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# Quality Evaluation of Biscuits Produced from Wheat, High-Quality Cassava, and African Walnut Composite Flours

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**Abstract** Biscuits were produced from wheat flour, high-quality cassava, and African walnut flours. The flour samples were mixed in different ratios of wheat, high-quality cassava, and walnut, baked at 220°C for 15 min. The biscuit samples were subjected to proximate, mineral, anti-nutritional, physical properties, and sensory analyses. The data generated was subjected to analysis of variance and significance was accepted at $P < 0.05$. For the proximate composition of the biscuit samples, the moisture, ash, protein, fat, fibre, and carbohydrate contents ranged from 2.61 - 5.60%, 0.26 - 0.59%, 9.16 - 14.69%, 13.61 - 18.10%, 0.50 - 2.09%, and 61.15 - 67.57%, respectively. For the mineral content, the iron, magnesium, and potassium contents ranged from 7.08 - 14.75 ppm, 0.80 - 8.75 ppm, and 74.84 - 148.21 ppm, respectively. For the antinutrients, the phytate, oxalate, and hydrogen cyanide ranged from 13.63 - 39.97 mg/100 g, 3.93 - 5.26 mg/100 g, and 0.95 - 6.10 mg/100 g, respectively. The physical properties of the biscuit samples showed the weight, diameter, and thickness ranging from 13.4 - 15.48 g, 41.94 - 47.20 mm, and 10.36 - 12.36 mm, respectively. High sensory scores were obtained for all the sensory attributes, with the overall acceptability showing little significant differences ($P < 0.05$) with the control sample. Substitution of wheat flour with high-quality cassava and African walnut flours improved the nutritional quality without significantly changing in sensory quality.

**Keywords** proximate composition, mineral content, anti-nutritional factors, physical properties, sensory quality.

## 1. Introduction

Biscuits are ready-to-eat and are formulated from a combination of ingredients such as flour, fats (such as butter or oil), leavening agents (like baking powder), sweeteners (such as sugar), and sometimes flavour enhancers or additives [1]. The dough is mixed, shaped, and baked until it transforms, resulting in a distinctive brittle product. With a standard biscuit's glycemic index of 70.2, biscuits can vary widely in ingredients, flavours, sizes, and shapes [2]. Wheat flour is the primary material used in biscuit production, and within the flour, starch is the principal component [3]. Wheat reduces the risk of breast and prostate cancer by lowering the level of estrogen in the blood [4].

However, countries such as Nigeria that have a high degree of dependence on wheat may be significantly burdened by the import of wheat [5]. The over-dependence of wheat as a core food source could produce consequences that ripple throughout the whole food system, and, more recently, Russia's Ukraine conflict serves as an important reminder of these vulnerabilities [6]. The conflict disrupted wheat trade routes and supply chains, as Ukraine is the world's biggest producer of wheat [2]. Food shortages and price spikes caused by the disruption of supply, leading to possible food security risks, have occurred in countries that are heavily dependent on wheat imports from Ukraine [4]. Additionally, allergic reactions in sensitive people could be triggered by the proteins that make up wheat's characteristic properties, especially gliadins and glutenin. It is desirable to consider other materials like cassava flour and African walnut flour that can be used to produce biscuits or similar products, given that biscuit production is spreading to countries where wheat is not abundant or is an expensive imported material [7].

Cassava (*Manihot esculenta Crantz*) is cultivated mainly in the tropic and sub-tropic regions of the world over a wide range of environmental and soil conditions [8]. According to FAO statistics, the world's cassava production had increased from about 176 – 277 metric tons per year from 2000–2013. Africa contributed between 54 and 58 % of the world's cassava within these periods [9]. Nigeria is the largest cassava root producer in the world, with an annual production of over 34 million tonnes [4]. Cassava's high starch content and unique starch properties have been harnessed to improve the texture, binding, and moisture retention in various products such as bakery products and pasta. Cassava can be used in combination with wheat flour to produce products that remain soft and acceptable for an extended period [8]. In many cases, biscuits lack sufficient nutrition since they are produced from refined wheat flour. The nutrient profile can be enhanced with good fats, proteins, and essential micronutrients by the inclusion of African walnuts.

