USE OF MILLET FLOUR IN THE RESTAURANT BUSINESS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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The prospects of using millet flour as an alternative gluten-free raw material for bread production in the restaurant business are considered. This corresponds to the principles of sustainable development and ensures the expansion of the range of gluten-free products. The results of a comparative analysis of the chemical composition and technological properties of millet flour from various producers (''Ms. Tally'', ''Zemledar'') with other types of flour are presented. The water absorption and moisture-binding capacities of millet flour were studied. Recommendations are provided regarding the use of millet flour in gluten-free bread production. This will expand the assortment and increase the nutritional value of millet flour bakery products in restaurant establishments. This corresponds to and takes into account modern trends in sustainable development. It corresponds to the principles of sustainable development and ensures the expansion of the range of gluten-free products and aligns with the global direction of development in the food industry. Polysaccharide structuring agents such as guar gum and xanthan gum were analyzed in order to compensate for the absence of a gluten framework. The possibility of using an alternative leavening agent, such as psyllium, in the production of millet-based bakery products for the restaurant business and craft bakeries was investigated.

Keywords: gluten-free raw materials, millet flour, bakery products, restaurant business

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Introduction

Nutrition is an essential component of human life. The quality of nutrition reflects the level of development of society, the economy, culture, and the government's care for its citizens. Therefore, progressive trends in the field of nutrition are an important indicator that should be studied and improved in the context of global tendencies toward effective and advanced sustainable development technologies.

Efficient use of food resources, particularly the expansion of raw materials with multifunctional purposes, is one of the priority directions in the production of food products for enterprises of various scales and the restaurant business. Multifunctional raw materials are those capable of performing multiple tasks: providing assortment diversity with a high-quality micro- and macronutrient composition, being safe for a wide range of consumers, and having technological appeal-namely, not complicating the production process with lengthy and resource-intensive stages. Millet is one such raw material, which was declared the "Plant of the Year" by the United Nations in 2023 due to its advantages in terms of food security, support for healthy nutrition, and environmental sustainability under climate change conditions. Millet has considerable nutritional value, particularly its high content of proteins, fiber, iron, magnesium, and phosphorus, its low glycemic index, and the

absence of gluten, making it an optimal product for expanding consumer options and for special gluten-free diets (FAO, 2023).

Gluten, a conglomerate of gliadin and glutenin, including protein fractions such as secalin, hordein, and their hybrids, is a structural component of the proteins found in most cereal grains and plays an important structural-mechanical role in cereal processing and product formation. However, beyond these evident technological advantages, even minimal quantities of these components, including trace contamination, pose direct health risks for certain individuals. These include people with gastrointestinal disorders, various forms of gluten intolerance, celiac disease, or gluten allergy (Gorach et al., 2024; Montemurro et al., 2021; Farage et al., 2017).

The issue of expanding the range of gluten-free products for craft production and restaurant establishments remains insufficiently addressed. Currently, the market for mass-consumption products free from gluten contamination is quite limited. Therefore, the use of millet and its processed derivatives as an alternative cereal raw material appears promising. The low glycemic index of this raw material for bread and bakery products offers an additional advantage, especially in light of the negative trends in the development of endocrine and cardiovascular diseases (Capriles et al., 2021; El Khoury et al., 2018; Sapone et al., 2012).

Materials and Methods

The object of the study is the technology of gluten-free bakery products based on millet flour. The subject of the study includes millet flour from “Ms. Tally” and “Zemledar”, as well as rice flour and first-grade wheat flour “Zolotyi Vrozhai” for comparison. To achieve the research objective - namely, to explore the feasibility of using alternative millet flour in bakery product technology - the composition and nutritional value of common gluten-free raw materials (rice flour and corn flour) were analyzed.

The main physicochemical and structural-mechanical properties of millet flour were studied and compared with the properties of wheat flour and common gluten-free alternatives such as rice and corn flour. The research involved statistical data, findings from leading scientists in the field of breadmaking, and relevant methodologies from current regulatory documents. The studied indicators included acidity, mass fraction of dry matter, and the water absorption capacity of raw materials. Moisture content was determined using an accelerated drying method in an electric drying oven. Titratable acidity was measured by titration of a water-flour suspension (mash) (Drobot et al., 2006). The water absorption capacity (WAC) of the fiber was evaluated using the water absorption coefficient, calculated as the ratio of the mass of the moistened sample to its initial mass, based on a known methodology (Drobot et al., 2006). The moisture holding capacity (MHC) of the flour was determined using the Schoch method, by centrifuging the sample with added water to evaluate moisture retention, followed by centrifugation for 15 minutes at 6000 rpm (Drobot et al., 2006).

