PHYSICAL AND SENSORY QUALITIES OF RIPE BANANA PEEL AND ACHA (*Digitaria exilis*) FLOUR BLEND BASED BISCUITS

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Abstract: The physical, chemical and sensory properties of biscuit produced from yellow ripe banana peel and acha flour blends. The yellow ripe banana peel flour was substituted (5, 10, 15, 20, 25%) into acha flour to produce flour blends using 100% wheat and acha flour as control. The flour blends were used to prepare biscuit which were analyzed for physical (break strength, diameter/thickness, spread ratio, volume and weight), sensory properties, minerals (zinc, magnesium and potassium), proximate (ash, moisture, fat, protein, fiber protein and carbohydrate) and phytochemicals (carotenoid, phenolic and flavonoids) The biscuit containing 25% yellow ripe banana peel flour had the ash, fat and fiber content of 2.19, 17.78, 2.86%, respectively. The magnesium content was 17.47, and zinc 1.28% of the biscuit containing 25% of yellow ripe banana peel. Break strength, weight, thickness, spread ratio and volume of the biscuit increased with the level of yellow ripe banana peel flour in the biscuit. The biscuit containing 25% yellow ripe banana peel flour was nor significantly different from 100% wheat flour. The average mean scores for all the sensory attributes decreased with the level of yellow ripe banana peel flour in the biscuit.
Keywords: Physical, sensory, banana peel, acha flour

Introduction

Biscuits are one of the confectionary food product consumed in Nigeria especially among children (Kulkarni, 1997). They are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance (Kulkarni, 1997). The major ingredients in biscuit production include flour, fat, sugar and water. Other ingredients added are either optional or added to give a desired sensory attribute.
The main problem facing the baking industry in Nigeria is the total dependence on the importation of wheat to sustain it. Nigeria has climatic conditions that are not so favourable for wheat cultivation but very suitable for other cereal crops such as sorghum, millet, maize and acha. Therefore, any effort made to substitute wheat flour by any of locally available cereal flours will contribute a lot to lowering the cost of baking products in Nigeria. Acha is one of the oldest African cereals and is classified as an underutilized crop (NRC, 1996). Acha is noted for its high pentosan, an attribute recognized for good baking operation (Lasekan, 1994). The grain is uniquely rich in methionine and cystine, and evokes low sugar on consumption (Ayo *et al*., 2003).
Banana (*Musa acuminata*) is an edible fruit botanically a berry produced by several kinds of large herbaceous flowering plants in the genus (*Musa)*. In some countries, bananas used for cooking may be called "plantains", distinguishing them from /dessert bananas. The fruit is variable in size, colour and firmness, but is usually elongated and curved, with soft flesh rich in starch covered with a rind, which may be green, yellow, red, purple, or brown when ripe. The fruits grow in clusters hanging from the top of the plant. Almost all modern edible seedless (parthenocarp) bananas come from two wild species *Musa acuminate* and *Musa balbisiana*. The scientific names of most cultivated bananas are *Musa acuminata*, (*Musa balbisiana*), and (*Musa paradisiaca)* for the hybrid *Musa acuminate (M. balbisiana*), depending on their genomic constitution.
The amount of waste from fruit peels is expected to increase with the development and progression of industrial manufacturing processes that use bananas as either green or ripe. For example accurate banana peels possibly introduce new products for various industrial and household uses (Bori *et al*., 2007). Fruits and vegetable flour is rich in fiber, protein and minerals and has a high water holding capacity (WHC) and oil holding capacity (OHC). Thus, it can be used in a new low calorie and cost products (Ferreira *et al*., 2013). Banana is called Musa specie and is among the leading fruit crops in the economic value in the world. It is ranked the fifth in the world trade (Guyle`ne *et al*., 2008).
Acha (*D. exilis*) is an annual, erect herbaceous plant of the family Graminae which reaches stature heights from 30 to 80 centimetres. The ears consist of two to five narrow part ears, which are up to 15 centimeters long. The spikelets comprise a sterile flower and a fertile flower, the latter of which gives rise to the fonio grain. The grain is a caryopsis, which remains surrounded by glumes and husks. Its size is very small, only 1.5 mm (around 2000 seeds to 1 gram).The colour ranges from white, yellow and purple. Fonio mature faster than all other cereals. Some varieties can already be harvested 42–56 days after sowing. Other ripens more slowly, usually in 165–180 days (Jideani, 2012).
Acha (*D. exilis*) also known as funio is of considerable importance in Nigeria where it is commonly eaten, often in preference to other cereals, as many as three times a day as a porridge, couscous or non-alcoholic beverage, valued as a weaning food because of its low bulk and high caloric density with minimal processing requirement, it grows even where rainfall and soil fertility are poor and can be stored in closed containers for many years without need of preservatives (Chukwu and Abdul-kadir, 2008).
Despite its valuable characteristics and widespread cultivation, fonio has generally received limited attention research and development, which is also why the species is sometimes referred to as an underutilized crop (Jideani, 2012). Acha showed a high water absorption capacity of 40, 60, 80 and 100% due to appreciable amounts of pentosans (Shelton, 1985). Acha contains 33 g/kg pentosan (Lasekan, 1994), which gives the ability to form gel. The high water absorption capacity of acha could be utilized in baked food products such as bread and biscuits. The broad objective is to determine the chemical composition, physical and sensory qualities of ripe banana peel-acha flour blend biscuit.

