

Evaluation of Nutritional and Sensory Attributes of Cookies Produced from Composite Flour of Wheat, African Yam Beans and Unripe Plantain

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Abstract

Four cookies samples were produced from composite flour of wheat, unripe plantain and African yam beans. Ratios used were: samples A (100:00:00), B (60:20:20), C (40:30:30) and D (20:40:40) wheat flour, whole unripe plantain flour and African yam bean flour respectively. The functional properties, physical properties, proximate composition, anti-nutritional factor and sensory attributes of the cookies made from the composite flour were analysed. The results of functional properties showed significant differences ($p < 0.05$) among the cookies samples except oil absorption capacity. On physical properties, there were significant differences ($p < 0.05$) among the weight ($2.68 \pm 3.40\text{g} - 3.95 \pm 0.33\text{g}$), thickness ($0.90 \pm 0.10\text{cm} - 1.90 \pm 0.10\text{cm}$) and spread ratio ($2.84 \pm 0.18 - 5.86 \pm 0.67$). All the samples including control had similarity in diameters. Proximate composition showed significant increased ($p < 0.05$) in moisture content ($3.33 \pm 0.04 - 4.62 \pm 0.03\%$), crude protein ($10.04 \pm 0.06 - 13.93 \pm 0.03\%$), ash ($2.44 \pm 0.04 - 5.60 \pm 0.01\%$) and crude fibre ($2.20 \pm 0.01 - 4.81 \pm 0.01\%$) while the carbohydrate ($81.82 \pm 0.04 - 73.04 \pm 0.02\%$) and lipid content $3.50 \pm 0.01 - 2.62 \pm 0.01\%$ significantly decreased ($P < 0.05$) with increase in level of whole unripe plantain and African yam beans. The Ca, K, Mg and Zn contents increased with increase in level of whole unripe plantain and African yam beans. Calcium ranged from 7.03 ± 0.03 in control and $18.21 \pm 0.04\text{mg}/100\text{g}$ in sample D. Potassium $18.10 \pm 0.03 - 93.33 \pm 0.03\text{mg}/100\text{g}$, magnesium $0.09 \pm 0.01 - 10.22 \pm 0.04\text{mg}/100\text{g}$ and zinc $0.02 \pm 0.01 - 16.11 \pm 0.02\text{mg}/100\text{g}$. On anti-nutritional factors, phytate, oxalate and tannin contents of the cookies ranged from $0.55 \pm 0.02 - 10.55 \pm 0.03\text{mg}/100\text{g}$, $2.64 \pm 0.04 - 5.96 \pm 5.96\text{mg}/100\text{g}$ and $126.90 \pm 0.07 - 153.96 \pm 0.03\text{mg}/100\text{g}$ respectively. The sensory scores showed that sample B was the most preferred by the panellists in terms of overall acceptability. The study indicated that, cookies of high nutritional quality could be produced from composite flour of wheat, unripe plantain and African yam beans. These cookies could help to alleviate the problem of protein-energy malnutrition that is still prevalent in some communities in Nigeria and also promote the utilization of these and similar underutilized crops thus enhancing food security.

Keywords: Unripe Plantain, African Yam Bean, Cookies, Food Security.

Introduction

Cookies are convenient baked products, ready-to-eat and easily available in different shapes and sizes at an affordable cost with high nutritive value (Vijerathna *et al.*, 2019). They are the most popular bakery items consumed among all age groups in many countries because they have a very acceptable taste and their low water activity allows a long shelf life (Chauhan *et al.*, 2015; Usman *et al.*, 2015). In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals and tuber crops available to domestic use. Recently, government has collaborated with the research institutes to encourage the use of composite flours in the production of food products such as cookies, bread etc. Several studies have reported the use of composite flour in cookies production (Akusu *et al.*, 2019; Obinna-Echem and Robinson, 2019; Ukeyima *et al.*, 2019; Bello *et al.*, 2020; Wabali *et al.*, 2020, Edima-Nyah *et al.*, 2023). All these efforts were aimed at improving the nutritional values of the cookies and also to enhance crop utilization.

Wheat (*Triticum aestivum*) is a common cereal grain in the world which belongs to the family poaceae gramineae (Okoye and Obi, 2017). Wheat plays an important role as global commodity due to its gluten forming proteins, which are capable of having extensibility and elasticity required for bakery products and pasta (FAO, 2013; Inyang *et al.*, 2018). Wheat contains 78.10% carbohydrate, 14.70% protein, 2.10% fat, 2.10% minerals and considerable proportions of vitamins (thiamine and vitamin B) and minerals (Kumar *et al.*, 2011).

