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Nutritional, Antinutritional, Functional and Organoleptic Properties of Cookies Produced from Composite Flours of Wheat (*Triticum Aestivum*), Pumpkin Seed (*Cucurbita Maxima*), and African Yam Bean (*Sphenostylis stenocarpa*)

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Abstract

Cookies are widely consumed bakery products, but conventional wheat-based cookies often lack essential nutrients. This study formulated and evaluated cookies produced from wheat, pumpkin seed, and African yam bean composite flour blends to enhance their nutritional value. The composite flours were prepared by incorporating varying proportions of pumpkin seed and African yam bean into wheat flour. Standard analytical methods were used to determine the proximate composition, antinutrient content, functional properties, amino acid profile, and sensory attributes of the cookies. Results showed that protein content significantly increased with the inclusion of pumpkin seed and African yam bean, with PAW4 (20% pumpkin seed + 40% African yam bean + 40% wheat flour) exhibiting the highest protein level (23.76%). Fiber and ash contents were also elevated, enhancing the nutritional profile. The composite cookies had lower trypsin inhibitor, tannin, and oxalate contents, improving digestibility. Functional properties, such as foaming and emulsification capacities, were enhanced, indicating suitability for bakery applications. Amino acid profiling revealed improved essential amino acid composition, particularly glutamic acid and leucine. Sensory evaluation showed that while composite cookies had slightly lower acceptability ratings than the 100% wheat control, they remained within acceptable limits. Incorporating pumpkin seed and African yam bean into wheat-based cookies improved their nutritional and functional properties while maintaining sensory acceptability. These composite cookies have the potential to serve as a nutritious, cost-effective alternative to conventional cookies, addressing protein-energy malnutrition in developing regions.

Keywords: Composite flour, Functional cookie, Antinutritional factors, Malnutrition intervention, Nutritional composition

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1. Introduction

Cookies are one of the most widely consumed bakery products globally, characterized by their low moisture content, high nutrient density, and extended shelf life. The global cookie market has shown remarkable growth, projected to reach USD 44.01 billion by 2025, with an annual growth rate of 7.2% during the forecast period (2020-2025). This growth is attributed to changing consumer preferences, busy lifestyles, and the increasing demand for convenient snack options that offer both nutrition and satisfaction. However, many cookies tend to be lacking in protein content, and if present, the quality is often subpar. This deficiency arises because cookies are predominantly derived from plant-based ingredients, particularly cereals (Adegbanke *et al.,* 2019). The global demand for protein is steadily rising (Belitz *et al.,* 2011), underscoring the necessity for enhancing the nutritional value of cookies, given their extensive consumption by both children and adults. Through proper processing and fortification with locally available protein sources, cookies could serve as a means to address protein deficiencies worldwide, particularly among low-income groups who may face challenges of affording costly Western foods and medications. Considering the mounting pressures of a growing population and the depletion of natural resources, it becomes imperative to explore new plant-based resources to fulfill the escalating needs of human society. Curiously, human reliance has been disproportionately centered on a small fraction of plant resources, encompassing fewer than 30 crops, among which are pumpkin seeds and African Yam Bean (AYB) (Ikala *et al.,* 2020). In a landscape where the food industry is increasingly shaped by trends in consumer health (Owheruo *et al.,* 2021), the need for nutritional as well as healthcare driven functional foods is imperative.

Cucurbita maxima, more commonly referred to as "pumpkin," is a member of the Cucurbitaceae family and is utilized as a vegetable due to its notable protein content. Depending upon the maturity stage, pumpkin has diversified food uses such as confectionary products, alcohol, sweets / candies or fermented into beverages While the young, unripe fruit is employed as a vegetable (Bhat and Anju, 2013). All plant parts including edible protein-rich seed, fruit and greens of pumpkin has wide nutritional aspects and food usage. It serves as a valuable food supplement due to its abundant beta-carotene content and moderate carbohydrate levels, as well as its supply of vitamins including B_6, K, thiamine, and riboflavin, alongside essential minerals such as potassium, phosphorus, magnesium, iron, and selenium. These attributes make it suitable for producing juice, pomade, pickles, and dried goods (Rakcejeva *et al.,* 2011). Pumpkin seeds are utilized as dietary supplements owing to their substantial concentration of both macro and micro minerals, including phosphorus, magnesium, calcium, manganese, copper, and zinc. Pumpkin is found to have various medicinal properties such as anti-inflammation, antioxidation, anticarcinogenic, anti-angiogenesis, anti-lipogenic effect, glucose-lowering activity and prevents chronic ailments (Kaur *et al.,* 2020). The numerous health benefits are because of presence of various phytochemicals, namely, tocopherol (α- and γ-tocopherol), carotenoid (β-carotene, β-cryptoxanthin, lutein and zeaxanthin), triterpenes and secondary metabolites such as β-sitosterol, dehydrodiconiferyl alcohol and tetrasaccharide glycerol glycolipid (Wang *et al.,* 2012; Kim *et al.,* 2012; Isutsa and Mallowa, 2013).

African yam bean (*Sphenostylis stenocarpa),* is a leguminous plant categorized within the leguminosae (Fabaceace) family. It holds significance as a vital component of a well-rounded human diet in numerous regions globally, attributed to its substantial proportions of protein, carbohydrates, vitamins and minerals. Nonetheless, it is noteworthy that African yam bean also harbors elevated levels of anti-nutritional compounds such as trypsin inhibitor, phytate, tannin, oxalate, and alkaloids (Adebowale *et al.,* 2009). *Sphenostylis sternocarpa* is an annual leguminous plant characterized by its climbing or prostrate-vine growth habit, which can attain heights of up to 3 meters or more. It necessitates support in the form of staking and thrives in lowland tropical environments. This plant is categorized as one of the lesser-recognized legumes and finds extensive cultivation within tropical and subtropical areas, predominantly in the southern regions of Nigeria. The beans contain considerable amount of essential protein (Amino acid, lysine and methionine) comparable to levels found in soy bean and are easily preserved through drying or stored in earthenware (Adewale *et al.,* 2012).

2. Materials and Methods

Materials

The wheat, pumpkin and African yam bean seeds were sourced from King's Market in Akure, Nigeria, and their authenticity was confirmed at the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure. All chemicals utilized in the study were of analytical grade.