Materials and Methods

Acha grains (*Digitaria exilis*) were purchased from a local market in Jos, while ripe banana (*Musa acuminata*) were purchased from Jalingo local market in Taraba state, Nigeria. Baking powder, baking fat, sugar (as sweetener) and salt were also purchased fromWukari new market in Taraba state.

Preparation of acha and ripe banana peel flour

According to the description by Ayo *et al.* (2007), acha grains were cleaned manually by handpicking the chaff and dust; stones were removed by washing in clean water (sedimentation). The washed and stone freed grains were oven dried at 45℃ for 3 h and then milled using milling machine (model R175A). The flour was sieved using (0.3 mn aperture) sieve, packaged (polyethylene) and stored under room temperature.

Fresh matured ripe banana were obtained, washed, hand-peeled and the peel was sliced or chopped into pieces about 5-10 mm thick and then steam blanched (Hughes Blancher Model:02-1471) for 3 min. The sliced banana peel were dried at 45°C in oven (San-Del Model 50) and milled using attrition mill (Inch 15HP Super 150-180 Kilogram Tw-HM-1016) and sieved (0.3 µm aperture size). Packaged in a polyethylene bag and stored (at temperature 5ºC). (Thompson *et al.* 2005).

Preparation of banana peel- acha flourblends

Ripe banana peel flour and acha flour were mixed at different proportions (5:95, 10:90, 15:85, 20:80 and 25:75) while one hundred percent (100%) acha flour and wheat was used as the control. The flours were thoroughly mixed using a Kenwood blender to a uniform blend by Ayo and Gidado (2017).

Preparation of banana peel- acha flour blend biscuits

Baking fat and sugar were blended to form a fluffy blend and the flour blends of ripe banana peel and acha flour (5:95, 10:90, 15:85, 20:80 and 25:75) mixed with other ingredients (baking powder, salt) to produce paste which was baked at 200ºC to produce flour blend biscuits.

Analytical methods

Determination proximate composition: The flours and the most acceptable biscuit were analysed for moisture, crude protein, ash, crude fat, proximate analysis of samples, Carbohydrate content and crude fiber was carried out on the flour:

Determination of moisture content: Determined as described by AOAC (2012) methods. A two (2.0) gram of sample was accurately weighed into a previously dried and weighed glass crucible. It was then dried in a thermostatically controlled forced convection oven (Gallenkamp, England) at 50℃ for 18 h. The glass crucibles were removed and transferred into desiccators for cooling and weighed. Moisture content was determined by difference and expressed as a percentage.