Plantain (*Musa paradisiaca*) is an important staple food in Central and West Africa (Makanjuola *et al.*, 2013). Plantains are abundant in Nigeria and other developing countries. Plantain fruit is composed of 75% different elements and 32% of carbohydrates and it also contains several vitamins including A, B, C and is very low in protein and fat but rich in minerals particularly iron. Also, it is free from cholesterol, high in fibre and low in sodium (Adewole and Duruji, 2010). Because plantains have poor amino acid profile, it should be supplemented with protein rich food crops like legumes. One of such legumes is African yam beans. The resulting products would be rich in both protein and carbohydrates.

African yam bean (*Sphenostylis stenocarpa*), an important legume in Africa with duo food product (seeds and tubers) and it is a lesser-known legume of the tropical and sub-tropical areas of the world which has attracted research in recent times (Azeke *et al.*, 2005). African yam bean is rich in carbohydrate, protein, vitamins and minerals (Onyenekwe *et al.*, 2000). African yam bean consists of protein that is made up of over 32% essential amino acids, with leucine and lysine being preponderant (Onyenekwe *et al.*, 2000). Therefore, incorporating it into wheat for the production of cookies would supply the lysine that is absent in wheat. This legume has also been reported to be of importance in the management of chronic diseases like hypertension, diabetes, and cardiovascular diseases because of its high dietary fibre content. In spite of all this, African yam bean is underutilized and hardly consumed in urban areas which are attributed to its complex preparation method. It is a good source of protein, carbohydrate, minerals and vitamins with its protein content, twice that of sweet or Irish potatoes and very much higher than those in yam and cassava (Day, 2013). Also, addition of legumes to cereals improves the amino acid balance of the product since legume

and cereal proteins are complemented in the essential amino acids, lysine and methionine (Qadri *et al.*, 2018).

Based on the foregoing, this study was carried out to elucidate the effect of supplementing wheat flour with African yam beans and unripe plantain flours on the quality characteristics of cookies made from the flour blends on the physical properties; proximate composition, anti-nutrient content, mineral and sensory attributes of the cookies samples.

Materials and Methods

Source of Materials

Wheat grains, African Yam Beans and Unripe plantain were purchased from Akpan Andem market in Uyo metropolis. Reagents used were purchased from chemical store in Uyo metropolis, Akwa Ibom State. All the reagents were of analytical grade.

Preparation of Wheat Flour

Wheat flour was produced following the method described by Inyang and Elijah (2020). The wheat grains were cleaned from dirt by sorting out contaminants such as sticks, leaves and sand, washed in clean water and dried for 6 hr at 60 °C in a conventional air oven (model pp, 22 us, Genlab, England). The dried grains were milled into flour using hammer mill and the flour was sieved through a 425µm mesh and packaged in airtight plastic container, labelled and stored at ambient temperature (27±2°C) for subsequent use.

Preparation of African Yam Beans Flour

African yam beans (AYB) flour was prepared following the method described by Yusufu, *et al.* (2014). AYB seeds were cleaned of dirt, parboiled (100 °C for 20 min) in an aluminum pot with lid. The parboiled seeds were drained for 5 minutes, dehulled manually and washed with clean water. The seeds were oven dried and toasted at 150 °C for 1 hr. The toasted seeds were milled in hammer mill and sieved through a 425µm mesh. The flour was packaged in an air tight container.

Preparation of Unripe Plantain Flour

Whole unripe plantain flour was prepared following the method described by Inyang *et al.* (2017). The plantain fruits were individually plucked from the plantain hands, washed in tap water, drained, the apex and stalk were cut off and discarded. The whole unripe fruits were individually cut into halves, steam blanched for 10 minutes to inactivate enzymes, drained, cooled, sliced to about 5mm thickness using a sharp stainless-steel knife and dried in an oven (model PP. 22 US, Genlab, England) at 60°C to a constant weight. The dried slices were milled into flour using hammer mill, sieved through a mesh of 425 µm aperture screen, packaged in air tight container, labelled and stored at ambient temperature (27±2°C) for subsequent utilization.

