The effect of gluten-free flour mixture and burdock root on organoleptic characteristics and porosity of bread

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Abstract. The paper considers the possibilities of using vegetable raw materials - burdock root flour with the addition of psyllium and a gluten-free mixture in the manufacture of enriched gluten-free bread, and their influence on the quality indicators of the obtained samples. To achieve this goal the obtained samples of gluten-free enriched bread, obtained with the introduction of various concentrations of flour from burdock root and gluten-free flour mixture containing psyllium - psyllium seed husk, were studied. Flour from burdock root and psyllium was added in the amount of 5-15% by weight of the gluten-free flour mixture directly with the replacement of the mixture during flour kneading. To study the obtained samples, organoleptic studies were used. The results obtained showed that when adding the burdock root additive, the porosity decreases in comparison with the control sample. The obtained values of the decrease in porosity in the control and sample 1 correspond to the standard values. Considering that the sample with the replacement of the main raw material with 5% burdock root additive is the best in terms of organoleptic indicators, it can be concluded that this concentration is optimal for using the introduced products for enrichment when obtaining gluten-free bread.

1 Introduction

According to statistics, about 1% of people suffer from congenital celiac disease. Gluten damages the villi of the small intestine, through which the body releases vitamins and minerals from food. "Impaired bowel function is fraught with the development of various concomitant diseases - from dermatitis to diabetes mellitus" [1].

The interest in the use of various plant components in the production of flour products, including bread, as well as gluten-free bread, is caused by many researchers for a large number of different reasons. First of all, this is due to a decrease in the cost of the product, an improvement in its organoleptic and physico-chemical parameters.

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For example, researchers Anna-Sophie Hager, Elke C. Arendt provide data on the use of a flour composition with ingredients other than wheat flour, teff flour and buckwheat. The authors note that this represents a "major technological challenge due to the lack of gluten viscoelastic bonding" and to address these issues, suggest in their research "the use of hydrocolloids such as xanthan gum and hydroxypropyl methylcellulose (HPMC), often included in gluten-free formulations" [1].

Other authors from the University of Brazil and the Institute of Agrochemistry and Food Technology of Spain, in their review article, propose protein fortification of rice-based flour, "consisting of protein isolates of casein and albumin, as well as transglutaminase to strengthen protein networks" [2]. They developed a method to optimize a gluten-free recipe suitable for baking bread.

In the scientific literature it is possible to find a description of the use of ingredients from various other pseudocereals. Researchers Dana Elgeti, Sebastian D. Nordlone show that the matrix of gluten-free bread and its foam stability are highly dependent on the choice of ingredients. The authors studied the effect of white quinoa flour on bread quality parameters, in particular volume. "Pseudo-cereals proved to be a suitable substrate for dough aeration with yeast, as significantly more glucose and higher activity of a-glucosidase enzymes were found compared to rice and corn flour." Consequently, white quinoa flour has been used to replace some of the rice and corn flour, which has improved the quality of gluten-free bread through the use of white quinoa flour [3].

In these studies, the authors Eva Campo, Lis del Arco note the positive effect of teff flour (5, 10 and 20%) and various dried (buckwheat or rice) or fresh (with the addition of lactobacillus) sourdough on organoleptic qualities and consumer preferences for gluten-free bread" [4]. "The combination of teff (10%) with grain sourdough (rice or buckwheat) enhanced the flavor of the bread, enhancing fruit, cereal and toast notes" [4].

A review article by authors Vanessa D. Caprilesa, Fernanda G., José - Alfredo G. Areasb focuses on current approaches that are used to increase nutrient and bioactive compounds in gluten-free bread (GFB), and highlights the use of nutrient-rich alternatives. raw materials, nutritional and functional ingredients and their combinations. The authors pointed out that, at the present stage, "few studies are devoted to micronutrient enrichment in GFB" [5].

The researchers conclude that, "Further research is needed to improve or develop new nutrient-rich GFBs (gluten-free bread) and evaluate them to understand or improve their effectiveness as carriers of micronutrients and bioactive compounds" [5].

V.D. Kaprilis and A.G. note Areas that the main problems in the production of gluten-free (FG) bread are associated with overcoming its poor structure, texture, shelf life, organoleptic and nutritional qualities. These problems arise because they are based on starchy ingredients and GF flour, and also because of the lack of raw materials that could adequately mimic the structure-forming role of gluten. A variety of approaches have been taken to overcome these problems, including the search for new ingredients, additives, process conditions, and technological alternatives. [6]

Also, some researchers note that the growing demand and consumption of gluten-free (GF) products have turned the gluten-free food market from a niche of specialized products into a trend in the global food sector [7].