African walnut (*Tetracarpidium conophorum*) is a perennial climbing shrub that grows mainly in the western region of Africa [4]. It is commonly referred to as African walnut because of its West African origin and in Nigeria, it is predominately found in the southwest States. It has been widely used to enhance the nutritional value of cookies and other baked products [1, 10]. The addition of African walnut enhanced the overall sensory appeal of the biscuits by adding a distinctive flavour as well as an appealing crunch [11]. These flours are not only rich in essential nutrients, but they are also abundant and affordable, making them an ideal option for producing composite blends. However, despite their potential, the use of these flours is often overlooked due to a lack of awareness and technical knowledge. In addition, there is often a stigma associated with cassava flour, which is seen as a "poor man's food" in some cultures. This study aimed to use African walnut flour in a composite of wheat flour and high-quality cassava flour to make biscuits.

## 2. Materials and Methods

### Source of Raw Materials

Raw walnuts, freshly harvested cassava roots, wheat flour, and other materials were procured from Ketu market in Lagos State, Nigeria.

### Production of High-quality Cassava Flour

High-quality cassava Flour was processed using the method described by [12]. Freshly harvested cassava roots were sorted to remove adhering sand and other contaminants. It was weighed using a weighing scale and peeled manually using a stainless knife. The roots were washed and grated mechanically using an attrition mill to obtain a mash. The mash was detoxified mechanically using a detoxifier for 1 h, granulated to fine granules, dried using a flash dryer, and milled using a hammer mill. It was packaged in polypropylene packaging materials and stored for use.

### Production of Walnut Flour

The method of [13] was used to produce walnut flour. Raw walnuts were sorted, appropriately washed with potable water, and boiled in a steel pot for 1 h. It was allowed to cool, de-shelled manually, and sliced manually using a stainless-steel knife for size reduction (3-5 mm) to aid drying. It was dried at 60ºC for 5 hours and milled using a domestic blender to pass through a 4 µm sieve. It was packaged in polypropylene packaging materials and stored for use.

### Experimental Design/Table of Design

The design was a three-component extreme vertices design carried out using statistical software (Minitab version 17.0). The three mixture components in this study are wheat flour (x1), High-quality cassava flour (x2), and walnut flour (x3). The number of runs was nine (9), as shown in Table 1.

**Table 1:** Experimental design table

| Experimental run No | Sample code | Wheat flour (g) $X_1$ | Cassava flour (g) $X_2$ | Walnut flour (g) $X_3$ |
|---|---|---|---|---|
| 1 | WWW | 100 | | |
| 2 | WAT | 90 | 5 | 5 |
| 3 | WCA | 80 | 15 | 5 |
| 4 | WSA | 80 | 5 | 15 |
| 5 | WAA | 80 | 10 | 10 |
| 6 | WAW | 80 | 0 | 20 |
| 7 | WCW | 80 | 20 | 10 |
| 8 | WAL | 70 | 15 | 15 |
| 9 | WCT | 60 | 20 | 20 |

**Production of biscuits**

Biscuits were produced from the nine formulations using the method described by [14] with slight modification. All the ingredients were weighed accurately. The pre-weighed flour blends, sugar, milk powder and baking powder were mixed thoroughly. The egg was added and mixed properly to make adequate dough and then the dough was rolled to a uniform sheet of thickness. The sheet was cut according to the desired shape and size of biscuits with a cutter and baked in the oven at a temperature of 220 ºC for 15 minutes. The biscuits were allowed to cool for 30 minutes and stored in polyethylene bags before further analysis as shown in Figure 1.

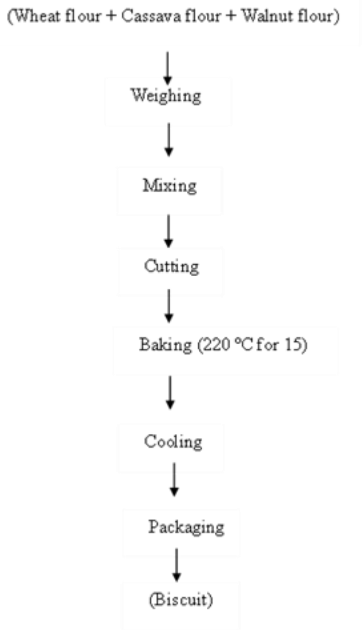


*Figure 1: Biscuit Production Flow Chart [14].*

**3. Chemical analysis**

**Proximate Analysis**

The proximate analysis was carried out using [15] methods.

