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Development and quality assessment of composite flour pancakes enriched with orange-fleshed sweet potato

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Abstract

This study aimed to develop and evaluate nutritionally enriched pancakes using composite flour formulations incorporating orange-fleshed sweet potato (OFSP), oats and wheat flour. Three formulations (T1, T2, T3) were standardized and subjected to sensory, nutritional and microbiological analyses. Among the variants, T2 (50% OFSP, 15% oats, 25% wheat flour) exhibited superior sensory acceptability across all evaluated parameters. Nutritional analysis of the T2 sample revealed a balanced composition with notable levels of protein (13.21 g/100 g), dietary fiber (4.7 g/100 g) and beta-carotene-derived vitamin A (613 µg/100 g), along with significant quantities of iron and calcium. Microbial assessments confirmed the product's safety, with minimal microbial load and absence of pathogenic organisms. The findings support the potential of OFSP-enriched pancakes as a functional food with sensory appeal and nutritional benefits, particularly for populations vulnerable to micronutrient deficiencies.

Keywords: Sweet potato; Composite flour; Functional food; Micronutrient fortification; Sensory evaluation; Pancake

1. Introduction

Micronutrient deficiencies remain a widespread public health challenge, particularly in low- and middle-income countries, where access to diverse and nutrient-rich diets is limited. Among the most pressing deficiencies are those of vitamin A, iron, and dietary fiber, which are associated with impaired immune function, vision problems, anemia, and increased susceptibility to infections and chronic diseases (WHO/FAO, 2003). Tackling these issues through food-based approaches—particularly via functional food development—offers a sustainable and culturally adaptable solution to improving nutritional status in vulnerable populations.

Sweet potato (*Ipomoea batatas*), particularly the orange-fleshed variety, is recognized as a promising, underutilized functional food ingredient due to its rich content of beta-carotene (a precursor to vitamin A), complex carbohydrates, dietary fiber, potassium and vitamin C (FAO, 2018). It is widely cultivated in many parts of Asia and sub-Saharan Africa, making it a locally accessible, low-cost option for dietary improvement. However, despite its nutritional benefits and availability, sweet potato remains underexploited in the development of processed or ready-to-eat food products (Molla & Bhadra, 2019).

The incorporation of sweet potato flour into familiar and widely consumed food items such as pancakes could provide a practical means to enhance dietary quality without compromising sensory acceptability. Pancakes are commonly consumed across various age groups due to their soft texture, palatability and ease of preparation. Using composite flours made from sweet potato, wheat and oats offers the dual advantage of improving the nutritional profile of the product while maintaining consumer-friendly characteristics (Chukwuma & Obi, 2020).

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Several studies have explored the substitution of wheat flour with other nutrient-dense ingredients to address malnutrition and promote health through diet (Shittu et al., 2007; Alam et al., 2016). However, limited research has focused specifically on the use of sweet potato in pancake formulations, particularly with respect to balancing nutritional content, sensory appeal and microbiological safety in a single product. The development of a fortified pancake with optimal levels of sweet potato flour could serve as an effective dietary intervention tool for addressing micronutrient deficiencies. The objectives of the present study were to develop and standardize sweet potato-based pancake formulations by partially substituting refined wheat flour with sweet potato flour and oats in varying proportions; to evaluate the organoleptic properties of the prepared samples through sensory analysis; to analyze the nutritional composition, including proximate content, vitamins and minerals of the most acceptable formulation also to assess the microbiological safety of the final product in accordance with established food safety standards.

2. Materials and Methods

2.1. Ingredient Purchase

Fresh orange-fleshed sweet potatoes were procured from local markets in Hyderabad, ensuring uniform maturity and free from defects. Refined wheat flour, oats, honey, milk, baking powder, salt, almonds, chia seeds, and cooking oil were purchased from certified grocery retailers

2.2. Preparation of Sweet Potato Flour

Sweet potatoes were washed under running water, peeled using a stainless-steel peeler, and uniformly sliced (2–3 mm). Slices were blanched in hot water at 70 °C for 2 minutes to inactivate enzymes, then dried in a hot-air oven at 60 °C for 6–8 hours until brittle. Dried slices were ground into fine flour using a dry grinder, passed through a 60-mesh sieve, and stored in airtight containers until use (Kalaimangai et al., 2019)

2.3. Formulation and Preparation of Pancake

Three formulations (T1, T2, T3) were developed by partially replacing wheat flour with sweet potato flour and oats (T2 = 50% SP + 15% oats + 25% WF + 10% other ingredients). Sweet potato, oats, and milk were blended to form a smooth paste before incorporating wheat flour, salt, baking powder, almonds, and chia seeds. Batter was prepared to homogeneity, then pancakes were cooked on lightly greased non-stick pans at low-to-medium heat until bubbles appeared; they were flipped and cooked until golden brown.