Some researchers believe that "the increase was mainly due to an increase in the prevalence of gluten-related diseases such as celiac disease, non-celiac gluten sensitivity (also called non-celiac wheat sensitivity), and wheat allergy, the treatment of which is to maintain lifelong gluten-free or a wheat-free diet to avoid symptoms and complications" [8].

Promising results have been obtained with several ingredients such as chickpea flour (CF), nutrient-rich raw materials, psyllium (PSY), natural bioactive soluble fiber extracted from the husk of Psyllium ovoid seed, and certain processing aids such as cyclodextrin glycosyltransferase (CGTase) enzymes and transglutaminase (TGase) to improve the quality and shelf life of GFB [9]

V.D. Capriles and others write that increasing the variety of tastier and healthier gluten-free foods is still an open challenge. It has been proposed to use ingredients rich in dietary fiber to improve the physical properties, organoleptic acceptability and nutritional value of GFB, as well as to reduce the glycemic response of such products. [10]

B. Singh notes that the bioactive polysaccharide from psyllium husk (Psyllium ovata Forsk) is a type of arabinoxylan, which is also known as psyllium husk, psyllium mucus, ispaghul, or isabgol. Psyllium husk is a source of natural viscous dietary fiber, which has health benefits, such as regulating bowel function, glucose and cholesterol levels in the blood. control [11].

Psyllium is considered by Camilli Fratelli et al. to be a promising GFB enhancing supplement, and it enables the hand-forming of gluten-free dough and buns in addition to increasing volume, appearance, texture, acceptability and fiber content and reducing the glycemic response of GFB.

Modeling the effects of psyllium and water in gluten-free bread: an approach to improve bread quality and glycemic response [12]

Some researchers believe that psyllium is the husk of a grain (Psyllium ovata) and is rich in water-soluble dietary fiber (about 70%), providing many health benefits as well as improving dough functionality for healthy baking [13].

Psyllium is also known for its beneficial effects in lowering low-density lipoprotein levels, lowering blood sugar levels in diabetes, and preventing constipation. [14]

Feeding psyllium husk has been shown in some studies to increase the production of heat shock proteins, which improve the function and integrity of intestinal epithelial cells, with beneficial effects on gut health. [15].

M. Ogata et al. have shown that psyllium fiber has antioxidant and hepatoprotective effects against hepatic toxicity caused by carbon tetrachloride.

2 Materials and methods

The ordinary recipe has been improved by adding psyllium burdock root flour, and using a gluten-free blend of three types of corn, rice, and millet flour to enrich gluten-free bread.

Additives were added in the amount of 5–15% to the mass of flour directly during kneading and other components.

Table 1. Recipe for gluten-free bread, with the addition of burdock root and psyllium seed husks when replacing the main raw materials (5%, 10%, 15%).

Name of the recipe component, g.	Sample 1 Control	Sample 2 5% additives	Sample 3 10 % additives	Sample 4 15% additives
Gluten-free flour mixture:	400	380	360	340
Rice	150	142	134	126
Corn	150	142	134	126
Millet	100	96	92	88
Corn starch	50	50	50	50
Potato starch	50	50	50	50
Yeast	3	3	3	3
Guar gum	10	10	10	10
Baking soda	2	2	2	2
Salt	1,5	1,5	1,5	1,5
Water	240	240	240	240

Jerusalem artichoke syrup	5	5	5	5
Burdock root	-	10	20	30
Psyllium	-	10	20	30

According to the recipes presented in Table 1, samples of gluten-free bread were made and their quality indicators were studied.

In organoleptic studies, the indicators were determined in accordance with the specified regulatory document. "Dietary bakery products" (GOST 25832-89).

2.1 Organoleptic characteristics of samples

Organoleptic indicators include the appearance of finished products, shape, surface condition, color, crumb condition, mess, porosity, taste and smell.

Organoleptic indicators are determined after the product has cooled down and GOST 34835-2022 Specialized food products are applied. Gluten-free bakery products. General specifications. Gluten-free bakery products must be manufactured in accordance with the requirements of this standard, GOST 34835-2022 and the standardization document in accordance with which the product of a particular name is manufactured, according to the recipe and technological instructions, and also comply with the regulatory legal acts of the state in whose territory these products are is in circulation.

To control the organoleptic characteristics of products (except for the shape, surface and color of the crusts), a representative sample is made by the "loose" method in accordance with GOST 18321-73.

Indicators such as shape, surface and color are controlled by inspection of the entire bakery product. Organoleptic indicators (except for the shape, surface and color of the product) are controlled through the senses (smell, touch, vision).

According to organoleptic indicators, gluten-free bakery products must meet the requirements presented.

When evaluating the appearance of the product, attention is paid to the correct shape and surface, the presence of cracks and explosions. The color of the product should be uniform, without burnt.

