FORTIFICATION OF BAMBARA-ACHA COMPOSITE FLOUR WITH PUMPKIN SEED FLOUR: EFFECTS ON FLOUR'S FUNCTIONAL PROPERTIES AND BISCUIT SENSORY ACCEPTABILITY

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Abstract: *The effects of fortifying Bambara groundnut-Acha composite flour with pumpkin seed flour on the functional properties and sensory qualities of biscuits were investigated. The objective of the study was to assess how the addition of pumpkin seed flour, known for its high protein and fat content, would influence the nutritional profile, functionality, and consumer acceptability of biscuit products. Bambara groundnuts (BGN), acha and pumpkin seeds were processed into their flours, which were then used in varying proportions to create different flour blends. These blends included control Sample (70% BGN and 30% acha flour) and substituted for other four samples with 2.5%, 5%, 10% and 12.5% pumpkin seed flour. The functional properties of the flour blends ranges were; bulk density (0.738 - 0.795 g/ml), water absorption capacity (208.35 - 224.96%), swelling power (12.03 - 15.48%), and dispersibility (62.48 - 68.52 %). Proximate composition ranged of the biscuit samples were; moisture content (10.06 – 12.79%), crude fat (15.31 – 18.04 %), total ash (1.14 – 1.59%), crude fibre (0.73 – 0.96%), crude protein (15.16 – 15.83%) and total carbohydrate (53.66 - 54.86 %). The sensory evaluation of biscuits samples were: crumb colour (7.27 to 8.20), taste (7.27 to 7.87), crumb texture (6.87 to 7.67), flavour (7.00-7.73), overall acceptability (7.27-7.93) and willingness to buy (7.00-8.00). The results demonstrate that BGN-Acha composite flour fortified with pumpkin seed flour may be used to create biscuits that are both nutritionally enhanced and sensorial acceptable.*

Keywords: Acha, bambara groundnut, composite flour, fortification, pumpkin seed.

Introduction

Biscuits are popular ready-to-eat snacks recognized all over the world for their desirable flavor, attractive appearance, flexibility in preparation techniques, sizes and shapes. However, conventional biscuits, typically made from wheat flour, often lack fiber, protein, and essential micronutrients. Due to their high fat, carbohydrate, and calorie content, they may not be ideal for regular consumption, particularly in diets focused on nutrient-rich foods (Vishwakarma *et al*., 2022). Increasing health consciousness has led to a rising consumer demand for food products with enhanced nutritional profiles, driving interest in fortification with nutrient-dense ingredients like composite flours (Mishra & Chandra, 2020). In developing countries, where malnutrition remains a significant challenge, incorporating locally grown, underutilized cereals, legumes, roots or tubers into daily diets has the potentials that can benefit both human health and the environment.

Bambara groundnut (BGN) (*Vigna subterraenea* (L.) verdc) is a lesser-known African legume often overshadowed by more popular legumes such as soybeans and groundnuts (Ramatsetse *et al*., 2023). Despite this, it is highly valued for its rich nutrient content, drought resistance, and ability to thrive in poor soil conditions where other legumes may struggle (Arise *et al*., 2015). BGN is significantly rich in protein with the amino acid- methionine, an essential amino acid that is often lacking in other legumes (Ijarotimi & Esho, 2009). BGN is a plant-based protein source available, especially, in regions affected by protein-energy malnutrition (Arise *et al*., 2015). Despite its enormous nutritional benefits, BGN remains underutilized, with its potential largely untapped in many parts of Africa. This is partly due to societal perceptions, as the crop is often excluded from more affluent diets and regarded as "poor man's food" (Arise *et al*., 2015). BGN's utilization in household meals is limited due to the long cooking time required to soften the beans. However, its nutritional advantages could be more widely recognized and utilized when incorporated into composite flours for baked products such as biscuits.