Table 1 Formulation for the T1, T2 and T3 sweet potato pan cake

Samples	Combinations
T1	40% SP + 20% Oats+ 20% W F +10% other ingredients
T2	50% SP + 15 % Oats + 25 % W F + 10% other ingredients
T3	65% SP + 15 % Oats + 10 % W F + 10% other ingredients

Note: SP – Sweet potato, Oat – Oats, WF – Wheat Flour, Oi – other ingredients (baking soda, milk, honey, Salt, almonds, chia seeds)

2.4. Sensory Evaluation

Twenty semi-trained panelists evaluated pancake samples using a structured 7-point hedonic scale (1 = “dislike extremely” to 7 = “like extremely”), assessing six sensory attributes: color, texture, aroma, taste, appearance, and overall acceptability. Mean scores and standard deviations were calculated, and one-way ANOVA was performed to detect significant differences among treatments (Chukwuma & Obi, 2020; Castillo et al., 2025).

2.5. Nutritional Analysis

Proximate composition—moisture, protein, fat, ash, and dietary fiber—was determined using AOAC standard methods: moisture by oven drying (AOAC 925.10), protein by Kjeldahl nitrogen (AOAC 2001), fat by Soxhlet extraction (AOAC 920.39), ash gravimetrically (AOAC 945.05) and dietary fiber enzymatically (AOAC 991.43). Carbohydrate was calculated by difference (100 – sum of other components).

2.6. Vitamin and Mineral Analysis

Vitamin A was quantified via spectrophotometric beta-carotene assay, vitamin C by 2,6-dichlorophenol-indophenol titration and vitamin D (AOAC 967.21). Mineral content (iron, calcium and potassium) was determined by flame atomic absorption spectrophotometry following standard digestion protocols (Popa et al., 2023).

2.7. Microbial Analysis and Shelf-life Studies

Microbial safety was assessed following FSSAI guidelines. Total viable count, yeasts and molds, E. coli, Salmonella, and coliform counts were determined using standard plating and enrichment procedures. Shelf-life studies involved monitoring microbial loads in pancake samples stored at ambient temperature (25 ± 2 °C) over 7 days; sensory quality was evaluated concurrently.

3. Results and Discursion

3.1. Sensory parameters of (T1, T2, T3) Sweet potato pancake

Sensory evaluation results (Table-2) revealed that the T2 formulation (50% sweet potato flour + 15% oats + 25% wheat flour) achieved the highest mean scores across all attributes, with color (6.64 ± 0.49), texture (6.89 ± 0.31), aroma (6.73 ± 0.45), taste (6.78 ± 0.41), and overall acceptability (6.70 ± 0.42). This indicates that the sensory quality of T2 was notably superior to T1 and T3, with statistically meaningful differences supported by a one-way ANOVA ($F = 4.12$, $p = 0.03$). T1 scored slightly lower—color 6.30 ± 0.58, texture 6.50 ± 0.61, aroma 6.57 ± 0.60, taste 6.72 ± 0.57, overall acceptability 6.50 ± 0.52—while T3 received the lowest ratings overall. The trend of improved acceptability at moderate sweet potato substitution parallels findings in sweet potato–composite bakery products, where intermediate inclusion levels (20–40%) often deliver optimal sensory balance (Abdel Ati et al., 2023). These results suggest that T2 represents a successful compromise between nutrient enhancement and consumer-perceived quality, reinforcing the use of a 50% sweet potato formulation for fortified pancake development.

Table 2 Sensory parameters of (T1, T2, T3) of Sweet potato pancake

Sample	Color	Texture	Aroma	Taste	Overall acceptability
T1	6.3±0.582	6.5±0.61	6.57±0.60	6.72±0.57	6.5 ± 0.52
T2	6.636± 0.49	6.89±0.31	6.73 ± 0.45	6.78 ± 0.41	6.7 ± 0.42
T3	6.47±0.51	6.44± 0.76	6.47 ± 0.69	6.42 ± 0.60	6.4 ± 0.6

3.2. Nutritional Analysis of Sweet potato pancake (T2)

Table 3 Nutritional Analysis of sweet potato pan cake

Test parameters	Results	units
Protein	13.21	g/100gm
Carbohydrates	53.4	g/100gm
Total fat	7.03	g/100gm
Dietary fiber	4.7	g/100gm
Ash	0.2	%
Moisture Content	41.08	%

