FABA BEAN FLOUR: AN ALTERNATIVE SOURCE FOR DEVELOPING GLUTEN-FREE PASTA WITH FUNCTIONAL PROPERTIES

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Abstract

This study aimed to develop a gluten-free pasta formulation enriched with bioactive compounds, proteins, fibers, and minerals through the incorporation of faba bean flour (FBF) at varying substitution levels. Four pasta samples were prepared using rice flour (RF) and FBF in ratios of 100:0, 90:10, 80:20, and 70:30. Standard laboratory analyses were conducted to assess proximate composition, cooking properties, sensory attributes, total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity (AA). The incorporation of FBF significantly enhanced the nutritional profile of the pasta, with protein, fiber, and ash contents progressively increasing across formulations, while carbohydrate levels decreased. Functional properties also improved: both TPC and TFC showed substantial increases, resulting in a notable rise in antioxidant activity relative to the control. However, higher FBF levels led to technological limitations, such as increased cooking time and higher cooking losses, which negatively impacted overall sensory acceptability. Despite these challenges, the addition of 20% FBF provided the most favorable balance, yielding gluten-free pasta with superior nutritional and functional quality while still maintaining acceptable sensory attributes.

Keywords: *fava bean flour, gluten-free pasta, high nutritional value, food application*

Introduction

In recent years, the rising prevalence of metabolic and cardiovascular disorders associated with obesity and nutritional imbalances has highlighted the importance of balanced diets rich in protein, fiber, phytochemicals, and antioxidants. Functional foods, through the inclusion of nutraceutical ingredients, may help mitigate health risks and enhance overall well-being [1]. A key recommendation is to address both macro- and micronutrient deficiencies through nutrition education programs that promote healthier dietary choices [2, 3]. In this context, growing interest has been directed toward the replacement of wheat flour with alternative flours in bakery and pasta products, particularly starchy roots and tubers, protein-rich legumes, and cereals [4]. Currently, a wide variety of gluten-free (GF) products (e.g., bread, cakes, muffins, pasta, noodles) are available for individuals with coeliac disease. However, many of these products are deficient in minerals and bioactive compounds, rendering them nutritionally inferior to the wheat-based foods they are intended to replace [5, 6]. Therefore, greater attention and continued research are needed to enhance their nutritional quality. In this context, pasta can serve as a complete protein source when complemented with other plant-based foods, such as legumes, which offset its lysine deficiency [5–7]. Moreover, legume-derived proteins and fibers have been shown to exert multiple beneficial health effects [5–7]. In this study, rice flour (RF) and faba bean flour (FBF) were selected for the formulation of gluten-free pasta with functional potential. The choice of FBF as a partial substitute for RF is based on its complex chemical composition, which underpins the high nutritional value and bioactive potential of legumes. Owing to its low cost and high protein and carbohydrate content, the faba bean is considered to be of substantial nutritional and economic importance [8]. Previous studies have highlighted the nutritional composition and polyphenolic content of FBF, suggesting its potential in the development of functional food products due to its beneficial health effects. Polyphenols from FBF exhibit antioxidant activity and the ability to inhibit enzymes involved in carbohydrate digestion, as demonstrated in vitro [9]. However, to date, only limited studies have reported on the impact of incorporating FBF on the antioxidant and nutritional properties of durum wheat pasta [8, 9]. This study aims to evaluate the potential of fava bean flour (FBF) as an affordable and protein-rich ingredient for the fortification of rice flour (RF) in gluten-free pasta production. The effects of different replacement levels were assessed with respect to nutritional composition, functional properties, cooking quality, and sensory characteristics. The overarching objective was to determine the quality attributes and consumer acceptability of pasta fortified with FBF.

Experimental

Materials

RF, FBF and the other ingredients used in this study were purchased from local market in Timisoara town, Romania.

Technological process for the production of pasta samples

Gluten-free pasta samples were prepared according to Chepkosgei et al. (2021) [4], with slight modifications. In the formulations, RF was partially substituted with FBF, while the control used only RF. The dough, prepared using water, salt, and egg, was kneaded, allowed to rest for 1 h, and then shaped into 6 mm strips with a hand-operated pasta machine. The strips were hung on glass rods and dried in a cabinet dehydrator at 70 °C for 12 h. Finally, the samples were cooled to room temperature, sealed in polyethylene bags, and stored until further analysis.