Acha (*Digitaria exilis*), also known as fonio or "hungry rice," is a small grain native to West Africa, particularly Nigeria. Traditionally, it has been used in various local dishes such as "tuwo" and "kunuu," and is often ground into flour for soups (Kamran *et al*., 2008). Its high dietary fiber content makes it beneficial for improving digestion and potentially lowering the risk of cardiovascular diseases (Kamran *et al*., 2008). Acha is highly nutritious, containing 8–10% protein, essential minerals such as calcium and phosphorus, and approximately 75% polysaccharides. One of the key benefits of acha is its low glycemic index, making it an ideal food for diabetics. Moreso, acha is rich in essential amino acids, such as cysteine and methionine, which are crucial for heart health and proper nerve function (Jideani, 2011; De Lumen *et al*., 2013). In the food industry, acha is increasingly gaining recognition as a functional food ingredient due to its ability to enhance the nutritional quality of composite flours.

Pumpkin seeds, derived from the *Cucurbita* species, is a nutritious agricultural commodity recently introduced into many food preparations. They are rich proteins, fiber, healthy fats, and essential minerals like zinc, magnesium, as well as vitamins A and E (Toan & Thug, 2018). Beside their nutritional benefits, pumpkin seed flour is increasingly being incorporated into baked goods for its distinctive flavor and color-enhancing properties. Pumpkin seed flour retains its beneficial components when processed in flour, hence can be incorporated into various food products, such as soups, pasta, and biscuits, to enhance their sensory appeal and nutritional profile (Mujaffar & Ramsumair, 2019). Pumpkin seed flour is rich in antioxidants, which help extend the shelf life of baked goods (Batista *et al*., 2018). These attributes suggest that incorporating pumpkin seed flour into Bambara groundnut-Acha composite flour could yield biscuits that are not only more nutritious but also visually appealing, better tasting, and possessing an enhanced shelf stability.

Traditionally, wheat flour has been the primary ingredient in biscuit production. Interest in composite flours that combine various grains and legumes is growing as consumers look for gluten-free and more nutrient-dense alternatives. This trend reduces dependence on wheat, which can pose challenges for individuals with gluten sensitivity or celiac disease, and facilitates the creation of biscuits that are higher in protein, fiber, and essential nutrients (Ayo *et al*., 2013). Production of biscuits with composite flours of bambara groundnut, acha and pumpkin seed is a promising effort toward improving the quality of biscuits. This study, therefore, aims to investigate the impacts of incorporating pumpkin seed flour into Bambara-Acha composite flour on the functional properties of the flour and the proximate and sensory qualities of the biscuits produced from the composite flour.

Materials and Methods

Sources of Materials

Bambara groundnuts were sourced from a retail market in Ilaro, Ogun State, Nigeria. Pumpkin pods were obtained from Idiyan village in Oyo State, while acha was purchased at Otto Market in Lagos State. Other ingredients (baking powder, sugar, whole egg, margarine, and milk powder) used for the biscuit production were acquired from Bola market in Orita-Pahayi, Ilaro. The experiments were conducted in the Department of Food Technology Laboratory at the Federal Polytechnic, Ilaro, Ogun State, Nigeria.

Production of Bambara Groundnut (BGN) Flour

Procedures outlined by Arise *et al*. (2015) were followed to produce the BGN flour. Bambara groundnut were thoroughly cleaned to remove any stones and other extraneous materials. After washing, the groundnuts were soaked in water for 12 hours. Once soaked, the seeds were manually dehulled and then dried in a cabinet dryer at 75 ºC for 24 hours. The dried nuts were subsequently ground using an attrition mill and stored carefully in airtight Ziplock bags until required for used.

Production of Acha Flour

Acha flour was prepared following the method outlined by Ayo & Okeye (2020). First, the chaff and other contaminants were manually removed from the acha grains through hand-picking. The grains were then thoroughly washed multiple times in plastic dishes with potable water to eliminate dust and sand. After cleaning, the grains were drained and dried for 6 hours at 50 ºC in a cabinet dryer. Once dried, the acha was ground into flour using an attrition mill and sieved through a mesh size of 100 µm (micrometers). Finally, the flour was bagged and stored in airtight Ziplock bags until needed for used.

