

Development and Nutritional Evaluation of Functional Veggie-Based Pappads Enriched with Sweet Corn, Beans and Semolina

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Abstract

The Present Study focuses on the Development and Nutritional evaluation of a functional, plant-based snack in the form of Veggie Delight Pappads, enriched with sweet corn, green beans, semolina and spices. Three variations (T1, T2, T3) were formulated with differing proportions of sweet corn and semolina; subjected to sensory evaluation, T2 showed as the most acceptable based on flavor, texture and overall palatability. Nutritional analysis of T2 revealed a balanced composition with high protein (15 g/100 g), moderate fiber (4.2 g/100 g) and low fat (3.2 g/100 g), along with significant amounts of essential vitamins and minerals including calcium, potassium, iron; vitamins A and C. Microbial evaluation up to one-month study under ambient conditions, with all parameters remaining within permissible limits. The findings highlight the feasibility of transforming traditional Indian snacks into functional foods through strategic incorporation of nutrient-dense ingredients, aligning with contemporary health trends and consumer demands.

Keywords: Functional foods; Plant-based snacks; Pappad formulation; Nutrient enrichment; Traditional Indian snacks

1. Introduction

Traditional Indian snacks such as *pappads* (also known as *papads*) have long been a staple accompaniment in meals, often appreciated for their crisp texture and savory flavor. These thin, disc-shaped items are typically prepared using lentil or rice flours and are sun-dried for storage before being roasted or fried for consumption. However, conventional pappads are often low in fiber and essential nutrients, limiting their health benefits, particularly in the context of rising lifestyle-related diseases such as obesity, type 2 diabetes, and cardiovascular disorders (Misra et al., 2011).

As dietary habits continue to shift globally, there is increasing demand for healthier alternatives to traditional snacks that retain cultural familiarity while offering improved nutritional value. This shift aligns with the World Health Organization's (WHO) advocacy for dietary diversification and functional foods to address micronutrient deficiencies and promote public health (WHO, 2020). Functional foods, particularly those derived from plant-based ingredients, have garnered attention for their role in enhancing health beyond basic nutrition, including support for gut health, immune function, and chronic disease prevention (Martirosyan & Singh, 2015).

In this context, modifying traditional Indian pappads using nutrient-rich, fiber-enhancing, and antioxidant-rich ingredients offers an opportunity to create value-added food products that align with modern dietary trends. Sweet corn (*Zea mays*) and green beans (*Phaseolus vulgaris*) are excellent candidates for such innovations due to their low glycemic index, high fiber content, and presence of bioactive compounds such as phenolics and carotenoids (Goufo & Trindade, 2014; Mudryj et al., 2014). Semolina, a coarse wheat product, provides structure, energy, and satiety, while sago contributes to the crisp texture and digestibility of the final product (Chinma et al., 2013).

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In addition to nutritional enhancement, ensuring the microbiological safety and shelf stability of such ready-to-eat products is critical for consumer acceptance and commercial viability. The integration of antimicrobial spices like cumin and black pepper not only elevates the flavor profile but also provides natural preservative functions (Peter, 2006). AOAC (2019) guidelines are widely used for standardizing the microbial and nutritional quality of functional foods and were adhered to during the evaluation of the developed product.

While numerous studies have explored the fortification of cereal-based snacks with legumes, the transformation of pappads using a blend of cereals, pulses, and vegetables in optimized proportions remains underexplored. This study bridges that gap by formulating and evaluating a Nutrient-Enriched Veggie Delight Pappad, targeting health-conscious consumers seeking traditional yet wholesome snack options. This study was framed to develop a plant-based, nutritionally enriched pappad using sweet corn, green beans, semolina and spices; to assess its nutritional value, microbial safety, sensory acceptability and shelf stability.

