



Nutritional Composition, Amino Acid Profile and Sensory Acceptability of Biscuits Produced from Wheat, Walnut and Orange-Fleshed Sweet Potato Flour Blends

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ABSTRACT

This work examined how blending wheat flour with walnut and orange-fleshed sweet potato (OFSP) flours affects the nutrient content, amino acid makeup, and sensory appeal of biscuits. Four biscuit formulations were prepared: a 100% wheat-flour control alongside 80:10:10, 60:20:20, and 40:30:30 wheat–walnut–OFSP blends. Nutrient composition was assessed through proximate analysis, amino acids were quantified by High-Performance Liquid Chromatography (HPLC), and consumer acceptance was evaluated sensorially, all following standard procedures. As the level of substitution rose, fibre, fat, ash, and energy values all increased significantly, and the essential amino acids lysine, methionine, and tryptophan were markedly higher in the composite biscuits than in the control. On sensory testing, the blend containing 80% wheat, 10% walnut, and 10% OFSP flour was rated as acceptable as the control. These findings indicate that moderate substitution with walnut and OFSP flours can boost the nutritional value of biscuits without sacrificing consumer acceptability.

Keywords: Composite flour, Walnut flour, Biscuits fortification, Amino acid profile, Sensory evaluation

1.0 INTRODUCTION

Biscuits rank among the most popular bakery items, prized for their convenience, extended shelf life, and pleasant eating qualities. Wheat flour remains the standard ingredient in biscuit-making because its gluten forms the structure and texture that consumers expect (Wang *et al.*, 2016). Orange-fleshed sweet potato (OFSP, *Ipomoea batatas* (L.) Lam) has been reported as a biofortification strategy for addressing vitamin A deficiency in several studies (Laurie *et al.*, 2018). It is rich in β -carotene, a precursor of vitamin A, and contains significant levels of protein, fiber, and minerals (Islam *et al.*, 2016). Walnuts (*Juglans regia* L.) are extensively consumed, and their industrialization is growing every year. Walnut flour presents a high level of polyunsaturated lipids, and it is a source of proteins, fibre, minerals, and other minor bioactive compounds (Burbano & Correa, 2021).

Although several studies have examined the incorporation of sweet potato, legumes and nut-based ingredients into wheat-based bakery products, relatively limited information is available on the combined use of walnut and orange-fleshed sweet potato (OFSP) flours in biscuit formulations, particularly with respect to their effects on amino acid composition and sensory acceptability. Previous studies have largely focused on single-substitution systems or combinations involving legumes and other tubers. The combined incorporation of walnut, a protein- and lipid-rich ingredient, with OFSP, a carotenoid-rich tuber, may provide complementary nutritional benefits; however, increasing substitution may also alter the technological and sensory properties

of biscuits (Xie *et al.*, 2022). Therefore, this study evaluated the proximate composition, amino acid profile and sensory acceptability of biscuits produced from graded wheat–walnut–OFSP flour blends to identify a formulation that provides an appropriate balance between nutritional improvement and consumer acceptability.

2.0 MATERIALS AND METHODS

2.1 Purchase of materials

Wheat flour and walnuts (*Juglans regia* L.) were purchased from Minna Central Market in Niger State, Nigeria. OFSP tubers (*Ipomoea batatas* (L.) Lam) UMUSPO3 variety, locally referred to as 'Mother's Delight' were obtained from Eko Farms, Ijebu Ode, Ogun State, Nigeria, it was then stored under ambient temperature in the laboratory for 2 days prior to its processing. Other items such as sugar, butter, eggs, baking powder, and salt were sourced locally as additional ingredients. All chemicals used in the analyses were of analytical grade.

All laboratory work was carried out in the Dry Food Processing Laboratory of the Department of Food Science and Technology, Faculty of Physical Sciences, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.