Production of Pumpkin Seeds into Flour

Pumpkin seed flour were prepared following the method described by Cerniauskiene *et al*. (2014). Using a sharp knife, the pumpkin seeds were carefully extracted from the pumpkin pods. Once the pods were opened, it was easy to remove the seeds. The seeds were then washed with water to eliminate any contaminants that could interfere with the drying process or affect their suitability for consumption. The seeds were rinsed and strained using a strainer before being sun-dried for approximately two weeks. Once fully dried, the seeds were peeled and ground into flour. To achieve a fine, high-quality pumpkin seed flour, a 100 µm mesh sieve was used to filter the flour. Subsequently, the flour was stored in an airtight Ziplock bag until it was ready for use.

Formulation and Mixing Ratios of Bambara-Acha Composite Flour Fortified with Pumpkin Seed Flour

Bambara-acha composite flour (BAF) was formulated with 70% bambara flour and 30% of acha flour. Pumpkin seed flour was mixed with the Bambara-acha composite flour in varying amounts of 0%, 2.5%, 5%, 10%, and 12.5% for sample BAF, BADF, BAFF, BAHF, and BAJF respectively. The specific mix ratios for each sample, detailed in grams, are presented in Table 1.

Table 1: Formulations of Bambara-Acha Composite Flour Fortified with Pumpkin Seed Flour

Sample	Bambara-Acha (grams)	Pumpkin seeds flour (grams)
BAF	100	0
BADF	97.5	2.5
BAFF	95	5
BAHF	90	10
BAJF	87.5	12.5

Production of Biscuits from Bambara-Acha and Pumpkin Seed Composite Flour

The composite flour blends made from bambara groundnut, acha and pumpkin seed flour were used to prepare biscuits. To 200 g of each of the flour blend, 60 g of sugar, 52 g of egg, 50 g of margarine, 50 g of milk powder and 0.5 g of baking powder were mixed thoroughly to create a homogeneous batter. The batter was kneaded until it reached a consistent texture. Subsequently, it was evenly rolled out on a stainless steel table, and the dough was cut into various shapes and sizes using a biscuit cutter. To prevent sticking during baking, the shaped dough pieces were carefully arranged on greased baking pans. The biscuits were baked in a preheated oven at 160 °C for approximately thirty minutes, resulting in a well-balanced texture with a soft interior and a crisp exterior. After baking, the biscuits were allowed to cool before serving.

Analysis

Determination of Proximate composition of Bambara groundnuts-Acha composite flour fortified with pumpkin seed flour.

Proximate parameters - moisture content, total ash, crude protein, crude fat, and crude fiber were determined by AOAC, (2018) methods. The total carbohydrate content was determined by difference using the method described by Rampersad *et al*. (2003).

Determination of Functional properties of Bambara groundnuts-Acha composite pumpkin seed flour.

Bulk density was determined Markakis (1981). Water absorptio composite flours were assessed methods. The method for determi of the sample was described by T The method for determining disp by Kulkarni *et al*. (1991).

Sensory Evaluation of Bisc Bambara groundnuts-Acha composite flour fortified with pumpkin seed flour.

A 30 panel members were selected from male (13) and female (17) staff and students of the Department of Food Technology, Federal Polytechnic, Ilaro, Ogun state. The panelists employed were educated on the requirements for the test and their taste acuity were evaluated. The panelists were asked to evaluate the biscuits' colour, taste, texture, flavor, overall acceptability, and willingness to buy using a 9-point Hedonic scale in coded randomized manner.

Statistical Analysis

Mean and standard deviation of the data generated were calculated using a one-way Analysis of Variance (ANOVA). Duncan Multiple Range test (Statistical Package for Social Science, version 25.0) were used for mean separation.

Results

Table 2: Functional properties of flour produced from composite flour of Bambara-Acha fortified with pumpkin seeds flour

Sample	BULK DENSITY (g/ml)	WATER ABSORPTION CAPACITY (%)	SWELLING POWER (%)	DISPI
BAF	0.738±0.00 ^{e}	217.27±0.03^{c}	12.03±0.02^{b}	65
BADF	0.741±0.00^{d}	208.35±0.03^{d}	12.48±0.02^{b}	62
BAFF	0.743±0.0^{c}	219.11±0.03^{b}	15.03±0.04^{ab}	64
BAHF	0.748±0.00^{b}	224.96±0.03^{a}	15.41±0.02^{a}	66
BAJF	0.795±0.00^{ab}	212.29±0.04^{e}	15.48±0.03^{a}	68