2. Materials and Methods

2.1. Ingredient Procurement

All ingredients used in the formulation of Veggie Delight Pappads were procured from local, certified food-grade suppliers in Hyderabad, Telangana. The primary raw materials included fresh sweet corn (*Zea mays*), green beans (*Phaseolus vulgaris*), semolina (*Triticum durum*) and sago (*Manihot esculenta*), alongside condiments such as cumin seeds, black pepper, and common salt. All ingredients were selected based on freshness, uniformity and absence of visual defects. The sourcing was conducted following food safety standards as outlined by the Food Safety and Standards Authority of India (FSSAI, 2020).

2.2. Preparation of the Product

The preparation was carried out in the Food Science and Nutrition Laboratory at Capital Degree and PG College, Hyderabad. Sweet corn was steamed and ground into a paste, while green beans were boiled until soft and mashed manually. Semolina was lightly roasted to enhance aroma and reduce microbial load, as recommended by Chinma et al. (2013). Sago pearls were soaked in water for 30 minutes to soften, then drained before use. Spices including cumin seeds and black pepper were dry-roasted and ground to fine powders to improve palatability and shelf stability (Peter, 2006).

2.3. Formulation of T1, T2 and T3 Veggie Delight Pappads

Three variations of the Veggie Delight Pappads (T1, T2, T3) were formulated by altering the proportions of sweet corn and semolina while maintaining the quantity of beans and sago constant. The ingredients were uniformly mixed to form a pliable dough. The dough was then portioned and rolled into thin circular discs (approximately 1.5 mm thick). These discs were subjected to hot air drying at 50 °C to 60°C for 6–8 hours in a tray dryer, ensuring removal of moisture content below 7% for extended shelf life (AOAC, 2016). The dried pappads were cooled to ambient temperature and stored in airtight polyethylene pouches.

Table 1 Ingredients used for T1, T2 and T3 Veggie Delight Pappads

Ingredients	T1	T2	T3
Sweet corn	8g	10g	12g
Green beans	8g	8g	8g
Semolina	54g	56g	58g
Sago	2.3g	2.3g	2.3g
Cumin seeds	1.2g	1.2g	1.2g
Black pepper	0.7g	0.6g	0.9g
Salt	1g	1g	1g

2.4. Sensory Evaluation (7-Point Hedonic Scale)

Sensory evaluation was performed by a panel of 10 semi-trained individuals familiar with traditional Indian snack products. A **7-point Hedonic scale** was employed to assess the organoleptic attributes including appearance, color, texture, taste, aroma, and overall acceptability, where 1 = Dislike very much and 7 = Like very much (Stone & Sidel, 2004). Panelists evaluated all three variations in randomized order under controlled lighting and ambient conditions. The data were compiled and analyzed statistically using mean and standard deviation to determine the most acceptable formulation.

2.5. Nutritional Analysis

Nutritional composition was assessed using standard methods prescribed by the Association of Official Analytical Chemists (AOAC, 2016). Moisture content was determined using the gravimetric oven-drying method (AOAC 925.10), protein content by the Kjeldahl method (AOAC 990.03), fat content by Soxhlet extraction (AOAC 920.39), carbohydrate content by difference method, and dietary fiber using enzymatic-gravimetric procedures (AOAC 972.29). Ash content was calculated to assess total mineral content (AOAC 923.03).

2.6. Vitamin and Mineral Analysis

Mineral content—including calcium, iron, potassium, and magnesium was carried by (AOAC 984.27). Vitamin A content was determined using spectrophotometric analysis after extraction with petroleum ether (AOAC 992.04), while vitamin C was assessed using 2,6-dichlorophenolindophenol titration (AOAC 967.21). All tests were conducted in triplicates to ensure consistency and reliability; the results were expressed in mg per 100g of sample.

2.7. Microbial Analysis and Shelf-Life Studies

Microbiological quality was determined to ensure the product's safety during storage. The Total Viable Count (TVC), Yeast and Mould Count, and detection of foodborne pathogens including *E. coli*, *Salmonella* spp., and coliforms were analyzed using AOAC-approved protocols (AOAC 990.12; 997.02; 991.14; 2011.03). The Veggie Delight Pappads were stored at ambient temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$) in sealed polyethylene pouches and microbial stability was monitored bi-weekly over a 1-month period. Products were deemed safe if microbial loads remained within permissible limits (ICMSF, 2011), with no signs of spoilage, off-odors, or discoloration.

