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Research Article

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Development of Herbal Fortified Millet Pasta

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A B S T R A C T

The present research focused on formulating millet-based pasta enriched with medicinal herbs and comparing it with control pasta prepared from 100% whole wheat. The functional pasta was produced using a composite mix of 60% wheat flour, 40% malted finger millet, 10% soybean flour, and 20 ml of herbal extract comprising basil, spinach, black nightshade, mint, and coriander. Analysis of physicochemical and nutritional characteristics revealed that the fortified pasta contained higher levels of calcium, dietary fibre, total phenols, and antioxidant activity than the control sample. Additionally, the herbal pasta demonstrated improved cooking qualities, including weight gain and water absorption capacity. Sensory evaluation showed significant ($p < 0.05$) differences between the fortified and control pasta. Shelf-life assessment indicated that the herbal pasta remained stable for 45 days under ambient storage conditions. The findings highlight the potential of substituting refined wheat flour with malted finger millet and enhancing pasta with medicinal herbs to improve its functional and nutritional value. Key words: Millets, Pasta, Extruded products, Medicinal herbs.

INTRODUCTION

Millets are a group of small-seeded grasses belonging to the family *Poaceae*, cultivated globally as staple food and fodder. Often referred to as the "poor man's food," they play a vital role in the diets of populations in developing countries, particularly in regions with limited rainfall. Finger millet, with grains resembling reddish mustard, is typically harvested during December and January. It is recognized as a nutrient-dense cereal, offering high-quality protein along with essential micronutrients such as vitamin A, vitamin B, and phosphorus, making it particularly beneficial for children, pregnant women, and the elderly (Desai *et al.*, 2010).

Traditionally, finger millet is processed through malting or fermentation. Malting enhances its digestibility, sensory acceptability, and nutritional quality, while also reducing antinutritional factors (Feillet *et al.*, 2000). In recent years, demand for ready-to-eat and convenience foods, such as extruded products, has risen due to urbanization, economic transitions, increased women's employment, and higher per capita income. Among such products, pasta stands out as one of the most widely consumed foods globally owing to its affordability, balanced nutritional profile, versatility, ease of preparation, long shelf life, and favorable sensory attributes. Pasta is generally categorized as dried (*pasta secca*) or fresh (*pasta fresca*). While dried pasta is predominantly manufactured industrially through extrusion, fresh pasta is usually prepared manually or with the help of small-scale equipment, though large-scale commercial production also exists (Bresciani *et al.*, 2022).

Functional foods, particularly those derived from medicinal plants, are increasingly valued for their bioactive compounds that not only provide specific health benefits but also interact beneficially with macronutrients such as proteins, lipids, and carbohydrates (Bordenave *et al.*, 2014). Considering these aspects, the present study was designed to develop malted finger millet-based pasta fortified with selected medicinal herbs to enhance both nutritional and functional properties.

MATERIALS AND METHODS

Malting of Finger Millet

Finger millet grains were thoroughly cleaned and washed to remove adhering soil and debris. The grains were then soaked, drained, and allowed to germinate for two days, with periodic sprinkling of water to maintain adequate moisture. Sprouting was confirmed by the emergence of rootlets. The germinated seeds were subsequently dried, ground into flour, and stored for use in pasta formulation.

Selection of Medicinal Plants

Commonly available and widely utilized medicinal herbs (Table 1) were selected for incorporation into the herbal pasta formulation.

Table 1: Medicinal herbs and their Botanical name

Sl. No	Common name	Family name	Botanical name
1	Holy basil (Tulsi)	*Lamiaceae*	*Ocimum tenuiflorum*
2	Spinach (Palak keerai)	*Amaranthaceae*	*Spinacia oleracea*
3	Black night shade (Manathakkalikeerai)	*Solanaceae*	*Solanum nigrum*
4	Mint (Pudhina)	*Lamiaceae*	*Mentha spicata*
5	Coriander (kothamalli)	*Apiaceae*	*Coriandrum sativum*

Preparation of herbal fortified pasta

Table 2 presents the formulation and treatment variations used for pasta preparation. The ingredients, including wheat flour, malted finger millet flour, soybean flour, and salt, were blended uniformly to avoid lump formation. A measured quantity (20 ml) of medicinal plant extract was incorporated into five different treatments, while the control sample was prepared without the extract. The resulting dough was extruded into the desired shapes using a pasta-making machine. The extruded pasta was dried in a hot-air oven at 60 °C for approximately 2 hours, after which it was packed in low-density polyethylene (LDPE) bags and stored for subsequent nutritional analysis.

