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EFFECT OF ORANGE-FLESHED SWEET POTATO FLOUR ON THE QUALITY OF WHEAT-BASED BISCUITS

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Abstract: This study evaluated the effect of orange-fleshed sweet potato flour (OFSPF) on the quality of wheat-based biscuits in response to the growing demand for nutrient-enriched functional bakery products. Wheat flour was substituted with OFSPF at 0, 10, 20, and 30% levels under a completely randomized design. Proximate composition, functional properties, and sensory acceptability were determined using standard analytical methods. Data were analyzed using ANOVA and Tukey's HSD test at $p < 0.05$. Results showed that increasing OFSPF substitution significantly increased moisture, ash, crude fiber, and water absorption capacity, while protein content, spread ratio, and sensory acceptability decreased. Carbohydrate content was not significantly affected by the treatments. Sensory evaluation indicated that biscuits containing up to 20% OFSPF remained highly acceptable, whereas 30% substitution reduced consumer preference. The study concludes that OFSPF can be incorporated into wheat-based biscuits at up to 20% substitution to improve nutritional quality without compromising acceptability.

Keywords: composite flour, functional properties, orange-fleshed sweet potato flour, proximate composition, sensory evaluation, wheat-based.

INTRODUCTION

Biscuits are among the most widely consumed bakery products globally due to their convenience, affordability, long shelf life, pleasant taste, and ready-to-eat nature (Gupta and Kaur, 2023). According to Olatona *et al*., (2023), they are commonly consumed by people of all age groups as snacks and are increasingly used as energy-giving foods because of their relatively high carbohydrate and fat contents. Traditionally, biscuits are produced mainly from wheat flour because of its desirable gluten-forming properties, which contribute to dough elasticity, texture, and overall product quality (Al Majzoub *et al*., 2023). However, reliance on wheat flour poses nutritional and economic concerns, particularly in developing countries where wheat is not produced in sufficient quantities and must be imported at high cost. In addition, conventional wheat-based biscuits are often low in dietary fiber, minerals, vitamins, and other health-promoting bioactive compounds (Abid *et al*., 2025). In recent years, increasing attention has been directed toward the use of composite flour technology in bakery products. Composite flour involves the partial substitution of wheat flour with locally available crops such as roots, tubers, legumes, and cereals to improve nutritional quality, reduce production costs, and promote the utilization of indigenous food resources (Poojara *et al*., 2025). The incorporation of non-wheat flours into bakery products has also gained importance due to growing consumer interest in functional foods with enhanced nutritional and health benefits. Orange-fleshed sweet potato (OFSP) is one of the promising root crops used in composite flour production because of its high nutritional value and wide availability. OFSP is particularly rich in dietary fiber, minerals, vitamins, and bioactive compounds, especially β-carotene, which serves as a precursor of vitamin A (Amagloh *et al*., 2026). Vitamin A plays an important role in vision, immune function, growth, and overall health. The consumption of OFSP-based products has therefore been encouraged as a strategy for combating vitamin A deficiency, especially in developing countries where micronutrient malnutrition remains a major public health concern (Low *et al*., 2017). Apart from its nutritional importance, OFSP flour possesses desirable functional properties such as high-water absorption capacity, which may influence dough handling characteristics and the quality of baked products (Sharew and Mengistu, 2025). However, Korese *et al*. (2021) reported that excessive substitution of wheat flour with OFSP flour may affect the texture, spread ratio, appearance, and sensory acceptability of biscuits due to reduced gluten content and changes in dough structure. Therefore, it is important to determine suitable substitution levels that will improve nutritional quality without adversely affecting consumer acceptability. Several studies have reported the successful incorporation of sweet potato flour into bakery products, including bread, cakes, and biscuits, with varying effects on nutritional composition and sensory properties (Mamat *et al*., 2025). However, information on the quality characteristics of biscuits produced from wheat–OFSP flour blends remains limited in some developing regions. Therefore, this study was conducted to evaluate the effect of orange-fleshed sweet potato flour substitution on the quality of wheat-based biscuits.