Values are mean ± standard deviation. Means in the same column with different superscript letters are significantly (<0.05) different

Table 3**:** Proximate composition of biscuits produced from Bambara-acha composite flour fortified with pumpkin seed flour

Sample	BAF	BADF	BAFF	BAHF
Moisture Content (%)	11.81±0.02^{c}	10.06±0.02^{b}	10.40±0.04^{b}	12.57±0.02^{a}
Crude Fat (%)	16.36 ±0.03^{c}	18.04±0.02^{a}	17.62±0.03^{b}	15.53±0.03^{d}
Total Ash (%)	1.35±0.02^{c}	1.59±0.03^{a}	1.52±0.03^{b}	1.22±0.02^{d}
Crude Fibre (%)	0.80±0.03^{c}	0.96±0.02^{a}	0.91±0.03^{b}	0.81±0.11^{c}
Crude Protein (%)	15.16±0.02^{b}	15.34±0.03^{b}	15.49±0.02^{ab}	15.68±0.01^{a}

bohydrate)	54.18±0.12^{a}	53.66±0.06^{b}	53.72±0.09^{b}	54.52±0.05^{a}	54.86±0.06^{a}

Values are mean ± standard deviation. Means in the same row with different superscript letters are significantly (p<0.05) different.

Table 4. Sensory evaluation of biscuits produced from Bambara-acha composite flour fortified with Pumpkin Seed Flour

mple	BAF	BADF	BAFF	BAHF	BAJF
Colour	7.27 ±1.79^{b}	7.73 ±1.58^{b}	8.20 ±0.86^{a}	8.00 ±1.06^{a}	7.73 ±1.16^{b}
ste	7.27±1.83^{a}	7.73±2.12^{a}	7.53±1.64^{a}	7.73±1.33^{a}	7.87±1.12^{a}
texture	6.87±1.68^{b}	7.00±2.00^{a}	7.07±1.98^{a}	7.20±1.01^{a}	7.67±0.97^{a}
vor	7.00±1.46^{a}	7.33±1.83^{a}	7.53±1.72^{a}	7.60±1.29^{a}	7.73±1.16^{a}
erall ability	7.27±1.53^{a}	7.53±1.80^{a}	7.80±1.56^{a}	7.93±1.22^{a}	7.87±0.99^{a}
gness to uy	7.00±2.10^{b}	7.33±2.16^{b}	7.80±1.69^{b}	7.80±1.20^{b}	8.00±1.00^{a}

KEY:
BAF = 70% Bambara groundnut flour + 30% Acha flour
BADF = 97.5% of BAF + 2.5% Pumpkin seed flour
BAFF = 95% of BAF + 5% Pumpkin seed flour
BAHF = 90% of BAF + 10% Pumpkin seed flour
BAJF = 87.5% of BAF + 12.5% Pumpkin seed flour

Discussion

The functional properties of Bambara-acha composite flour (BAF**)** fortified with pumpkin seed flour are presented in Table 2. The flour's bulk density ranged from 0.738 to 0.795 g/ml, with significant variations among the flour samples (p<0.05). The flour formulated with 70% Bambara and 30% Okara (BAF) had the lowest bulk density (0.738 g/ml), the flour produced from 87.5% BAF fortified with 12.5% pumpkin seed flour had the highest bulk density (0.795 g/ml). The bulk density gradually increased as pumpkin seed flour inclusion increased. The bulk density of this study is in line with the results of Zhang *et al*. (2022). Bulk density of flours is essential for shipping purpose and meeting customer expectations of a complete package (Yeboah-Awudzi *et al*., 2018).