Formulation of Composite Flour

Four treatments with different proportions of wheat, unripe plantain and African yam beans flours were formulated and designated as B, C and D. Flour with 100% wheat was designated as A and served as the control. Flours were formulated to 300g per sample. The blending ratios are shown on Table 1.

Table 1: Blending Ratios of the Different Flours

Flour Samples	Treatments			
	A	B	C	D
WHEAT FLOUR	100	60	40	20
UNRIPE PLANTAIN FLOUR	0	20	30	40
AFRICAN YAM BEANS FLOUR	0	20	30	40

Key: A: wheat flour 100% (control)

B: wheat flour (60%) +AYB flour (20%) + Plantain flour (20%)

C: wheat flour (40%) +AYB flour (30%) + Plantain flour (30%)

D: wheat flour (20%) +AYB flour (40%) + Plantain flour (40%)

Table: 2: Ingredients Combination for Cookies made from Composite flour of Wheat, African Yam Beans and Unripe Plantain flour (per 300g)

Ingredients	Treatments			
	100:0:0 (A)	60:20:20 (B)	40:30:30 (C)	20:40:40 (D)
Composite Flour (g)	300	300	300	300
Sugar (g)	150	150	150	150
Margarine (g)	100	100	100	100
Vanilla flavour (g)	15	15	15	15
Baking Powder (g)	5	5	5	5
Egg (g)	50	50	50	50
Milk (g)	10	10	10	10
Water (ml)	50	50	50	50

Key: A: wheat flour 100% (control)

B: wheat flour (60%) +AYB flour (20%) + Plantain flour (20%)

C: wheat flour (40%) +AYB flour (30%) + Plantain flour (30%)

D: wheat flour (20%) +AYB flour (40%) + Plantain flour (40%)

Cookies Production

Cookies were produced using the method described by Arisa *et al.* (2013) with slight modifications. Sugar (150 g) and margarine (100 g) were cream together at medium speed until fluffy. Egg (50 g) was added during mixing and then mixing continued for about 30 min. 300 g of sifted flour, 5 g of baking powder and 15 g of vanilla essence flavour were slowly added to the mixture and kneaded to form dough. It was then rolled on a flat rolling board sprinkled with flour to a uniform thickness and cut to a uniform diameter. The cut dough was left for 30 min to rest then placed on greased baking trays and baked in the oven at 180 °C for 30 min. The baked products were cooled at ambient ($27\pm 2^{\circ}\text{C}$) temperature for 30 min, packaged in high density polyethylene, labelled and stored at room temperature for various determinations.

Method of Analysis

Determination of functional properties of the flour blend

Bulk Density, Swelling Capacity, Water and Oil Absorption and Foaming Capacity, dispersibility according to the standard methods described by (AOAC, 2010).

Determination of physical characteristics of cookies

The cookies diameter was determined by placing six cookies horizontally (edge to edge) in a row and the diameter was measured with a digital Vernier calliper with 0.01mm accuracy (Man *et al.*, 2014). The mean value was recorded as the diameter of the cookies. Thickness of cookies was determined by stacking six cookies, one on top of another and the average thickness was taken, using digital Vernier calliper with 0.01mm accuracy (Man *et al.*, 2014). The mean value was recorded as the thickness of the cookies. The spread ratio was calculated as the average diameter/thickness (Akubor and Ukwuru, 2004).

Determination of the proximate composition of the cookies

Proximate composition (moisture content, protein, lipid, ash, fibre) of the cookie was determined using standard methods (AOAC, 2006). Carbohydrate content was determined by difference.

Determination of mineral content of the cookies

The minerals (Ca, K, Mg, Zn) were determined using Atomic Absorption Spectrophotometer (UNICAM model 939) described by Fraga *et al.* (2004).

Determination of anti-nutritional factors of the cookies

Tannins, Phytate, and Oxalate was determined following the standard methods of Onwuka (2005).

Determination of Sensory Evaluation of cookies samples

Sensory characteristics of the coded cookies were evaluated for different sensory attributes by twenty (20) semi trained panellists drawn from the Department of Food Science and Technology, University of Uyo. All the panellists were briefed before the commencement of the evaluation process. Sensory attributes evaluated were appearance, taste, colour, sweetness, crunchiness, aroma, after taste and overall acceptability. The rating was on a nine-point hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely) (Ihekoronye and Ngoddy, 1985).

Statistical Analysis

All the data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were then separated with the use of Duncan New Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) 23.0 software.

