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INFLUENCE OF PUMPKIN PROCESSING PRODUCTS ON STRUCTURAL AND MECHANICAL PROPERTIES OF DOUGH AND BREAD QUALITY

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ABSTRACT

The prevalence of gastrointestinal diseases, including irritable bowel syndrome, has been a concern over the past decade. The main approach to reducing the incidence of this disease is diet therapy. Since such a segment of products, in particular bakery products, is practically not represented at the Ukrainian market, the urgent task is to develop approaches to diet therapy using bakery products. According to the recommendations of the diet low in FODMAP (diet for irritable bowel syndrome), pumpkin is the product recommended for consumption. The influence of pumpkin flour and pumpkin fiber on the structural and mechanical properties of the dough and the quality of finished products from wheat flour, which additionally included lecithin, was studied. Pumpkin flour and pumpkin fiber contain 3.8 and 4 times more protein than high-grade wheat flour and 3.2 and 9.1 times more dietary fiber. They also contain a significant amount of the amino acid lysine, which is the limit in wheat flour. It was established that the use of pumpkin processing products reduced the gas content due to the influence of the components of this raw material on gluten. The gluten skeleton lost elasticity due to the content of dietary fiber and pectin in pumpkin raw materials, which reduced its ability to retain carbon dioxide. The viscosity of the dough changed under the action of the components of the pumpkin raw material. There was a tendency to reduce the content of crude gluten when using flour and pumpkin fiber. The elasticity and hydration ability of gluten also decreased, its extensibility increased. As the percentage of replacement of wheat flour with pumpkin flour and pumpkin fiber increased, the initial and final acidity increased. The shape stability of bread did not change significantly. Along with this, the taste of the products improved, which acquired a pleasant pumpkin hue. The bread crumb was elastic, well fluffed. Bread made with the studied raw materials had good consumer properties.

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ВПЛИВ ПРОДУКТІВ ПЕРЕРОБКИ ГАРБУЗА НА СТРУКТУРНО-МЕХАНІЧНІ ВЛАСТИВОСТІ ТІСТА ТА ЯКІСТЬ ХЛІБА

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Протягом останнього десятиліття занепокоєння викликає поширеність захворювань шлунково-кишкового тракту, зокрема синдрому подразненого кишечника. Основним підходом до зниження захворюваності на ці хворобу є дієтотерапія. А оскільки на ринку України практично не представлений такий сегмент продукції, зокрема хлібобулочної, актуальним завданням є розроблення підходів до дієтотерапії за використання хлібобулочних виробів. Згідно з рекомендаціями дієти з низьким вмістом FODMAP (дієти при синдромі подразненого кишечника) продуктом, рекомендованим для споживання, є гарбуз.

У статті досліджено вплив гарбузового борошна та гарбузової клітковини на структурно-механічні властивості тіста та якість готових виробів з пшеничного борошна, до складу яких додатково внесено лецитин. Борошно гарбузове та гарбузова клітковина містять у 3,8 та 4 рази більше білка, ніж пшеничне борошно вищого сорту, та у 3,2 та 9,1 раза більше харчових волокон. Також вони містять значну кількість амінокислоти лізину, що є лімітуючою в борошні пшеничному. Встановлено, що за використання продуктів переробки гарбуза знижується газоутримання, що обумовлено впливом складових цієї сировини на клейковину. Клейковинний каркас втрачає еластичність за рахунок вмісту харчових волокон і пектинових речовин у гарбузовій сировині, що призводить до зниження його здатності утримувати діоксид вуглецю. Під дією складових гарбузової сировини змінюється в'язкість тіста. Встановлено тенденцію зменшення вмісту сирої клейковини при використанні борошна та клітковини гарбуза. Знижується також пружність і гідратаційна здатність клейковини, підвищується її розтяжність. Зі збільшенням відсотка заміни борошна пшеничного гарбузовим борошном та гарбузовою клітковиною зростає початкова та кінцева кислотність. Формостійкість хліба не значно змінюється. Поряд з цим покращується смак виробів, що набуває приємного гарбузового відтінку. М'якушка хліба еластична, добре розпушена. Хліб, виготовлений з досліджуваною сировиною, має добрі споживчі властивості.

