ULST Timisoara
Multidisciplinary Conference on Sustainable Development
21-22 May 2026

FUNCTIONAL ENRICHMENT OF WHEAT BREAD WITH CHESTNUT FLOUR AND AMLA POWDER: EFFECTS ON PHYSICOCHEMICAL, NUTRITIONAL AND ANTIOXIDANT PROPERTIES

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Abstract: The aim of this study was to evaluate the effect of partial substitution of wheat flour (WF) with chestnut flour (CF) and amla powder (AP) on the physicochemical, nutritional, sensory and antioxidant properties of bread. WF was partially replaced at 0%, 5%, 10%, and 15% (*w/w*), corresponding to CF and AP additions of 4.75% + 0.25%, 9.5% + 0.5%, and 14% + 1%, respectively. Standard analytical methods were used to determine proximate composition, physical quality parameters (loaf volume, porosity, crumb structure), sensory characteristics, total phenolic content (TPC), and antioxidant capacity (AC) of the bread samples. The results indicated that the incorporation of CF and AP improved both the nutritional and functional profile of the bread. A gradual increase in dietary fiber, ash and fat content was observed with increasing substitution level, reflecting the compositional profile of chestnut flour and amla powder. A slight decrease in energy value was also noted (from 246.24 to 240.43 kcal/100g), a characteristic that may be considered beneficial in the context of functional food development. Total phenolic content increased from 32.22 mg GAE/100 g in the control bread to 86.40 mg GAE/100 g in the enriched samples, while antioxidant capacity increased from 7.44 to 13.20 mmol TEAC/100 g. The increase in antioxidant capacity was associated with the combined contribution of phenolic compounds from CF and AP, even at low levels of amla incorporation. From a physical perspective, the 9.5% CF + 0.5% AP formulation maintained loaf volume, porosity, elasticity and height-to-diameter ratio within acceptable quality limits, while higher substitution levels led to a slight reduction in loaf volume. Sensory analysis revealed that enriched bread exhibited a darker crumb color and a slightly acidic and mildly astringent taste due to amla, while samples containing up to 10% total substitution were considered acceptable. In conclusion, the combined use of chestnut flour and amla powder represents an effective strategy for the development of functional wheat bread with improved nutritional and antioxidant properties. A substitution level of 10% provides an optimal balance between enhanced functional value and acceptable physical and sensory characteristics.

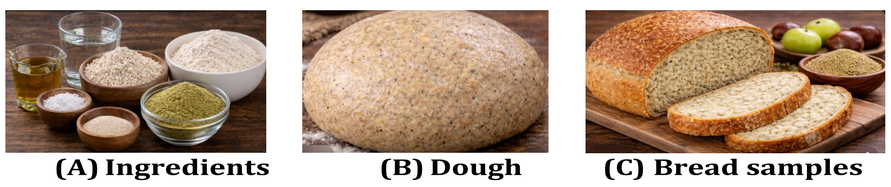
Keywords: *chestnut flour, amla powder, functional bread, antioxidant capacity.*

Introduction

The growing consumer interest in functional foods has led to the development of bakery products enriched with natural ingredients that provide additional health benefits beyond basic nutrition. Bread is one of the most widely consumed staple foods worldwide, making it an ideal carrier for functional compounds. Chestnut flour is a valuable ingredient due to its high content of complex carbohydrates, dietary fiber and minerals, contributing to the improvement of the nutritional profile of bakery products. In addition, amla (*Phyllanthus emblica*) is recognized for its high levels of vitamin C, polyphenols and hydrolysable tannins, which are associated with strong antioxidant capacity. The combination of chestnut flour and amla powder offers a promising strategy for the development of functional wheat bread with enhanced nutritional and antioxidant properties. However, limited studies have investigated their combined effect on bread quality. Therefore, the aim of this study was to evaluate the impact of partial substitution of wheat flour with chestnut flour and amla powder on the physicochemical, nutritional, sensory and antioxidant properties of bread.

Material and method

Wheat flour (WF), chestnut flour (CF), amla powder (AP), and the other ingredients used in this study were purchased from the local market in Timișoara, Romania. Standard analytical methods were applied to determine the proximate composition, physical and sensory properties, total phenolic content (TPC), and antioxidant capacity (AC) of the bread samples. Antioxidant capacity (AC) was determined using the ABTS radical cation decolorization assay and expressed as mmol Trolox Equivalent Antioxidant Capacity per 100 g of sample (mmol TEAC/100g).