Preparation of pumpkin flour

Pumpkin flour was prepared following the procedure outlined by Onwuka (2016). Healthy bulbs were selected, washed and broken open to remove the seeds. The seeds were then dried in a hot-air oven at temperatures of 60-70℃ for a duration of 3 hours. Subsequently, the dried seeds underwent a dehulling process and were further dried in the oven (at 60-70℃ for 3 hours). The dried seeds were then milled using an attrition mill and sieved through a 0.4 mm wire mesh to obtain the final flour suitable for subsequent analysis.

Preparation of African Yam bean flour

The African yam bean flour was obtained according to the procedures previously described by Alagbe & Malomo (2024). The seeds were cleaned and sorted to remove foreign materials, defective seeds, insects etc. The healthy beans were washed and conditioned for germination by soaking overnight, drained, spread on flat trays and covered in a closed environment (20-25 ºC) for about 2-3 days for sprouting. The germinated beans were dried to remove the sprouts, then dehulled and milled in attrition mill and finally sieved through 0.4 mm wire mesh to obtain the final flour for further analysis.

Production of cookies

Cookies were produced from the pumpkin, African yam bean and wheat composite flours using standard procedures earlier described by Malomo and Udeh (2018)**.**

Preparation of formulated food sample aqueous extracts

The food sample flour (500 g) was extracted exhaustively via maceration for 48 h. with 2.5 L of distilled water. After maceration, the mixture was filtered (Muslin cloth and Whatman No.1 filter paper, Qualitative Circles 150 mm Cat No. 1001 150); and the filtrate was concentrated (Rotary evaporator) at 35 ℃ for 24 h. and thereafter, the filtrate was freeze-dried and the dried extract was stored (~27 ℃) until required for use.

Table 1: Flour blends formulations

Samples	Flour Formulations	Pumpkin	African yam bean (AYB)	Wheat	Total (%)
PAW 1	Wheat (commercial product)	-	-	100	100
PAW 2	Pumpkin+AYB+Wheat	10	20	70	100
PAW 3	Pumpkin+AYB+Wheat	20	30	50	100
PAW 4	Pumpkin+AYB+Wheat	20	40	40	100

Proximate composition analysis

The standard methods outlined in AOAC (2012) were employed to determine the proximate compositions of the experimental food samples. This encompassed assessing moisture content, ash, crude fiber, crude fat, and crude protein levels

Carbohydrate content was determined by difference as follow: Carbohydrate (%) = 100 – (%Moisture + %Fat + %Ash + %Crude fibre + %Crude protein) Eq. (1)

The gross energy values of the samples were determined (MJ/kg) by using Gallenkamp Adiabatic bomb calorimeter (Model CBB-330-01041; UK).

The caloric content of the food samples was computed using Atwater factor values. Specifically, the carbohydrate content was multiplied by 4, lipid by 9, and protein by 4. The resulting values were then summed to derive the energy content (kcal/100 g) of the food samples.

Functional properties

The functional properties of the samples, including bulk density, water absorption, oil absorption, foaming capacity/stability, emulsion and gelatinization, were assessed following the procedure outlined by Iwe et al. (2016). Additionally, swelling capacity was determined using the method described by Akpata and Miachi (2001)

Amino acid analysis

The amino acid composition of the functional cookies was assessed using HPLC method as described by Malomo *et al.* (2020)**.**

Antinutritional factors assays

Phytate levels were assessed using the anion-exchange method described in method number 986.11, with phosphate serving as the standard. Oxalate content of the food samples was determined following the procedure outlined by AOAC (2012). Tannin contents were determined using a modified vanillin-HCl method as described by Nwinnuka et al. (2005). Trypsin activity was determined using the method provided by AOAC (2005). Saponin and alkaloid content were determined through a Spectrophotometric method based on the protocol by Ibrahim and Fagbohun (2012).

Evaluation of sensory attributes

The cookies were coded and presented to 50 semi-trained panellists for evaluation of their appearance, texture, taste, aroma, mouth feel using a Hedonic scale of 1 to 9, where 1 = dislike extremely and 9 = like extremely as described by Malomo and Udeh (2018).

Statistical analysis

All determinations were carried out in triplicates. Data were subjected to analysis of variance (ANOVA) using SPSS (version 21, USA), while means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance ($p<0.05$).

3. Results and Discussion

Proximate composition of wheat-pumpkin seed-African yam bean composite flour and cookies

The macronutrient compositions of the formulated wheat-pumpkin seed-African yam bean composite and control flour and cookies samples are presented in Table 2a and 2b respectively. The moisture content of the composite flour varied from 5.46 g/100 g in PAW3 (20%Pumpkin+30%AYB+50%Wheat) to 6.49 g/100 g in PAW2 (10%Pumpkin+20%AYB+70%Wheat). Meanwhile, that of cookies samples varied from 13.48 g/100 g in PAW2 to 15.38 g/100 g in PAW4 (20%Pumpkin+40%AYB+40%Wheat) respectively. Inference can be drawn from the results that the moisture content of the composite flours exhibited a statistically significant decrease ($p<0.05$) compared to the control sample (8.61 g/100 g). Conversely, in the case of the composite cookies, the moisture content was notably higher ($p<0.05$) than that of the control sample, which measured 12.15 g/100 g. Furthermore, the moisture contents of the composite and control flours were lower than < 10 g/100 g recommended for flour samples (NIS, 2004; Malomo and Udeh, 2018). The observed results suggest that the formulated flours exhibit satisfactory shelf-life characteristics, indicating their ability to be stored over extended periods without significant deterioration in nutritional quality or spoilage (Oluwajuyitan *et al.*, 2021a). It is widely recognized that food products with moisture contents exceeding 10 g/100 g typically exhibit limited capacity for prolonged storage (FAO, 2003). Thus, the composite and control cookies samples might be needed to be consumed as soon as possible to avoid deteriorations or a safe method of preservation employed to safe guard the composite cookies from spoilage (Adeyemo *et al.*, 2022). Findings have shown that food-samples with high moisture contents make nutrients hard to access and promoted the activities and growth of microorganisms, thereby resulting in speedy food-samples' spoilages (Adeoti and Osundahunsi, 2017; Malomo and Udeh, 2018; Oluwajuyitan *et al.*, 2021a).

