	Taste	Aroma	Crumb chewing
Starch bread (control sample)	3.0±0.3	4.0±0.3	4.5±0.3	4.0±0.3	4.0±0.3	4.6±0.3
Starch - sorghum bread with whey	4.9±0.3	4.8±0.3	4.6±0.3	4.8±0.3	4.9±0.3	4.8±0.3
Starch-sorghum dairy bread	5.0±0.3	4.9±0.3	5.0±0.3	5.0±0.3	5.0±0.3	5.0±0.3
Starch-sorghum pumpkin bread	4.6±0.3	4.8±0.3	4.7±0.3	5.0±03	5.0±0.3	4.9±0.3

Author's development

Table 3

The content of bisulfite binders, mg.-eq / 100 g of bread

Sampling	Starch bread (control sample)	Starch - sorghum bread with whey	Starch-sorghum dairy bread	Starch-sorghum pumpkin bread
After 4 hours in the crust	9.10	11.41	12.10	11.74
After 4 hours in the crumb	2.06	2.38	2.49	2.43
After 24 hours in the crust	7.50	9.70	10.57	10.10
After 24 hours in the crumb	2.26	2.73	3.68	3.59
Crust color	Light cream	Light brown	Light brown	Light brown

Author's development

During storage of products in all samples the content of aromatic substances decreased both in the crust and in the crumb due to partial weathering and decomposition of these compounds. However, products according to the developed recipes lost less aromatic substances during storage than products made of starches.

An important characteristic of the consumer properties of bread was the duration of freshness. Raw materials included in the formulation of the developed products had high water absorption capacity. Sorghum flour, meal of pumpkin seed kernels contained a significant amount of dietary fiber, casein was a high-protein substance. This should have helped keep the products freshness.

To confirm this, the tendency of the developed gluten-free products to harden during storage was studied by changing the structural and mechanical properties of the crumb (table 4), and water absorption capacity during bread storage (table 5).

Table 4

Changes in bread crumb deformation

Duration of storage, hours	Starch bread (control sample)	Starch - sorghum bread with whey	Starch-sorghum dairy bread	Starch-sorghum pumpkin bread
4	71	68	72	70
24	25	29	33	32
48	10	13	15	16
The degree of freshness, after hours, %				
24	35	43	46	48
48	14	19	21	23

Author's development

The total deformation of the crumb after four hours after baking of starch-sorghum bread with whey and starch-sorghum pumpkin bread was slightly less than in the control sample, apparently due to the incorporation of dietary fiber into the structure of crumb, which increased its rigidity. However, during further storage - 24 and 48 hours, all samples of the developed bread kept freshness better than the control sample. Starch-sorghum dairy bread and starch-sorghum pumpkin bread were preserved the best, which was due to the properties of milk protein and components of pumpkin meal kernels.

Studies of changes in the hydrophilic properties of bread samples made according to the developed recipes showed that due to the content of casein, dietary fiber, whey, sorghum flour protein and meal of pumpkin seed kernels, these products lost less water-binding capacity. This led to a lower tendency for them to harden.

Table 5

Hydrophilic properties of bread, % to DM

Duration of storage, hours	Starch bread (control sample)	Starch - sorghum bread with whey	Starch-sorghum dairy bread	Starch-sorghum pumpkin bread
4 hours	268	280	295	300
24 hours	250	263	271	285
48 hours	242	251	263	259

Author's development

An indicator of the physiological value of bread was the digestibility and assimilation of its components. During the studies, the digestibility of proteins of the developed products was determined *in vitro* under the action of enzymes pepsin and trypsin on the accumulation of products of enzymatic hydrolysis of proteins-free amino acids. It was found that the most intensively hydrolyzed proteins were in starch-sorghum dairy bread at both pepsin and trypsin stages due to good digestibility of casein. High digestibility of proteins was observed in bread enriched with meal of pumpkin seed kernels and less in starch-sorghum bread with whey. This was due to the content and susceptibility of proteins of this raw material to enzymatic hydrolysis. It was also found that the developed products contained more sugars than starch bread due to the sugars of sorghum flour, whey and pumpkin seed meal. However, a significant intensification of the enzymatic hydrolysis of carbohydrates of these products compared to the sample of starches was not observed.

According to the calculations of the nutritional value of the developed bread, gluten-free products made according to the developed recipes had a more valuable chemical composition than control sample. The protein content in these products was 3.3-5.4 times higher - 26.9%, while in control sample - 2.6%. They contained more than 30-51% of fat, as well as up to 3.3% of dietary fiber, vitamins and minerals. The energy value of the developed products was higher by 32-47% compared to the control sample.

Conclusions.

It was established that the use of meal of pumpkin seed kernels, micellar casein, whey and citrates of Ca and Mg as sources of physiologically functional substances improved the organoleptic properties of gluten-free bakery products, their aroma, preservation of freshness. The amount of protein, dietary fiber, minerals and vitamins increased. The digestibility of bakery products improved. With the introduction of bread made according to the developed recipes into production, patients with celiac disease and other consumers of gluten-free products will be better provided with substances necessary for the normal functioning of the body.

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Анотація. *У статті розглянута проблема необхідності виробництва безглютенового хліба підвищеної харчової цінності. Розглянуто сучасний стан виготовлення цієї продукції та сировину здатну забезпечити її якість та харчову цінність. Приділена увага хімічному складу соргового борошна, шроту ядер насіння гарбуза, міцелярного казеїну, молочної сироватки, як сировини, здатної підвищити харчову цінність хліба.*

Встановлено, що за використанням цієї сировини, як джерела фізіолічно-функціональних речовин, покращуються органолептичні властивостей виробів, їхній аромат, подовжується збереження свіжості. Підвищується харчова цінність за вмістом білка, харчових волокон, мінеральних речовин та вітамінів. Покращується перетравлюваність цих виробів.

На основі результатів досліджень розроблено і затверджено в установленому порядку рецептури і технологічні інструкції на три види хлібобулочних виробів з підвищеними споживчими властивостями та харчовою цінністю.

Ключові слова: *безглютеновий хліб, сировина, споживчі властивості, харчова цінність.*

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