

Development of Gluten-Free Bread: A Composite Flour Approach Using Sorghum, Rice, and Plantain Flours

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ABSTRACT

The study was to obtain the gluten-free bread as the substitution of wheat gluten, for the people who are gluten intolerant. Gluten intolerance can be a chronic condition since it harms the inner lining of the small intestines and causes a painful and bloated abdomen after eating the gluten from wheat. The a blend of rice flour (RF), sorghum flour (SF) and plantain flour (PF) along with other ingredients such as salt, sugar, dry yeast, psyllium husk(isabgol) oil, water was taken in the ratio RF/SF/PF = 50:30:20 and 30:50:20 respectively for the two recipes and all the ingredients were used in the proportion mentioned above, to produce a gluten free bread, and sensory, physical and proximate analyses were carried out. The results indicated that in the proximate analysis, the performance of the two formulations was compared and showed that Formulation B (high rice) with a 50% rice content performed better than Formulation A, (high sorghum) with 50% of sorghum overall. Physico-chemical analysis showed that (formulation B) exhibited slightly higher moisture content and ash content (showing good water retaining ability and mineral content) while (formulation A) had high fat content. The higher moisture in formulation B could have helped to improve the softness and shelf-life properties of the breads. From the sensory analysis, it is found that the bread made from (high %) of rice flour with ratio RF/SF/PF 50:30:20 have more acceptability score based on Taste, Texture and Overall Acceptability score according to the panelist.

Keywords- Gluten free bread, Gluten Intolerance, RF/SF/PF, Rice flour, Sorghum flour, Plantain flour, Sensory analysis.

I. INTRODUCTION

Bakery products such as bread are a crucial component of nutrition in the daily diet around the globe. Thus, novel and natural components to create gluten-free products are still desirable. Developing gluten-free recipes is difficult as gluten-free ingredients need to give dough elasticity and enhance nutritional and sensory properties at the same time. Increased consumer awareness about the gluten free diet, the growing market for gluten free products, the growth of gluten intolerance, and the rapid expansion of the gluten-free market have driven the need for expansion and diversification of gluten-free and functional food. The recommended maximum daily quantity of gluten is around 10 mg but

some gluten-free products have been known to exceed this limit, some baked goods including over 20 mg per serving.

These years, the number of people that are aware of gluten-free consumption has grown greatly. The small intestine in people with Celiac disease becomes damaged when they eat foods containing gluten. This will diminish the absorption of nutrients and have a negative impact on overall health. Gluten is a protein that is found in many grains including wheat and barley. To overcome this, there are different gluten-free flour options such as buckwheat, sorghum, rice, corn, and flaxseed flour. Bread is one of the most popular staple foods, so it is the subject of a lot of research into producing gluten-free bread. People with gluten intolerance cannot eat traditional

wheat-based bread and it may not have a higher nutritional value. Thus, researchers have turned to alternative GF flours like rice, maize, sorghum, buckwheat and plantain flour as a way to enhance nutritional value and acceptability of GF bread. While gluten-free bread is different from wheat bread, however, it may not be as familiar as people used to wheat breads. Products will tend to be shorter, staler, and less elastic. Additionally, their flavor varies depending on the types of ingredients used. A primary technical difficulty with gluten-free baking is the lack of gluten, which helps give structure, elasticity and volume to baked goods. This makes it hard to get desirable characteristics like soft crumb, adequate volume and an attractive crust. These challenges can be addressed by making the gluten-free bread using composite flours, which are composed of a mixture of rice (*Oryza sativa*), sorghum (*Sorghum bicolor*) and plantain (*Musa paradisiaca*) to enhance the overall quality and acceptability of the final product.

II. REVIEW OF LITERATURE

In this review paper, researcher's meticulously analyze various gluten-free flours, which are used for the development of gluten-free bread by Nazira Utarova, et al., (2024). After experimenting with different ratios of the ingredients, researchers have found a 40:40:20 ratio of corn flour, green buckwheat flour and plantain flour to be the best gluten-free flour for gluten-free bread. The unique cereal/pseudo-cereal flour blend dramatically increased the quality of texture and flavour in the bread, while keeping the gluten content under 3ppm. (C.Fratelli et al., 2021) Consequently, a gluten-free final product very much resembled a traditional wheat bread in terms of texture, smell, softness and quality. Besides these encouraging findings, the study's authors also looked at the nutritional content of the gluten-free bread. Although promising results were obtained, there is a need for additional studies to develop the understanding of the impact of gluten-free fermentation on the resulting product. Overall, the study was a significant contribution to the gluten-free bread development with a comprehensive evaluation of the characteristics of the alternative flour. The results provide important information for manufacturers and researchers to further develop gluten-free baked products. Future studies should be conducted to further investigate the interactions between various flour blends and other ingredients to enhance recipes and develop better gluten-free bread.