**Mineral Determination**

The mineral (Mg, K, Fe) was carried out using the [15] atomic absorption spectrophotometric methods.

**Determination of Selected Anti-nutrients**

**Determination of Phytate**

The phytic acid was determined using the procedure described by [16]. Two (2) g of sample were weighed into a 250 mL conical flask. About 100 mL of 2 % HCl acid was used to soak each sample in the conical flask for 3 hrs. and then filtered through a double layer of hardened filter papers. Fifty (50) ml of each filtrate was placed in a 250 mL beaker and 100 mL of distilled water was added to each to give proper acidity. Ten (10) mL of 0.3 % ammonium thiocyanate solution was added into each solution as an indicator. Each solution was titrated with standard iron chloride solution, which contained 0.00195 g Fe/ml. The endpoint colour was slightly brownish yellow, which persisted for 5 min. The percentage phytic acid was calculated.

Phytate=phytate phosphorus×3.65g (1)

**Determination of Oxalate**

Oxalate was determined by using the method of [17]. One (1) g of sample was placed each in a 250 mL volumetric flask, 190 mL of distilled water and 10 mL of 6 M HCl were added. Each mixture was warmed in a water bath at 90 ºC for 4 hrs and the digested samples were centrifuged at a speed of 2,000 rpm for 5 min. The supernatant was then diluted to 250 mL. Three (3) 50 mL aliquots of each supernatant were evaporated to 25 mL, and then the brown precipitate was filtered off and washed. The combined solution and washings were titrated with concentrated ammonia solution in drops until Salmon pink colour of methyl orange changed to faint yellow. The solutions were heated on a water bath to 90 ºC and the oxalate was precipitated with 10 mL of 5 % calcium chloride ($CaCl_2$) solution. The solutions were allowed to stand overnight then centrifuged. Each precipitate was washed into a beaker with hot 25 % $H_2SO_4$, diluted to 125 mL with distilled water and after warming to 90ºC it was titrated against 0.05 M $KMnO_4$.

Titre value x 0.0025 xDF5 (2)

Oxalate %=Nsample size x1001 (3)

Where; DF = dilution factor

0.0025 = volume of KMnO

**Determination of Hydrogen Cyanide**

Hydrogen cyanide content was assessed by hydrolysing samples, distilling with NaOH, and titrating with $AgNO_3$ solution using [15] methods.

**Physical Properties of the Biscuits**

The biscuit samples were analysed to determine their weight, diameter, and thickness.

**Determination of Weight**

The weight of the biscuit was determined according to the method described by [18]. The weight was determined by weighing the biscuit on a weighing balance.

**Determination of Diameter**

The diameter was determined according to the method described by [19]. The diameter of the biscuit was measured using a Vernier calliper and reported in millimetres (mm).

**Determination of Thickness**

The thickness was determined according to the method described by [20]. The thickness of the biscuit was measured using a micrometre screw gauge and reported in millimetres (mm).

**Sensory Evaluation**

Sensory evaluation was conducted on the biscuit samples, using twenty-five semi-trained panellists from the Staff and Students of the Food Technology Division of Federal Institute of Industrial Research, Oshodi, Lagos State, and Students of Food Science and Technology Students Nnamdi Azikiwe University, Awka, who are familiar with the sensory attributes of biscuit. A 9-point Hedonic test as described by [21] was used. Where 1 and 9 represented dislike extremely and like extremely, respectively. The attributes evaluated were colour, taste, flavour, texture, and overall acceptability. Table water was used for mouth rinsing intermittently.

**Statistical Analysis**

Analysis of data was done using the Statistical Package for Social Science (SPSS) version 25. The means were separated using Duncan Multiple Ranged Test and significance was accepted at $P < 0.05$.

## 4. Results & Discussion

**Proximate Composition of Biscuit Samples**

The moisture content ranged from 2.61 to 5.60 %. The biscuit sample with flour formulation ratio 80:20:0 recorded the highest value (5.6 %) of moisture while 80:15:15 had the lowest value (2.61 %). The moisture content of the biscuit samples was in the range with the value of 3.60 to 5.80 % reported by [22] and 2.68 to 4.25 % reported by [23]. The biscuit sample with flour formulation ratio of 80:15:5 as shown in Table 2 is the best in terms of moisture (2.61 %) and would have a longer storage stability. This complies with the regulations given by [9], which specifies 6 % as the maximum moisture content of baked products. High moisture content reduces the shelf life of foods by creating a suitable environment for micro-organisms' growth and replication [24].