Table 2: Raw material used to prepare herbal fortified pasta

Ingredients	C	T_1	T_2	T_3	T_4	T_5
Malted Finger millet flour	40g	40g	40g	40g	40g	40g
Wheat flour	60g	60g	60g	60g	60g	60g
Soybean flour	10g	10g	10g	10g	10g	10g
Basil Extract	-	20ml	-	-	-	-
Spinach Extracts	-	-	20ml			
Black nightshade Extract	-	-	-	20ml	-	-
Mint Extract	-	-	-	-	20ml	-
Coriander Extract	-	-	-	-	-	20ml

Organoleptic evaluation of pasta

Sensory evaluation of pasta samples was performed to assess attributes such as appearance, color, taste, texture, and flavor. A panel of 10 trained members conducted the evaluation using a 9-point hedonic scale. The mean sensory scores for each attribute were calculated, and based on the overall acceptability, the top three treatments were selected for further nutritional analysis.

Nutrient analysis

The colour of pasta samples was assessed visually, with variations noted depending on intensity. Moisture content was determined by the hot-air oven method (Ogawa *et al.*, 2014). Calcium content was estimated using the triple acid method (Palacios *et al.*, 2021), while crude fiber was quantified following acid and alkali digestion (Yadilal *et al.*, 2017). Total phenolic content was analyzed according to Koch (2019), and antioxidant activity was evaluated using the 2,2-diphenylpicrylhydrazyl (DPPH) radical scavenging assay (Khan *et al.*, 2013).

Cooking characteristics

Cooking quality was determined using the AACC approved method (2000). The water absorption ratio (WAR) was evaluated following Chanu and Jena (2015). For this, 30 g of dried pasta was cooked in water at a ratio of 1:10 for 4 minutes. The cooked pasta was weighed after 5 minutes, and WAR was calculated using the formula:

$$WAR = Wf/wb$$

Where, WAR (g/g) is the water absorption ratio, Wf and Wb is the weight of cooked and uncooked sample respectively

Storage studies

The storage stability of herbal millet pasta was assessed under ambient conditions. Samples were packed in low-density polyethylene (LDPE) bags and monitored over a 45-day period. Changes in dry weight were recorded at 15-day intervals to evaluate storage performance.

RESULTS AND DISCUSSION

Organoleptic Evaluation

The herbal-fortified millet pasta samples showed significant variation in sensory attributes ($p < 0.05$). Color and texture were identified as the most influential characteristics for consumer preference. Among the treatments, spinach-based pasta (T2) obtained the highest overall acceptability score (7.51), followed by basil-fortified pasta (T1, 7.48) and black nightshade pasta (T3, 7.24). In contrast, the control sample without herbal extracts received a lower mean score of 6.66. ANOVA confirmed significant differences among treatments, and the top three formulations (T1, T2, and T3) were selected for nutritional analysis.

Table 3: Average mean score for herbal fortified millet pasta

Description	C	T_1	T_2	T_3	T_4	T_5
Appearance	7.2	7.8	7.7	7.4	7.7	7.7
Colour	6.8	7.6	7.9	7.5	7.7	7.5
Taste	6.9	7.5	7.2	7.2	7.2	7.2
Texture	6	7	7.35	6.6	6.7	7.2
Flavour	6.4	7.5	7.4	6.7	6.9	6.9
Overall acceptability	6.66	7.48	7.51	7.24	7.08	7.3

***P-value* - 2.95027E-07**

C- Control pasta; T1- Tulsi pasta; T2- Palak pasta; T3- Black night shade pasta;

T4- Mint pasta; T5- Coriander pasta

Nutritional Composition

Malting of finger millet enhanced both digestibility and nutritional value of the developed pasta. Table 4 presents the

moisture, calcium, and fiber content of the herbal pasta formulations. Color differences were also noted, which play a significant role in consumer preference. Among the treatments, black nightshade pasta (T3) exhibited a greenish hue, whereas basil (T1) and spinach (T2) pasta appeared brown in color. Similar findings were reported by Chanu and Jena (2015), who observed brown coloration in millet-fortified pasta.

Moisture content was highest in black nightshade pasta (T3) at 9.1%, comparable to the results of Vijayakumar *et al.* (2010), who reported a value of 10.7% in noodles prepared with a millet–wheat–soy blend. With respect to mineral composition, spinach-fortified pasta (T2) showed the highest calcium content (1490 mg/100 g), while black nightshade pasta (T3) recorded the lowest (164 mg/100 g). Fiber content was also significantly elevated in T3 (23.8 mg/100 g), which can be attributed to the incorporation of medicinal herbs. These findings are consistent with the study by Nithya Priya *et al.* (2020), which demonstrated that millet- and herb-enriched noodles exhibited superior nutritional properties compared to conventional commercial products.