Gluten free breads can be made from sorghum flour, (J. Tilman et al., 2005). The research carried out on the different sorghum hybrids indicates that there is variation in gluten-free leavened bread production ability. The crumb characteristics, which include crumb size and number of air cells, and the texture of the crumb based upon the TPA hardness are most apparent differences, while loaf volume and height are fairly consistent from hybrid to hybrid. Such differences are significant as a

result of parameters such as kernel hardness and damaged starch during milling. Process-wise, sorghum breads are more likely to have good loaf volume if the flour is mixed with corn starch; and if using a high water level to prepare a low-viscosity batter. However, the addition of xanthan gum or skim milk powder generally has a negative effect upon the crumb structure. Damage to the starch is an important factor in bread quality, and manipulating milling processes to reduce this starch damage may be a worthwhile future research approach to developing high-quality gluten-free sorghum breads.

(Park and Kim 2023) Conducted a detailed literature review of the role of rice in the development of gluten-free foods and recent technological advancements in gluten-free technology. Rice is one of the world's most significant staple cereals, and is readily available, has a mild flavor and can be used in a wide range of foods without gluten. Rice-based GFPs rely on a number of factors such as the milling process, particle size of the rice flour and rice variety properties. For instance, the nutritional value and functional properties of the final product can be affected by the proteins and the amylose content of brown rice. Researchers have investigated using rice in combination with other (gluten-free) grains and have utilized functional ingredients (hydrocolloids, proteins and emulsifiers) as alternatives to gluten. These can be used to improve the structure of the dough, increase the volume and texture of the baked product, and the cooking quality of noodles and pasta.

III. MATERIALS

Raw ingredients like rice flour (RF), sorghum flour (SF), plantain flour (PF), and other ingredients yeast, sugar, sunflower oil, psyllium husk, salt, warm water, all the ingredients were purchased from trusted and certified brands.

Table 1 Ingredients used and their ratio.

S.no	Formulation	Ratio RF:SF:PF	Other ingredients (g), (ml)
1.	A	30:50:20	Yeast-2g, sugar- 5g, oil- 8g, psyllium husk- 3g, salt- 2g, water- 110ml
2.	B	50:30:20	Yeast-2g, sugar- 5g, oil- 8g, psyllium husk- 3g, salt- 2g, water- 110ml

Sorghum Flour

Sorghum flour is a naturally gluten-free flour made from whole sorghum grains and is widely used in

gluten-free baking because of its mild flavor and good nutritional profile. It provides a soft, light texture to bread due to its fine particle size and balanced starch-to-protein ratio, making it suitable for improving crumb softness and volume when combined with other flours. However, like other gluten-free flours, sorghum does not contain gluten, so it cannot trap gas effectively on its own, leading to dense or crumbly breads unless binders like xanthan gum or psyllium husk are added. Despite this, sorghum flour remains a popular choice because it improves texture, nutrition, and overall quality when used as part of a gluten-free flour blend.

Plantain flour

Plantain flour, a naturally gluten-free flour that is made from unripe green plantains is highly desirable in gluten-free backings due to its functional and nutritional characteristics. It is rich in starch, especially resistant starch, which has a positive effect on the structure and moisture retention of bread. Therefore, bread prepared using plantain flour tends to be softer than many other gluten-free breads and slightly elastic. Plantain flour is also used to add a subtle taste and natural sweetness to breads, which helps to balance out the flavor of other ingredients. It also contains some dietary fibre, potassium, vitamins and prebiotics that can be beneficial for digestive health. Plantain flour is gluten-free and lacks the ability to add elasticity and gas-holding capacity needed in the bread making process. It is typically used in conjunction with other gluten-free flours and binding agents to make the bread light and fluffy. Plantain flour is an important ingredient in gluten-free bakery formulations which enhances the softness, color, texture and nutritional value of gluten-free bread when used in the proper proportions, typically 10–30% of flour mixture.