The crude protein contents of the flour and cookies samples varied from 19.23 g/100 g in PAW2 to 28.79 g/100 g in PAW4, and 15.90 g/100 g in PAW2 to 23.76 g/100 g in PAW4, respectively. The result showed that the crude protein contents of the composite flour (11.82 g/100 g) and cookies (10.57 g/100 g) samples were significantly higher ($p<0.05$) than that obtainable for the control sample. These results suggest that the formulated flours and cookies in this study have a higher nutritional value, particularly in terms of protein content, compared to the commercial product. This observation is consistent with a previous study by Oguntuase *et al.* (2022a), which also reported enhanced nutritional and protein content in products derived from wheat-Bambara groundnut composite flour. However, this justified the substitution of wheat flour with the pumpkin seed and African yam bean to improve nutritional quality of the final food product as the current values were all above the 15% recommended by World Health Organization (2001) for food products (Osundahunsi and Aworh, 2002; Malomo and Udeh, 2018; Adeoti and Osundahunsi, 2017). Therefore, the composite cookies may serve as cheap meal substitute to reduce malnutrition and promote growth in young children, which have been a burden, especially in developing countries (Owheruo *et al.*, 2021). In addition to the nutritional potentials of high protein content diet foods, proteins are essential for biochemical activities as well as in the building and repair of new body tissues (Oyarekua, 2010). Furthermore, the regular intake of diets high in quality protein has been proven to be essential in diabetic management (Oluwajuyitan *et al.*, 2021).

Table 2a: Proximate composition of wheat-pumpkin seed-African yam bean composite flour (%)

Sample	Moisture	Ash	Fat	Fibre	Protein	CHO
PAW1	8.61 ± 0.40^{a}	1.62 ± 0.46^{b}	1.54 ± 0.17^{b}	13.77 ± 0.09^{a}	11.82 ± 1.89^{d}	62.81 ± 1.21^{a}
PAW2	6.49 ± 0.38^{b}	2.29 ± 0.15^{ab}	4.71 ± 0.02^{a}	11.80 ± 0.37^{c}	19.23 ± 0.64^{c}	55.35 ± 0.30^{b}
PAW3	5.46 ± 0.08^{c}	3.03 ± 0.04^{a}	5.58 ± 0.35^{a}	12.68 ± 0.16^{b}	22.11 ± 0.45^{b}	50.76 ± 0.31^{c}
PAW4	6.06 ± 0.53^{bc}	2.61 ± 0.62^{a}	7.05 ± 2.36^{a}	10.12 ± 0.10^{d}	28.79 ± 1.01^{a}	44.20 ± 0.35^{d}

Means ± Standard error of mean with different superscripts alphabets along the same column are significantly (P<0.05) different. Key: PAW 1 = 100% wheat flour (Control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour

Table 2b: Proximate composition of wheat-pumpkin seed-African yam bean composite cookies (%)

Sample	Moisture	Ash	Fat	Fibre	Protein	CHO
PAW1	12.15 ± 2.44^{b}	4.12 ± 0.24^{a}	11.57 ± 0.84^{a}	6.32 ± 0.07^{c}	10.57 ± 1.13^{d}	56.12 ± 0.17^{a}
PAW2	13.95 ± 0.15^{ab}	3.67 ± 0.27^{b}	15.64 ± 1.12^{b}	7.49 ± 0.05^{a}	15.90 ± 0.02^{c}	42.81 ± 1.46^{b}
PAW3	13.48 ± 0.05^{ab}	3.02 ± 0.14^{c}	17.63 ± 0.82^{a}	7.14 ± 0.11^{b}	17.46 ± 0.41^{b}	41.19 ± 1.10^{b}
PAW4	15.38 ± 0.68^{a}	3.26 ± 0.24^{bc}	18.50 ± 0.02^{a}	6.30 ± 0.08^{c}	23.76 ± 0.12^{a}	32.86 ± 0.68^{c}

Means ± Standard error of mean with different superscripts alphabets along the same column are significantly (P<0.05) different. Key: PAW 1 = 100% wheat flour (Control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour

The crude fibre contents of the flours ranged from 10.12 g/100 g in PAW4 to 12.68 g/100 g in PAW3, meanwhile, that of the cookies samples were from 6.30 g/100 g in PAW4 to 7.49 g/100 g in PAW2, respectively. The current crude fibre contents of the composite flours were significantly lower (p<0.05) than that obtainable for the control sample (13.77 g/100 g). Contrarily, with the exception of PAW4, all the crude fibre contents of the composite cookies were significantly higher (p<0.05) than 6.32 g/100 g obtained for the control sample. The notable disparity in crude fiber content observed between the composite flours and cookies in contrast to the control flours and cookies can be attributed to the incorporation of pumpkin seed and African yam bean within the composite blends. However, the composite flour (PAW4) with the lowest wheat composition has the lowest crude fibre content, which might indicate that retaining appropriate inclusion of wheat in the composite flour and cookies formulation influenced significant crude fibre content. Numerous investigations have demonstrated that consistent consumption of dietary fiber can lead to slower digestion, support the human digestive process, enhance carbohydrate absorption within the gastrointestinal tract, and subsequently lower postprandial blood glucose levels and the risk of diabetes (Jin *et al.,* 2020; Li *et al.,* 2020; Oguntuase *et al.,* 2022a). Furthermore, dietary fibre has been established to improve insulin sensitivity in type-2 diabetic conditions, as well as possess hypoglycemic and hypolipidemic potentials characterized by interrupted assimilation and breakdown of carbohydrates in human gastrointestinal tract (Osundahunsi, 2009; Mirmiran *et al.,* 2014; Shah *et al.,* 2015).

More so, the crude ash contents of the flour and cookies samples varied from 2.29 g/100 g in PAW2 to 3.03 g/100 g in PAW3, and 3.02 g/100 g in PAW3 to 3.67 g/100 g in PAW2, respectively. The crude ash contents of the composite flours were significantly higher (p<0.05) than 1.62 g/100 g for the control sample while those of the composite cookies were significantly lower (p<0.05) than 4.12 g/100 g for the control sample, respectively. Meanwhile, the crude ash is the indication of mineral content of a food sample and the quality parameter for contamination (Lee *et al.,* 2007; Owheruo *et al.,* 2021). However, the disparity in the crude ash contents between the composite flours and cookies in comparison to the control samples could be attributed to the additional heat processes the cookies samples have been exposed to (Malomo and Udeh, 2018).