The obtained results were compared with the corresponding indicators of wheat flour, as the primary technological parameters in breadmaking are oriented around the properties of the main raw material - wheat flour. Determining these indicators and understanding their impact on the production process makes it possible to select optimal technological and recipe modifications for developing a product that not only meets gluten-free standards but also maintains the quality characteristics of traditional baked goods (Riznyk et al., 2023; Riznyk et al., 2021; Koshova et al., 2020). Three samples of bakery products based on millet flour were baked. Psyllium was used as the structuring agent. The first sample was prepared using a millet flour sourdough; the second sample was made without

sourdough, using pressed yeast “Lvivski Drizhdzhi”; and the third sample was prepared by scalding millet flour with hot water heated to 90°C and using pressed yeast, according to laboratory trial baking methodology (Drobot et al., 2006).

All three samples, after kneading, were left to ferment at a temperature of 32 °C for 1.5 hours. Upon completion of this stage, the dough samples were placed in a proofing cabinet for final proofing for 60 minutes. They were then baked in a combi-steam oven at 200 °C for 45 minutes.

Results and Discussion

Market analysis and research by domestic scientists working on expanding the range of gluten-free products made it possible to identify several producers of millet flour for further study. One of the main arguments for selecting the samples was the official right to use the “Crossed Grain” trademark. The respective companies have implemented the AOECS standard for the sale of gluten-free products. Thus, the study used flour from the brands “Ms. Tally” (Ukraine) which holds an AOECS license, and “Zemledar” (Ukraine), which is in the process of obtaining the corresponding certification. The comparison was conducted with first-grade wheat flour (“Zolotyi Vrozhai” as the control) and with other tested gluten-free flour samples: rice, corn, and oat flours. The chemical composition was determined both experimentally and based on research by other scientists (Riznyk et al., 2023; Riznyk et al., 2021; Koshova et al., 2020).

Table 1. Comparative characteristics of quality indicators of gluten-free Flours “Ms Tally”, “Zemledar”

Indicators	Wheat flour (1st grade)	Millet flour		Corn flour	Rice flour	Oat flour
		“Ms. Tally” (Sample 1)	“Zemledar” (Sample 2)			
Mass fraction of moisture, %	11.7± 0.1	8.9 ± 0.1	8.8 ± 0.1	4.0 ± 0.1	12.5 ± 0.1	8.0 ± 0.1
Titratable acidity, deg	5.0± 0.1	7.0± 0.1	5.0± 0.1	4.2 ± 0.1	5.4 ± 0.1	1.2 ± 0.1
Proteins, %	9.6± 0.1	11.5± 0.1	11.5± 0.1	13.0 ± 0.1	9.0 ± 0.1	6.8 ± 0.1
Fats, %	1.5± 0.1	4.3± 0.1	3.3± 0.1	6.8 ± 0.1	4.9 ± 0.1	1.4 ± 0.1
Carbohydrates, %	76.1± 0.1	75.0± 0.1	68.4± 0.1	61.3 ± 0.2	71.8 ± 0.1	80.8 ± 0.1
Fiber, %	2.4± 0.1	3.5± 0.1	3.6± 0.1	6.5 ± 0.1	7.3 ± 0.1	0.4 ± 0.1
Ash content, %	0.5± 0.1	1.1± 0.1	1.0± 0.1	1.97 ± 0.1	1.45 ± 0.1	0.6 ± 0.1
Energy value, kcal/100 g	366± 5	366± 5	316± 5	369 ± 5	370 ± 5	366 ± 5

According to Table 1, the tested millet flour samples are characterized by higher acidity. For example, Sample 1 shows titratable acidity values that are 29 - 66.7% higher compared to the other samples, which can be explained by the presence of organic acids in its composition. This affects the organoleptic properties, particularly the taste of the bakery products, and will require additional technological steps to neutralize this factor. Sample 2 does not differ significantly from the compared samples, except for oat flour, which has an acidity value 4.5 times lower.

Protein content is a critical parameter for bakery products in general and especially for gluten-free products due to its typically low levels. The protein content in millet flour is 12% higher than in the control sample and is only 8.9% lower than that of the alternative corn flour.

Dietary fiber plays a significant role in the formation of a gluten-free product range with high biological value. The fiber content in millet flour is 49 - 55% lower than in rice and corn flour, but 9 times higher than in the oat flour sample and 1.5 times higher than in wheat flour. Therefore, the analysis of key indicators of chemical composition supports the recommendation of millet flour as an alternative raw material for expanding the range of gluten-free bakery products.

To determine the potential technological properties of the dough and finished bakery products, indicators reflecting the structural and mechanical characteristics of the dough were studied - namely, the moisture holding capacity (MHC) and water absorption capacity (WAC) of millet flour and the results were compared with control samples.

Table 2. Characterization of functional and technological properties of gluten-free flours and wheat flour

Indicators	Results of determination			
	Wheat flour "Zolotyi Vrozhai"	Rice flour	Millet flour	
			"Ms. Tally" (Sample 1)	"Zemledar" (Sample 2)
Moisture holding capacity (MHC), %	115.1 ± 1.0	139.3	125.2	120.3
Water absorption capacity (WAC), %	54.8±1.0	70.7±1.0	65.3±1.0	62.7±1.0

The moisture holding capacity (MHC) is determined by the flour's particle size (dispersity) and chemical composition, particularly the content of proteins, pentosans, starch, and non-starch polysaccharides. The fine particle structure of rice flour provides high hygroscopicity, while the swelling of starch granules contributes to 21% better moisture retention compared to wheat flour. Millet flour has higher dispersity and slightly lower starch and fiber content, which correlates with its moisture holding capacity. However, despite the absence of gluten, this indicator in gluten-free raw materials remains sufficiently high and does not negatively impact dough formation.