Rice flour

Rice flour is one of the most popular gluten-free flour alternatives used in gluten-free bread formulations because of its texture, appearance and overall bread quality. It has a neutral flavor and light color that gives it a wonderful versatility as a flour for bakery uses, where it can add pleasant flavor to the product and reduces the strong or bitter taste that is found in flours like sorghum or buckwheat. Rice flour is small and starch-rich which makes the bread less dense and contributes to a soft crumb

and good volume. It also assists in devising a more uniform structure when mixed with binders such as psyllium husk. Moreover, rice flour helps to distribute moisture in the dough, resulting in better mouth feel and more alike bread to regular wheat bread. In general, it serves as a base flour to help control texture, flavor and appearance in gluten-free bread products.

3.1 Bread preparation

The preparation of gluten-free bread begins with the accurate weighing of all dry ingredients. The yeast is then activated separately using warm water to initiate fermentation. Meanwhile, psyllium husk is mixed with approximately 80 ml of water to form a gel, which acts as a binding agent in the absence of gluten. After this, all dry ingredients are thoroughly mixed, followed by the addition of activated yeast and psyllium gel to form the dough. The dough is then properly kneaded and shaped into the desired rectangular or round form. It is allowed to undergo proofing for about 30–40 minutes to enable proper rising. Once proofed, the dough is baked at a temperature ranging from 110°C to 180°C for approximately 30 minutes. After baking, the bread is cooled and sliced, and finally, it is packaged for storage or consumption.

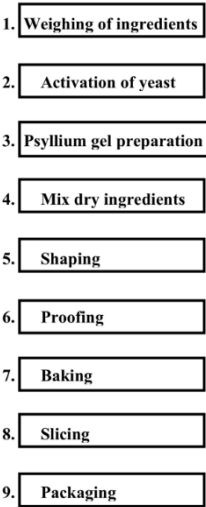


Figure 1- Bread preparation flowchart



Figure 2.1 Weighing of all dry ingredients



Figure 2.2 Proper risen loaf after proofing.



Figure 2.3 Slices of baked bread

3.2 Sensory analysis of bread

The gluten-free bread samples after baking were left to cool to room temperature before being offered for sensory evaluation. A panel of 11 semi trained members of Sharda University conducted the sensory assessment. The overall acceptability of the bread was assessed on a nine-point hedonic scale by each panelist with a score of 1 being “dislike extremely” and a score of 9 being “like extremely.”

3.3 Proximate analysis of bread

3.3.1 Moisture content

Moisture content of the bread samples was determined according to the recommendation of standard procedure of the AOAC. Aluminium moisture dishes were cleaned in a hot air oven for 30 mins, cooled in a desiccator and weighed to get their initial weight. About 5g of each sample was accurately weighed in the pre weighed dishes and the analysis was repeated twice. The samples were subsequently dried about 1 hour in a hot air oven at 130°C. The dishes after drying were carefully removed by using tongs and kept in a desiccator for 30 minutes to cool them. The cooled dish weights were recorded again and the moisture content was determined by the difference in the weight of the dish before and after cooling, and the equation below was used to calculate.

$$\text{Moisture content (\%)} = \frac{(W_2 - W)}{(W_1 - W)} \times 100$$

W = Weight of the empty aluminium weighing dish (g)

W₁ = The initial mass of the aluminium dish and sample before the sample is put in the oven (g)

W₂ = Mass of the aluminium dish and the sample after the sample has been oven dried (g)

3.3.2 Ash content

Ash content of the bread samples were thermally tested with the standard method as AOAC (2000) with the help of a muffle furnace. About 2 g of each specimen was placed with accuracy in a pre-ignited porcelain crucible which was previously cooled in a desiccator and weighed. Analysis was carried out twice. The crucibles were heated in a muffle furnace at a temperature of 550°C for overnight to complete combustion of all organic matters in the samples. The crucibles were then gently moved to the desiccator and allowed to cool for about 30 minutes after the ashing process. Crucibles were cooled and weighed immediately and ash content was determined from the difference in weight. The equation below was used to report the final ash content as a percentage.

$$\text{Ash \%} = \frac{W_2 - W_1}{W} \times 100$$

Where, W = Sample mass;

W₁ = Empty crucible mass;

W₂ = Mass of crucible + ash.