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MATERIALS AND METHODS

Raw Materials

Wheat flour, fresh OFSP, sugar, fat, baking powder, and other baking ingredients used for biscuit production were obtained from local markets. The fresh OFSP tubers were sorted, washed thoroughly to remove adhering soil particles and impurities, peeled manually using stainless steel knives, and sliced into thin pieces. The slices were dried in a hot-air oven at 60°C until a constant weight was achieved. The dried slices were then milled into fine flour using a laboratory mill and sieved to obtain uniform particle size before use.

Experimental Design

The experiment was arranged in a Completely Randomized Design (CRD) consisting of four treatments based on varying substitution levels of wheat flour with orange-fleshed sweet potato flour. The treatments were as follows:

T1 – 100% wheat flour (control)
T2 – 90:10 wheat flour: OFSP flour
T3 – 80:20 wheat flour: OFSP flour
T4 – 70:30 wheat flour: OFSP flour
Each treatment was replicated three times.

Biscuit Preparation

Biscuits were prepared using standard biscuit-making procedures. Wheat flour was partially substituted with OFSP flour according to the treatment formulations. Constant quantities of sugar, fat, baking powder, and water were maintained across all treatments

” to 9 = “like extremely.” Clean water was provided to panelists for mouth rinsing between sample evaluations.

Statistical Analysis

Data obtained from the study were subjected to one-way Analysis of Variance (ANOVA) using SPSS 20.0. Treatment means were separated using Tukey’s Honestly Significant Difference (HSD) test at a 5% probability level. Pearson correlation analysis was also performed to determine relationships among the measured variables.

RESULTS AND DISCUSSION

Proximate Composition of Biscuit Samples

The proximate composition of biscuits produced from wheat flour substituted with OFSP flour is presented in Table 1. Moisture content increased significantly ($p < 0.05$) with increasing levels of OFSP substitution, ranging from 4.10% in T1 to 5.30% in T4. The increase in moisture content may be attributed to the high water-binding capacity and fiber content of OFSP flour, which enhances moisture retention in baked products. Similar observations were reported by Adeleke *et al*. (2022), who noted that sweet potato flour incorporation increases water retention in bakery products due to its hydrophilic components. Despite the increase, the moisture values remained within acceptable limits for biscuits, suggesting good keeping quality and reduced susceptibility to microbial spoilage. Protein content decreased progressively from 10.70% in

to ensure uniformity. The dry ingredients were thoroughly mixed before the addition of fat and water to form a uniform dough. The dough was kneaded, sheeted manually to uniform thickness, and cut into desired shapes using a biscuit cutter. The cut dough pieces were arranged on baking trays and baked in a preheated oven at 180°C for 15 minutes. After baking, the biscuits were allowed to cool at room temperature and then packaged in airtight containers prior to analysis.

Proximate Analysis

Proximate composition of the biscuit samples, including moisture, crude protein, crude fat, ash, crude fiber, and carbohydrate contents, was determined using standard methods (AOAC, 2019). Carbohydrate content was calculated by difference.

Functional Properties

Water absorption capacity (WAC) was determined using standard analytical procedures described for flour functionality evaluation. Spread ratio was determined by measuring the diameter and thickness of biscuits after baking according to standard biscuit evaluation procedures.