The crude fat content (a major component of energy value) of the flour and cookies samples varied from 4.71 g/100 g in PAW2 to 7.05 g/100 g in PAW4, and 15.64 g/100 g in PAW2 to 18.50 g/100 g in PAW4, respectively. Significantly, the energy content of a food product is intricately tied to its protein, fat and carbohydrate composition, and this interplay likely contributes to the observed variations in the energy values of the products (Ojinnaka *et al.,* 2018). The elevated fat content identified in this study could potentially contribute to a higher energy value, thus providing ample calories necessary for daily activities (Hasan *et al.,* 2020; Simanjuntak *et al.,* 2020). However, it's important to note that while a higher fat content can offer nutritional benefits by increasing dietary energy, it may also compromise the shelf life and stability of the food product during storage (Adeoti and Osundahunsi, 2017). Also, the carbohydrate (CHO) content of the flour and cookies samples varied from 44.20 g/100 g in PAW4 to 55.35 g/100 g in PAW2, and 32.86 g/100 g in PAW4 to 42.81 g/100 g in PAW4, respectively, which were all significantly lower (p<0.05) in comparison to the flour and cookies control samples. An indication that the inclusion of pumpkin seed and African yam bean played important roles in preventing and managing diabetes by reducing intake of carbohydrates, slowing down carbohydrate digestion and glucose absorption in the small intestine (McKeown *et al.,* 2004).

Antinutrient composition of wheat-pumpkin seed-African yam bean composite cookies

The result of the antinutritional composition of the wheat-pumpkin seed-African yam bean composite cookies were found to be significantly (p<0.05) reduced for trypsin, tannin and oxalate contents but significantly (p<0.05) showed increased compositions of phytate and alkaloids as presented in Table 3. the trypsin content of the composite cookie samples varied between 3.91 in PAW4 and 18.77 in PAW2, which were significantly (p<0.05) lower than 45.85% for the control sample. Also, the tannin content of the composite cookie samples varied from 10.59 mg/g in PAW4 to 10.84 mg/g in PAW3, which were significantly (p<0.05) lower than that obtainable for the control sample (11.18 mg/g). More so, the oxalate content of the composite cookie samples varied from 2.10 mg/g in PAW2 to 4.29 mg/g in PAW3, which were lower than 11.18 mg/g for the control sample. Meanwhile, the phytate content of the composite cookie samples varied from 15.93 mg/g in PAW2 to 18.58 mg/g in PAW3, which were significantly (p<0.05) higher than 10.29 mg/g for the control sample. Furthermore, the saponin content of the composite cookies samples (16.06 mg/g in PAW2 to 73.91 mg/g in PAW4), were significantly (p<0.05) higher than the control cookies sample (26.30 mg/g). Finally, the alkaloid content of the composite cookies samples was from 17.43% in PAW4 to 40.04% in PAW3, and found significantly (p<0.05) higher than11.81% for the control sample.

Table 3: Antinutrient composition of wheat-pumpkin seed-African yam bean composite cookies

Samples	Trypsin (%)	Tannin (mg/g)	Oxalate (mg/g)	Phytate (mg/g)	Saponin (mg/g)	Alkaloids (%)
PAW1	45.85 ± 1.80^{a}	11.18 ± 0.30^{a}	4.35 ± 0.14^{a}	10.29 ± 0.56^{c}	26.30 ± 0.17^{b}	11.81 ± 0.42^{b}
PAW2	18.77 ± 1.43^{b}	10.66 ± 0.12^{b}	2.10 ± 0.26^{b}	15.93 ± 0.75^{b}	16.06 ± 0.25^{d}	25.29 ± 10.87^{ab}
PAW3	10.88 ± 0.74^{c}	10.84 ± 0.18^{ab}	4.29 ± 0.61^{a}	18.58 ± 0.50^{a}	22.98 ± 0.10^{c}	40.04 ± 22.25^{a}
PAW4	3.91 ± 0.83^{d}	10.59 ± 0.08^{b}	3.78 ± 0.18^{a}	17.92 ± 0.28^{a}	73.91 ± 0.25^{a}	17.43 ± 0.89^{ab}

Means ± Standard error of mean with different superscripts alphabets along the same column are significantly (P<0.05) different. Key: PAW 1 = 100% wheat flour (Control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour.

Result showed significant (p<0.05) decrease in trypsin content with the different percentage inclusions of pumpkin seed and African yam bean, an indication that the activities of trypsin inhibitor (a protease inhibitor) have been enhanced, resulting in the formation of irreversible trypsin-enzyme inhibitor complex (Adeoti and Osundahunsi, 2017). Hence, the formation of this complex would inferably result in delayed dietary protein digestion, thus leading to bioavailability of protein for coupling with carbohydrates, thereby reduction in bioavailability of the sugar concentrations that could result in hyperglycemia (Pugalentin *et al.,* 2005). Also, tannins have been reported by Obot *et al.* (2007) as polyhydric phenols that inhibited trypsin, chymotrypsin, amylase and lipase enzymes. They formed insoluble complexes with proteins, carbohydrates and lipids leading to a reduction in digestibility of these biomolecules. Inferentially, the depletion of the trypsin content of the composite cookies may be linked to the presence of tannins in the composite cookies. However, tannins are only therapeutically beneficially when at lower concentrations (Harvey, 2008), an indication that the slightly lowered tannin content of the composite cookies would make it more beneficial compared to the commercially available samples.

Oxalates, a type of phytochemical that have the ability to bind with essential trace elements, rendering them inaccessible for crucial enzymatic activities and other vital metabolic processes. Ingesting substantial quantities of oxalic acid can lead to corrosive gastroenteritis, shock, convulsive symptoms, reduced plasma calcium levels, elevated plasma oxalates, and potential kidney impairment. The established toxic threshold or lethal dose for oxalates is documented to be ≥ 5 mg/g, as humans lacked the enzymes required to metabolize oxalate (Gomathi *et al.,* 2014). Therefore, the values obtained for the composite and control cookies were within the safety limits. Interestingly, the significantly (p<0.05) higher phytate content of the composite cookies in comparison with the control sample indicated higher potentials to chelate divalent cations, thereby leading to the formation of insoluble complexes with proteins at elevated pH. This would thus impair the digestibility as well as the bioavailability of essential nutrients to humans (Jude-Ojei *et al.,* 2017).