3. Results and Discursion

3.1. Sensory Evaluation of Veggie Delight Pappads

The sensory evaluation of the three Veggie Delight Pappad formulations (T1, T2, T3) revealed that all variations were positively received by the panelists (Table 2), with T2 achieving the highest scores across most parameters. Texture and flavor, two key attributes influencing snack preference, were rated highest in T2 (6.8 ± 0.40 and 6.9 ± 0.32 , respectively), indicating a well-balanced composition of moisture, crispness, and spice infusion. The semolina and sago combination in T2 likely contributed to the desirable crispness, while the sweet corn and green beans enriched both mouthfeel and taste, supporting findings by Mudryj et al. (2014) and Goufo and Trindade (2014) on the palatability of pulse-vegetable blends. Overall acceptability of T2 (6.8 ± 0.39) was significantly higher compared to T1 and T3, suggesting that the ingredient ratio in T2 offers the most consumer-friendly sensory profile. These results align with Stone and Sidel's (2004) assertion that a moderately trained panel can effectively differentiate and score functional food formulations. Based on sensory outcomes, T2 was selected for further Nutritional and microbial analysis.

Table 2 Sensory analysis of T1, T2 and T3 Veggie Delight Pappads

Sensory Attribute	T1 (Mean \pm SD)	T2 (Mean \pm SD)	T3 (Mean \pm SD)
Appearance	6.1 \pm 0.57	6.4 \pm 0.52	6.2 \pm 0.48
Color	6.2 \pm 0.42	6.6 \pm 0.51	6.3 \pm 0.60
Texture	6.3 \pm 0.49	6.8 \pm 0.40	6.5 \pm 0.50
Taste	6.0 \pm 0.45	6.7 \pm 0.47	6.4 \pm 0.53
Flavor	6.2 \pm 0.60	6.9 \pm 0.32	6.3 \pm 0.55
Overall Acceptability	6.2 \pm 0.51	6.8 \pm 0.39	6.4 \pm 0.44

3.2. Nutritional Analysis of Veggie Delight Pappads

The nutritional analysis of the optimized Veggie Delight Pappad formulation (T2) demonstrated a balanced nutrient profile, making it a viable health-oriented snack (Table 3). The carbohydrate content was found to be 54 g/100 g, providing a significant source of energy suitable for moderate snacking, consistent with the caloric value expected from semolina and sweet corn-based products (Chinma et al., 2013). Protein content was recorded at 15 g/100 g, which is relatively high for a plant-based snack and is attributable to the incorporation of green beans—a legume recognized for its protein density (Mudryj et al., 2014). The fat content remained low at 3.2 g/100 g, indicating the product's suitability for individuals on fat-restricted or heart-healthy diets. Dietary fiber was measured at 4.2 g/100 g, reflecting the contributions of both sweet corn and beans, which are known to enhance gastrointestinal health and promote satiety (Goufo & Trindade, 2014). The moisture content of 6.7 g/100 g and ash content of 1.2 g/100 g fall within acceptable limits for dehydrated food products, supporting the product's shelf stability and mineral presence (AOAC, 2016). Overall, these findings confirm that the pappad variation T2 aligns with current consumer demand for nutrient-rich, low-fat, and fiber-enhanced ready-to-eat snacks, offering both functional benefits and palatability without compromising storage safety.