Results and Discussion

Functional Properties of Composite Flour of Wheat, Unripe Plantain and African Yam Beans

The bulk density of flour is the density measured without the influence of any compression (Adeyanju *et al.*, 2021). The bulk density of the flour blends ranged from 0.76 ± 0.01 to 0.80 ± 0.01 g/cm³. The results showed decrease in the proportion of wheat flour led to an increase in bulk density of composite flours. The high bulk density makes the flour suitable for use in food preparations. The high bulk density of the composite flours indicates their ability to function as thickeners in food products and for use in food preparation since it helps to reduce paste thickness which is an important factor in convalescent and child feeding. Bulk density of the composite flours increased significantly as unripe plantain and African yam bean flour incorporated into wheat flour increased. Similar findings were reported by Adeyanju *et al.* (2021) for composite flour from wheat, African yam beans and acha seed flours.

The water absorption capacity (WAC) for composite flour is given in Table 3. The WAC ranged from 1.57 ± 0.06 to 2.33 ± 0.06 g/g for the flour blends. The WAC was observed to be lowest in the sample A (100% wheat flour) and highest in sample D (20% wheat flour). The result showed that the addition of unripe plantain and African yam bean flour to wheat flour had effects on the level of water absorption. This could be as a result of the molecular structure of the starch of wheat which prevented water absorption, as could be seen from the higher values of WAC, sample with increased proportions of other flours, compared to the higher wheat flour. A similar observation was reported by Ubbor *et al.* (2022) for composite flour from wheat, acha seed and whole orange fleshed sweet potato flour. High WAC of composite flours showed that the flours could be used in preparation of some foods such as sausage, dough, processed cheese and bakery products (Adeyanju *et al.*, 2021).

The oil absorption capacity (OAC) of composite flour ranged from 1.03 ± 0.06 to 1.17 ± 0.06 g/g (Table 3). The lowest OAC was observed in sample B whilst the highest value was observed in sample D. However, the OAC of the composite flour had no significant

difference ($p>0.05$). The presence of high-fat content in the flours might have affected adversely the OAC of the composite flours.

Chandra *et al.* (2014) reported similar result when compared with the present study. Maruatona *et al.* (2010) reported higher oil absorption capacity of defatted flour from unheated marama beans. This related to the fact that defatted flour from unheated marama beans contained more amino acids with non-polar side chain than the other flours. This is because non polar amino acid side chains forms hydrophobic interaction with hydrocarbon chains of lipid (Jitugarmkusol *et al.*, 2008), thereby adversely affecting the adsorption capacity of the flours. It is also reported that protein is a major chemical component that affect oil absorption capacity and hydrophobic parts, and hydrophobic part can interact with the hydrocarbon chain. However, the flours in this study are potentially useful in food particularly in flavour retention, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorption is desired (Aremu *et al.*, 2007).

The swelling capacity of flour blends ranged from 4.00 ± 0.00 g/g to 5.67 ± 0.58 g/g with the control (sample A) having the highest and sample D the lowest. The swelling capacity of flours depends on types of variety, size of particles and types of processing methods or unit operations. The swelling capacity of composite flours decreased as the level of incorporation ratio of unripe plantain and African yam bean increased.

Dispersibility measures how individual molecules of flour disperse and homogenize with a medium of dispersion (Olapade *et al.*, 2014). The percentage dispersibility of the composite flour ranged from $70.00 \pm 0.15\%$ for sample D to $75.33 \pm 0.58\%$ for the control sample. The dispersibility values obtained in this study were similar to (73.75 – 75.25%) reported by Adeyanju *et al.* (2021) for composite flour from wheat, African yam beans and acha flours. Flour with a higher dispersibility indicates its ability to reconstitute better in water (Kulkarni *et al.*, 1991). Thus, samples A and B have a good reconstitution behaviour in water than the other samples.