Comparatively, the saponin level observed for the present study are significantly (p<0.05) higher than those reported in previous study (Adeyemo *et al.,* 2022). On the other hand, the percentage alkaloid contents of the composite cookies were significantly (p<0.05) higher than that obtained for the control sample, which were beneficial to human consumption due to its exploration in varying medical therapies such as prevention or management of degenerative disease due to the synergistic effects of its bio-composites such as isoquinoline, indole, pyrroloindole, oxindole, piperidine, pyridine, aporphine, vinca, β-carboline, methylxanthene, lycopodium, and erythrine byproducts (Hussain, *et al.,* 2018).

Functional properties of wheat-pumpkin seed-African yam bean composite cookies

The result of the functional properties of the wheat-pumpkin seed-African yam bean composite cookies were as expressed in Table 4. The bulk density of the composite cookies' samples varied from 2.68 g/cm^3 in PAW4 to 2.92 g/cm^3 in PAW3. Bulk density refers to the relationship between the weight of flour and its volume, measured in grams per milliliter. This metric indicates the density or heaviness of the flour and holds significance as a key factor in assessing the appropriateness of flour for facilitating the handling and transportation of particulate materials in food packaging (Adeoti and Osundahunsi, 2017). Meanwhile, the bulk densities of the composite cookies were higher than that of the control cookies, which is a disadvantage in ready-to-eat food products because it will necessitate denser packaging materials, which could limit the nutrient intake per feed (Isah *et al.,* 2013; Oluwajuyitan *et al.,* 2022). However, the high bulk density value would be insignificant for adults who were able to consume enough of the composite cookies to satisfy their nutritional and energy needs (Adeoti and Osundahunsi, 2017). Results also showed that water absorption capacities of the composite cookies varying from 0.58% in PAW3 to 0.69% in PAW2, and were found significantly (p<0.05) reduced when compared to the control cookies (0.74%). The observed water absorption capacities could be accredited to the differences in the degree of the cookies' interaction with water, the cookies conformational characteristics and protein contents, as previously established (Butt and Rizwana, 2010). Inferentially, the low values of the water absorption capacities observed with the composite cookies is of nutritional advantage as it indicated enhanced energy density and nutritional content (Jude-Ojei *et al.,* 2017). Percentage oil absorption capacities of the composite cookies ranged from 0.67 in PAW4 to 0.73 in PAW2 which were significantly (p<0.05) lower in comparison to the control cookies (0.81%). Oil absorption capacity is a vital functional property, for instance, a function of the physical entrapment of oil, which is considered important as flour retainer and enhanced the mouth-feel of food products (Adeoti and Osundahunsi, 2017). Although, still comparatively acceptable with the control, the high fat contents of the composite cookies may have adversely affected the oil absorption capacities of the composite cookies (Suresh *et al.,* 2015).

Foaming capacity of a protein pertains to the extent to which the protein can generate interfacial area. Foam consists of numerous gas bubbles confined within a liquid or solid matrix, with minuscule air bubbles enveloped by delicate liquid films (Tasnim *et al.,* 2020). Interestingly, the foaming capacity of the composite cookies ranged from 8.96% in PAW3 to 19.79% in PAW4, which were significantly (p<0.05) higher in comparison to the control cookies (8.64%). This is an indication that the cookies would form larger air bubbles surrounded by thinner films in comparison with the control sample. Adequate foam capacity is a favorable characteristic for flours within the food system, given its substantial porosity. This feature is valuable for creating an array of baked goods and serves as a functional element in food formulations (El-Adawy and Taha, 2001). Comparatively, the values obtained in the present study is within the same range reported by Adeoti and Osundahunsi, (2017) and Tasnim *et al.* (2020), which is an indication of the beneficiary status of the composite cookies to both young and old individuals.

Percentage gelatinization, or least gelation concentration, pertains to the minimum protein concentration at which a gel substance remains intact within an inverted tube, varied between 2.03 in PAW2 to 6.54 in PAW4, which are significantly (p<0.05) different in comparison to the control cookies (2.91). The varying gelling properties of the composite cookies could be attributed to the different percentage inclusions of pumpkin seed and African yam bean, resulting in different ratios of carbohydrates, lipid and protein contents (Oluwajuyitan *et al.,* 2021). Interestingly, lower gelatinization has been understood to improve gelating ability of protein ingredient and swelling abilities of flour products (Kaushal *et al.,* 2012; Oluwajuyitan *et al.,* 2021), an indication that PAW2 would be the most favored cookies in terms of gelatinization. Furthermore, the percentage gelatinization values obtained in the present study is lower than the 7.59% to 8.94% range previously reported by Adeoti and Osundahunsi, (2017) for ogi-moringa seed flour complementary diets, an indication that the composite cookies possessed quality gelatinization values. The emulsion capacity ranged from 37.26 in PAW3 to 44.43 in PAW2, which are significantly (p<0.05) lower when compared to the control cookies (46.36). Interestingly, the emulsion capacities of the composite were similar to that previously reported by Jariyah *et al.* (2016) for composite cookies from wheat-pedada fruit flour.

Table 4: Functional properties of wheat-pumpkin seed-African yam bean composite cookies

Samples	Bulk density (g/cm3)	Water absorption (%)	Oil absorption (%)	Foaming capacity (%)	Gelatinisation (%)	Emulsion capacity (%)
PAW1	2.29 ± 0.03^c	0.74 ± 0.05^a	0.81 ± 0.01^a	8.64 ± 0.05^c	2.91 ± 0.79^b	46.36 ± 0.33^a
PAW2	2.78 ± 0.02^b	0.69 ± 0.03^a	0.73 ± 0.01^b	13.74 ± 0.13^b	2.03 ± 0.06^c	44.43 ± 0.94^b
PAW3	2.92 ± 0.10^a	0.58 ± 0.02^b	0.69 ± 0.01^c	8.96 ± 0.37^c	6.35 ± 0.15^a	37.26 ± 1.32^d
PAW4	2.68 ± 0.10^b	0.62 ± 0.01^b	0.67 ± 0.00^d	19.79 ± 0.67^a	6.54 ± 0.09^a	40.96 ± 0.54^c

Means ± Standard error of mean with different superscripts alphabets along the same column are significantly (P<0.05) different. Key: PAW 1 = 100% wheat flour (Control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour.