The state of the crumb of bakery products is assessed by bakedness, profusion, porosity and elasticity. The crumb should be baked, not sticky to the touch, without foreign inclusions. The porosity should be uniform, without traces of hardening and voids.

Taste and smell should correspond to this type of product. When chewing the product, there should be no crunch on the teeth due to the presence of mineral impurities.

Table 2 presents the organoleptic quality indicators of gluten-free bread with vegetable additives.

Table 2. Organoleptic quality indicators of gluten-free bread with vegetable additives

Indicator	**Characteristic according to GOST 34835-2022**	**Sample 1 Control**	**Sample 2 5% substitutions for burdock root and psyllium**	**Sample 3 10% substitutions for burdock root and psyllium**	**Sample 4 15% substitutions for burdock root and psyllium**
Appearance: shape and surface, colour	Appropri-ate for the type of product Light yellow to dark brown	Square according to the baking dish, no pressure, no blurry yellow colour	Square in accordance with the baking dish, without prints, not blurry. Brown colour	Square in accordance with the baking dish, without prints, not blurry. Brown colour	Square according to the baking dish, no pressure, no blurry dark brown colour

Condition of the crumb: baked, mixed, porosity	Baked, not moist to the touch. No traces of mess. Peculiar to a product of a particular name, uneven, undeveloped, with the presence of large pores, voids and compaction of the crumb is allowed	Baked, not moist to the touch. No traces of mess. Porosity uniform moderately developed, with small voids	Baked, not moist to the touch. No traces of mess. The porosity is uniform, well developed, without voids and compaction of the crumb	Baked, not moist to the touch. No traces of mess. The porosity is uniform and well developed, without voids and compaction of the crumb	Baked, slightly moist to the touch. No traces of mess. The porosity is uniform, well developed, there are crumb compactions
Taste	Peculiar to this type of product, without foreign taste. When using a food flavoring - a taste characteristic of the added flavoring	With millet taste	With a millet taste and a slight taste of burdock roots	With millet flavor and flavor of burdock roots	With a millet taste and a pronounced taste of burdock roots
Smell	Peculiar to this type of product, without foreign smell	No aftertaste odor, with millet aroma	No aftertaste, with a millet aroma, burdock root powder with a nutty flavor	Without postorenny smell, with a millet aroma, with a mild odor of burdock root powder	No foreign smell, with a spicy aroma with a pronounced smell of burdock root powder
Consistency (frozen products)	Firm	Firm	Firm	Firm	Firm

It can be seen from the data presented in Table 1 that gluten-free products enriched with vegetable raw materials correspond to the indicators of GOST 34835-2022.

Samples of the resulting gluten-free bread in the context are shown in Figure 1.

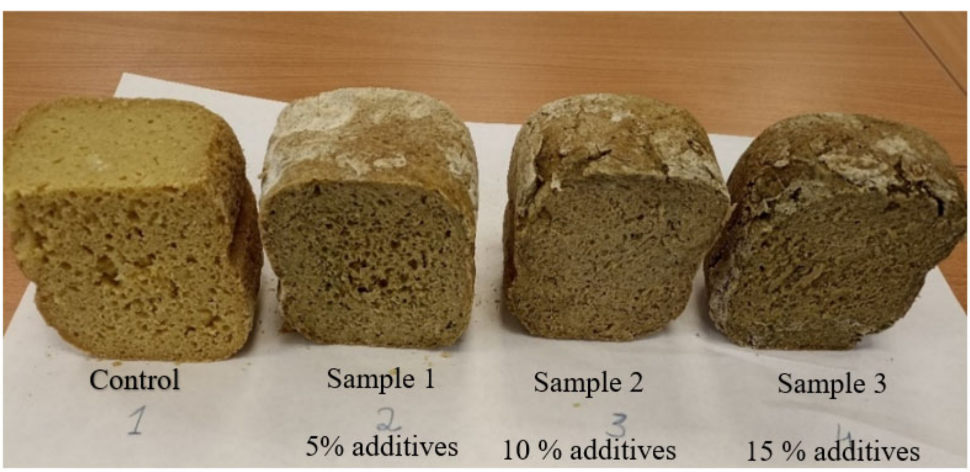

Fig. 1. Gluten-free bread with additives in the cut

The results of organoleptic studies, reflected in Table 1, show that the obtained samples of gluten-free bread correspond to the normative organoleptic indicators, however, bread containing high concentrations of replacement additives for burdock root and psyllium have worse organoleptic indicators of taste and aroma compared to samples lower concentration. The samples with 5% replacement of gluten-free flour mixture with burdock root and psyllium turned out to be optimal in terms of these indicators.