Ключові слова: *хліб, гарбузове борошно, гарбузова клітковина, лецитин, структурно-механічні властивості тіста, споживчі властивості.*

Formulation of the problem. The prevalence of gastrointestinal diseases, including irritable bowel syndrome (IBS), has been a concern over the past decade. The prevalence of IBS is from 14 to 48 patients per 100 thousand population. The fact that the age peak incidence occurs at 20—40 years — the working segment of the population is of considerable concern, there is a tendency for a more frequent incidence of women (2—4 times) than men. This problem is global, because according to statistics, even in

highly developed countries, such diseases rank 2nd as the cause of disability. The etiology of these diseases is still unknown. In addition, IBS is the cause of other diseases, such as excessive bacterial growth syndrome, etc. (Степанов, Федорова & Зигало, 2019).

The main approach to reducing the incidence of this disease is diet therapy. Since such a segment of products, in particular bakery products, is practically not represented at the Ukrainian market, and therefore there are no approaches to the creation of appropriate bakery products, the urgent task is to develop approaches to diet therapy using bakery products. According to the recommendations of the diet low in FODMAP (diet for irritable bowel syndrome), pumpkin is the product recommended for consumption (Гібсон & Шеперд, 2010). Therefore, it is important to study the impact of pumpkin processing products on the technological process and quality of manufactured bakery products.

Analysis of recent research and publications. One of the ways to effectively supplement the diet of insufficient dietary fiber, vitamins and minerals is to enrich these nutrients in consumer products, and bread in particular, as evidenced by domestic and international experience. For this purpose, it is necessary to use non-traditional raw materials in bread recipes, which can change not only the organoleptic properties of bread, but also enrich it with the necessary essential nutrients, increasing its functional properties (Плахотін, Пасічний & Коваленко, 2012).

The use of pumpkin processing products in the manufacture of bakery products from wheat flour, namely semi-finished products — juice and puree from different varieties of pumpkin, obtained using different technologies are known. Varieties of pumpkin nutmeg "Dolya" — late ripening, large-fruited "Pink Banana" — medium ripe and hardwood "Danaya" — medium ripe were used. Organoleptic evaluation showed an improvement in the organoleptic properties of bread with the addition of the studied raw materials (Бараболя *et al*., 2018).

Developments for adding a mixture of other types of flour to wheat flour, in particular pumpkin and spelled flour, were proposed. Determining the mineral composition of this raw material proved the feasibility of its use to improve the macro- and microelement component of bread, as well as prolong the freshness of finished products (Миколенко & Гезь, 2017).

Scientists considered the possibility of introducing intensive technologies, namely the use of pumpkin powder in the dough for frozen semi-finished products, which was obtained by the method of activation drying to reduce the speed of its preparation and maximum preservation of vitamin C (Коркач, Пшенишнюк & Кананихина, 2010).

The influence of pumpkin flour on the properties of gluten in the process of making bread was studied by domestic scientists (Столярчук, 2010).

Developments of foreign scientists in the direction of enrichment of bread with products of pumpkin processing — puree, juice, candied fruit, oil are known. The effect of pumpkin pomace and pumpkin powder on the quality of wheat bread was evaluated. It was found that the volume of bread decreased with increasing dosage of this raw material. The total carotene content in wheat bread increased with the addition of pumpkin products (Kampuse, Ozola, Straumite & Galoburda, 2015; Rakcejeva, Galoburda, Cude, & Strautniece, 2011).

However, there are insufficient data on the impact of pumpkin products — flour and fiber on the technological process of manufacturing products.

For people suffering from IBS, the use of phospholipids, in particular phosphatidylcholine, is important because it is one of the main membrane phospholipids, which prevents damage to the upper and lower gastrointestinal tract, and is involved in the formation of a protective layer of intestinal mucin. Phosphatidylcholine provides hydrophobicity of the mucin layer covering the intestinal epithelium. Due to this, microorganisms cannot be fixed on its surface and are mechanically removed from the intestinal wall.

Phosphatidylcholine is more than 80% of intestinal mucin phospholipids in the organism of healthy person, while for patients with IBS, its content decreases by more than 70% (Дорофеев, Руденко, Швец & Дорофеева, 2017). One of the sources rich in phosphatidylcholine is lecithin. In addition, studies of the effect of lecithin on the course of the technological process of manufacturing gluten-free bakery products showed an improvement in gas content in the dough and fermentation capacity of yeast (Медвідь, Шидловська & Доценко, 2019).

Therefore, the **purpose** of the work was to determine the influence of pumpkin flour and pumpkin fiber on the structural and mechanical properties of dough and the quality of finished products from wheat flour, which additionally included lecithin.