Analytical procedures

The proximate composition, cooking properties, total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity (AA) of the gluten-free pasta samples were determined using standard procedures [10–15]. All analyses were performed in triplicate, and the results were expressed as mean values. Statistical evaluation was conducted using Microsoft Excel.

Sensory evaluation

Cooked, coded pasta samples were evaluated by a panel of twenty assessors, who scored color, appearance, odor, flavor, and overall acceptability using a 9-point hedonic scale, where 1 corresponded to “dislike extremely” and 9 to “like extremely.” Pasta made with 100% RF served as the control [12, 14].

Results and discussion

Proximate composition of pasta samples

Table 1 presents the proximate analysis of the pasta samples. Moisture content decreased significantly with increasing FBF levels, ranging from 12.25% in the 100% RF control to 10.84% in the formulation containing 30% FBF.

Table 1. Proximate composition of gluten-free pasta samples

Proximate composition (%)	**Gluten-free pasta samples**			
	PC	**P10FBF**	**P20FBF**	**P30FBF**
Moisture	12.25 ± 0.07	11.84 ± 0.22	11.24 ± 0.09	10.84 ± 0.24
Fat	2.04 ± 0.24	2.36 ± 0.45	2.92 ± 0.14	3.54 ± 0.11
Protein	8.64 ± 0.09	12.22 ± 0.32	16.46 ± 0.22	18.20 ± 0.04
Crude fiber	1.74 ± 0.12	2.25 ± 0.33	4.22 ± 0.09	6.44 ± 0.54
Ash	1.44 ± 0.21	2.60 ± 0.15	3.24 ± 0.22	3.68 ± 0.07
Carbohydrates	73.89 ± 0.08	68.73 ± 0.42	61.92 ± 0.25	57.30 ± 0.33

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD). ***PC*** *– control pasta sample prepared with 100% rice flour (RF);* ***P10FBF*** *– pasta prepared with 90% RF and 10% FBF;* ***P20FBF*** *– pasta prepared with 80% RF and 20% FBF;* ***P30FBF*** *– pasta prepared with 70% RF and 30% FBF.*

The addition of FBF led to a marked improvement in the nutritional profile of the pasta samples (P10FBF, P20FBF, P30FBF) compared with the control (PC). Protein content increased proportionally with the substitution level, ranging from 12.22% in P10FBF to 18.20% in P30FBF. A similar trend was recorded for fiber and ash contents, which rose from 2.25% to 6.44% and from 2.60% to 3.68%, respectively, compared with 1.74% and 1.44% in PC. These results demonstrate that pasta fortified with FBF can be considered a valuable source of proteins, dietary fiber, and minerals, thereby offering high functional potential. The findings are consistent with previous reports by Rady et al. (2020) [7], Betrouche et al. (2022) [9], and Stoin et al. (2022) [13], reinforcing the suitability of bean flour as a nutritional fortifier in various food products.

Table 2. Cooking properties of gluten-free pasta samples

Treatments	**Gluten-free pasta samples**			
	PC	**P10FBF**	**P20FBF**	**P30FBF**
Cooking time (min)	5.5 ± 0.11	9.5 ± 0.08	10 ± 0.21	10.5 ± 0.22
Cooked weight (%)	3.46 ± 0.08	3.77 ± 0.38	4.42 ± 0.22	4.88 ± 0.09
Cooking loss (%)	6.42 ± 0.86	9.34 ± 0.44	10.62 ± 0.05	11.87 ± 0.44