The ash content of the biscuit samples ranged from 0.26 to 0.59 %. The biscuit produced from the control flour sample ratio of 100:0:0 had the highest value (0.59 %) and 80:10:10 had the lowest value (0.26 %). The ash content obtained in this study was lower than the value (1.5 %) reported for cookies produced from wheat-African walnut flour [13]. The presence of ash content in food is simply the burning away of organic content, living in organic minerals [24].

The crude protein content of the biscuit samples ranged from 9.16 to 14.69 %. However, the result was in range with the value of 7.43 to 13.04 % reported by [25] on wheat-walnut biscuits. The biscuit (80:0:20) with the highest protein content could be a result of the addition of a higher ratio of walnut flour. Protein is important in building the bones, muscle, cartilage, skin, and blood [32].

Fat content ranged from 13.61% to 18.10%, akin to [25] (14.39% to 16.57%). 80:0:20 had the highest fat (18.10%), attributed to walnut's high fat. The increased fat content of the formulated biscuit samples could be attributed to the high-fat content of the African walnut, as reported by [25]. Fat can act as an alternative energy source.

The crude fat content of the biscuit samples ranged from 13.61 to 18.10 %. The fat content of the formulated biscuit was within the range of 14.39 to 16.57 % reported by [25] for wheat-walnut biscuits. The biscuit sample with a flour formulation ratio of 100:0:0 (control) had the highest value of 70.09 %, and 80:10:10 had the lowest value of 61.15 %. The result obtained was in the range of 69.18 to 76.81 % reported by [3]. The increased fat content of the formulated biscuit samples could be attributed to the high-fat content of the African walnut, as reported by [25]. Fat can act as an alternative energy source.

**Table 2:** Proximate composition of biscuit samples

| Sample Code | Description W: C: T | Moisture (%) | Ash (%) | Crude Protein (%) | Fat (%) | Crude Fiber (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|---|
| **WWW** | 100: 0: 0 | $3.34^{d} \pm 0.01$ | $0.59^{a} \pm 0.02$ | $10.80^{e} \pm 0.28$ | $13.61^{h} \pm 0.23$ | $1.56^{c} \pm 0.03$ | $70.09^{a} \pm 0.51$ |
| **WAT** | 90: 5: 5 | $4.27^{c} \pm 0.04$ | $0.37^{de} \pm 0.03$ | $12.01^{d} \pm 0.30$ | $16.26^{e} \pm 0.10$ | $0.53^{g} \pm 0.08$ | $66.54^{c} \pm 0.04$ |
| **WCA** | 80: 15: 5 | $2.61^{h} \pm 0.03$ | $0.29^{f} \pm 0.01$ | $13.10^{bc} \pm 0.01$ | $16.85^{c} \pm 0.08$ | $0.50^{g} \pm 0.02$ | $66.64^{c} \pm 0.15$ |
| **WSA** | 80: 5: 15 | $3.23^{e} \pm 0.06$ | $0.37^{cd} \pm 0.01$ | $12.34^{d} \pm 0.01$ | $16.57^{d} \pm 0.06$ | $1.14^{f} \pm 0.04$ | $66.42^{c} \pm 0.01$ |
| **WAA** | 80: 10: 10 | $3.10^{f} \pm 0.01$ | $0.26^{g} \pm 0.01$ | $13.53^{b} \pm 0.31$ | $17.71^{b} \pm 0.07$ | $4.24^{a} \pm 0.19$ | $61.15^{g} \pm 0.05$ |
| **WAW** | 80: 0: 20 | $2.78^{g} \pm 0.01$ | $0.40^{c} \pm 0.01$ | $14.69^{a} \pm 0.32$ | $18.10^{a} \pm 0.65$ | $1.36^{de} \pm 0.03$ | $62.66^{f} \pm 0.38$ |
| **WCW** | 80: 20: 0 | $5.53^{b} \pm 0.02$ | $0.34^{e} \pm 0.01$ | $9.16^{f} \pm 0.37$ | $15.19^{g} \pm 0.02$ | $2.09^{b} \pm 0.05$ | $67.57^{b} \pm 0.32$ |
| **WAL** | 70: 15: 15 | $5.60^{a} \pm 0.01$ | $0.54^{b} \pm 0.01$ | $12.94^{c} \pm 0.01$ | $16.00^{f} \pm 0.07$ | $1.46^{cd} \pm 0.06$ | $63.45^{e} \pm 0.16$ |
| **WCT** | 60: 20: 20 | $3.23^{e} \pm 0.04$ | $0.36^{de} \pm 0.02$ | $12.06^{d} \pm 0.28$ | $17.58^{b} \pm 0.03$ | $1.23^{ef} \pm 0.02$ | $65.53^{d} \pm 0.35$ |