Materials and methods. High-grade wheat flour, sunflower lecithin with a content of 95.3% phosphatidylcholine, pumpkin flour obtained from low-fat purified pumpkin seeds of large-fruited, hard-skinned variety “Pink Banana”, pumpkin fiber obtained from seed kernels were used for research.

Samples were prepared with the addition of lecithin in an amount of 3% by weight of flour. This dosage was chosen based on the recommendations of the daily norm of lecithin for people with IBS (Partridge *et al*., 2019). Pumpkin flour was dosed in the amount of 5%, 10%, 15%, 20% to replace wheat flour, pumpkin fiber — 5%, 7%, 10%, 15% to replace wheat flour. The control was a sample without additional raw materials.

The structural and mechanical properties of the dough were characterized by the gas holding capacity in terms of the specific volume of the dough and the shape holding capacity in terms of the spread of the dough ball.

Indicators of finished products were determined by standard methods.

Statistical data processing was performed using Microsoft Excel XP software.

Results and discussion. Analysis of the chemical composition of the studied raw materials showed that pumpkin flour and pumpkin fiber are valuable sources of protein and dietary fiber (Table 1).

Table 1. **Chemical composition of pumpkin processing products in comparison with high-grade wheat flour**

Content per 100 g of product	High-grade wheat flour	Pumpkin flour	Pumpkin fiber
Protein, g	10.3	40	42
Fat, g	1.1	9	6
Carbohydrates, g	69.8	23	16
-including fiber, g	3.5	12	32

Pumpkin flour and pumpkin fiber contain 3.8 and 4 times more protein than high-grade wheat flour and 3.2 and 9.1 times more dietary fiber (DF). They also contain a significant amount of the amino acid lysine, which is the limit in wheat flour.

Acidity of pumpkin flour was 5.2 degrees, of pumpkin fiber — 4.8 degrees.

The gas holding capacity of the dough was characterized by its specific volume during 3 hours of its fermentation.

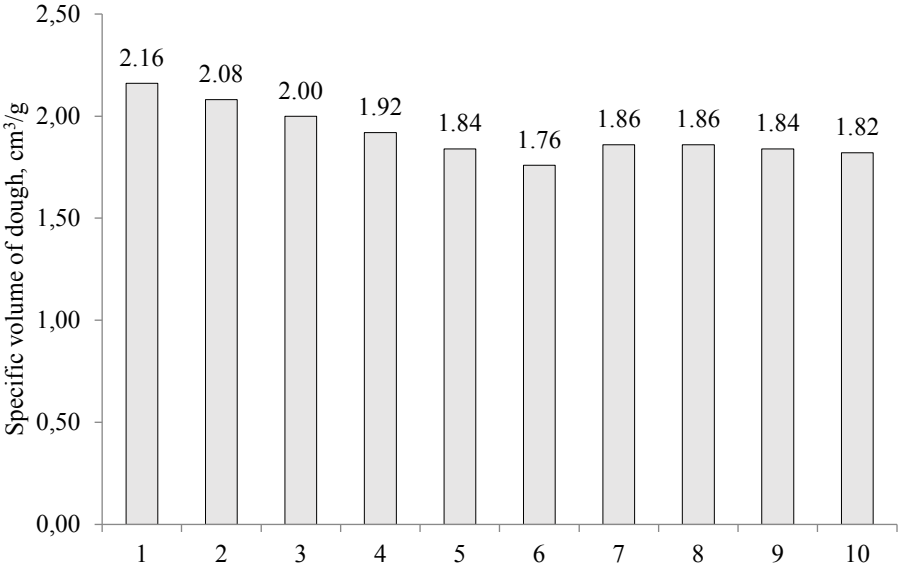

Fig. 1. Specific volume of dough:
1 — control sample; 2 — sample with lecithin; 3, 4, 5, 6 — sample with lecithin and pumpkin flour 5%, 10%, 15%, 20% to replace wheat flour; 7, 8, 9, 10 — sample with lecithin and pumpkin fiber 5%, 7%, 10%, 15% to replace wheat flour

It was established that the use of pumpkin processing products reduced gas content by 3.8—15.3% with pumpkin flour and by 10.5—12.5% with pumpkin fiber (Fig. 1). This was due to the influence of the components of these raw materials on gluten.

The gluten skeleton lost elasticity due to the content of DF and pectin substances in pumpkin raw materials, which reduced its ability to retain carbon dioxide. With an increase in the bread recipe of these products, this was manifested to a greater extent.