Determination of ash content: A two (2.0) gram of sample was accurately weighed into a pre-ignited and previously weighed crucible, placed in a muffle furnace (Gallenkamp, England) and heated for 2 h at 600ºC. After ashing, the crucibles were cooled below 200ºC in a furnace for 20 min and further cooled to room temperature in a desiccator. The crucibles and their contents were weighed, and the weight was reported as percentage ash content (AOAC, 2012)

The percentage ash was calculated as:

$$\%Ash = \frac{WeightofAsh}{Weightoforiginalfood} x\ 100$$

Determination of crude fat content : A two (2.0) gram of sample was transferred into a paper thimble plugged at the opening with glass wool to evenly distribute the solvent as it drops on the sample during extraction and placed into a thimble holder. The sample packet was placed in the butt tubes of the soxhlet extraction apparatus. The extraction flask was placed on an oven for about 5 min at 110°C then cooled and weighed. The fat was extracted with petroleum ether for 2 – 3 h by gentle heating. The extraction flask was dismantled and allowed to cool. The ether was evaporated on steam or water bath until no odour of ether remains. It was then allowed to cool to room temperature and the extraction flask and its extract were recorded (AOAC, 2012).

$$Fat = \frac{Weightoffat}{Weightofsample} x100$$

Determination of crude fibre content: The sample from the crude fat determination was transferred into a digestion flask. A 200 ml of boiling sulphuric acid (H_2SO_4) solution and anti-foaming agent (asbestos) was added to the flask and immediately connected to a digestion flask with a condenser and heated. The sample was boiled for 30 min during which the entire sample was allowed to become thoroughly wetted while any of it was prevented from remaining on the sides of the flask and out of contact with the solvent. After 30 min, the flask was removed; its contents filtered through linen cloth in a funnel and washed with boiling water until the washings were no longer acidic. The sample with asbestos was washed back into the flask with 200 ml boiling sodium hydroxide (NaOH) solution. The flask was reconnected to the condenser and boiled for 30 min. The content were again filtered through linen cloth in a funnel and washed thoroughly with boiled water, then with 15 ml of 95% ethanol. The residue was transferred into previously dried and weighed porcelain, in an oven at 110ºC to a constant weight. It was then cooled in a desiccator and weighed. The crucible and its contents were ignited in a muffle furnace at 550ºC for 30 min until the carbonaceous matter has been consumed. Cooled in a desiccator and weighed (AOAC, 2012).

$$\%Crudefibre = \frac{LossinWeightofalterincineration}{Weightoforiginalfood} x100$$

Determination of protein content: The protein content of the samples was determined according to AOAC (2012). Half (0.5) gram of a finely grounded samples were weighed into a digestion flask and one kjeldahl catalyst tablet was added, 10 ml of conc. H_2SO_4 was added and digested for 4 h until a clear solution is obtained. The digest was cooled and transferred into 100 ml volumetric flask and made up to mark with distilled water. 20 ml of boric acid were dispensed into a conical flask and 5 drops of indicator and 75 ml of distilled water was added to it 10 ml of the digest were dispensed into Kjedahl distillation flask, the conical and the distillation a flask were fixed in place and 20 ml of 2% NaOH was added through the glass funnel into the digest. The steam exit was closed and timing started when the solution of the boric acid and indicator turned green. The distillation was done for 15 min and the distillate was titrated with 0.05 NHCl.

%Total Nitrogen = Titre Value x Atomic mass of nitrogen × Normality of HCl used ×4 Therefore, the crude protein content is determined by multiplying percentage Nitrogen by a constant factor of 6.25 i.e. %crude protein = %N x 6.25.

Determination of carbohydrate content: This was calculated by the difference as described by AOAC (2012).

$$\%Carbohydrate = 100 - (\%Moisture + \%Fat + \%Protein + \%Ash + \%Crudefibre)$$

Determination of mineral content

Determination of potassium: Determination of potassium was done according to the method of AOAC (2012). An oral rehydration sachet was carefully opened and the contents were emptied into a clean 250 ml beaker. About 150 ml distilled water was added and the contents was gently swirled until it dissolved. The solution was poured into a 200 ml volumetric flask and rinsed out the beaker with small amounts of distilled water, adding the washings to the flask. Finally, made up the flask to exactly 200 ml and then mixed thoroughly. A 1/50 dilution of the redissolved sachet solution was made by accurately pipetting 2 ml of the solution into a 100 ml volumetric flask and making up to 100 ml with distilled water. A beaker of distilled water was placed into position at the left hand side of the instrument and the narrow draw tube was inserted into it to allow water to pass through the photometer, the gas control was adjusted to give a flame with a large central blue cone then, with water passing through the instrument, the gas control was slowly closed until ten separate blue cones just formed. The galvanometer was set to zero using the "Set zero" control and then the distilled water was replaced with the 5 mMNaCl standard and the sensitivity control adjusted till the galvanometer reads 100. The 5 mMNaCl standard was replaced with standards of decreasing concentration from 4 mM to 0.25 mM and the readings noted. Water was run through the instrument again for 1-2 min then the draw tube was placed into a beaker containing the 1 in 50 diluted rehydration sachet solution and note the galvanometer reading. Water was run through the instrument again and then the sodium was replaced with the potassium filter, the above procedure was repeated with KCl standards, setting to 100 with 2.0 mMKCl; then the others were read in reverse order alongside 1 in 50 diluted rehydration sachet solution. Finally, water was run through the instrument until the flame appeared free of colour again. The galvanometer readings was plotted against Na+ and K+ concentrations on the graph paper provided (separate graph for each ion) and from these calibration curves determine the Na+ and K+ concentrations in the diluted sachet solution. Finally, the Na+ and K+ concentrations were calculated in the undiluted sachet solution.