The results of the study on water absorption capacity are consistent with the previous indicator and are related to the structural features of the starch granules in gluten-free raw materials, which are smaller in size and thus have a larger surface area for water interaction. A higher content of mineral substances, particularly sodium and chlorine, contributes to increased osmotic pressure within the cells and enhances water retention (Riznyk et al., 2023).

Based on the conducted research, it has been established that millet flour possesses significant potential as a promising gluten-free raw material for the production of bakery products. Comparative analysis of its chemical composition and functional-technological properties revealed that millet flour is characterized by a higher content of proteins and dietary fiber, which, combined with its natural gluten-free nature, enhances the biological and nutritional value of the final products. Additionally, the flour demonstrated strong water absorption and moisture retention capacities, making it especially attractive for developing high-quality formulations in the functional food segment.

As part of further research, structure-forming additives were selected to compensate for the absence of gluten and to ensure a stable, elastic dough structure. To achieve this, three types of natural hydrocolloids were studied: xanthan gum, guar gum, and psyllium. All of them belong to the group of polysaccharides that have the ability to form a gel-like structure in the presence of water.

Xanthan gum is a product of microbial fermentation of sugars and is characterized by high thixotropy. In the test samples, it demonstrated good system stabilization and the formation of a viscous, plastic mass, as confirmed by increased viscosity and structural uniformity.

Guar gum provided moderate dough stabilization but proved to be less elastic compared to xanthan gum. The sample containing guar gum exhibited poorer structure during mixing (slow flow, weaker stretch), although the overall consistency remained satisfactory.

Psyllium proved to be the most effective structuring agent. Due to its high content of soluble fiber, it forms a stable gel that ensures excellent moisture retention, a resilient dough texture, and good product shape.

Based on previous studies focused on the impact of structuring agents on the functional and technological properties of gluten-free dough, formulations were developed for laboratory baking of bakery products. The test samples included millet flour, rice flour, a structuring agent (psyllium), compressed yeast, millet flour-based sourdough, table salt, drinking water, and sunflower oil. Three experimental formulations were created, differing in the type of fermentation system, ingredient dosage, and dough mixing method.

It was established (Table 3) that Sample 1 (bread made with millet sourdough) had the best volume, uniform porosity, resilient crumb texture, and a pleasant taste and aroma. The surface of the product indicates effective dough development and the structural stability of the bread after baking. Sample 2, prepared without sourdough, had a denser, finer-porous structure and was shorter in height compared to Sample 1. Although porosity was less developed, the structure remained homogeneous. Sample 3, produced by scalding millet flour with hot water heated to 90°C and using pressed yeast showed a compact crumb structure, poorly developed porosity, and the presence of large isolated voids. This indicates insufficient gas formation in the dough and delayed fermentation.

Table 3. Analysis of baking results and sensory evaluation of experimental bread samples

Sample	Appearance	Crumb structure	Color	Consistency
Sample 1	Evenly risen, distinct dome, well-formed crust	Even porosity, clear capillary network, no compact areas	Light yellow, uniform	Elastic, resilient, quickly recovers shape
Sample 2	Symmetrical profile, moderate volume	Fine-pored, denser structure	Uniform yellowish	Soft, moderately resilient, slightly moist
Sample 3	Low profile, compact form	Overly dense, isolated cavities, weak structural network	Uniform yellowish	Dense, slow shape recovery, reduced elasticity

Figure 1 presents a comparative analysis of three bread samples made from millet flour using different technological approaches to dough fermentation and structuring.

Figure 1. Laboratory baking of millet flour bread samples:
Sample 1 – using millet sourdough, Sample 2 – using pressed yeast,
Sample 3 – produced by scalding millet flour with hot water heated to 90 °C

Conclusions

Based on the results of the conducted research, it has been established that millet flour holds great potential as a promising gluten-free raw material for use in the restaurant industry. Comparative analysis of its chemical composition and functional-technological properties showed that millet flour has advantages in terms of protein and dietary fiber content, contributing to the increased biological and nutritional value of final products. At the same time, the identified high acidity of millet flour requires the implementation of additional technological solutions for its neutralization. The bread baking trials using millet flour demonstrated that Sample 1, made with sourdough, had the most optimal organoleptic quality indicators in terms of both volume and structure, indicating the feasibility of using millet sourdough in gluten-free breadmaking technology. Considering the obtained data, it is recommended to more broadly introduce millet flour into the restaurant sector as an ecologically safe and nutritionally valuable alternative to traditional raw materials to meet the needs of various consumer categories.

Conflict of interest

There is no conflict of interest.

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