The viscosity of the dough changed under the action of the components of the pumpkin raw material. The viscosity of the dough with different amounts of pumpkin flour and pumpkin fiber was characterized by the spread of the dough ball during its fermentation during 3 hours.

It was found (Fig. 2) that the diameter of the ball during fermentation decreased by 3.8—15.3% with pumpkin flour and by 10.5—12.5% with pumpkin fiber depending on the dosage. This indicated an increase in the viscosity of the dough system due to the content of pumpkin raw materials of DF and pentosans.

An important indicator of structural and mechanical properties is the quantity and quality of gluten washed from the dough.

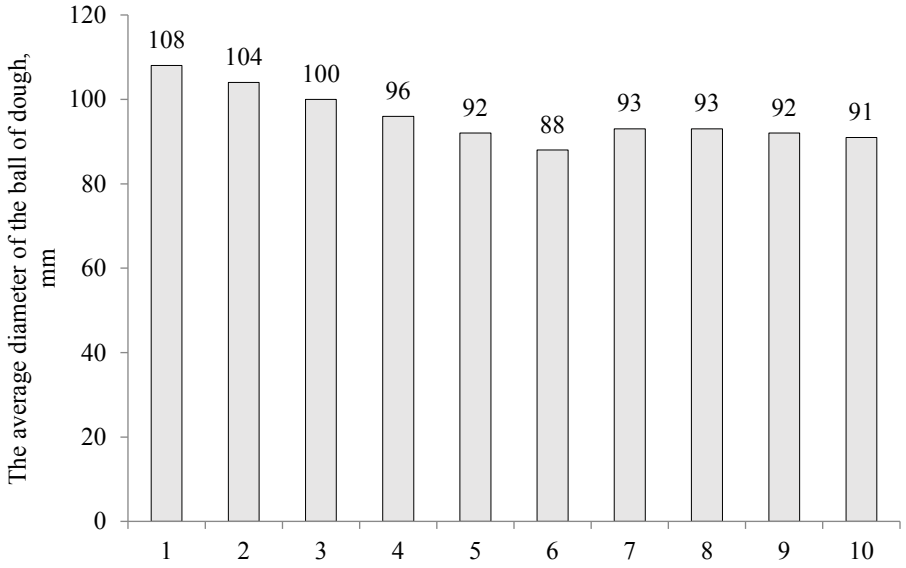

Fig. 2. Dilution the ball of dough:
1 — control sample; 2 — sample with lecithin; 3, 4, 5, 6 — sample with lecithin and pumpkin flour 5%, 10%, 15%, 20% to replace wheat flour; 7, 8, 9, 10 — sample with lecithin and pumpkin fiber 5%, 7%, 10%, 15% to replace wheat flour

Table 2. **Quantity and quality of gluten washed from the dough**

Sample	The amount of enricher, %	The amount of crude gluten, %	The amount of dry gluten, %	The value of IDG, units	Hydration capacity, %	Elongation, cm
Control sample	—	25.30	8.5	70	195.5	15.2
Sample with lecithin	3	23.60	8.0	76	194.8	15.8
Sample with lecithin and pumpkin flour	5	20.11	6.88	82	192.2	16.2
	10	16.23	5.64	88	187.6	16.9
	15	13.21	4.64	93	184.6	17.2
	20	12.12	4.29	95	182.1	17.6
Sample with lecithin and pumpkin fiber	5	21.24	7.24	79	193.3	16.5
	7	18.61	6.38	80	191.5	16.7
	10	16.70	5.77	83	189.1	17.3
	15	14.81	5.15	86	187.5	17.9

It was found that the introduction of lecithin reduced the amount of raw and dry gluten. This was due to the formation of compounds between the proteins of flour and lecithin, which were lost during leaching of gluten. At the same time the hydration ability of gluten slightly decreased, its elasticity decreased, extensibility increased.

The tendency of decrease in the content of crude gluten at use of flour and fiber of pumpkin with increase in their dosage was established (Table 2). This was apparently due to a decrease in the dough ability to form bound mass due to the interaction of the

lipid components of pumpkin and lecithin with wheat flour proteins. The elasticity and hydration ability of gluten also decreased, its extensibility increased.

Regularities of change of technological characteristics of dough semi-finished products and influence of raw materials on quality of bread were defined by means of baking. The results are shown in tables 3 and 4.