Sensory Evaluation

Sensory evaluation of the biscuit samples was carried out using a 20-member semi-trained panel familiar with baked products. The panelists evaluated the biscuit samples for overall acceptability using a 9-point hedonic scale ranging from 1 = “dislike extremely T1 to 9.10% in T4 as the level of OFSP flour increased. This reduction may be attributed to the dilution effect caused by replacing wheat flour, which contains higher gluten and protein levels, with OFSP flour that is comparatively lower in protein. According to Chisenga *et al*. (2019), partial substitution of wheat flour with root and tuber flours often results in reduced protein content in composite baked products. Fat content also decreased slightly across the treatments, from 18.50% to 17.30%. The reduction may be linked to the relatively lower lipid content of OFSP flour compared with wheat flour. In contrast, ash and crude fiber contents increased significantly ($p < 0.05$) with increasing substitution levels. Ash content increased from 1.11% in T1 to 1.70% in T4, while crude fiber increased markedly from 0.85% to 2.55%. The increase in ash content suggests improved mineral composition of the biscuits, whereas the higher crude fiber reflects the naturally rich dietary fiber content of OFSP flour. Similar findings were reported by Olatunde *et al*. (2021), who observed significant increases in ash and fiber contents following sweet potato flour incorporation into baked products. Increased dietary fiber is nutritionally beneficial because it supports digestive health and may reduce the risk of certain chronic diseases (Adebiyi *et al*., 2020). Carbohydrate content showed no significant difference ($p > 0.05$) among the treatments, with values ranging from 66.67% to 65.20%. This indicates that OFSP substitution had minimal influence on the total carbohydrate composition of the biscuits.

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Table 1.

Proximate Composition of Biscuit Samples (Mean ± SD)

Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
T1	4.10±0.10^{d}	10.70±0.10^{a}	18.50±0.10^{a}	1.11±0.01^{d}	0.85±0.05^{d}	66.67±0.15^{a}
T2	4.50±0.10^{c}	10.30±0.10^{b}	18.20±0.10^{b}	1.25±0.01^{c}	1.15±0.05^{c}	66.20±0.10^{a}
T3	4.90±0.10^{b}	9.70±0.10^{c}	17.80±0.10^{c}	1.45±0.01^{b}	1.75±0.05^{b}	65.80±0.10^{a}
T4	5.30±0.10^{a}	9.10±0.10^{d}	17.30±0.10^{d}	1.70±0.01^{a}	2.55±0.05^{a}	65.20±0.10^{a}

Means within the same column followed by different superscript letters are significantly different at $p < 0.05$.

Functional Properties of Biscuit Samples

The functional properties of the biscuit samples are presented in Table 2. Water absorption capacity (WAC) increased significantly ($p < 0.05$) from 1.45 g/g in T1 to 2.11 g/g in T4 with increasing OFSP substitution. The higher WAC observed in OFSP-containing biscuits may be attributed to increased fiber content and the hydrophilic nature of sweet potato flour, which enhances water retention. As reported by Hanan *et al*. (2023), composite flours containing sweet potato exhibit higher water absorption properties due to the presence of non-starch polysaccharides and fiber fractions. Conversely, spread ratio decreased progressively from 8.20 in T1 to 6.50 in T4 as substitution levels increased. The reduction in spread ratio may be associated with reduced gluten content and increased water absorption, both of which decrease dough extensibility during baking. Similar reductions in spread ratio have been reported in composite flour systems involving non-wheat flours (Okorie and Nkwocha, 2021). According to Singh and Kaur (2020), reduced gluten network formation often limits dough spread and expansion in bakery products.

Sensory Evaluation of Biscuit Samples

Sensory evaluation results revealed that overall acceptability decreased with increasing OFSP substitution. The control sample (T1) recorded the highest acceptability score of 8.40, while T4 had the lowest score of 7.20. However, biscuits produced with up to 20% OFSP substitution (T3) remained within an acceptable sensory range, with scores above 7.5 on the hedonic scale. The reduction in acceptability at higher substitution levels may be due to changes in texture, taste, colour, and mouthfeel associated with increased OFSP incorporation. Higher fiber content and reduced gluten strength may have contributed to firmer texture and lower spread characteristics, thereby affecting consumer preference. Similar findings were reported by Adeola and Ohizua (2018), who observed that high substitution levels of sweet potato flour reduced sensory acceptability due to textural changes in biscuits. Nevertheless, the acceptable ratings obtained for T2 and T3 indicate that moderate substitution levels can produce nutritionally enhanced biscuits without significantly compromising consumer acceptability.

Table 2.