The Nutritional analysis of the Sweet Potato Pancake revealed a favorable macronutrient composition, highlighting its potential as a nutritious food product (Table 3). The protein content was recorded at 13.21 g/100 g, indicating a moderate level that can contribute to daily protein requirements, particularly in plant-based or vegetarian diets. Carbohydrates, the primary energy-yielding macronutrient, were present at 53.4 g/100 g, which aligns with expected values for starchy, tuber-based products (Olatunde et al., 2016). The total fat content stood at 7.03 g/100 g, reflecting a moderate fat profile suitable for maintaining palatability without excessive lipid intake. Notably, the dietary fiber content was 4.7 g/100 g, supporting the role of sweet potato-based formulations in promoting gastrointestinal health and satiety (Trinidad et al., 2006). The moisture content was relatively high at 41.08%, which may influence shelf life and microbial stability, necessitating appropriate packaging or preservation techniques. Ash content, representing total mineral residue, was low (0.2%), suggesting limited inorganic content, although specific mineral analysis would be necessary for detailed insights. Overall, the composition suggests that sweet potato pancakes could serve as a functional food option, balancing macronutrient contributions with dietary fiber and offering an alternative to conventional cereal-based pancakes.

3.3. Mineral and Vitamin Analysis of Sweet potato pancake (T2)

The Mineral and Vitamin composition of the Sweet Potato Pancake revealed a nutritionally significant profile, particularly rich in micronutrients essential for human health (Table 4). The iron content was found to be 4.9 mg/100 g, contributing notably toward the recommended dietary allowance (RDA) for both children and adults, potentially supporting anemia prevention strategies (WHO, 2020). Calcium was measured at 78.01 mg/100 g, suggesting a moderate contribution to bone health when consumed as part of a balanced diet. Vitamin A content was notably high at 613 µg/100 g, indicating that sweet potato pancakes can serve as an effective dietary source of provitamin A carotenoids, which are critical for vision and immune function (Rodriguez-Amaya, 2016). Additionally, the presence of Vitamin C (10.5 mg/100 g) enhances non-heme iron absorption and provides antioxidant benefits (Carr & Maggini, 2017). Although Vitamin D was present in relatively low amounts (0.2 mg/100 g), its inclusion is still nutritionally relevant given widespread global insufficiency. The overall micronutrient profile supports the potential of sweet potato-based products in addressing micronutrient deficiencies in vulnerable populations, particularly in regions with limited access to diverse diets.

Table 4 Minerals and Vitamin Analysis of sweet potato pan cake

Test parameters	Results	units
Iron	4.9	mg/100 gm
Calcium	78.01	mg/100 gm
Vitamin A	613	mg/100 gm
Vitamin C	10.5	mg/100 gm
Vitamin D	0.2	mg/100 gm

3.4. Microbial Analysis of sweet potato pan cake

The microbial analysis of the formulated sweet potato pancake revealed excellent microbiological quality, indicating its safety for consumption. As shown in Table 5, the total viable count (TVC) and yeast and mold counts were both recorded at less than 10 CFU/g, which is well below the acceptable limits established by international food safety standards (ICMSF, 2011). Furthermore, the absence of *Escherichia coli*, *Salmonella* spp., and coliforms per 25 g sample underscores the hygienic processing and storage conditions maintained during production. These findings align with earlier reports that emphasize the importance of adequate thermal processing and good manufacturing practices (GMPs) in controlling microbial contamination in composite flour products (Mensah et al., 2020). The absence of pathogenic organisms suggests that the product is microbiologically stable and safe for human consumption, which is essential for ready-to-eat or minimally processed food items. This also supports the suitability of sweet potato as a functional ingredient in value-added products due to its low inherent microbial load and compatibility with thermal preparation processes (Adugna & Labuschagne, 2002).

Table 5 Microbial Analysis of sweet potato pan cake

Test parameters	Results	units
Total viable count	<10	CFU/g
Yeast & molds	<10	CFU/g
E.coli	Absent	CFU/g
Salmonella	Absent	CFU/25 g
Coliform count	Absent	CFU/25 g

4. Conclusion

The present research successfully demonstrated that incorporating orange-fleshed sweet potato into composite flour-based pancake formulations can significantly enhance both nutritional quality and sensory attributes without compromising microbial safety. The T2 formulation, which combined sweet potato flour, oats and wheat flour in optimal proportions, emerged as the most acceptable variant, offering a good balance of macronutrients and essential micronutrients such as vitamin A, iron, and calcium. The low microbial load further confirmed the hygienic preparation and potential shelf stability of the product under ambient conditions. These findings highlight the promise of OFSP-based composite products as affordable, culturally adaptable interventions to combat hidden hunger and support dietary diversification in resource-limited settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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