2.2 Preparation of Flours

2.2.1 Preparation of orange-fleshed sweet potato (OFSP) flour

OFSP flour was prepared following the procedure of Chikpah *et al.* (2020), with minor adjustments. Sound OFSP roots were selected manually by sorting, trimmed, and hand-washed, then peeled and cut into

uniform 3 mm slices with an electric slicer. Sliced pieces were dipped in a 5 g/L sodium metabisulfite solution for 5 minutes and left to drain for a further 5 minutes. Roughly 300 g of the treated slices was arranged as a single layer on perforated trays and dried in a cabinet dryer at 60 °C. The dried flour was sealed in high-density polyethylene bags and held in a dry cabinet at 25 °C ± 2 until all the drying was done.

2.2.2 Preparation of walnut flour

Walnut flour was prepared following the method of Offia-Olua (2014). Whole walnuts were washed thoroughly to eliminate surface debris, then boiled in a steel pot for 30 minutes to loosen the shells for

removal. The deshelled kernels were cut into smaller pieces with a stainless-steel knife, blanched in hot water for 5 minutes, and drained. The blanched walnuts were subsequently dried in a hot-air oven at 60 °C for 5 hours until the moisture was removed, after which the dried kernels were milled and sieved into walnut flour.

2.2.3 Composite Flour Formulation

Composite biscuits were formulated by combining wheat flour with walnut and OFSP flours on the basis of dry weight/weight fractions in the ratios presented in Table 1.

Table 1: Formulation Table for the Production of Biscuits

Samples	Wheat flour (%)	Walnut flour (%)	OFSP (%)
A	100	0	0
B	80	10	10
C	60	20	20
D	40	30	30

2.2.4 Biscuits production

Composite biscuits were produced using the procedure of Bakare *et al.* (2020), with minor modification, applied to the 100:0:0, 80:10:10, 60:20:20, and 40:30:30 blends of wheat flour, walnut flour, and OFSP flour. Sugar (15 g) and margarine (22 g) were creamed together in a mixer at medium speed for approximately 12 minutes until light and fluffy. Milk (10 ml), flour (100 g), baking powder (5 g), and vanilla flavour (5 g) were then incorporated and mixed for a further 5 minutes to form a stiff dough. The dough was rolled out on a lightly floured board to a uniform thickness of about 3.27 mm using a domestic roller, cut into 6.4 cm circular biscuits, arranged on greased baking trays, and baked at 160 °C for 15 min.

2.3 Determination of Proximate Composition

Moisture (AOAC method 925.10), crude protein (AOAC method 2001.11), crude fat (AOAC method 920.39), ash (AOAC method 923.03), and crude fibre (AOAC method 962.09) contents of the samples were determined as percentages following standard official analytical procedures (AOAC, 2000). Carbohydrate content of the samples was determined using the by-difference method while energy value of the samples was calculated using the general Atwater general factor system (Atwater formula = $4.0 \times \% \text{Protein} + 9.0 \times \% \text{Fat} + 4.0 \times \% \text{Carbohydrate}$).

2.4 Determination of Amino Acid Profile

The amino acid profile of each sample was determined by the HPLC-Pico-Tag procedure (AOAC method 982.30) outlined in AOAC (2005), with the indispensable amino acid (IAA) chemical score (A.S) calculated as: IAA content (g/100 g) of the test protein $\times 100$, divided by the IAA content (g/100 g) of the FAO/WHO (1991) reference protein pattern.

2.5 Sensory Evaluation

Sensory acceptability was assessed with a 9-point Hedonic scale by a panel of twenty student judges from the Department of Food Science and Technology, Ibrahim Badamasi Babangida University, Lapai, Niger State, selected on the basis of their familiarity with biscuit products. Samples were served individually on disposable trays, and judges rated colour, texture, aroma, taste, and overall acceptability. Scores were subjected to one-way ANOVA ($n=20$) in SPSS version 23.0, with $p < 0.05$ taken as the threshold for significance.

The 9-point Hedonic scale was represented as:

9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely (Ihekoronye and Ngoddy, 1985).

