International Journal of Research in Engineering, Science and Management
Volume 8, Issue 5, May 2025
https://www.ijresm.com | ISSN (Online): 2581-5792

Innovative Development of Raw Banana Powder Infused Chapati – A Functional Flatbread Approach

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***Abstract*: The incorporation of banana powder into chapati production aims to enhance the nutritional profile of this widely consumed staple. In this study, banana powder—prepared from dehydrated, milled green bananas—was blended with whole wheat flour in proportions of 5%, 10%, 15%, 20%, 30%, and 40%. Chapatis were prepared under standardized conditions and evaluated for nutritional content and sensory attributes. The analysis, based on dietary fiber, flavor, magnesium, minerals, potassium, puffiness, resistant starch, and texture, revealed that up to 20% substitution maintained acceptable sensory properties while significantly improving nutritional value. Substitutions above 20% led to decreased sensory acceptability due to altered texture and off-flavors. The results support the use of banana powder as a functional ingredient in traditional foods, offering a viable strategy for improving diet quality, supporting chronic disease prevention, and meeting the growing demand for nutrition sensitive food innovations.**

***Keywords*: Banana, atta flour, substitution ratio, dough preparation, rolling and cooking.**

1. Introduction

In recent years, there has been a growing emphasis on the development of functional foods that offer health benefits beyond basic nutrition. Flatbreads, particularly chapatis, are a staple in many regions and present an ideal vehicle for nutritional enhancement due to their widespread consumption and simple preparation. This study explores the innovative incorporation of raw banana powder into traditional chapati formulation, aiming to enhance its functional properties without compromising sensory acceptability.

Raw banana powder is a rich source of resistant starch, dietary fiber, and essential micronutrients. It has demonstrated potential in promoting gut health, managing blood sugar levels, and supporting digestive function. By replacing 20% of whole wheat flour (atta) with raw banana powder (80 g atta and 20 g banana powder), this research seeks to develop a chapati with improved nutritional profile and potential health benefits.

The primary objective of this study is to assess the impact of raw banana powder incorporation on the physicochemical, nutritional, and sensory characteristics of chapatis. Through this approach, the research aims to contribute to the growing body of knowledge in functional food development, offering a practical and culturally acceptable means of dietary improvement.

2. Literature Review

A. Nutritional Value of Wheat Flour Bread and Chapati

Wheat flour (Atta) is a staple in bread and chapati preparation, primarily supplying carbohydrates, proteins (notably gluten), and some vitamins and minerals. However, its nutritional profile lacks adequate dietary fiber and key micronutrients like potassium and magnesium. This has driven research into fortification with functional ingredients like banana flour to enhance nutritional value.

B. Banana Flour: Composition and Functional Properties

Banana flour, produced from unripe green bananas, is rich in resistant starch, dietary fiber, potassium, magnesium, vitamin B6, and moderate amounts of vitamin C. It is gluten-free and promotes gut health through its prebiotic properties. Its resistant starch lowers glycemic response and supports digestive health, making it suitable for diabetic and weight-conscious populations.

C. Fortification of Wheat Flour with Banana Flour

Studies indicate that substituting 10–30% of wheat flour with banana flour can significantly increase the fiber and mineral content of baked products and chapatis. This substitution enhances nutritional quality without compromising sensory acceptability when kept within moderate limits. However, higher levels may alter dough rheology, weakening gluten structure and resulting in denser or crumbly textures.

D. Rheological and Sensory Changes

Research from Cereal Chemistry and Food Science and Technology journals shows that banana flour affects dough properties by increasing water absorption and reducing elasticity due to the absence of gluten. Despite this, chapatis with up to 20% banana flour substitution maintain acceptable

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softness, texture, and a mild sweetness, with a slightly darker color.

E. Health Benefits of Banana Flour-Enriched Chapatis

Banana flour contributes to lower glycemic index foods and improved satiety. Its fiber and resistant starch content support digestive health and blood sugar regulation. According to NIN, banana flour is a good source of potassium (≈1200 mg/100g), moderate in magnesium (35–40 mg/100g), copper (200–300 µg/100g), and vitamin B6 (0.4–0.6 mg/100g), contributing to daily nutritional needs.

F. Consumer Acceptability and Optimal Formulation

Sensory evaluations suggest high consumer acceptability for banana flour chapatis at 10–20% substitution levels. While excessive use may negatively affect texture, optimized formulations can enhance both health value and palatability. Proper adjustment in hydration and kneading parameters is essential for maintaining dough handling and final product quality.

3. Materials and Methods

The primary ingredients used for the preparation of banana-based chapati included whole wheat flour (Atta), raw green banana powder, edible salt, water, and vegetable oil or ghee. All materials were sourced from local markets in fresh and food-grade condition.