(A) Ingredients (B) Dough (C) Bread samples

Figure 1. Preparation of bread samples

Results and discussion

The partial substitution of wheat flour with chestnut flour (CF) and amla powder (AP) slightly modified the proximate composition of bread. Dietary fiber and ash contents increased with increasing substitution level, due to the higher fiber and mineral content of CF and AP. In contrast, protein content showed a slight decrease, while fat content increased slightly. A small reduction in carbohydrate content and energy value was also observed. The incorporation of chestnut flour (CF) and amla powder (AP) influenced the physical properties of bread. The sample with 4.75% CF + 0.25% AP showed improved loaf volume and porosity, while the 9.5% CF + 0.5% AP formulation maintained acceptable quality parameters. At higher substitution levels (14% CF + 1% AP), a slight decrease in volume, porosity and elasticity was observed, due to gluten dilution and reduced gas retention.

Table 1. Proximate composition of WF, CF, AP and bread samples

Samples	Chemical Parameters						
	Moisture (%)	Fat (%)	Protein (%)	Fiber (%)	Ash (%)	CRB* (%)	Energy value (kcal/ 100 g)
Flour and powder							
WF	12.744±0.214	1.047±0.033	11.534±0.248	1.589±0.034	0.538±0.015	72.548	345.751
AP	6.690±0.180	0.520±0.020	4.980±0.150	12.670±0.320	6.820±0.210	60.320	265.900
CF	7.420±0.120	3.790±0.200	6.710±0.120	9.230±0.150	2.790±0.100	70.011	340.990
Bread samples							
CB	37.721±0.275	2.018±0.024	10.265±0.027	2.231±0.065	1.011±0.024	46.754	246.238
B5CFAP	37.950±0.221	2.100±0.026	10.050±0.031	2.550±0.054	1.140±0.023	46.210	243.140
B10CFAP	38.180±0.208	2.190±0.028	9.830±0.029	2.890±0.050	1.280±0.026	45.630	241.990
B15CFAP	38.460±0.196	2.310±0.030	9.560±0.027	3.280±0.046	1.460±0.028	44.930	240.430

WF - Wheat flour; CF – Chestnut flour; **AP** – Amla powder; **CB** – Control bread (100% wheat flour (WF): 0% chestnut flour: 0% amla powder (AP); **B5CFAP** - Bread sample with 95% wheat flour (WF): 4.75% chestnut flour (CF): 0.25% amla powder (AP); **B10CFAP** - Bread sample with 90% wheat flour (WF): 9.5% chestnut flour (CF): 0.5% amla powder (AP); **B15CFAP** - Bread sample with 85% wheat flour (WF): 14% chestnut flour (CF): 1% amla powder (AP);

Table 2. Physical properties of bread samples

Bread samples	Bread quality indicators			
	Volume (cm^3/100 g)	Porosity (%)	Elasticity (%)	Ratio between height and diameter (H/D)
CB	410±0.064	78.696±0.194	73.629±0.058	0.494±0.015
B5CFAP	420±0.070	79.800±0.201	73.950±0.060	0.499±0.013
B10CFAP	414±0.068	79.100±0.189	73.500±0.059	0.495±0.014
B15CFAP	392±0.072	77.600±0.196	72.800±0.061	0.486±0.013

Table 3. Phytochemical profile of bread samples

Bread samples	Phytochemical Parameters	
	Total phenolic compounds (mg GAE/100g)	Antioxidant capacity (mmol TEAC/100g)
CB	32.222±0.110	7.442±0.101
B5CFAP	48.110±0.070	8.620±0.221
B10CFAP	69.116±0.133	11.270±0.104
B15CFAP	86.400±0.131	13.200±0.133

A progressive increase in total phenolic content and antioxidant capacity was observed with increasing levels of CF and AP. This enhancement is attributed to the presence of polyphenols in both ingredients, with amla contributing significantly even at low incorporation levels. Sensory analysis showed that bread enriched with up to 10% substitution was well accepted. Higher levels resulted in a darker crumb and a slightly acidic and astringent taste due to amla, which slightly affected overall acceptability.

Conclusions

The results demonstrated that the incorporation of chestnut flour (CF) and amla powder (AP) significantly improved the nutritional and functional profile of wheat bread, as evidenced by increased dietary fiber, mineral content and antioxidant capacity. A progressive enhancement of total phenolic content and antioxidant capacity was observed with increasing substitution level. From a technological and sensory perspective, the formulation containing 9.5% CF + 0.5% AP exhibited the most balanced characteristics, maintaining satisfactory loaf volume, porosity, elasticity and overall acceptability. In contrast, higher substitution levels led to slight deterioration of physical properties and sensory quality. Therefore, a substitution level of 10% represents the optimal formulation, providing an effective balance between improved nutritional value, enhanced antioxidant properties and acceptable technological and sensory characteristics.