Addition of pumpkin seed flour resulted in significant increase in water absorption capacity (WAC) of the flours from 208.35% to 224.96%. Flour sample with 90% BAF fortified with 10% pumpkin seed flour had highest WAC, next to the 70% and 30% BAF which serves as control sample. This results is consistency with the results of Mumyapan *et al*. (2022), where WAC significantly increases (p<0.05) as protein concentration increased. A product's water absorption capacity is its ability to bond with water in conditions where water is limited, such as in dough and pastes. The capacity to absorb water is essential when making ready-to-eat foods. A flour capacity to absorb water is positively influenced by the amount and kind of hydrophilic ingredients, such as proteins, as well as the pH level (Sert *et al*., 2022). It has been demonstrated that high absorption capacity ensures product cohesiveness. Ihembe *et al*. (2023) state that bulking and uniformity of items, as well as baking applications, depend heavily on water absorption ability.

The swelling capacity of flour granules is the strength of associative forces inside the granules and their water absorption index during heating (Ihembe *et al*., 2023). A flour's capacity to swell is influenced by its particle size, variety, and processing methods or unit activities (Awolu *et al*., 2017). Swelling capacity values vary from 12.03% to 15.48%. Flour produced from 100% BAF had the lowest swelling capacity, with a mean value of 12.03%, while the flour with 95% BAF fortified with 5% pumpkin seed flour had the highest swelling capacity, with a mean value of 15.48%. The findings showed that as the amount of BAF decreased and the percentage of pumpkin seed flour increased, the swelling capacity of composite flour increased. The swelling capacity values found in this study were less than those found by Ihembe *et al*. (2023), this suggests that reduction in the carbohydrate content of the composite flours and high binding forces in BAF might be the cause of the increase in swelling capacity.

Dispersibility measures flour's ability to be reconstituted in water; the easiness with which flour can spread out as individual particles across the surface and throughout most of the component water (Anosike *et al*., 2020). The mean value for dispersibility of composite flours ranged from 62.48% to 68.52%. Significant variations (p<0.05) were observed amongst the flour samples. The maximum dispersibility (68.52%) was found in the flour produced from 87.5% BAF and 12.5% pumpkin seed flour, while the lowest dispersibility (62.48%) was found in the flour produced from 97.5% BAF and 2.5% pumpkin flour. Consequently, it is evident that as the proportion of pumpkin seed flour increased, the dispersibility of composite flours increased. Bose and Pandey (2022) reported results (69.80% to 52.27%) were similar to this finding. However, lesser than the values for supplemental meals developed by Anosike *et al*. (2020). High dispersibility signal that flour can quickly be reconstituted to produce a fine-consistency paste, properties ideal for baby food (Berti & Socha., 2023).