Table 3: Functional Properties of Composite Flour of Wheat, Unripe Plantain and African Yam Beans

Parameters	A	B	C	D
Bulk Density (g/cm ³)	$0.76^d \pm 0.01$	$0.78^{bc} \pm 0.00$	$0.78^b \pm 0.01$	$0.80^a \pm 0.01$
Water Absorption Capacity (g/g)	$1.57^d \pm 0.06$	$2.07^c \pm 0.06$	$2.20^b \pm 0.00$	$2.33^a \pm 0.06$
Oil Absorption Capacity(g/g)	$1.13^a \pm 0.12$	$1.03^a \pm 0.06$	$1.10^a \pm 0.00$	$1.17^a \pm 0.06$
Swelling Capacity (g/g)	$5.67^a \pm 0.58$	$4.67^{ab} \pm 0.58$	$4.33^b \pm 0.58$	$4.00^b \pm 0.00$
Dispersibility (%)	$75.33^a \pm 0.58$	$72.00^b \pm 0.00$	$70.67^c \pm 0.58$	$70.00^d \pm 0.15$

Values are means $\pm$ SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $P<0.05$.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Physical Characteristics of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

The result of the physical characteristics of cookies prepared from the composite of wheat, unripe plantain and African yam beans flours are shown in Table 4. The weight of the cookies ranged from 2.68 ± 3.40 g to 3.95 ± 0.33 g. Cookies produced from all the composite flours had lower weights than the control (3.95 ± 0.33 g). This could be attributed to the rise in the protein content from the incorporation of the whole unripe plantain and African yam beans flours. Although the range of weight for cookies recorded in this study was lower than 5.35 - 6.49g reported for cookies produced from wheat, African yam beans and acha seed flours (Adeyanju *et al.*, 2021). The cookies diameter ranged from 5.27 ± 0.15 cm to 5.40 ± 0.10 cm. It was observed that all cookies' samples from composite flours had higher values than the control (100% wheat). Moreover, the diameter was found to increase as the proportion of unripe plantain and African yam beans flours increased. Diameter determines the quality of flour used (Bala *et al.*, 2015). According to Adejuyitan *et al.* (2009), wheat flour has a higher gluten content than its composite counterparts with less elastic network that result in cookies structure contraction during baking. This explains the low diameter value recorded for cookies produced from wheat, plantain, and AYB flour.

The thickness of the cookies ranged from 0.90 ± 0.10 cm for the control (100% wheat) to 1.90 ± 0.10 cm for cookies produced from wheat, plantain, and AYB flour (20:40:40). The higher values for thickness obtained in cookies made from composite flours could be due to the higher adsorption of moisture by the dough owing to the presence of water binding component (Ikuomola *et al.*, 2017). Interestingly, Peter-Ikechukwu *et al.* (2017) reported that the higher the thickness of cookies the higher its ability to withstand stress. This implies that cookies from the composite flours have the ability to withstand stress more than the control (100% wheat). The range of thickness obtained in cookies produced in this study was similar to 1.25 – 1.35 cm reported for cookies produced from wheat flour and fermented *Azizium Africanum* flour (Igbabul *et al.*, 2018) and (0.95 – 1.10 cm) of thickness obtained in wheat-based cookies supplemented with OFSP flour (Temesgen *et al.*, 2015).

The differences in the various cookies could be attributed to the thickness of the dough rolled out during processing. The spread ratio of the cookies ranged from 2.84 ± 0.18 for sample D to 5.86 ± 0.67 for sample A. Spread ratio of the cookies reduced with increase in substitution of unripe plantain and African yam beans flours. Spread ratio is used to determine flour quality and the rising capacity of the produced cookies (Bala *et al.*, 2015). According to Kiin-Kabari *et al.* (2021), low spread ratio values can be attributed to tightly bound starch polymer molecules which results in a less viscous dough of non-wheat flours. The values of spread ratio obtained in cookies produced in this study was lower than 5.20 - 5.93 reported for cookies produced from acha seed and tiger nut (Ayo *et al.*, 2018). Cookies thickness can impact spread, increased cookies thickness leads to increased spread

(Panghal *et al.*, 2018). This is an evident that, cookies with the highest value for spread ratio possess high value for thickness.

Table 4: Physical Properties of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans (Dry Matter)

Parameters	Samples			
	A	B	C	D
Weight (g)	3.95 ^a ± 0.33	3.49 ^b ± 4.05	2.88 ^c ± 0.98	2.68 ^{bc} ± 3.40
Diameter (cm)	5.27 ^a ± 0.15	5.30 ^a ± 0.00	5.30 ^a ± 0.17	5.40 ^a ± 0.10
Thickness (cm)	0.90 ^b ± 0.10	1.13 ^b ± 0.23	1.43 ^{ab} ± 0.40	1.90 ^a ± 0.10
Spread Ratio	5.86 ^a ± 0.67	4.69 ^b ± 1.09	3.71 ^{bc} ± 0.96	2.84 ^c ± 0.18

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Proximate Composition of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

The proximate composition and energy value of the cookies are presented in Table 5. The moisture content of the cookies flour ranged from 3.30 ± 0.04 to $4.62 \pm 0.03\%$ with the control sample (100% wheat flour) having the lowest and sample D having the highest value. The moisture content of the cookies increases with increase in addition of whole unripe plantain and African yam bean flour. The moisture content of the cookies was within an acceptable limit for stable shelf life as reported by Edima-Nyah *et al.* (2023). Moisture content is very essential for life maintenance and analysis of it is one of the most widely used instruments which determine the way the food was processed and its shelf life (Akinsanmi *et al.*, 2015). It has also been used as a measure of stability and susceptibility to microbial contamination.