2.6 Statistical Analysis

All measurements were performed in triplicate ($n=3$) and expressed as mean $\pm$ standard deviation (SD). Differences among sample means were tested for statistical significance using one-way ANOVA at $p < 0.05$, and Duncan's multiple-range test (DMRT) was used for mean separation. All analyses were carried out in SPSS version 23.0 (SPSS Inc., Chicago, IL, USA).

3.0 RESULTS AND DISCUSSION

3.1 Proximate Composition

Table 2 presents the proximate composition of the wheat–walnut–OFSP composite biscuits, with most parameters differing significantly ($p < 0.05$) among samples. Moisture content spanned 8.45% in the 100% wheat–flour biscuits to 8.79% in the 60:20:20 wheat–walnut–OFSP blend. Despite the absence of a significant difference ($p > 0.05$) among samples, the marginally higher moisture recorded for the 40:30:30

blend may reflect the hygroscopic character of OFSP, which holds onto moisture during baking. Because moisture stayed below 10% in every sample, the biscuits can be expected to store well with minimal risk of microbial spoilage. This is consistent with Adeola and Ohizua (2018), who reported moisture levels of 7.9–9.5% in composite biscuits containing plantain, tiger nut, and soybean flours, and with the findings of Ezegbe *et al.* (2023), who found velvet-bean-fortified biscuits retained moisture below 5%, favouring shelf stability.

Ash content showed only a modest rise, from 2.12% in the wheat-only biscuits to 2.31% in the 60:20:20 blend. Even though this change was not statistically significant ($p>0.05$), the upward trend with increasing substitution suggests mineral enrichment from walnut and OFSP, both good sources of calcium, potassium, and iron. Ndife *et al.* (2014) reported a comparable rise in ash content (1.8–2.5%) for wheat–plantain biscuits, reflecting the mineral contribution of composite flours, as did Oluwamukomi *et al.* (2011), who found that blending wheat with cassava and soy flours significantly raised ash content, pointing to greater micronutrient availability.

Fibre content rose significantly ($p<0.05$), from 1.60% in the wheat-only control to 3.15% in the 40:30:30 blend, climbing steadily with each increase in substitution; the 80:10:10 and 60:20:20 blends recorded 2.00% and 2.60%, respectively. This progressive rise reflects the naturally high fibre and cellulose content of both walnut and OFSP. Fibre-rich biscuits of this kind can support digestive health and help guard against constipation. A similar pattern was reported by Eke-Ejiofor and Deedam (2015), who found fibre content climbing from 1.2% to 3.0% as sweet potato flour inclusion increased, and by Adegunwa *et al.* (2014), who observed a marked fibre increase in soybean-flour-enriched biscuits that improved both their nutritional and functional quality.

Fat content increased significantly ($p<0.05$), from 1.80% in the wheat-only biscuits to 15.40% in the 40:30:30 blend, with the 80:10:10 and 60:20:20 blends recording intermediate values of 6.85% and 11.40%, respectively. This rise tracks directly with the oil-rich walnut flour, which supplies substantial unsaturated fatty acids and natural oils. The elevated fat levels in

the 60:20:20 and 40:30:30 blends contributed to richer flavour, texture, and caloric value. Shydakova-Kameniuka *et al.* (2025) similarly reported higher fat content in nut-flour-supplemented biscuits relative to 100% wheat, attributing the effect to oil from the nuts, and Adeola and Ohizua (2018) recorded a comparable fat increase, from 2.6% to 13.5%, in plantain–soybean composite biscuits.

Protein content ranged from 10.95% in the 40:30:30 blend to 12.60% in the 60:20:20 blend, with the wheat-only control (12.54%) and the 80:10:10 blend (11.45%) recording intermediate values. Notably, the 60:20:20 blend gave the highest protein content, possibly because this ratio offers the best complementation of amino acids from the three flours. The slightly lower value in the 40:30:30 blend may stem from a dilution effect, since wheat gluten protein declines as substitution increases. Adegunwa *et al.* (2014), who reported protein enrichment in legume-based composite biscuits, with values rising to 14.2% against 9.8% in the pure wheat control.