The proximate composition of biscuits produced from Bambara-acha composite flour (BAF) fortified with pumpkin seed flour is shown in Table 3. The moisture content of biscuits ranged from 10.06% to 12.79%. The sample with 97.5% BAF and 2.5% pumpkin seed flour had the lowest moisture level (15.06%), whereas the biscuit produced with 87.5% BAF fortified with 12.5% pumpkin seed flour had the greatest moisture content (12.79%). than the control sample ($P < 0.05$). As the amount of pumpkin seed flour fortification increased the moisture content increased. The findings are consistent with earlier research by Amin *et al*. (2019). However, biscuits with low moisture content will have longer shelf life because they prevent microbial development and enzymatic activity.
The crude fat content in the biscuits ranged from 15.31% to 18.04%. The crude fat content of the 87.5% BAF fortified with 12.5% pumpkin flour had the lowest mean value (15.31%) when compared to the other samples, with the exception of the control sample, which had a mean value of 16.36%. The 97.5% BAF and 2.5% pumpkin flour had the highest mean value (18.04%). The crude fat contents in this study were greater than the result (13.14% to 14.27%) reported by Babatunde and Saka (2020). The biscuits' low fat level might be attributed to the quantity of bambara-acha composite flour fortified with pumpkin seed flour. In order to regulate weight, foods with low fat content help reduce their overall calorie content. Also, the stability of the product may suffer if the acceptable fat level is exceeded since unsaturated fatty acids are more likely to undergo oxidative rancidity (Makanjuola *et al*., 2022).
Ash content, as a reflection of the mineral content in the biscuits, ranged from 1.22 to 1.59%. Biscuits prepared with 97.5% BAF fortified with 2.5% pumpkin seed flour had the highest total ash content (1.59%), whereas samples produced with 90% BAF fortified with 10% pumpkin seed flour had the least (1.22%). There were significant variations ($p<0.05$) among biscuit samples. These ash contents' observed were within values (1.01 - 2.87) reported by Twinomuhwezi *et al*. (2020) in a comparative study of proximate composition of amaranth, rice, millet, and soybean. According to Devi *et al*. (2018) pumpkin seed flour has high natural ash. The ash level of the pumpkin seed four has a lot of potential to provide vital minerals to the body.
The crude fiber content ranged from 0.73% to 0.96%. Significant differences ($p < 0.05$) were observed across the various biscuit samples. Crude fiber content was highest in biscuits produced with 97.5% BAF fortified with 2.5% pumpkin seed flour (0.96%), while the lowest was in the sample produced with 87.5% BAF fortified with 12.5% pumpkin seed flour (0.73%). The result from this study supports the findings of Wanigasooriya *et al*. (2023), who discovered that increase pumpkin seed flour substitution level amount in significant increase in crude fiber, from 0.71 to 0.90%. Crude fiber has the potential to protect heart from diseases; regular consumption suppresses diabetes, and colon cancer, among other health conditions (Awuchi, 2019). These are achieved by decreasing the rate at which glucose enters the bloodstream and reducing intracolonic pressure; crude fiber reduces the risk of colonic cancer (Awuchi, 2019).
Biscuit samples from 100% BAF had the lowest protein content, with a mean value of 15.16%, while 87.5% BAF fortified with 12.5% pumpkin seed flour had the highest, with a mean value of 15.83%. The observed improvement in protein content might be due to the substitution of pumpkin flour. Similarly, Mitiku & Bereka (2021) discovered that using more pumpkin seed flour in place of bambara flour increased the biscuits' protein content. The biscuits' protein contents in this study was higher than that (10.18% to 13.12%) reported by Simwaka *et al*. (2017). Additionally, George (2020) have demonstrated that biscuits products manufactured with pumpkin seed flour have a higher protein content. Protein is necessary for the body's maintenance, development, and repair.
The amount of carbohydrates content in the biscuits ranged from 53.72% to 54.86%. The sample with the highest carbohydrate content (54.86%) produced with 87.5% BAF fortified with 12.5% pumpkin seed flour. In biscuits produced with 70% and 30% BAF, the amount of carbohydrates content increased from 54.18% in the control sample to 54.86% in biscuits produced with 97.5% BAF fortified with 2.5% pumpkin seed flour. The variations in the biscuits' carbohydrate content were significant ($p<0.05$). The results of Dixit *et al*. (2019), who discovered that adding pumpkin seed flour to biscuits increased their carbohydrate content, are closely aligned with this findings. Carbohydrates are the main source of energy for cells, particularly red blood cells and those in the central nervous system (CNS) (Adekoge *et al*., 2024).
Table 4 presents the sensory evaluation results of biscuits produced from composite flour of Bambara-acha (BAF) fortified with pumpkin seed flour. The crumb colour of the biscuit samples ranged from 7.27 to 8.20. Biscuits produced with 95% BAF and 5% pumpkin seed flour received the highest mean score of crumb color (8.20), whereas the biscuits produced with 100% BAF (70% bambara groundnut and 30% acha) had the lowest mean score of crumb color (7.27). The results showed substantial variation in the crumb colours of biscuits ($p > 0.05$).

Similar results (7.00 to 8.13) were obtained by Gebremariam *et al.* (2024) for cakes developed from wheat-pumpkin seed bakes composite flour. Crumb colour is a crucial criterion for assessing properly created biscuits since it provides information about the product's formulation and quality as well as the right raw material utilized for production (Feyera, 2020). The biscuit samples' average taste ratings ranged from 7.27 to 7.87, and the differences were statistically significant ($p < 0.05$). The biscuits produced with 100% BAF (70% bambara groundnut and 30% acha) had the lowest taste test score, whereas the biscuits produced with 87.5% BAF fortified with 12.5% pumpkin flour received the highest taste score (7.87). The results showed that the addition pumpkin seed flour improves the taste of biscuits. As the percentage amount of pumpkin flour substitution increased, the taste ratings increases. The findings of Gebremariam *et al.* (2024) support the findings in this study, that the biscuits fortified with pumpkin seed flour were acceptable for good tasting. Their taste rating results (7.04 to 7.62) agrees with the findings in the present study. Due to the interaction between taste stimuli and taste receptors on the tongue, humans are able to discriminate between basic flavours such as sweet, sour, bitter, umami, and salty (Kusakabe *et al*., 2021).