3 Results and discussion

Such an indicator as porosity characterizes an important property of the product - its digestibility. Instrumentally, the porosity of bakery products was determined according to GOST 5669-96 using a Zhuravlev probe. Zhuravlev probe is shown in Figure 2.

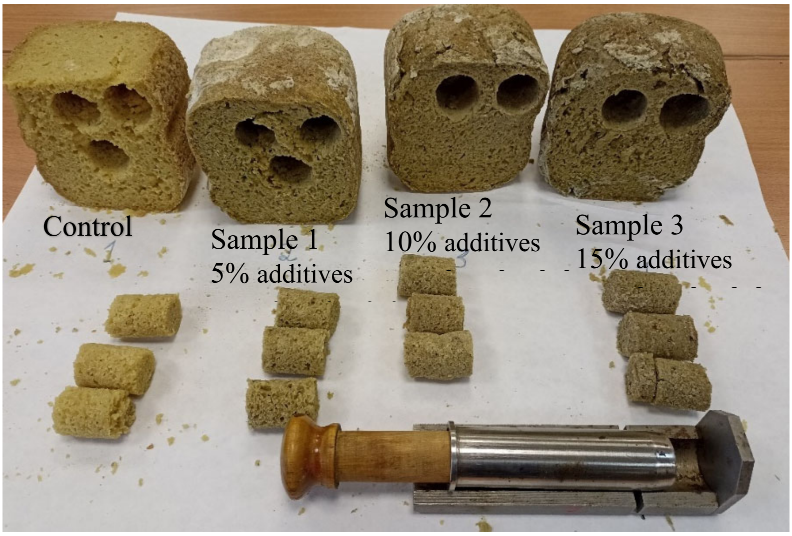

Fig. 2. Determination of the porosity of gluten-free bread with Zhuravlev probe.

The porosity in percent was determined by formula (1). The results obtained for all samples are presented in Table 3.

Table 3. Porosity in samples.

Indicator	Sample 1 Control	Sample 2 5% additives	Sample 3 10 % additives	Sample 4 15% additives
Porocity in samples, %	56.93	56.33	47.37	41.08

The obtained results show that the added additives reduce the porosity of gluten-free bread. The porosity is within the normal range, for the control sample and sample No. 1, as according to GOST 34835-2022, the crumb porosity, %, is not less than 50, the norm for gluten-free bakery products.

4 Conclusions

As a result of the studies carried out in accordance with the previously designated goal, the tasks were successfully solved.

Performed theoretical and experimental studies, as well as testing them in laboratory conditions, confirmed the effectiveness of the use of burdock root flour in the manufacture of gluten-free bread. The best-performing samples are those with 5% flour replaced with burdock root and psyllium products.

The practical significance of the study performed makes it possible to apply the results obtained in practice in the production of gluten-free enriched bread.

A sample of gluten-free bread with the addition of 5% burdock root and psyllium flour by weight of flour can be recommended for inclusion in the human diet, based on individual functional characteristics.

References

1. A.-S. Hager, E. K. Arendt, Food Hydrocolloids **32** 195-203 (2003)
2. C.R. Storck, et al., Food Science and Technology **53** 346-354 (2013)
3. D. Elgeti, et al., Journal of Cereal Science **59** 41-47 (2014)
4. E. Campo, et al., Journal of Cereal Science **67** 75-82 (2016)
5. V.D. Capriles, et al., Journal of Cereal Science **67** 83-91 (2016)
6. V. D. Capriles, A. G. Areas, Comprehensive Reviews in Food Science and Food Safety **13** 871-890 (2014)
7. V. D. Capriles, F. G. Santos, E. V. Aguiar, *Trends in wheat and bread production* (Academic press, 2020) pp. 371-404
8. F. Browns, G. van Rooy, P. Shuri, S. Rustgi, D. Jonkers, Comprehensive Reviews in Food Science and Food Safety **18(5)** 1437-1452 (2019). https://doi.org/10.1111/1541-4337.12475
9. F. G. Santos, E. V. Aguiara, CEP **136** 11015-020 (2020)
10. V.D. Capriles, F.G. dos Santos, J.A.G. Areas, Journal of Grain Sciences **67** 83-91 (2016)
11. B. Singh, International Journal of Pharmacy **334(1-2)** 1-14 (2007)
12. F. Camilli, D.J. Muniz, F.J. Santos, V.D. Capriles, CEP **136** 11015-020 (2020)
13. E.A. Nazario-Franco, et al., Food Science Trends. Technol. **96** 166-175 (2020).
14. Y.M. Cassidy, et al., J. Funkts. Products **46** 423-439 (2016)
15. M. Ogata, T.V. Hung, Nutri. Res. **39** 25-33 (2017)