N/B: Values are represented as means ± standard deviation of three (3) replicates. Data in the same column bearing different superscripts differed significantly (p<0.05). W=Wheat flour, C=High-quality cassava flour and T=Walnut.

The fibre content of the biscuit samples ranged from 0.50 to 4.24 %. The biscuit sample with a flour formulation ratio of 80:10:10 had the highest value of 4.26 %, and 80:15:15 had the least value of 0.50 %. The crude fibre content obtained was higher than the value of 0.64 % reported by [25] on wheat-walnut biscuits. This compared favourably with 2.56 to 3.54 % reported by [23]. Thus, the formulated biscuit samples are an efficient source of dietary fibre, which is important for reducing cholesterol in the body to minimise risks of cardiovascular diseases caused by high plasma cholesterol [24].

The Carbohydrate content of the biscuit samples ranged from 61.15 to 70.09 %. The biscuit sample with a flour formulation ratio of 100:0:0 (control) had the highest value of 70.09 %, and 80:10:10 had the lowest value of 61.15 %. The result obtained was in range with the value of 69.18 to 76.81 % reported by [25. The biscuit sample produced with 100 % wheat flour (control) was significantly different ($P < 0.05$) when compared with the other biscuit samples. This was because composing the flour tends to reduce the carbohydrate content of the formulated samples. Carbohydrates affect the blood glucose more than any other nutrients in the body [24].

**Mineral Composition**

The iron content of the biscuit samples ranged from 7.08 to 14.47 ppm. These values are within the range of 14.49 ppm reported by [26] for wheat flour biscuits. The iron content of the biscuit produced from 100 % wheat flour varied significantly ($P < 0.05$) from other samples, but the biscuit sample with a composite flour ratio of 70:15:15 recorded the highest iron content of 14.47 ppm. The high iron content of the sample can help solve the issue of iron deficiency. Inadequate intakes of micronutrients have been associated with severe malnutrition. The magnesium content of the biscuit samples ranged from 0.80 to 8.75 ppm.

The biscuit produced from a composite flour formulation ratio of 80:0:20 recorded the highest value of 8.75 ppm, and 80:20:0 recorded the lowest value of 0.80 ppm as shown in Table 3. Biscuit samples made from 80:0:20 flour ration recorded the highest value of 8.75 ppm, which is in the range of 8.00 ppm obtained by [27] for wheat-sweet potato biscuits. Magnesium is vital for bone health, nerve, and muscle function [26]. High amounts of magnesium, calcium and potassium have been reported to reduce blood pressure in humans [8].

**Table 3:** Mineral composition of the biscuit samples

| Sample Code | Description W: C: T | Iron (Fe) Ppm | Magnesium (Mg) Ppm | Potassium (K) ppm |
|---|---|---|---|---|
| **WWW** | 100: 0: 0 | $14.04^{b} \pm 0.02$ | $1.62^{g} \pm 0.01$ | $125.07^{d} \pm 0.01$ |
| **WAT** | 90: 5: 5 | $7.01^{h} \pm 0.01$ | $2.68^{e} \pm 0.01$ | $125.26^{d} \pm 2.80$ |
| **WCA** | 80: 15: 5 | $8.76^{g} \pm 0.02$ | $1.65^{f} \pm 0.02$ | $74.89^{h} \pm 0.01$ |
| **WSA** | 80: 5: 15 | $10.91^{d} \pm 0.01$ | $3.38^{d} \pm 0.01$ | $140.02^{b} \pm 0.01$ |
| **WAA** | 80: 10: 10 | $9.98^{e} \pm 0.01$ | $7.20^{b} \pm 0.01$ | $108.88^{e} \pm 0.01$ |
| **WAW** | 80: 0: 20 | $7.08^{h} \pm 0.01$ | $8.75^{a} \pm 0.01$ | $95.18^{g} \pm 0.01$ |
| **WCW** | 80: 20: 0 | $8.83^{f} \pm 0.01$ | $0.80^{i} \pm 0.01$ | $148.21^{a} \pm 0.02$ |
| **WAL** | 70: 15: 15 | $14.47^{a} \pm 0.01$ | $4.06^{c} \pm 0.01$ | $128.86^{c} \pm 0.01$ |
| **WCT** | 60: 20: 20 | $13.15^{c} \pm 0.01$ | $1.46^{g} \pm 0.01$ | $97.27^{f} \pm 0.02$ |