3.3.3 Fat Content

The crude fat content of the bread samples was measured in accordance with AOAC (2000) method with a little modification by Goldfish extraction apparatus. About 4 g of each sample was placed in a cellulose extraction thimble and wrapped in filter paper. Each

analysis was repeated twice. Approximately 40 mL of petroleum ether was added to pre-weighed Goldfish extraction beakers and the extraction was performed for about 4 hours to ensure complete extraction of the lipid fraction. The beakers were then removed and left to cool, then left under a fume hood overnight to ensure the complete evaporation of the petroleum ether. The beakers were then dried in a hot air oven at 130°C for 15 minutes to get rid of any solvents. The beakers were then placed in a desiccator for 30 minutes after which they were reweighed. The amount of crude fat was determined by measuring the weight loss of the extraction beaker, and then calculating the percentage as follows.

$$\text{Crude fat (\%)} = \frac{\text{Weight of ether soluble material (g)}}{\text{Weight of sample taken (g)}} \times 100$$

IV. RESULTS AND DISCUSSION

4.1 Sensory attributes

Table 2 shows the sensory evaluation results showed that for colour, Sample B had a slightly higher score (7.27) compared to Sample A (7.18). The taste ratings were similar with Sample B receiving the higher score (7.18) and Sample A receiving the lower score (6.81). Sample B had a higher score (6.90) than Sample A (6.72) for texture. The scores for appearance were equal (7.18) for both samples. The aftertaste of Sample B was higher (7.18) than Sample A (7.09). The highest overall acceptability was for Sample B (7.39), while Sample A (7.13). The score of had was relatively low (7.13). So, Sample B was preferred to sample A in most of the sensory properties.

Table 2: Sensory properties of gluten-free bread

Attributes	Sample A	Sample B
Colour	7.18±1.07	7.27±1.27
Taste	6.81±1.32	7.18±1.16
Texture	6.72±0.90	6.90±1.22
Appearance	7.18±0.87	7.18±0.98
After taste	7.09±1.97	7.18±1.32
Overall Acceptability	7.13±0.95	7.39±1.05

All The Values Are Mean ±Std Deviation Of Triplicate Replications Here; Sample A: made with 50% rice; B: containing 50% sorghum flour.

4.2 Nutritional analysis

Table 3 shows the results of the nutritional analysis of sample(A) and sample(B). The sample A had a moisture content of 46.55±0.99, and sample B had 48.33±0.18. And the ash content in gluten free bread were 2.07±0.66 in Sample A. And 3.16±2.41 respective. Sample B also contained slightly more moisture and ash content, suggesting that it had a slightly higher water retention and mineral content, while sample A had a higher fat content. The greater moisture content of

(Sample B) may have helped to improve the softness and shelf-life properties of the bread

Samples	Moisture (%)	Ash (%)	Fat (%)
Sample A	46.55±0.99	2.07±0.66	13.99±0.79
Sample B	48.33±0.18	3.16±2.41	7.29±0.41

All The Values Are Mean ±Std Deviation Of Triplicate Replications Here; Samle A: High Sorghum with 50% sorghum flour,30% rice and 20% plantain flour. Sample B: High rice Containing 50% rice flour, 30% sorghum flour and 20 % Plantain flour

V. CONCLUSION

The present study successfully showed the development of gluten-free bread using non-wheat flour like sorghum flour, rice flour and plantain flour as gluten replacement with psyllium husk. The overall performance of Sample B (high rice flour: 30:50:20) was better than that of (Sample A). The sensory evaluation scores indicated the sample (B) to be better in taste, texture and overall acceptability which may be attributed to the higher rice flour content that resulted in a softer crumb structure and better texture from Physico-chemical analysis, it showed that (Sample B) had slightly higher moisture content and ash content that showed better water retention and mineral content, while the sample (A) showed higher fat content. The higher moisture in (Sample B) may have resulted in better softness and shelf-life properties of bread. Moreover, Psyllium husk (isabgol) can be used as a gluten substitute as it forms a gel in dough, which helps in enhancing the binding, elasticity and gas holding capacity of the dough. Increases moisture, texture and acceptability of gluten-free bread.

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