Protein content increased with increasing addition of both unripe plantain and African yam beans flours. This could be due to the higher protein content in African yam beans than in wheat and unripe plantain. The range of crude protein values obtained in this present study was similar to the values (12.61 - 15.03%) obtained in cookies from wheat, Acha seed and pigeon pea flour blends (Adeyanju *et al.*, 2018). The high level of protein in the samples indicates the effect of supplementing legumes in cookies (Usman, 2012). Although protein from plant sources are nevertheless "complete" because they contain at least trace

amounts of amino acids that are essential in human nutrition, eating various plant foods in combination can provide a protein of higher biological value (McDougall, 2002).

The fat content of the cookies significantly ($P < 0.05$) decreased with increasing addition of unripe plantain and African yam beans flours. The fat content of the cookies ranged from $2.62 \pm 0.01\%$ for sample D to $3.50 \pm 0.01\%$ for the control (100% wheat). There were significant differences ($p > 0.05$) among the fat content of the cookies. Cookies produced from the control sample (100% wheat) had the highest value for fat (3.50%). Higher value (12.61 - 15.03%) were reported by Adeyanju *et al.* (2021) for cookies from wheat, acha and African yam beans flour blends. Fat in food will not only increase the energy density but is also a transport vehicle for fat soluble vitamins (Eka *et al.*, 2010). Excessive fat intake however predisposes to childhood obesity and cardiovascular diseases (Milner and Allison, 1999). Also, high fat content in foods affect the shelf stability of such food as it could lead to the development of rancid flavour as a result of auto-oxidation.

The fibre content of the cookies significantly increased ($P < 0.05$) with increase in unripe plantain and African yam beans flour substitution. The result was higher than the values reported by Adeyanju *et al.* (2021) for cookies from wheat, acha seed and African yam beans flour blends. fibre is needed to assist in digestion and keep the gastrointestinal tract healthy; fibre also aids in lowering blood cholesterol levels and slows down the process of absorption of glucose, thereby helping in blood glucose level control (Anderson *et al.*, 2009). It also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body, increases satiety and hence impacts some degree of weight management (Mickelson *et al.*, 1979). It slows down the release of glucose during digestion, so cells require less insulin to absorb that glucose. The American Diabetes Association recommends that people with diabetes should consume 25-50g of fibre per day (Trinidad *et al.*, 2006). The faecal bulking action of insoluble fibre makes it useful in the treatment of constipation and diverticular disease (McKevith, 2004).

The ash contents of the cookies showed significant difference ($p < 0.05$) with a range of values from $2.44 \pm 0.04\%$ in the control sample to $5.60 \pm 0.01\%$ in sample D. Ash content increased with increase in unripe plantain and African yam beans flour addition. The values obtained in this present study were higher than the values (1.36 – 1.49) reported by Adeyanju *et al.* (2021) for cookies from wheat, acha seed and African yam beans composite flour. Ash is a measure of total mineral content in food materials. The high ash values recorded in this work may be attributed to the increasing levels of unripe plantain and African yam beans in the formulations.

The carbohydrate content decreased significantly ($P < 0.05$) among samples as unripe plantain and African yam beans levels increased. The values decreased from $81.82 \pm 0.04\%$ in the control sample to $73.04 \pm 0.02\%$ in sample D. The reduction in carbohydrate content in the samples also depended on other parameters since it was calculated by difference.

The caloric (energy) value of the cookies ranged from 371.46 ± 0.08 (Kcal/100g) in sample D to 398.94 ± 0.03 (Kcal/100g) in the control sample. The protein, fat and carbohydrate constituents contributed to the calculated caloric value of the samples with fat as the major contributor (9 kcal/g) while protein and carbohydrate have about 4 kcal/g. This explains why

the caloric value was higher in samples with higher fat content than in sample with lower fat content.