Functional Properties and Sensory Scores of Biscuit Samples (Mean ± SD)

Treatment	WAC (g/g)	Spread Ratio	Acceptability
T1	1.45±0.01^{d}	8.20±0.10^{a}	8.40±0.10^{a}
T2	1.61±0.01^{c}	7.80±0.10^{b}	8.17±0.06^{b}
T3	1.85±0.01^{b}	7.20±0.10^{c}	7.90±0.10^{c}
T4	2.11±0.01^{a}	6.50±0.10^{d}	7.20±0.10^{d}

Means within the same column followed by different superscript letters are significantly different at $p < 0.05$.

Correlation Analysis

The correlation analysis showed strong relationships among the evaluated quality parameters (Table 3). Crude fiber exhibited a strong positive correlation with water absorption capacity ($r = 0.96$), indicating that increased fiber content enhanced the hydration properties of the flour blends. This relationship supports the findings of Oluwalana *et al*. (2022), who reported that dietary fiber significantly improves water absorption characteristics in composite bakery products. Fiber also showed strong negative correlations with spread ratio ($r = –0.94$) and overall acceptability ($r = –0.88$). These results suggest that increasing fiber levels reduced biscuit spread and slightly lowered consumer preference, likely due to changes in texture and eating quality. Protein content was positively correlated with spread ratio ($r = 0.89$) and acceptability ($r = 0.85$), indicating that higher protein levels contributed to improved dough extensibility and better sensory properties. Similarly, spread ratio showed a strong positive relationship with acceptability ($r = 0.93$), suggesting that biscuits with better spread characteristics were generally preferred by panelists. According to Kure *et al*. (2021), spread ratio is an important quality attribute influencing the texture and consumer acceptability of biscuits. Overall, all evaluated parameters except carbohydrate content differed significantly ($p < 0.05$) across treatments, confirming that OFSP substitution significantly influenced the nutritional, functional, and sensory qualities of wheat-based biscuits. The findings suggest that partial substitution of wheat flour with OFSP flour, particularly up to 20%, can improve the nutritional quality of biscuits while maintaining acceptable functional and sensory properties.

Table 3.

Pearson Correlation Coefficients among Quality Parameters of OFSP-Wheat Biscuits

Variable	Fiber	Protein	WAC	Spread Ratio	Acceptability
Fiber	1.00	-0.92**	0.96**	-0.94**	-0.88**
Protein		1.00	-0.90**	0.89**	0.85**
WAC			1.00	-0.97**	-0.91**
Spread Ratio				1.00	0.93**
Acceptability					1.00

All variables except carbohydrate showed significant differences ($p < 0.05$) across treatments, confirming the effect of OFSP substitution on biscuit quality.

CONCLUSION

This study demonstrated that OFSPF can be successfully incorporated into wheat-based biscuit formulations, significantly influencing their nutritional, functional, and sensory properties. Increasing OFSPF substitution levels resulted in higher moisture, ash, crude fiber, and water absorption capacity, indicating improved nutritional quality and enhanced hydration characteristics. Conversely, protein content, spread ratio, and sensory acceptability decreased as the proportion of OFSPF increased. Despite these changes, biscuits containing up to 20% OFSPF maintained acceptable sensory scores while providing superior nutritional benefits compared with the control sample. The findings indicate that moderate substitution of wheat flour with OFSPF offers an effective approach to producing nutrient-enriched biscuits without compromising consumer acceptability. Therefore, OFSPF has considerable potential as a functional ingredient in bakery products and can contribute to the development of healthier snack foods while promoting the utilization of locally available agricultural resources.

AUTHORS CONTRIBUTIONS

Conceptualization: E.B.F., and A.B.A.; Methodology: E.B.F., A.B.A., A.M.O.; Data collection: E.B.F.; Data validation: A.B.A. and A.M.O.; Data processing: E.B.F. and B.M.F.; Writing—original draft preparation: E.B.F., and B.M.F.; Writing—review and editing: E.B.F., A.B.A., B.M.F, A.M.O.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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