Carbohydrate content fell significantly ($p<0.05$), from 73.49% in the wheat-only biscuits to 59.73% in the 40:30:30 blend, with intermediate values of 68.90% and 62.32% for the 80:10:10 and 60:20:20 blends, respectively. This decline mirrors the displacement of carbohydrate-dense wheat flour by fat- and fibre-rich walnut and OFSP flours, and a lower carbohydrate content could translate to a reduced glycaemic index that benefits individuals managing diabetes. Ezegbe *et al.* (2023) reported a comparable decline (69% to 63%) with velvet bean flour inclusion, and Adeola and Ohizua (2018) likewise found that substituting wheat with legume flours significantly lowered carbohydrate levels, reinforcing the trend observed here.

Energy values climbed steadily with substitution, from 360.31 kcal/100g in the wheat-only biscuits to 421.31 kcal/100g in the 40:30:30 blend, with the 80:10:10 and 60:20:20 blends recording 383.03 kcal/100g and 402.25 kcal/100g, respectively. This consistent rise reflects the added fat from walnut flour, which supplies about 9 kcal/g compared with roughly 4 kcal/g from carbohydrate or protein. Oluwamukomi *et al.* (2011) similarly found that soybean-flour enrichment raised the caloric value of biscuits through its higher fat contribution.

Table 2: Proximate Composition of Biscuits from Blends of Wheat, Walnut, and Orange-Fleshed Sweet Potato (OFSP) Flour.

Samples	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	Protein (%)	CHO (%)	Energy (Kcal/g)
A	8.45 ^a ±0.08	2.12 ^a ±0.01	1.60 ^a ±0.14	1.80 ^a ±0.42	12.54 ^b ±0.60	73.49 ^c ±1.10	360.31 ^a ±1.82
B	8.58 ^a ±0.74	2.23 ^a ±0.16	2.00 ^a ±0.14	6.85 ^b ±0.07	11.45 ^{ab} ±0.14	68.90 ^b ±0.37	383.03 ^b ±1.40
C	8.79 ^a ±0.25	2.31 ^a ±0.28	2.60 ^b ±0.00	11.40 ^c ±0.14	12.60 ^b ±0.12	62.32 ^a ±0.30	402.25 ^c ±0.56
D	8.52 ^a ±0.01	2.26 ^a ±0.06	3.15 ^c ±0.07	15.40 ^d ±0.42	10.95 ^a ±0.06	59.73 ^a ±0.64	421.31 ^d ±1.51



Mean with the same superscript in the same column are not significantly different at ($p < 0.05$).

KEY:

CHO = Carbohydrate

A = Biscuits produced from 100% wheat flour

B = Biscuits produced from 80% wheat flour, 10% walnut flour and 10% OFSP

C = Biscuits produced from 60% wheat flour, 20% walnut flour and 20% OFSP

D = Biscuits produced from 40% wheat flour, 30% walnut flour and 30% OFSP

3.2 Amino Acid Composition of Biscuits made from Blends of Wheat, Walnut, and Orange-Fleshed Sweet Potato (OFSP) flour.

Table 3 shows the amino acid composition of the composite biscuits, which differed significantly ($p < 0.05$) across all samples. Lysine rose significantly, from 2.64 g/100g in the wheat-only biscuits to 3.76 g/100g in the 40:30:30 blend, with the 80:10:10 and 60:20:20 blends giving intermediate values of 3.17 and 3.54 g/100g, respectively. This increase tracks the growing proportion of walnut and OFSP flours, both good lysine sources, and helps offset the lysine deficiency characteristic of wheat. The trend echoes Adeola and Ohizua (2018), who reported rising lysine levels in soybean–plantain composite biscuits, and Sengeve *et al.* (2015), who found elevated lysine in wheat–legume blends that improved overall protein quality.