Amino acid profiles of wheat-pumpkin seed-African yam bean composite cookies

The result of the amino acid profiling of the wheat-pumpkin seed-African yam bean composite cookies were as presented in Table 5. About nine non-essential amino acids were identified in the wheat-pumpkin seed-African yam bean composite cookies, namely glycine, alanine, serine, proline, aspartic acid, cysteine, glutamic acid, tyrosine and arginine while nine essential amino acids were identified namely phenylalanine, histidine, methionine, valine, tryptophan, threonine, isoleucine, leucine and lysine. The glutamic acid concentration of the composite cookies samples was significantly (P<0.05) higher than other amino acids, which were similar with the reports of Ndungu *et al.* (2015), Malomo *et al.* (2020) and Wiedemair *et al.* (2020), that glutamic acid is abundant in plant-based food products. The ranges of values for Total Essential Amino Acid (TEAA), Total Non-Essential Amino Acid (TNEAA) and Total Amino Acid (TAA) were 37.75 (PAW2) to 48.04 (PAW3), 38.22 (PAW3) to 45.35 (PAW4), and 73.05 (PAW2) to 89.51 (PAW 4), respectively. These values were relatively higher when compared to those of control cookies: 33.07, 31.56 and 64.63. This indicated that the composite cookies could be employed as suitable food product to support physiological maintenance in adults and growth in children (Oluwajuyitan *et al.*, 2021).

Indeed, regular consumption of both essential and non-essential amino acids has been recognized for its health benefits, particularly in the context of managing type-2 diabetes. These amino acids play essential roles in various physiological processes that contribute to improved health outcomes for individuals with diabetes (Floegel *et al.,* 2013). research has demonstrated that the intake of amino acids, both essential and non-essential, can contribute to the prevention and management of chronic diseases like diabetes and hypertension. These amino acids can influence various metabolic pathways and physiological functions that are crucial in maintaining optimal health and reducing the risk of these chronic conditions. (Tejero *et al.,* 2008; Floegel *et al.,* 2013). For instance arginine is an amino acid that plays a significant role in promoting the production of nitric oxide in the body. Nitric oxide functions as a vasodilator, causing blood vessels to relax and expand. This relaxation of arteries improves blood flow and circulation, which in turn helps to lower blood pressure and reduce the risk of hypertension. Therefore, a diet rich in arginine-containing foods can contribute to better cardiovascular health by supporting proper blood vessel function and reducing the strain on the heart. (Tejero *et al.,* 2008). Comparatively, the TEAA of the composite cookies was similar to those reported for millets diets complemented with legumes (Anitha *et al.,* 2020) to enhance human dietary nutrition. The present result was also consistent with the past reports (Sodipo *et al.*, 2020; Oguntuase *et al.,* 2022a) on the inclusion of medicinal plants in cookies samples to improve its amino acid contents, which invariably elicited hypoglycemic effects in high-fat diet streptozotocin-induced diabetic rats

Summarily, the percentage inclusion of pumpkin seed and African yam bean into the composite cookies resulted in a substantial enhancement of the amino acid content in comparison to the control sample (PAW1). Furthermore, the outcomes indicated that the essential amino acid composition of the composite cookies surpassed the recommended Threshold EAA (TEAA) value of 27.1 as specified in the FAO/WHO reference (Aderinola *et al.,* 2020). This finding thus inferred that the composite cookies contained appreciable amount of essential amino acids, particularly important and necessary for proper growth especially in children, the major consumers of cookies (Malomo *et al.,* 2020; Oluwajuyitan *et al.,* 2021).

Table 5: Amino acid profiles of wheat-pumpkin seed-African yam bean composite cookies

Samples/Amino acids	PAW 1	PAW 2	PAW 3	PAW 4	Average ± Std		#LSD (p<0.05)
Aspartic acid	7.62	10.37	12.87	13.13	10.99	0.86	0.34
Threonine	2.53	2.89	2.92	3.23	2.89	0.18	0.04
Serine	4.34	4.13	4.44	4.85	4.44	0.39	0.34
Glutamic acid	10.52	13.49	12.01	17.36	13.35	0.23	1.75
Proline	2.10	2.47	2.78	2.04	2.35	0.14	0.51
Glycine	3.18	3.60	3.21	3.28	3.32	0.10	0.74
Alanine	2.58	2.76	2.52	3.18	2.76	0.12	0.03
Cystine	1.22	1.24	0.39	1.51	1.09	0.34	0.02
Valine	4.28	4.68	4.76	4.64	4.59	0.44	0.03
Methionine	2.14	2.56	2.62	2.91	2.56	0.32	0.10
Isoleucine	2.67	2.69	2.70	2.69	2.69	0.09	0.61
Leucine	3.48	4.57	3.91	4.62	4.15	0.55	0.21
Tyrosine	3.03	3.61	3.49	4.31	3.61	0.41	0.24
Phenylalanine	4.32	4.91	4.42	7.98	5.41	1.78	0.11
Histidine	3.40	3.73	3.72	4.13	3.75	0.54	0.12
Lysine	3.12	3.85	3.70	4.72	3.85	0.22	0.03
Arginine	2.61	2.44	2.88	3.61	2.89	0.51	0.04
Tryptophan	1.49	1.06	0.91	1.32	1.20	0.54	0.01
TEAA	33.07	37.75	48.04	44.16	40.76	1.86	1.11
TNEAA	31.56	38.38	38.22	45.35	38.38	1.98	1.12
TAA	64.63	73.05	86.26	89.51	78.36	3.39	1.03

TEAA- Total Essential amino acids, TNEAA- Total Non-essential amino acid, TAA- Total amino acid., #LSD = Least significant difference. Key: PAW 1 = 100% wheat flour (Control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour

Nutritional qualities of wheat-pumpkin seed-African yam bean composite cookies

The nutritional qualities of the formulated cookies samples were presented in Table 6. The hydrophobic amino acid (HAA) content of the wheat-pumpkin seed-African yam bean composite cookies ranged from 28.50 in PAW3 to 34.20 in PAW4, as against the 27.31 for the 100% wheat flour (PAW1) cookies sample. Also, the aromatic amino acid (AAA) content of the wheat-pumpkin seed-African yam bean composite cookies were 9.58 for PAW2, 8.82 for PAW3 and 13.61 for PAW4 in comparison to the 100% wheat flour (PAW1) (8.84) cookies sample. The arginine/lysine ratio of the wheat-pumpkin seed-African yam bean composite cookies ranged from 0.63 for PAW2 to 0.78 for PAW3, which were lower comparable to the 100% wheat flour (PAW1) (0.84) cookies sample. Besides, the branched chain amino acid (BCAA) content of the wheat-pumpkin seed-African yam bean composite cookies ranged from 11.37 for PAW3 to 11.95 for PAW4, which were higher than 10.43 for the 100% wheat flour (PAW1) cookies sample. Furthermore, the negatively charged amino acid (NCAA) content of the pumpkin seed-African yam bean-wheat composite cookies ranged from 23.86 (PAW2) to 30.49 (PAW4) and higher than 18.14 for PAW1 cookies.