N/B: Values are represented as means ± standard deviation of three (3) replicates. Data in the same column bearing different superscript differed significantly (p<0.05). W=Wheat flour, C=High-quality cassava flour and T=Walnut flour

The potassium content had the highest value among the minerals analysed. The value ranged from 95.18 to 148.21 ppm. The samples were within the range of 78.72 to 90.56 ppm obtained by [26] for wheat flour biscuits. Potassium intake is required in relatively large amounts in the body [4] because it functions as an important electrolyte in the nervous system [8].

**5. Anti-nutritional Content of the Biscuit Samples**

The results of the anti-nutritional content (Phytate, Oxalate, and HCN) of the biscuit samples are presented in Table 4. Generally, there was a decrease in the antinutrient content of the biscuit when compared with levels found in the raw cassava and walnut seed samples. The phytate content of the biscuit sample was highest compared to other antinutrients analysed. The value ranges from 15.6 to 39.9 mg/100 g. The result obtained was higher than the value of 3.47 mg/kg reported by [20] on wheat-walnut biscuits. Values were within 670 to 1350 mg/100 g limit [28]. Phytate forms mineral complexes, limiting bioavailability [29]. Oxalate content ranged from 3.93 to 5.26 mg/100 g, highest in 100% wheat flour biscuit (5.26 mg/100 g). The value of the oxalate content of the biscuit samples ranged from 3.93 to 5.26 mg/100 g. The oxalate content was highest in the biscuit sample produced from 100 % wheat flour, with a value of 5.26 mg/100 g [30]. The value obtained was below the recommended amount for kidney stone prevention, below 100 mg of oxalate daily [19]. Higher intake of oxalate reduces calcium availability [24].

The value of the biscuit samples ranged from 0.95 to 6.10 mg/100 g as shown in Table 4. The acute reference dose (ARfD) values for cyanogenic glycosides are 0.09 mg/kg body weight of cyanide equivalents and 20 µg/kg bw/d.

**Table 4:** Anti-nutritional content of the biscuit samples

| Sample Code | Description (W: C: T) | Phytate (mg/100g) | Oxalate (mg/100g) | HCN (mg/100g) |
|---|---|---|---|---|
| **WWW** | 100 % | $16.57^{de} \pm 9.75$ | $5.26^{a} \pm 8.76$ | $3.650^{c} \pm 1.62$ |
| **WAT** | 90:5:5 | $15.60^{ef} \pm 19.50$ | $4.85^{abc} \pm 6.33$ | $1.72^{e} \pm 0.37$ |
| **WCA** | 80:15:15 | $24.37^{c} \pm 9.75$ | $4.43^{bcd} \pm 2.11$ | $0.95^{f} \pm 0.43$ |
| **WSA** | 80:5:15 | $18.51^{d} \pm 9.75$ | $3.93^{d} \pm 2.07$ | $3.56^{c} \pm 4.64$ |
| **WAA** | 80:10:10 | $25.45^{c} \pm 19.58$ | $5.14^{ab} \pm 6.70$ | $5.09^{b} \pm 1.62$ |
| **WAW** | 80:0:20 | $28.27^{b} \pm 9.75$ | $4.17^{cd} \pm 0.27$ | $3.24^{d} \pm 0.32$ |
| **WCW** | 80:20:0 | $16.57^{de} \pm 9.75$ | $4.02^{d} \pm 4.47$ | $1.60^{e} \pm 0.32$ |
| **WAL** | 70:15:15 | $13.63^{f} \pm 0.29$ | $4.51^{abcd} \pm 2.15$ | $3.63^{c} \pm 0.81$ |
| **WCT** | 60:2:20 | $39.97^{a} \pm 9.75$ | $4.53^{abcd} \pm 0.32$ | $6.10^{a} \pm 0.54$ |

N/B: Values are represented as means ± standard deviation of three (3) replicates. Data in the same Column bearing different superscript differed significantly ($p<0.05$). HCN=Hydrogen cyanide. W=Wheat flour, C=High-quality cassava flour and T=Walnut flour

The ARfD value was derived from a benchmark dose lower confidence limit for a 10 % increased incidence (BMDL10) for fetal skeletal defect of 85 mg/kg bw from a developmental toxicity study conducted in hamsters with linamarin [31].