Methionine content rose from 2.32 g/100g in the wheat-only biscuits to 4.93 g/100g in the 40:30:30 blend. As a sulfur-containing amino acid, its increase reflects the higher sulfur-amino-acid content of walnut relative to wheat, corroborating the observation of Oluwamukomi *et al.* (2011) that soybean-flour composite biscuits carried improved methionine levels, a finding echoed by Ndife *et al.* (2014), who likewise found elevated methionine in plantain–soy composite biscuits, pointing to improved protein balance.

A similar pattern was seen for threonine, which rose from 1.87 g/100g in the wheat-only biscuits to 4.41 g/100g in the 40:30:30 blend. The marked gains in the 60:20:20 and 40:30:30 blends underline the complementary amino acid contribution of walnut and OFSP. Adegunwa *et al.* (2014) similarly reported significant threonine improvement in soybean-enriched biscuits.

Isoleucine values obtained ranged from 1.04 g/100g to 4.97 g/100g with 40:30:30 blend having the highest value (4.97 g/100g) while 80:10:10 blend had the lowest value (1.04 g/100g), and leucine values also ranged from 2.65 g/100g to 4.13 g/100g across the samples respectively, comparing the wheat-only control with the 40:30:30 blend. Both are branched-chain amino acids important for muscle metabolism and tissue repair, and their higher levels in the 60:20:20 and 40:30:30 blends point to nutritional gains from walnut inclusion, consistent with Wabali (2022), who

reported that walnut fortification significantly boosted branched-chain amino acid content in biscuits.

Phenylalanine ranged from 1.77 g/100g in both the wheat-only control and 80:10:10 blends to 3.84 g/100g in the 40:30:30 blend, while valine rose from 2.87 g/100g to 4.17 g/100g over the same comparison. Both amino acids are important for protein synthesis and nervous-system function, and these gains align with Adeola and Ohizua (2018), who found comparable improvements with soybean and tiger-nut flour enrichment — a further indication that nut inclusion enhances the aromatic amino acid profile of baked products.

Tryptophan rose from 2.77 to 5.11 g/100g, histidine from 2.96 to 6.45 g/100g, and arginine from 2.33 to 4.96 g/100g, comparing the wheat-only control with the 40:30:30 blend. The particularly high histidine and arginine values in the 40:30:30 blend reflect walnut's contribution, since both amino acids are abundant in nuts, a finding consistent with Sengeve *et al.* (2015) found similar amino acid enhancement in wheat–soybean blends, and with Adeola and Ohizua (2018), who found that composite biscuits showed better arginine and tryptophan profiles than 100% wheat biscuits.

Serine rose from 1.88 to 6.78 g/100g, cysteine from 0.88 to 3.97 g/100g, and tyrosine from 2.83 to 3.82 g/100g and then dropped to 3.82 g/100g in 60:20:20 blend before rising again to 3.65 g/100g in 40:30:30 blend, comparing the wheat-only control with the 40:30:30 blend. All three contribute to enzyme formation and antioxidant activity, and their rise here is attributable to the high sulfur and aromatic amino acid content of walnut. Ndife *et al.* (2014) reported a similar rise when nuts or legumes were incorporated into wheat-based formulations.

Alanine values obtained followed an increasing pattern from 1.98 g/100g to 2.15 g/100g between the wheat-only control, 80:10:10 and 60:20:20 blends and then a sharp decline was observed in 40:30:30 blend; aspartic acid varied from 2.46–3.35 g/100g within the blends, it increased from 2.46 g/100g in wheat-only control to 3.35 g/100g in 80:10:10 blend and then further maintained a decline between 60:20:20 and 40:30:30 blends (2.91 g/100g); and glutamic acid rose from 1.61 g/100g to 2.11 g/100g between the wheat-only control and 80:10:10 blend, then a sharp decline was observed in 60:20:20 (1.61 g/100g) blend followed by an increase in 40:30:30 blend (2.11 g/100g), this shows

a haphazard behaviour within the values obtained. Together these amino acids shape flavour and palatability, and the modest increases observed likely enhance taste, since glutamic acid underlies umami flavour. This is consistent with Adegunwa *et al.* (2014), who found protein fortification improved amino-acid-derived flavour precursors in biscuits, and Adeola and Ohizua (2018), who likewise recorded elevated glutamic acid in composite flours.