According to Alshehry (2020), texture is a qualitative factor that indicates how soft or firm a biscuit is and how easily it may be munched. The biscuits produced with 87.5% BAF fortified with 12.5% pumpkin seed flour had the highest texture (7.67), whereas the biscuits produced with 100% BAF (70% bambara groundnut and 30% acha) had the lowest texture (6.87). These variations were significantly (<0.05). The panelists adjudged that all the biscuits samples had similar texture. The textural outcome of this finding was consistent with the results of Anita *et al*., (2020), who produced biscuits with different substitution ratios of pumpkin flour at 2.5%, 5%, 7%, and 10%.

Okache *et al*. (2020) claimed that flavor is a basic sensory characteristic that describes the feelings that arise in the nostrils as a result of volatile substances in food or beverages. The biscuit samples' flavor scores varied from 7.00 for those produced with 70% and 30% BAF to 7.73 for those produced with 87.5% BAF and 12.5% pumpkin flour. The findings demonstrated that adding pumpkin seed flour to biscuits did not negatively impact flavor sample, as shown by panelists' 7.00 and above hedonic rating, suggesting that they were generally well-liked. There were notable variations in the biscuits' flavors ($p < 0.05$). The results of this study closely matched the results (6.82 to 7.12) reported by George (2020).

The mean ratings for overall acceptability ranged from 7.27 to 7.93. The lowest scoring biscuits were produced with 100% BAF (70% bambara groundnut and 30% acha), whereas the best rated biscuit was the sample produced with 90% BAF and 10% pumpkin seed flour blend. The biscuits' total acceptance ratings demonstrated how much the panelists valued each sample. The results indicated that the biscuits' overall approval rating increased significantly ($p < 0.05$) with the addition of pumpkin seed flour. The study's mean values results align with the results (7.08 to 7.83) reported by Babatunde and Saka (2020). The findings demonstrated that the overall acceptability of the produced biscuits increased with the amount of pumpkin seed flour added to the recipe.

The willingness-to-buy of biscuits sample results ranging from 7.00 to 8.00, the biscuit samples showed a moderate to high degree of customer interest. The sample produced from 87.5% BAF fortified with 12.5% pumpkin seed flour received the highest score (8.00), while the control sample produced with 70% bambara groundnut and 30% acha (BAF) had the lowest willingness to buy score (7.00). The biscuits willingness to buy in this study are higher than the result (5.27 to 6.45) reported by Oyewole and Olagunju (2018), and they also support the findings of Makanjuola *et al*. (2022), who reported that increase in percentage of pumpkin seed flour increased baked goods and appeal to consumers. Based on the hedonic evaluations of the panelists, the biscuits that had the highest score were "liked very much," while those that had the lowest score were "liked moderately.

Conclusion and Future Works

This study assessed the functional, proximate, and sensory properties of biscuits produced from Bambara-acha composite flour (BAF) fortified with pumpkin seed flour, highlighting the nutritional and sensory benefits of incorporating these ingredients. The functional properties of flour sample improved with the addition of pumpkin seed flour. Specifically, pumpkin seed flour significantly enhance bulk density, water absorption, swelling power and dispersibility. In term of proximate composition, the addition of pumpkin seed flour significantly improved the nutritional profile of biscuits. Biscuits produced from 97.5% Bambara-acha composite flour (70% bambara and 30% acha) fortified with 2.5% pumpkin flour significantly increased protein content, moisture content and carbohydrates, while total ash, and crude fat slightly decrease. Sensory evaluation results revealed that biscuits containing 10% pumpkin seed flour were the most preferable, particularly in terms of flavour, texture and taste. This implies that fortifying the biscuits improves both their nutritional value and organoleptic qualities of the biscuits.

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