Table 5: Proximate Composition of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

Parameters	A	B	C	D
Moisture Content	3.30 ^d ± 0.04	4.06 ^c ± 0.05	4.31 ^b ± 0.04	4.62 ^a ± 0.03
Protein (%)	10.04 ^d ± 0.06	11.82 ^c ± 0.03	12.14 ^{bc} ± 0.05	13.93 ^a ± 0.03
Ash (%)	2.44 ^d ± 0.04	4.51 ^c ± 0.02	4.91 ^b ± 0.02	5.60 ^a ± 0.01
Fibre (%)	2.20 ^d ± 0.01	4.22 ^c ± 0.02	4.52 ^b ± 0.01	4.81 ^a ± 0.01
Fat (%)	3.50 ^a ± 0.01	3.21 ^b ± 0.01	2.69 ^c ± 0.01	2.62 ^d ± 0.01
Carbohydrate (%)	81.82 ^a ± 0.04	76.24 ^b ± 0.05	75.76 ^c ± 0.01	73.04 ^d ± 0.02
Caloric value (Kcal/100g)	398.94 ^a ± 0.03	381.13 ^b ± 0.09	375.81 ^c ± 0.05	371.46 ^d ± 0.08

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at P<0.05.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Mineral Content of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

Minerals are essential for the maintenance of the overall mental and physical wellbeing. They are also important constituents for the development and maintenance of bones, teeth, tissues, muscles, blood, and nerve cells. They aid acid base balance, response of the nerves to physiological stimulation and blood clotting (Wardlaw and Kessel, 2002). The Ca, K, Mg and Zn contents of the cookies increased significantly with increase in unripe plantain and African yam beans flours in the blends (Table 6). The calcium content values obtained in the present study (7.03 ± 0.03 mg/100g to 18.21 ± 0.04 mg/100g) were higher than the range (10.11mg/100g – 13.12mg/100g) reported by Adeyanju *et al.* (2021) for cookies from wheat, acha seed and African yam beans flour blends.

The potassium content of the cookies was lower than 130.71 - 211.76mg/100g reported by Adeyanju *et al.* (2021) for cookies from wheat, acha seed and African yam beans flour

blends. The higher potassium values obtained in the present study may be attributed to contribution from plantain. Studies have shown that increasing the potassium intake of hypertensive rats that were fed high sodium diets lowered blood pressure, reduced incidence of stroke and stroke-related death, and prevented cardiac hypertrophy, mesenteric vascular damage, and renal injury (Liu *et al.*, 1994).

The zinc content of the cookies from sample A (100% wheat) was lowest (0.02 ± 0.01 mg/100g) while that of sample D (40% wheat) was highest (16.11 ± 0.02 mg/100g). Zinc is needed for the activity of many enzymes, tissues growth and repair proper immune function, storage and release of insulin, mobilization of vitamin A from the liver and stabilization of cell membrane (Grossvenor and Smolin, 2002).

Table 6: Mineral Content of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

Parameters	A	B	C	D
Calcium(mg/100g)	$7.03^d \pm 0.03$	$13.06^c \pm 0.05$	$15.12^b \pm 0.04$	$18.21^a \pm 0.04$
Potassium(mg/100g)	$18.10^d \pm 0.03$	$26.87^c \pm 0.01$	$60.17^b \pm 0.03$	$93.33^a \pm 0.03$
Magnesium(mg/100g)	$0.09^d \pm 0.01$	$6.11^c \pm 0.01$	$8.16^b \pm 0.05$	$10.22^a \pm 0.04$
Zinc(mg/100g)	$0.02^d \pm 0.01$	$8.03^c \pm 0.03$	$11.34^b \pm 0.03$	$16.11^a \pm 0.02$

Values are means $\pm$ SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Anti-nutritional Properties of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

The anti-nutritional contents of the cookies varied significantly ($P < 0.05$) among the samples as shown in Table 7. The presence of anti-nutrients in food hinders the absorption and bioavailability of some essential nutrients including protein and some minerals. The recorded increases in the phytate and tannin contents in the cookies with increasing levels of unripe plantain and African yam beans flour incorporation could be due to higher content of these anti-nutrients in unripe plantain and African yam beans flours than in wheat flour. Phytates are known to form complexes with protein and minerals such as calcium, iron, zinc and magnesium thereby making them biologically unavailable (Wu *et al.*, 2009).