Glycine remained fairly constant across samples, ranging from 1.81 to 1.86 g/100g, whereas proline increased markedly, from 1.51 g/100g in the wheat-only control to 4.37 g/100g in the 40:30:30 blend. Proline influences biscuit structure and texture through its effect on gluten network formation, and the elevated level in the 40:30:30 blend may stem from walnut's

substantial protein fraction. Oluwamukomi *et al.* (2011), who found that soybean-flour composite biscuits had improved texture linked to higher proline content.

The 40:30:30 blend recorded the highest values for nearly every amino acid measured, pointing to superior protein and overall nutritional quality. The steady improvement seen from the wheat-only control through to the 40:30:30 blend illustrates the synergy achieved by combining a cereal (wheat), a legume-like nut (walnut), and a tuber (OFSP), yielding a more balanced amino acid profile overall. This supports the conclusions of Adeola and Ohizua (2018) and Sengeev *et al.* (2015), both of whom highlighted the nutritional benefit of composite flours in developing protein-enriched bakery products.

Table 3: Amino acid composition of biscuits made from blends of wheat, walnut and orange-fleshed sweet potato (OFSP) flours

Amino acids	Sample A	Sample B	Sample C	Sample D
Lysine	2.64 ^d ± 0.02	3.17 ^c ± 0.01	3.54 ^b ± 0.01	3.76 ^a ± 0.01
Methionine	2.32 ^d ± 0.01	3.12 ^c ± 0.01	4.86 ^b ± 0.01	4.93 ^a ± 0.01
Threonine	1.87 ^d ± 0.02	2.66 ^c ± 0.01	3.75 ^b ± 0.01	4.41 ^a ± 0.01
Isoleucine	1.78 ^c ± 0.01	1.04 ^d ± 0.01	4.01 ^b ± 0.01	4.97 ^a ± 0.01
Leucine	2.65 ^c ± 0.02	2.65 ^c ± 0.02	3.25 ^b ± 0.01	4.13 ^a ± 0.01
Phenylalanine	1.77 ^c ± 0.01	1.77 ^c ± 0.01	3.75 ^b ± 0.00	3.84 ^a ± 0.01
Valine	2.87 ^c ± 0.02	2.87 ^c ± 0.02	3.87 ^b ± 0.01	4.17 ^a ± 0.01
Tryptophan	2.77 ^d ± 0.02	3.26 ^c ± 0.01	3.72 ^b ± 0.01	5.11 ^a ± 0.01
Histidine	2.96 ^d ± 0.01	3.86 ^c ± 0.01	4.54 ^b ± 0.02	6.45 ^a ± 0.00
Arginine	2.33 ^d ± 0.02	3.32 ^c ± 0.01	3.62 ^b ± 0.01	4.96 ^a ± 0.01
Serine	1.88 ^d ± 0.01	2.45 ^c ± 0.00	2.80 ^b ± 0.01	6.78 ^a ± 0.01
Cysteine	0.88 ^{cd} ± 0.01	0.98 ^c ± 0.01	1.56 ^b ± 0.01	3.97 ^a ± 0.01
Tyrosine	2.83 ^d ± 0.02	3.82 ^a ± 0.01	3.23 ^c ± 0.01	3.65 ^b ± 0.01
Alanine	1.98 ^c ± 0.01	2.15 ^b ± 0.00	2.80 ^a ± 0.01	2.15 ^b ± 0.00
Aspartic acid	2.46 ^a ± 0.02	3.35 ^a ± 0.01	2.91 ^a ± 0.02	2.91 ^a ± 0.02
Glutamic acid	1.61 ^b ± 0.01	2.11 ^a ± 0.01	1.61 ^b ± 0.01	2.11 ^a ± 0.01
Glycine	1.81 ^{bc} ± 0.02	2.05 ^a ± 0.01	1.86 ^b ± 0.03	1.86 ^b ± 0.03
Proline	1.51 ^d ± 0.02	2.18 ^c ± 0.01	2.72 ^b ± 0.02	4.37 ^a ± 0.00
TEAA	21.63	24.40	35.29	41.77
TNAA	17.29	22.41	23.11	32.76
Hydrophilic	9.27	11.96	13.20	20.67
Hydrophobic	14.37	16.86	26.26	33.06
Basic	7.93	10.35	11.70	15.17
Acidic	4.07	5.46	4.52	5.02