Determination of magnesium content: determination of Magnesium was done according to the method of AOAC (2012). Ashed sample (2 g) was transferred into 3 test tubes and 3 ml of water added; 2 ml of 10% sodium tungstate, 2 ml of 0.67N sulphuric acid were added, centrifuged for 5 min. 5 ml of the supernatant was taken and 1 ml of water was added, 1 ml of 0.5% titan yellow, and 1 ml of 0.1% gum ghatti. 2 ml of 10% sodium hydroxide was added and the absorbance taken at 520 nm against a blank.

Determination Zinc Content: atomic Absorption Spectrophotometry (AAS) method as described in AOAC (2012) was used. The stock solution of Zn (II) were prepared from Zinc chloride (LobaChemie). The stock solution was standardized gravimetrically by Zn pyrophosphte. A digital pH meter, (Elico Private Ltd, India) with a combined glass and calomel electrode (Toshniwal - Mollar, India) and UV 2100 spectrophotometer (Shimadzu) with glass cells of path length 1 cm was used. Synthesis of 1-phenyl-1-hydrazonyl-2-oximino propane – 1, 2 – dione (HPHOPD) reagent: The reagent HPHOPD was synthesized (P. P. Tekale) by carrying out a reaction between *iso*-nitrosopropiophenone and 85 %hydrazine hydrate. The purity of the product was checked by melting point and GC-MS technique. An aqueous solution (10.0 cm^3) containing 0.1 mg Zn (II) metal and 0.005 M of 1-phenyl-1-hydrazonyl-2-oximino propane -1,2- dione reagent in n-butanol, after adjusting the pH = 8.5 was equilibrated with 10.0 cm^3 of n-butanol for 1 min. After separation of the phases, the absorbance of the Zn (II): HPHOPD complex in organic phase was directly measured at 415 nm. Zn: HPHOPD complex after extraction from aqueous phase into organic phase was scanned from 300 to 600 nm against reagent blank. Maximum Absorbance value was observed at 415 nm. Therefore, 415 nm was selected for the absorbance measurement throughout the experiments.

Determination of phytochemicals

The following phytochemicals were determined according to standard methods; carotenoid, total phenol.

Determination of carotenoids content: Carotenoids content was determined according to the method described by Krishnaiah *et al*. (2009). A measured weight of banana peel-acha composite biscuit sample was homogenized in methanol using a laboratory blender. A 1:10 (1%) mixture was used. The homogenate was filtered to obtain the initial crude extract, 20 ml of other was added to the filtrate and mixed well and then treated with 20 ml of distilled water in a separating funnel. The ether layer was recovered and evaporated to dryness at low temperature (35 – 50^{o}C) in a vacuum desiccator. The dry extract was then saponified with 20 ml of ethanoic potassium hydroxide and left over in a dark cupboard. The next day, the carotenoid was taken up in 20 ml of ether and the washed with two portions of 20 ml distilled water. The carotenoid extract (ether layer) was dried in a dessicator and then treated with light petroleum (petroleum spirit) and allowed to stand overnight in a freezer (-10^{o}C). The precipitated steroid was removed by centrifugation after 12 h and the carotenoid extract was evaporated to dryness in a weighed evaporation dish, cooled in a dessicator and weighed. The weight of carotenoid was determined and expressed as a percentage of the sample weight.

$$Percentagecarotenoidscontent = \frac{Weightofsample}{Weightofsampletaken} \times 100$$

Total phenolic content (TPC): Total polyphenols were determined following the Folin-Ciocalteu's method using gallic acid as standard as described by Priyanka (2016). Folin-Ciocalteu's reagent (12.5 µl) along with 7% sodium carbonate (125 µl) was added to the banana peel extracts. Samples were then incubated for 90 min at room temperature. The absorbance was measured at 750 nm using microplate reader (Synergy HT, Bio Tek Instruments, Winooski, VT, USA).