The values of oxalate contents were higher in sample D (5.96 ± 0.02 mg/100g) than in the rest of the samples. However, oxalate contents of these samples fell within the safety level of 9 mg/100g by (Siddharuji and Becker, 2001).

The tannin content in the cookies ranged from 126.90 ± 0.07 mg/g in the control sample to 153.96 ± 0.03 mg/100g in sample D. Tannins are naturally occurring plant polyphenols. It is reported that they form complexes with protein and mineral elements thereby interfering with their absorption and availability (Pikuda and Ilelaboye, 2013). But consumption of high amount of legume seed tannins have been reported to cause any known toxicity or physiological disorders upon ingestion (Moses, 2022).

Table 7: Anti-nutritional Properties of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans (%)

Parameters	A	B	C	D
Phytates(mg/100g)	$0.55^d \pm 0.02$	$1.58^c \pm 0.02$	$9.56^b \pm 0.02$	$10.55^a \pm 0.03$
Oxalates(mg/100g)	$3.55^b \pm 0.04$	$2.86^c \pm 0.03$	$2.64^d \pm 0.04$	$5.96^a \pm 0.02$
Tannins(mg/100g)	$126.90^d \pm 0.07$	$151.94^c \pm 0.04$	$152.64^b \pm 0.03$	$153.96^a \pm 0.03$

Values are means $\pm$ SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Sensory Evaluation of the Cookies Samples

The results of the sensory evaluation of the cookies prepared from the composite flour of wheat, unripe plantain and African yam beans are presented in Table 8. There was no significant difference ($p > 0.05$) among the sensory parameters of the cookies. The sensory mean score values revealed that cookie produced from sample B composite flour was the most acceptable in terms of colour, taste, crunchiness, aftertaste, aroma and overall acceptability while those produced from the control sample was most preferred in terms of sweetness and appearance. This was due to the mean score values for these attributes being higher than the rest of the samples.

Table 8: Mean Sensory Scores of Cookies made from Composite Flour of Wheat, Unripe Plantain and African Yam Beans

Parameters	A	B	C	D
Taste	7.10 ^a ± 1.37	7.20 ^a ± 0.92	6.70 ^a ± 0.95	6.50 ^a ± 0.97
Colour	6.90 ^a ± 1.29	7.10 ^a ± 0.88	7.00 ^a ± 0.94	6.70 ^a ± 1.16
Sweetness	7.20 ^a ± 1.32	6.50 ^a ± 1.18	6.50 ^a ± 0.97	6.60 ^a ± 1.08
Crunchiness	5.10 ^a ± 0.88	5.60 ^a ± 1.17	6.00 ^a ± 1.33	5.30 ^a ± 0.95
Aftertaste	7.10 ^a ± 1.10	7.30 ^a ± 0.67	6.60 ^a ± 0.97	6.30 ^a ± 1.25
Appearance	7.40 ^a ± 0.97	7.40 ^a ± 0.84	7.20 ^a ± 0.79	6.90 ^a ± 0.88
Aroma	6.50 ^a ± 1.27	7.00 ^a ± 1.05	6.70 ^a ± 0.95	6.70 ^a ± 1.25
Overall Acceptability	7.40 ^a ± 1.08	7.60 ^a ± 0.70	7.20 ^a ± 0.63	6.80 ^a ± 1.03

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with same superscripts are not significantly different at $P > 0.05$.

A = (100% WF, 0% UPF, 0% AYBF), B = (60% WF, 20% UPF, 20% AYBF), C = (40% WF, 30% UPF, 30% AYBF), D = (20% WF, 40% UPF, 40% AYBF) Where: WF = wheat flour, UPF = unripe plantain flour, AYBF = African yam beans flour

Conclusion

The result of the present study showed that formulation of composite flour from wheat, unripe plantain and African yam beans had varying effects on the functional properties of the flour blends. The crude protein, crude fibre and ash contents of the cookies made from the blends increased while the fat and carbohydrate contents decreased with increase in unripe plantain and African yam beans. The phytate and tannin levels of the cookies increased with increasing unripe plantain and African yam beans. The mean score values for the sensory attributes of the cookies showed that cookies produced from treatment B was most acceptable. Consumption of the produced cookies could help to address the problem of protein-energy malnutrition that is still prevalent in some communities in Nigeria, as well as encourage and promote production of cookies from underutilized crops which will help to enhance food security and economic diversification.

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