The biscuit sample with flour formulation ratio of 80:10:10, 80:20:0, and 70:15:15 recorded the highest mean value (7.80) for general acceptability while sample 90:5:5 had the lowest value (6.50). This might be because this product is a novel one and as such, it is unknown to people. There was no significant ($P < 0.05$) difference between the control sample (100:0:0) and some of the biscuit samples in all the sensory attributes analysed.

**Table 5:** Sensory Evaluation of the Biscuit Samples

| Sample | Description W: C: T | Colour | Taste | Flavour | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| **WWW** | 100: 0: 0 | $7.20^{abc} \pm 1.43$ | $7.50^{ab} \pm 0.68$ | $6.90^{ab} \pm 0.85$ | $7.60^{a} \pm 0.94$ | $7.70^{a} \pm 1.12$ |
| **WAT** | 90: 5: 5 | $7.30^{abc} \pm 1.30$ | $6.50^{c} \pm 0.82$ | $7.00^{ab} \pm 0.91$ | $6.40^{c} \pm 1.23$ | $6.50^{b} \pm 0.68$ |
| **WCA** | 80: 15: 5 | $7.50^{ab} \pm 0.94$ | $7.00^{bc} \pm 0.79$ | $6.80^{b} \pm 0.89$ | $7.20^{ab} \pm 1.10$ | $7.30^{a} \pm 0.80$ |
| **WSA** | 80: 5: 15 | $6.90^{bc} \pm 1.33$ | $7.30^{ab} \pm 1.03$ | $7.10^{ab} \pm 0.96$ | $7.70^{a} \pm 0.65$ | $7.30^{a} \pm 0.92$ |
| **WAA** | 80: 10: 10 | $7.40^{abc} \pm 0.94$ | $7.20^{ab} \pm 0.89$ | $7.20^{ab} \pm 0.61$ | $7.60^{a} \pm 0.68$ | $7.80^{a} \pm 0.76$ |
| **WAW** | 80: 0: 20 | $6.80^{c} \pm 0.76$ | $6.50^{c} \pm 0.82$ | $7.00^{ab} \pm 0.91$ | $6.90^{bc} \pm 1.25$ | $6.60^{b} \pm 1.04$ |
| **WCW** | 80: 20: 0 | $7.70^{a} \pm 1.12$ | $7.00^{bc} \pm 0.91$ | $7.10^{ab} \pm 1.33$ | $7.30^{ab} \pm 0.80$ | $7.80^{a} \pm 1.00$ |
| **WAL** | 70: 15: 15 | $7.60^{a} \pm 0.82$ | $7.70^{a} \pm 0.80$ | $7.40^{a} \pm 0.82$ | $7.80^{a} \pm 0.76$ | $7.80^{a} \pm 0.76$ |
| **WCT** | 60: 20: 20 | $7.30^{abc} \pm 1.03$ | $7.00^{bc} \pm 0.79$ | $7.20^{ab} \pm 0.61$ | $7.70^{a} \pm 1.12$ | $7.50^{a} \pm 0.82$ |

N/B: Values are represented as means ± standard deviation of three (3) replicates. Data in the same column bearing different superscripts differed significantly ($p<0.05$). W=Wheat flour, C=High-quality cassava flour, and T=Walnut.

## 6. Conclusion

The study demonstrated that incorporating African walnut and high-quality cassava flour into biscuit production can lead to variations in nutritional, functional, and sensory properties. Adding cassava and walnut flour significantly affected the biscuits' nutritional composition, with little or no significant differences in the samples' overall acceptability. Despite some differences in specific attributes, the composite biscuits were generally acceptable and could potentially offer nutritional benefits, validating the organoleptic appeal of the composite biscuits. These results highlight the potential for blending Cassava and African walnut seed flours to produce bakery products that are both good in terms of nutrition and function.

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