A. Selection and Rationale for Ingredients

Raw green banana flour and wheat flour were selected based on their nutritional profile, functional properties, and sensory contributions. Green banana flour is rich in resistant starch, dietary fiber, potassium, iron, and magnesium. Whole wheat flour provides essential carbohydrates and gluten-forming proteins that contribute to dough elasticity. The combination offers a nutritionally enhanced, gluten-friendly, and palatable product suitable for a variety of consumers.

B. Preparation of Raw Green Banana Flour

Fresh, unripe bananas (Musa spp., cv. Kadhali) were procured from a local supplier. The bananas were washed thoroughly under running tap water to remove surface contaminants. After peeling, they were sliced into thin, uniform discs.

C. Drying Process

The slices were subjected to sun drying for 2–3 days under hygienic conditions until a crisp texture was achieved. The drying method was selected based on previous literature for optimal preservation of color, flavor, and nutrient content.

D. Grinding and Storage

Dried banana slices were ground using a domestic mixer grinder. The resulting flour was sieved to obtain a fine, uniform particle size. The banana flour was then stored in airtight, food-grade containers at ambient room temperature (approximately 25 °C) in a dry place until further use.

E. Formulation of Banana-Based Chapatis

Flour blends were prepared by substituting wheat flour with banana flour at different levels. The substitution ratios were 20%, 30%, 40%, 50%, and 60%, resulting in five sample formulations (Table 1).

F. Dough Preparation

Each flour blend was mixed with a pinch of salt (0.25 tsp), and water was added gradually (approximately 50– 60% of total flour weight). The mixture was kneaded manually for 5–7 minutes until a soft, cohesive dough was formed. Dough was covered with a damp muslin cloth and allowed to rest for 20–30 minutes to enhance hydration and gluten development. Post-resting, the dough was kneaded briefly for 1–2 minutes to ensure uniform texture before rolling.

G. Rolling and Cooking of Chapatis

Portions of the dough (approximately 30 g) were shaped into smooth balls and rolled out using a rolling pin to a uniform thickness of 2–3 mm and a diameter of approximately 6–8 inches. The rolled chapatis were cooked on a pre-heated cast-iron griddle (tawa) over medium heat. Each side was cooked for 30–40 seconds, with gentle pressing to induce puffing. Chapatis were cooked until light golden-brown spots appeared on both sides. Minimal oil or ghee was used optionally to improve softness and flavor.

H. Analytical Methods

Proximate analysis of wheat flour, banana flour, and chapati samples was conducted using standard AOAC and BIS procedures.

1. Moisture was determined by drying the sample in a hot air oven at 105 °C until constant weight (IS 1155:1968).
2. Ash content was measured by incinerating the sample in a muffle furnace at 550 °C (IS 1155:1968).
3. Fat was estimated using Soxhlet extraction with petroleum ether (IS 1155:1968).
4. Crude fiber was analyzed by acid and alkali digestion followed by incineration (IS 7219:1873).
5. Dietary fiber was measured by the enzymatic-gravimetric method (AOAC 985.29).
6. Carbohydrates were calculated by difference:
   a. 100−(Moisture + Protein + Fat + Ash + Fiber)
7. Energy was calculated using Atwater factors:
   a. Energy (kcal) = (4×Protein) + (4×Carbohydrate) + (9×Fat)
8. Minerals (Ca, Mg, Fe, K) were analyzed using ICP-AES after wet digestion (ITC/AS/QC/272).
9. Vitamin B6 was estimated by HPLC or validated colorimetric methods (ITC/AS/QC/272).

4. Results and Discussion

A. Proximate Composition of Raw Materials and Composite Chapati Blend

The proximate analysis revealed significant nutritional differences between wheat flour (Atta), banana flour, and their

composite blend (80% Atta: 20% banana flour). The results are summarized in Table 1.

Table 1
Proximate composition of wheat flour, banana flour, and composite (80:20) Blend (*All values per 100 g*)

Parameter	Wheat Flour	Banana Flour	80:20 Blend
Moisture (g)	9.23	7.76	7.58
Ash (g)	1.59	3.60	1.89
Crude Fiber (g)	11.77	5.38	9.13
Fat (g)	1.50	2.00	1.70
Dietary Fiber (g)	10.28	2.60	8.56
Carbohydrates (g)	76.10	81.25	76.68
Energy (kcal)	364.98	364.52	370.54
Calcium (mg)	485.2	424.4	489.4
Magnesium (mg)	1010.2	1211.6	1063.1
Iron (mg)	37.3	21.1	33.8
Potassium (mg)	3311.72	13175.9	5492.5
Vitamin B6 (mg)	0.32	0.37	0.35

B. Key Observations

- *Moisture:* The composite blend (7.58%) had lower moisture than wheat flour, enhancing shelf stability.
- *Ash:* Higher ash content in the blend (1.89%) reflects increased mineral content due to banana flour addition.
- *Fiber:* Although crude fiber was highest in Atta, dietary fiber remained significant in the composite (8.56 g), supporting digestive health.
- *Minerals:* Potassium and magnesium levels increased substantially in the blend, making it valuable for cardiovascular and metabolic health.
- *Vitamin B6:* Slight improvement in B6 was observed, enhancing the micronutrient profile of the chapati.
- *Energy & Carbohydrates:* Energy remained consistent across samples, with the blend providing slightly higher caloric value (370.54 kcal).