With respect to cooking time, a progressive increase was observed as the proportion of FBF increased. The shortest cooking time was recorded in the control sample (5.5 min), whereas the longest was observed in the formulation containing 30% FBF (10.5 min). These differences can be attributed to the distinct gelatinization temperatures of starches from the different flours [12, 14]. Regarding cooking weight, an increasing trend was also observed with higher FBF levels. The lowest value was recorded in the control sample (3.46%), gradually rising to 4.88% in the formulation with 30% FBF. Similarly, cooking loss increased with higher FBF levels and lower RF content. The lowest cooking loss was 6.42% in the control, while the highest was 11.87% in the pasta sample with 30% FBF. These findings are consistent with previous studies, such as Betrouche et al. (2022) [9] and Stoin et al. (2022) [13].
Color scores showed no major differences among samples, although higher values were associated with increased FBF content, with the 20% FBF sample scoring the highest (6.85) and the 100% RF control the lowest (6.33). Panelists displayed a clear preference for the control pasta made from 100% RF, as increasing the proportion of FBF resulted in progressively lower scores for appearance, odor, flavor, and overall acceptability. Appearance scores declined from 4.68 in the control to 4.08 in the 30% FBF sample; odor from 4.48 to 3.86; flavor from 4.66 to 3.84; and overall acceptability from 4.45 to 4.19 [12, 13].

Table 3. Sensory evaluation of gluten-free pasta samples

Sensory evaluation	**Gluten-free pasta samples**			
	PC	**P10FBF**	**P20FBF**	**P30FBF**
Color	6.33 ± 0.87	6.52 ± 1.22	6.85 ± 0.11	5.88 ± 0.08
Appearance	5.49 ± 0.14	4.68 ± 0.12	4.86 ± 0.04	4.08 ± 0.14
Odor	5.22 ± 0.17	4.48 ± 0.36	4.62 ± 0.11	3.86 ± 0.33
Flavor	5.55 ± 0.47	4.66 ± 0.13	4.78 ± 0.25	3.84 ± 0.18
Overall acceptance	5.34 ± 0.33	4.45 ± 0.14	4.62 ± 0.26	4.19 ± 0.41

The lowest scores were consistently observed in the pasta containing 30% FBF, whereas the highest were recorded in the control sample. These results indicate that higher FBF levels negatively affected sensory properties, in agreement with earlier reports on pasta fortified with other vegetable and legume flours [12 - 14].

Table 4. Phytochemical content and antioxidant activity of pasta samples

Gluten-free pasta samples	**Phytochemical parameters**		
	TPC (mg GAE/100g DW)	**TFC (mg QE/100 g DW)**	**AA (µM TE/100g DW)**
PC	20.62 ±0.22	21.36 ± 0.33	24.21 ± 0.14
P10FBF	38.33 ± 0.33	28.45 ± 0.09	35.44 ± 0.03
P20FBF	49.55 ± 0.22	37.36 ± 0.04	45.74 ± 0.08
P30FBF	62.02 ± 0.04	49.78 ± 0.08	54.98 ± 0.04

The results showed that the levels of TPC, TFC, and AA increased with the proportion of FBF added to the pasta samples. The highest TPC and TFC contents were observed in the P30FBF sample (62.02 mg GAE/100 g DW and 49.78 mg QE/100 g DW, respectively), whereas the lowest values were recorded in the control sample (20.62 mg GAE/100 g DW and 21.36 mg QE/100 g DW). A similar trend was observed for antioxidant activity (AA), with the highest level found in P30FBF (54.98 µM TE/100 g DW) and the lowest in the control (24.21 µM TE/100 g DW) [8, 9, 13, 16]. This study demonstrates that incorporation of FBF into egg pasta increases protein and fiber contents compared with RF pasta. Moreover, pasta represents a source of polyphenols and antioxidants, whose levels are strongly influenced by the type of ingredients and processing conditions [16, 17].

Conclusions

The results of this study demonstrate that the incorporation of FBF in pasta formulations leads to products with enhanced functional properties. Sensory evaluation indicated that substitution levels of up to 20% FBF yielded higher consumer acceptance compared with the control. Furthermore, the addition of FBF markedly increased the phenolic compound content, total flavonoid content, and antioxidant activity of the gluten-free pasta. Overall, the nutritional, physicochemical, phytochemical, and sensory assessments confirmed that FBF represents a valuable plant-based ingredient for the development of innovative food products with improved functionality.

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