Table 3. **Quality indicators of finished products with pumpkin flour**

Indicators	Control sample	Sample with lecithin	Samples with pumpkin flour, % to replace wheat flour			
			5	10	15	20
Dough						
Humidity, %	41.8	41.7	41.9	41.9	41.7	41.7
Acidity, degrees -initial -final	 1.8 2.4	 1.8 2.4	 1.8 3.1	 1.9 3.4	 2.1 3.6	 2.3 4.0
Duration of fermentation, min	150					
Duration of keeping, min	44	44	46	47	50	52
Bread						
Specific volume, $cm^3/100$ g	224	234	220	218	178	146
Shape stability, H/D	0.56	0.61	0.60	0.58	0.55	0.53
Porosity, %	73	75	67	65	62	54
final acidity, degrees	2.0	2.0	2.5	2.8	3.1	3.4
Surface condition	smooth, without cracks				smooth, without cracks, uneven	
Crumb color	light			with a barely noticeable dark tinge	with a green tinge	with a noticeable green tinge
Crust color	light-yellow				darkened	greenish
The porosity structure	uniform, small, thin-walled				uniform, small, thick-walled	
Taste	inherent in the product		with pumpkin flavor		with a pronounced pumpkin flavor	

Table 4. **Quality indicators of finished products with pumpkin fiber**

Indicators	Control sample	Sample with lecithin	Samples with pumpkin fiber, % to replace wheat flour			
			5	7	10	15
1	2	3	4	5	6	7
Dough						
Humidity, %	41.8	41.7	41.9	41.9	41.7	41.7
Acidity, degrees -initial -final	 1.8 2.4	 1.8 2.4	 1.8 3.1	 1.9 3.2	 2.1 3.5	 2.3 3.7

Continuation of Table 4

1	2	3	4	5	6	7
Duration of fermentation, min	150					
Duration of keeping, min в	44	44	43	41	40	38
Bread						
Specific volume, $cm^3/100$ g	224	234	216	214	161	138
Shape stability, H/D	0.56	0.61	0.59	0.57	0.57	0.57
Porosity, %	73	75	72	72	70	70
final acidity, degrees	2.0	2.0	2.2	2.5	2.9	3.1
Surface condition	smooth, without cracks					smooth, without cracks, uneven
Crumb color	light			with a barely noticeable dark tinge	with a green tinge	with a noticeable green tinge
Crust color	light-yellow		light-yellow, with splashes of fiber		with green tinge, with splashes of fiber	
The porosity structure	uniform, small, thin-walled				uniform, small, thick-walled	
Taste	inherent in the product		with pumpkin flavor		with a pronounced pumpkin flavor	

As the percentage of replacement of wheat flour with pumpkin flour and pumpkin fiber increased, the initial and final acidity increased, which was caused by the higher acidity of the studied raw materials. The duration of aging of dough pieces was reduced.

The shape stability of bread did not change significantly. The acidity of the crumb of the studied products was higher than the control due to the higher acidity of the added raw materials.

The decrease in the specific volume and porosity of bread samples can be explained by the specifics of pumpkin fiber swelling. Due to the presence in the dough of dietary fiber, which swelling, was in the form of inclusions in the dough, gluten lost its integrity. Fiber from the studied raw materials during the period of fermentation and keeping was built into the gluten frame, destroying its integrity, reduced the gas-holding capacity of the dough, reduced the volume of finished products. Along with this, the taste of the products improved, which acquired a pleasant pumpkin hue. The bread crumb was elastic, well fluffed. Bread made with the studied raw materials had good consumer properties.

Conclusions

The expediency of enriching wheat bread with pumpkin processing products — flour and fiber in a mixture with lecithin, as a source of phospholipids, due to the structural and mechanical properties of the dough and bread quality indicators was established.

The use of pumpkin processing products reduced the gas content by 3.8—15.3% with pumpkin flour and by 10.5—12.5% with pumpkin fiber.

The viscosity of the dough system increased by 3.8—15.3% with pumpkin flour and by 10.5—12.5% with pumpkin fiber depending on the dosage.

The introduction of pumpkin raw materials significantly reduced the amount of raw and dry gluten due to the formation of compounds between the proteins of flour and components of the lipid nature of these raw materials, which are lost during washing gluten.

The specific volume and porosity of the samples were also reduced. However, consumer properties improved. It is rational to replace no more than 10% of wheat flour with pumpkin and no more than 7% of wheat flour with pumpkin fiber.

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