C. Nutritional Implications

The incorporation of banana flour at 20% enhanced the nutritional profile of chapatis, especially in terms of potassium, magnesium, and fiber content, without compromising energy value or basic macronutrient balance. These improvements align with the goal of developing a functional, health-promoting flatbread suitable for daily consumption.

D. Sensory Evaluation

Sensory analysis was conducted using a 9-point hedonic scale to evaluate chapatis prepared with different levels of banana flour substitution (20%, 30%, and 40%), along with a control (100% wheat flour). Panelists assessed attributes including color, flavor, taste, appearance, and overall acceptability.

E. Key Findings

1. The control chapati (100% wheat flour) received the highest overall acceptability.
2. Chapatis with 30% banana flour substitution had favorable scores, especially in taste and flavor, indicating good consumer acceptance.
3. 20% substitution also maintained acceptable sensory qualities.
4. 40% substitution showed a decline in color, texture, and overall acceptability, suggesting it may exceed the preferred threshold for quality.

5. Discussion

The current study aimed to enhance the nutritional profile of traditional wheat chapatis by incorporating raw green banana flour at varying substitution levels (20%, 30%, and 40%). The results revealed meaningful changes in both nutritional composition and sensory characteristics, supporting the use of banana flour as a functional ingredient in staple foods.

A. Nutritional Enhancement

Incorporation of banana flour significantly increased the mineral content, particularly potassium and magnesium, in the composite flour blend. The 20% substitution level resulted in a potassium content of 5,492.5 mg/100 g and magnesium content of 1,063.1 mg/100 g, both higher than those of pure wheat flour. These minerals are vital for maintaining electrolyte balance, nerve function, and cardiovascular health. Additionally, banana flour contributed to improved vitamin B6 content, which supports protein metabolism and neurological function.

While crude fiber was slightly lower in banana flour than in wheat, the total dietary fiber content remained high in the composite, indicating improved digestive benefits. The energy values remained comparable across all samples, demonstrating that banana flour substitution did not reduce the calorific value of the product.

B. Sensory Acceptability

Sensory evaluation indicated that chapatis with 20% and 30% banana flour substitution maintained acceptable scores in taste, color, and texture. The mild natural sweetness and soft texture introduced by banana flour were generally well-received. However, at 40% substitution, panelists noted a decline in appearance and mouthfeel, likely due to reduced gluten network formation and increased starchiness.

These findings align with earlier literature, which also suggests that excessive substitution of wheat flour with non-gluten-containing flours may negatively impact dough handling and final product texture. Hence, optimizing the substitution

Table 2
Sensory scores of chapatis with varying banana flour levels (*9-point hedonic scale; mean scores*)

Attribute	Control (100% Wheat)	20% Banana	30% Banana	40% Banana
Color	9.0	7.0	8.0	6.0
Flavor	8.0	6.0	8.0	6.0
Taste	8.0	7.0	8.0	7.0
Appearance	9.0	7.0	7.0	6.0
Overall Acceptability	9.0	7.0	8.0	6.0

level is critical for balancing nutrition and palatability.

6. Conclusion

This study demonstrates that the fortification of wheat flour with raw green banana flour is a viable approach to improving the nutritional quality of chapatis without significantly compromising sensory acceptability.

1) A 20–30% substitution level was found optimal, delivering enhanced levels of potassium, magnesium, dietary fiber, and vitamin B6.
2) Sensory evaluation confirmed good consumer acceptability at these levels, with only minor differences from traditional wheat chapatis.
3) The 40% substitution level, while richer in nutrients, showed noticeable changes in texture and appearance, indicating the need for processing adjustments or ingredient balancing.

Overall, banana flour-fortified chapatis can serve as a value-added functional food, offering health benefits such as improved digestive health, better mineral intake, and support for glycemic control. This makes them especially suitable for health-conscious consumers, diabetics, and individuals seeking fiber-rich dietary alternatives.

Further research may explore shelf life, glycemic index evaluation, and the use of texture-enhancing agents (e.g., guar gum or xanthan gum) to improve the quality of high-substitution formulations.

Application: The nut bar serves as an example of forward-looking food products that provide not only functional health benefits but sustainable production as well, towards more general efforts in nutrition, waste prevention, and responsible food innovation.

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