The Protein Efficiency Ratio (PER) of the wheat-pumpkin seed-African yam bean composite cookies ranged from 4.58 g/100 g in PAW2 to 5.89 g/100 g in PAW4, which are higher in comparison to the 100% wheat flour (PAW1) (4.11) cookies sample. Also, the Essential Amino Acid Index (EAAI) of the wheat-pumpkin seed-African yam bean composite cookies ranged from 0.79 for PAW2 to 0.88 for PAW4, when compared to PAW1 (0.74). The percentage Essential Amino Acid Index [EAAI (%)] of the wheat-pumpkin seed-African yam bean composite cookies ranged from 79.28% for PAW2 to 88.25% for PAW4, which are higher in comparison to the 100% wheat flour (PAW1) (74.16%) cookies sample. The Biological Value (BV) of the wheat-pumpkin seed-African yam bean composite cookies ranged from 80.66% (PAW2) to 86.28% (PAW4) as against 77.28% of PAW1. Furthermore, the Fischer ratio of the wheat-pumpkin seed-African yam bean composite cookies were 1.18, 1.25, 1.29 and 0.88 for PAW1, PAW2, PAW3, and PAW4.

The arginine/lysine ratio of the wheat-pumpkin seed-African yam bean composite cookies was lower than that obtained for the 100% wheat flour cookies sample, which are both significantly ($P<0.05$) lower than 1.19 – 1.44 reported (Oluwajuyitan *et al.*, 2021) for plantain-based dough meal. This is an indication that arginine intake from the composite cookies might be inadequate in nitric oxide production for the management of free blood flow-related diseases. However, that did not negate the possibility of the cookies being efficient in the management of other diseases such as diabetes (Tejero *et al.*, 2008). Also, the higher BCAA of the wheat-pumpkin seed-African yam bean composite cookies further validated their medical recreational abilities, especially in type-2 diabetes management (Floegel *et al.*, 2013).

The PER of the wheat-pumpkin seed-African yam bean composite cookies was higher than that obtained for the 100% wheat flour cookies sample, which were all significantly ($p<0.05$) higher than 0.08 – 0.32 and 2.80 – 4.88 obtained for blends of cowpea-fonio (Olapade and Aworh, 2012) and African locust bean-bambara groundnut (Ijarotimi and Keshinro, 2012) complementary foods, respectively. The higher NCAA contents of the wheat-pumpkin seed-African yam bean composite cookies also implied the composite cookies to possess very good bioactivities, and served as potent antioxidants for antidiabetic purposes (Famakin *et al.*, 2016; Adeyemo *et al.*, 2022).

The BV estimated the competence of protein to support growth via nitrogen retention in the human body and the assessment of the absorbed protein from the foods that integrated into the body system (Oluwajuyitan and Ijarotimi, 2019; Grzeszczuk *et al.*, 2020). This is an indication that the cookies samples would maintain the body while promoting growth. The present study revealed that the BV, EAAI and EAAI% of the composite cookies were higher than the control cookies sample and the dietary recommended values (> 70%) for ideal food products. This is an indication that the wheat-pumpkin seed-African yam bean composite cookies would be appropriate as a food product for physiological maintenance in adults and growth support in children. This is due to the fact that the composite cookies components would be biologically available for vital body metabolic processes (Oluwajuyitan *et al.*, 2022). The higher Fischer ratio obtained for PAW2 and PAW3 when compared to the control cookies sample is a vital medical advantage, since higher Fischer ratio inferred higher anti-diabetic activities. Interestingly, the obtained Fischer ratio is similar to that reported for functional plant flour-enriched plantain cookies (Famakin *et al.*, 2016; Adeyemo *et al.*, 2022). Typically, the result of the present study correlated with other studies that reported improved nutritional quality and health benefits of foods formulated by the inclusion of two (or more) plant-based food materials (Okpala and Okoli 2011; Ijarotimi and Keshinro 2012; Oluwajuyitan and Ijarotimi 2019). Therefore, the composite cookies may serve as cheap meal substitute in place of expensive imported foods to reduce malnutrition and promote growth, as well as health management diets in place of synthetic medications that come along with adverse side-effects (Owheruo *et al.*, 2021). The consistent result of the present study regarding nutritional values of the composite cookies inferred its essentiality in developing countries such as Nigeria which is characterized with high prevalence of protein-energy malnutrition and low nutritional qualities of traditional foods (Ikujenlola and Adurotoye 2014; Oluwajuyitan and Ijarotimi 2019).

Table 6: Estimated and predicted nutritional quality of Wheat-Wheat-pumpkin seed-African yam bean composite cookies samples

	Cookies Samples			
Parameters	**PAW 1**	**PAW 2**	**PAW 3**	**PAW 4**
HAA	27.31	30.00	28.50	34.20
AAA	8.84	9.58	8.82	13.61
Arg/Lysine	0.84	0.63	0.78	0.77
BCAA	10.43	11.94	11.37	11.95
NCAA	18.14	23.86	24.88	30.49
PER (g/100 g)	4.11	4.58	5.39	5.89
EAAI	0.74	0.79	0.86	0.88
EAAI (%)	74.16	79.28	86.21	88.25
BV (%)	77.28	80.66	83.22	86.28
Fischer Ratio	1.18	1.25	1.29	0.88

__HAA__- Hydrophobic amino acid__,__ __AAA__- Aromatic amino acid __BCAA__- Branched chain amino acid__,__ __NCAA__- Negatively charged amino acid __PER__- Protein Efficiency Ratio__,__ __EAAI__- Essential amino acid index__,__ __BV__- Biological value__. Key:__ PAW 1 = 100% wheat flour (__Negative control__); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour

Sensory attributes of wheat-pumpkin seed-African yam bean composite cookies

The result of the sensory attributes of the wheat-pumpkin seed-African yam bean composite cookies were found to be significantly reduced ($p<0.05$) for appearance, taste, texture, mouthfeel, aroma and overall acceptability (Table 7). The appearance of the wheat-pumpkin seed-African yam bean composite cookies ranged from 6.75 in PAW4 to 7.82 in PAW2, which were significantly ($p<0.05$) lower in comparison to 100% wheat flour (PAW1) (8.07) and commercial (PAW5) (8.90) cookies samples. The taste of the wheat-pumpkin seed-African yam bean composite cookies (7.56-8.10) were significantly ($p<0.05$) compared lower to 100% wheat flour (PAW1) (8.18) and commercial (PAW5) (8.80) cookies samples, respectively. The texture of the wheat-pumpkin seed-African yam bean composite cookies ranged from 7.12 for PAW4 to 7.68 for PAW3, which were significantly ($p<0.05$) lower in comparison to 100% wheat flour (PAW1) (8.12) and commercial (PAW5) (8.85) cookies samples, respectively.

Meanwhile, the mouthfeel of the wheat-pumpkin seed-African yam bean composite cookies ranged from 7.34 for PAW4 to 7.92 for PAW2/PAW3, which were significantly ($p<0.05$) lower in comparison to 100% wheat flour (PAW1) (8.38) and commercial (PAW5) (8.90) cookies samples. Also, the crumbling of the wheat-pumpkin seed-African yam bean composite cookies were 6.05 for PAW4, 8.30 for PAW3 and 8.65 for PAW2, while 100% wheat flour (PAW1) and commercial (PAW5) cookies samples had 8.20 and 8.65 for crumbling, respectively. The aroma of the wheat-pumpkin seed-African yam bean composite cookies ranged from 7.72 in PAW4 to 7.94 for PAW2, which were significantly ($p<0.05$) lower in comparison to 100% wheat flour (PAW1) (8.16) and commercial (PAW5) (8.70) cookies samples. Lastly, the overall acceptance of the wheat-pumpkin seed-African yam bean composite cookies ranged from 7.57 for PAW4 to 8.24 for PAW3, but were significantly ($p<0.05$) compared lower to 100% wheat flour (PAW1) (8.90) and commercial (PAW5) (8.97) cookies samples, respectively.

The sensory attributes of food products have been established to influence consumers' approval and desire of the product, leading to the success or failure in the marketing of such food products (Adeyemo *et al.*, 2022). The results of the present study agreed with the past studies (Aderinola *et al.* 2020; Jian *et al.* 2020; Adeyemo *et al.* 2022) that observed decrease in overall acceptability of composite cookies when percentage functional plant-based flours were included. Even though such changes were not having any significant adverse effect on nutritional and biological parameters of the final cookies. Typically, the disparities in sensory attributes were majorly attributed to familiarities of panellists with wheat flour cookies as the overall acceptability of the 100% wheat cookies showed no significant difference to the commercial cookies sample (Aderinola *et al.*, 2020). Nevertheless, commercialization of the newly developed cookies samples is possible considering that there was no much disparity between the samples as well as the significant nutritional and health benefits of the samples.

Table 7: Sensory attributes of wheat-pumpkin seed-African yam bean composite cookies

Samples	Appearance	Taste	Texture	Mouthfeel	Crumbling	Aroma	Overall Acceptability
PAW 1	8.07^{b}	8.18^{b}	8.12^{b}	8.38^{b}	8.20^{ab}	8.16^{b}	8.90^{a}
PAW 2	7.82^{c}	8.10^{b}	7.39^{d}	7.92^{c}	8.65^{c}	7.94^{bc}	7.86^{c}
PAW 3	7.39^{d}	7.87^{c}	7.68^{c}	7.92^{c}	8.30^{ab}	7.88^{c}	8.24^{b}
PAW 4	6.75^{e}	7.56^{cd}	7.12^{de}	7.34^{d}	6.05^{d}	7.72^{d}	7.57^{d}
PAW 5	8.90^{a}	8.80^{a}	8.85^{a}	8.90^{a}	8.65^{a}	8.70^{a}	8.97^{a}

Means (n=50) with different letter in the column are significantly different (p<0.05). Key: PAW 1 = 100% wheat flour (Negative control); PAW 2 = 10% pumpkin seed flour + 20% African yam bean flour + 70% wheat flour; PAW 3 = 20% pumpkin seed flour + 30% African yam bean flour + 50% wheat flour; PAW 4 = 20% pumpkin seed flour + 40% African yam bean flour + 40% wheat flour; PAW 5 = Commercial sample (Positive control).

Conclusion

This study evaluated the nutritional, antinutrient, functional, and organoleptic properties of cookies produced from wheat-pumpkin seed-African yam bean composite flour blends. The findings highlight the potential of these composite cookies as a nutritious alternative to conventional wheat-based cookies. The proximate analysis revealed that the inclusion of pumpkin seed and African yam bean significantly improved the protein content of the composite cookies compared to the 100% wheat flour control. The highest protein content (23.76%) was observed in PAW4 (20% pumpkin seed + 40% African yam bean + 40% wheat flour), demonstrating the potential of these cookies to address protein-energy malnutrition. The fiber and ash contents of the composite cookies were also enhanced, indicating potential health benefits such as improved digestion and higher mineral content. The analysis of antinutritional factors showed a reduction in trypsin inhibitor, tannins, and oxalates in the composite cookies, suggesting improved digestibility and bioavailability of essential nutrients. However, phytate and alkaloid levels were slightly elevated, which could have implications for mineral bioavailability. Functional properties, including bulk density, water and oil absorption, foaming capacity, gelatinization, and emulsion capacity, demonstrated the suitability of the composite flours for cookie production. The composite cookies exhibited improved foaming and emulsification properties, which may enhance their application/

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Conflict of interest
The authors declared no conflict of interest.

Authors' contributions
Malomo S. A designed the experiment, supervised the study, analyzed the data, and thoroughly read and edited the manuscript. Obiwusi P. E. and Alagbe I. C. performed the experiment, collected and analyzed the data as well as prepared the draft of the manuscript. Gbadegesin I. O and Sangotoye E. O assisted in analyzing the data and in preparing the manuscript. All authors have read and agreed to the published version of the manuscript.

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