Table 4: Physicochemical Evaluation of herbal-fortified millet pasta

Treatments	Colour	Moisture (%)	Calcium (mg/100g)	Fibre (mg/100g)
T_1	Brown	8.3	1015	14.6
T_2	Brown	6.3	1490	16.1
T_3	Green	9.1	164	23.8
			P-value	0.451908

T_1- Tulsi pasta T_2- Palak pasta
T_3- Black night shade pasta

Biochemical analysis

Foods rich in phenolic compounds are recognized for their antioxidant potential. Millets are a natural source of phytochemicals that provide additional health benefits beyond basic nutrition. The total phenolic content of basil-, spinach-, and black nightshade-fortified pasta was recorded as 17.5 mg/100 g, 6.8 mg/100 g, and 8.2 mg/100 g, respectively. Among the treatments, basil pasta exhibited the highest antioxidant activity at 550 mg/100 g. These findings suggest that the incorporation of herbal extracts into millet-based pasta is an effective approach to enhance the phytochemical profile of the product. Similar observations were reported by Gull *et al.* (2018), who noted a 35% increase in the antioxidant activity of millet–pomace pasta.

Table 5: Biochemical properties of herbal-fortified millet pasta

Treatment	Total phenol content (mg/100g)	DPPH Antioxidant activity (mg)
T_1	17.5	550
T_2	6.8	516
T_3	8.2	536

Cooking Time

Cooking time refers to the optimum duration required for pasta to become palatable. The results indicated that all herbal-fortified pasta samples reached optimum cooking in approximately 4 minutes. In comparison, Anjali *et al.* (2016) reported a longer cooking time of 6–8 minutes for kodo millet-based pasta.

Water Absorption Ratio

Water absorption denotes the capacity of pasta to uptake water during cooking, which is essential for achieving desirable texture and overall product quality. Among the formulations, black nightshade pasta (T3) exhibited the highest water absorption ratio (3.4), while basil pasta (T1) recorded a lower value of 2.6. These findings are in close agreement with the study of Petitot *et al.* (2010), who reported a water absorption ratio of 2.06 in pasta, a value comparable to that observed for spinach pasta in the present study.

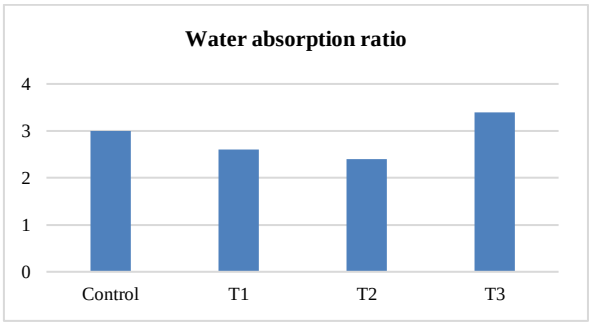

Figure 1: Water absorption ratio of herbal fortified millet pasta

Storage Stability

The storage stability of herbal-fortified pasta was evaluated over a 45-day period under ambient conditions. Samples were packed in sealed polyethylene zip-lock bags, and changes in cooking time and dry weight were monitored at 15-day intervals. The initial cooking time of 4 minutes remained consistent across all treatments throughout the storage period, with no significant variation observed. However, a gradual reduction in dry weight was recorded during storage. In the control sample, the weight decreased from 4.0 g to 3.45 g after 45 days. Similar trends were observed in fortified samples, with T1 decreasing from 3.0 g to 2.56 g, T2 from 4.0 g to 3.54 g, and T3 from 4.0 g to 3.76 g. These findings are in line with the study of Attanzio *et al.* (2019), who reported a decrease in pasta dry weight from 6.0 g to 5.4 g during five months of storage, while cooking time remained unaffected.

Table 6: Storage changes in herbal fortified millet pasta

Treatment	Storage period	Cooking time (Minutes)	Weight of the pasta (Dry) (g)
Control(C)	1-15 days	4	4
	15-30 days	4	3.95
	30-45 days	4	3.45
Tulsi (T_1)	1-15 days	4	3
	15-30 days	4	2.98
	30-45 days	4	2.56
Palak (T_2)	1-15 days	4	4
	15-30 days	4	3.87
	30-45 days	4	3.54
Black night shade(T_3)	1-15 days	4	4
	15-30 days	4	3.98
	30-45 days	4	3.76

CONCLUSION

Several studies have demonstrated that the inclusion of millets and medicinal herbs in the diet can help lower the risk of chronic conditions such as diabetes, cardiovascular diseases, and certain cancers. Pasta, being a widely consumed, versatile, and affordable food, also forms an integral part of the Mediterranean diet. The present study highlights that pasta developed with malted finger millet and herbal fortification offers a nutrient-dense alternative to conventional refined flour pasta. The product is particularly rich in calcium and phenolic compounds, with lower caloric content, thereby serving as a healthier substitute that can aid in reducing overall calorie intake. For future research, emphasis should be placed on evaluating the bioactive potential of such formulations through in vivo and clinical intervention studies to validate their functional health benefits.

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