Mean with the same superscript in the same row are not significantly different at ($p < 0.05$).

KEY:

A = Biscuits produced from 100% wheat flour

B = Biscuits produced from 80% wheat flour, 10% walnut flour and 10% OFSP flour

C = Biscuits produced from 60% wheat flour, 20% walnut flour and 20% OFSP flour

D = Biscuits produced from 40% wheat flour, 30% walnut flour and 30% OFSP flour

TEAA = Total Essential Amino acids = tryptophan + histidine + leucine + isoleucine + phenylalanine + valine + lysine + methionine + threonine; TNAA = Total Non-essential Amino Acids = arginine + alanine + aspartic acid + glutamic acid + glycine + tyrosine + cysteine + proline + serine; Hydrophobic amino acids = tryptophan + leucine + isoleucine + phenylalanine + valine + methionine + alanine + proline; Hydrophilic amino acids = threonine + glycine + tyrosine + cysteine

+ serine; Basic amino acids = histidine + lysine + arginine; Acidic amino acids = glutamic acid + aspartic acid.

3.3 Sensory Evaluation of Biscuits made from Blends of Wheat, Walnut, and Orange-Fleshed Sweet Potato (OFSP) Flour.

Table 4 presents the sensory evaluation results, showing how varying the ingredient ratio shaped

consumer preference. Mean colour scores ranged from 6.30 to 7.90, with the wheat-only control rated highest (7.90), followed by the 80:10:10 blend (7.40) and the 60:20:20 blend (6.70), while the 40:30:30 blend (6.30) scored lowest. The declining colour score with greater substitution reflects the darker pigmentation from walnut and the orange hue of OFSP, both of which depart from the familiar golden-brown of wheat biscuits, in line with the observations of Ubbor *et al.* (2022), who linked OFSP inclusion to darker colouration from β -carotene, and with Abedin (2026), who reported that soy flour and guava powder alter biscuit colour through Maillard browning and pigment intensity. Texture scores ranged from 5.30 to 7.30, with the 80:10:10 blend rated highest (7.30), followed by the wheat-only control (7.00) and the 40:30:30 blend (5.90), while the 60:20:20 blend scored lowest (5.30). The favourable texture of the 80:10:10 blend likely reflects a beneficial balance between wheat gluten and walnut oil that promotes crispiness, whereas greater substitution weakens the gluten network, producing denser, softer biscuits. Eke *et al.* (2019), who reported that excessive sprouted-soybean flour reduces crispiness through greater oil absorption and moisture retention. Taste scores ranged from 5.90 to 7.00: the 80:10:10 blend (7.00) was most preferred, the wheat-only control and the 40:30:30 blend tied at 6.50, and the 60:20:20 blend (5.90) was least liked. The pleasing