Determination of flavonoids content: The flavonoid content was determined as described by Singleton *et al*. (1999). 10g of flour sample was extracted respectively with 100 ml of 80% aqueous methanol at room temperature (30±2^{0}C). The mixture was then filtered through a Whatman No. 42 grade filter paper into a weighed 250 ml beaker. The filterate was transferred into a water bath, evaporated to dryness and weighed.

The percentage of flavonoid was calculated as:

$$\%flavonoidscontent = \frac{Weightofresidue}{Weightofsampletaken} \times 100$$

Determination of physical properties

Spread ratio: The spread ratio was calculated by method described by Ayo *et al.* (2007). The length and height of three rows and column were measured respectively of four well-formed biscuits. The spread ratio was calculated as diameter divided by height.

Weight: The weight of the banana peel-acha composite biscuit was determined by weighing on an electronic weighing balance (Mettler PF160 Balance, Switzerland) (Ayo *et al.*, 2007).

Diameter and thickness: The banana peel-acha composite biscuit diameter and thickness were determined using venire calipers (Ayo *et al.*, 2007).

Breaking strength: Break strength of banana peel-acha composite biscuit was determined using the method described by Ayo *et al.* (2010). Biscuitsample of 0.4 cm and 5 – 20 mm thickness respectively was placed centrally between two parallel metal bars (3 cm apart) and weights were applied until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

Volume: The volume of the acha-banana peel composite biscuit was determined using the formula.

$$V = \pi r^2 h$$

Where$V$ = Volume, $\pi = \frac{22}{7}$ (constant), $r =$ radius, h = height.

Sensory evaluation

The sensory evaluation of the banana peel-acha biscuits was carried out by thirty untrained panellists, randomly selected from (Department of Food Science and Technology Federal

University Wukari, Nigeria) based on their familiarity with the biscuit. The biscuits, appropriately coded (ACH, ABF, ABP, ACB, BAC, BAF and WHF) and of the same size and temperature (29 ± 3°C) were placed in white plastic plates separated by compartment and placed in sensory laboratory. The panellists were instructed to evaluate the coded samples for colour, crispiness, aroma, taste, texture, and general acceptability. The panellists rinsed their mouths with bottled water after tasting each sample and were not allowed to make comment during evaluation to prevent influencing other panellist. A nine-point Hedonic scale with one (1) representing "extremely dislike" and nine (9) "extremely like" was used, presented as a questionnaire. The qualities assessed were color, texture, flavour, taste, crispness and general acceptability as described by Ayo and Gidado (2017).

Statistical analysis

All the analyses were conducted in duplicates in completely randomized design. The data were subjected to analysis of variance using Statistical Package for Social Science (SPSS) software version 23, 2017. Means where significantly different and separated by the least significant difference (LSD) test. Significance was accepted at $p<0.05$.

Results and Discussion

Proximate composition of ripe banana peel-acha flour blend biscuit

The proximate composition of ripe banana peel and acha flour blend is presented in Table 1. The carbohydrate and moisture content decreased from 60.45 to 53.25, and 15.72 to 15.56%, respectively. The ash, protein, fat and fibre content increased from 1.73 to 2.19,7.50 to 8.36, 14.11 to 17.78, and 1.30 to 2.86% respectively, with increase (0-25%) in the added ripe banana peel flour. The effect of adding banana peel to acha are generally significant, p=0.05. The 75:25% banana peel-acha samples had the highest value for ash, fat and fibre, while the 100:0% acha samples had the highest value for moisture and carbohydrate and 95:5 had the highest value for protein.