Table 3 Nutritional Analysis of Veggie Delight Pappads (T2)

Test parameters	Results	Unit
Carbohydrates	54	g/100g
Protein	15	g/100g
Fat	3.2	g/100g
Fibre	4.2	g/100g
Moisture	6.7	g/100g
Ash	1.2	g/100g

3.3. Mineral and Vitamin Analysis of Veggie Delight Pappads (T2)

The Mineral and Vitamin composition of Veggie Delight Pappads (T2) highlights its potential as a micronutrient-enriched functional food (Table 4). The calcium content was found to be 98.3 mg/100 g, offering considerable contribution to daily dietary calcium needs, particularly for bone health and metabolic regulation (Weaver et al., 2016). Potassium levels were recorded at 320 mg/100 g, supporting its role in maintaining fluid balance, nerve transmission and cardiovascular function, especially in sodium-sensitive individuals (He & MacGregor, 2008). The iron content, measured at 3 mg/100 g, reflects the presence of legumes and green vegetables, and is beneficial in addressing mild iron deficiency, especially in vegetarian diets (Hurrell & Egli, 2010). Magnesium was present at 56 mg/100 g, supporting enzymatic activity and neuromuscular function, with values aligning with those found in other pulse-based foods (Volpe, 2013). The product also contained moderate but nutritionally relevant levels of vitamin A (50 mg/100 g) and vitamin C (10 mg/100 g), likely derived from sweet corn and the use of green herbs and spices. These vitamins play key roles in immune support, antioxidant protection and vision health (Tanumihardjo, 2013; Carr & Maggini, 2017). The presence of these essential micronutrients enhances the nutritional value of the product and demonstrates its suitability as a supplementary food item for improving dietary quality in diverse populations.

Table 4 Mineral and Vitamin Analysis of Veggie Delight Pappads (T2)

Test parameters	Results	Unit
Calcium	98.3	mg/100g
Potassium	320	mg/100g
Iron	3	mg/100g
Magnesium	56	mg/100g
Vitamin A	50	mg/100g
Vitamin C	10	mg/100g

3.4. Microbial analysis of Veggie Delight Pappads (T2)

The Microbiological quality of the Veggie Delight Pappads was assessed after one month of ambient storage to ensure food safety and compliance with regulatory standards (Table 5). The total viable count (TVC) was found to be <10 CFU/ml, indicating an extremely low microbial load and suggesting effective processing, drying, and hygienic handling procedures (AOAC, 2016). Similarly, yeast and mold counts remained below detectable limits (<10 CFU/ml), demonstrating the product's stability against fungal contamination during the observed shelf life. Importantly, foodborne pathogens including *Escherichia coli*, *Salmonella* spp., and coliform bacteria were all absent in the tested samples, confirming microbiological safety and validating the sanitary quality of raw materials and post-processing storage conditions (Jay et al., 2005; ICMSF, 2011). The absence of *E. coli* and coliforms is critical, as these organisms serve as indicators of potential fecal contamination and poor handling practices. The combination of low moisture content (6.7%) and airtight packaging likely contributed to inhibition of microbial growth, aligning with best practices for shelf-stable, ready-to-eat dry snack products (Fellows, 2009). Overall, the microbial results meet food safety standards and affirm the product's suitability for consumption over a 1-month storage period without the use of synthetic preservatives.

Table 5 Microbial analysis of Veggie Delight Pappads for 1-month study

Test Parameter	Unit	Results	Test Method
Total Viable Count	CFU/ml	<10	AOAC 990.12
Yeast & molds	CFU/ml	< 10	AOAC 997.02
E.Coli Count	CFU/ml	Absent	AOAC 991.14
Salmonella	CFU/25 ml	Absent	AOAC 2011.03
Coliform Count	CFU/25 ml	Absent	AOAC 991.14

4. Conclusion

The successful formulation and evaluation of Veggie Delight Pappads demonstrate the potential for incorporating sweet corn, green beans, semolina and spices into traditional snack formats to enhance their nutritional value and functional appeal. Among the three formulations, T2 achieved the highest sensory acceptability and exhibited a superior nutrient profile, with appreciable levels of protein, fiber, vitamins and minerals while maintaining microbiological safety and shelf stability. This innovation addresses the growing consumer interest in health-oriented, plant-based and culturally relevant food options. The study supports the importance of functional food development in public health nutrition and provides a scalable model for integrating vegetables and cereals into widely consumed snack items without compromising sensory or safety standards.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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