taste of the 80:10:10 blend is attributable to a balanced nutty note from walnut alongside the mild natural sweetness of OFSP, whereas at higher inclusion the 60:20:20 and 40:30:30 blends developed a stronger, earthier flavour from walnut, with the higher carotenoid concentration possibly reducing palatability. Ibrahim *et al.* (2022), who found that moderate OFSP substitution (10–20%) enhances flavour via natural sugars, and with Wirkijowska *et al.* (2025), who found that high nut inclusion can introduce bitterness from phenolic compounds. Aroma scores ranged from 6.70 to 7.60, with the 80:10:10 blend rated highest (7.60), followed by the wheat-only control (7.00) and the 40:30:30 blend (6.90), while the 60:20:20 blend (6.70) was least preferred. The stronger aroma of the 80:10:10 blend can be linked to volatile aromatic compounds from walnut combined with the natural sweet smell of OFSP, whereas higher substitution levels may promote lipid oxidation that dulls aroma. Kolawole *et al.* (2020), who found moderate OFSP addition enhances aroma through β -carotene derivatives, and with Oladele & Sogunle (2020), who reported that excessive nut flour reduces aroma acceptability through oxidative changes during baking. The consistently high ratings for the wheat-only biscuits (Sample A) may simply reflect the panelists' greater familiarity with conventional wheat-based biscuits.

Table 4: Sensory Evaluation of Biscuits Made from Blends of Wheat, Walnut, and Orange-Fleshed Sweet Potato (OFSP) Flours.

Sample	Color	Texture	Taste	Aroma	Overall Acceptability
A	7.90 ^a ± 0.99	7.00 ^{ab} ± 1.70	6.50 ^a ± 1.43	7.00 ^a ± 1.56	8.10 ^a ± 0.74
B	7.40 ^{ab} ± 1.08	7.30 ^a ± 0.48	7.00 ^a ± 1.76	7.60 ^a ± 1.27	7.20 ^{ab} ± 1.75
C	6.70 ^b ± 0.95	5.30 ^{cd} ± 1.30	5.90 ^a ± 1.59	6.70 ^a ± 1.42	6.10 ^{bc} ± 1.97
D	6.30 ^b ± 1.49	5.90 ^{bc} ± 1.29	6.50 ^a ± 1.58	6.90 ^a ± 1.59	5.80 ^{bc} ± 1.69

Mean with the same superscript in the same column are not significantly different at ($p < 0.05$).

KEY:

Sample A = Biscuits produced from 100% wheat flour

Sample B = Biscuits produced from 80% wheat flour, 10% walnut flour and 10% OFSP flour

Sample C = Biscuits produced from 60% wheat flour, 20% walnut flour and 20% OFSP flour

Sample D = Biscuits produced from 40% wheat flour, 30% walnut flour and 30% OFSP flour

4.0 CONCLUSION

This study shows that replacing part of the wheat flour with walnut and orange-fleshed sweet potato (OFSP) flours substantially improves the nutritional profile of biscuits, with fibre, fat, ash, and energy content all rising steadily as substitution increased. The amino acid data reinforce this picture, with essential amino acids such as lysine, methionine, and tryptophan significantly higher than in the 100% wheat control, lifting the overall protein quality of the composite biscuits. These nutritional gains were not without cost, however: carbohydrate content fell, and the higher substitution levels (60:20:20 and 40:30:30) produced darker colour, denser texture, and stronger flavour

notes that lowered consumer acceptability. The 80:10:10 wheat–walnut–OFSP blend struck the best overall balance, matching the control on colour, texture, taste, aroma, and overall acceptability while still delivering enhanced fibre, fat, protein, and amino acid content. This ratio therefore represents the most favourable compromise between nutritional improvement and consumer acceptance. Taken together, the findings confirm that blending wheat with walnut and OFSP flours is a viable and effective way to produce biscuits with improved amino acid levels and proximate composition without necessarily posing an effect on sensory quality, provided the optimum substitution level is utilized. Future work should

examine the shelf-life stability, cost-effectiveness, and glycaemic response of these composite biscuits, and confirm consumer acceptance across a larger, more diverse panel.

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