The decrease in moisture content could be due to the relative increase in the fibre content of the added banana peel as it is hygroscopic. Fibres have the ability of absorbing moisture. The crude fibre increased with increase in added banana peel powder. This could be due to the presence of high dietary fibre content in fruits and vegetables (Villanueva-suarez *et al.*, 2003). Measuring the fibre content of foods is critical to making a sound benefit claim, whether it is a nutrient claim, structure-function claim, or health claim (Mermelstein, 2009). Ash content indicates the presence of mineral matter in food. Increase in ash content indicates that samples with high percentage of ash will be good sources of minerals. The carbohydrate decreased with increase in banana peel powder addition. The results obtained in this study are within the ranges earlier reported for acha (McWatters *et al.*, 2004; Ayo and Gidado, 2018).Wheat is an important source of carbohydrates (71.18 g)in 100 grams, wheat provides 1,370 kilojoules (327 kilocalories) of food energy and is a rich source (20% or more of the Daily Value, DV) of multiple essential nutrients, such as protein, dietary fiber, (Shewry and Hey, 2015).Globally, it is the leading source of vegetable protein in human food, having a protein content of about 13%, which is relatively high compared to other major cereals like acha but relatively low in protein quality for supplying essential amino acids. When eaten as the wholegrain, wheat is a source of multiple nutrients and dietary fiber (12.2 g) (Shewry and Hey 2015). Olapade *et al.* (2011) also reported a similar range for biscuits from acha and cowpea flour. The carbohydrate contents of these samples are an indication that the products are good sources of energy.

Table 1: Proximate composition of ripe banana peel-acha flour blend biscuit (%)

Acha flour	Ripe banana peel flour	Moisture Content	Ash Content	Crude Protein	Fat Content	Carbohydrate	Fiber
100	0	15.72 ^{d}±.74	1.73^{d}±.22	7.50 ^{d}±.13	14.11 ^{b}±.04	60.45 ^{ab}±.67	1.30^{a}±.01
95	5	15.70 ^{c}±.50	1.76^{a}±.52	8.48 ^{c}±.86	14.14 ^{a}±4.05	59.35 ^{d}±5.10	1.45^{d}±.13
90	10	15.67 ^{bc}±.14	1.89^{bc}±.09	8.46 ^{ab}±.06	14.45 ^{bc}±.11	57.95 ^{ab}±.29	1.58 ^{b}±.21
85	15	15.63^{a}±.07	1.95^{a}±.01	8.43±.24	15.68 ^{d}±.67	56.83 ^{cd}±.08	1.66^{b}±4.02
80	20	15.59 ^{ab}±.68	2.08^{a}±.01	8.42 ^{b}±.50	16.75 ^{d}±.67	54.96 ^{ab}±.1.24	2.42^{b}±.42
75	25	15.56 ^{bc}±.68	2.19^{ab}±.14	8.36 ^{a}±.01	17.78 ^{cd}±.74	53.25 ^{abc}±.93	2.86 ^{b}±.01
100% wheat	0	14.23 ^{c}±.16	2.04^{cd}±.32	12.88 ^{a}±.01	8.25 ^{cd}±1.01	61.71^{a}±.77	0.89^{bc}±.01

** Average mean score with the same letter(s) on the same column are not significantly different if P=o.05*

Table 2: Minerals and phytochemical composition of ripe banana peel-achaflour blends

Acha flour %	Ripe banana peel (%)	Magnesium (mg/l)	Potassium (mg/l)	Carotenoid (mg/100g)	Total Phenol (mg/100g)	Flavonoid (mg/100g)	Zinc (mg/l)
100	0	17.25^{a}±.01	668.62 ^{a}±.00	0.75 ^{e}±.00	2.91 ^{a}±.33	0.83 ^{a}±.01	0.99 ^{c}±.00
95	5	17.28^{b}±.00	677.62 ^{c}±.00	0.85 ^{c}±.00	.46 ^{b}±.01	0.86 ^{c}±.02	1.13^{bc}±.00
90	10	17.32^{e}±.00	674.96 ^{c}±.00	1.10 ^{f}±.00	.40 ^{b}±.01	0.91 ^{ab}±.01	1.16^{b}±.00
85	15	17.38^{d}±.00	672.15^{c}±.00	1.18 ^{b}±.00	.39 ^{b}±.00	1.01 ^{b}±.00	1.18^{c}±.00
80	20	17.42^{c}±.00	668.07 ^{d}±.01	1. 23 ^{a}±.00	.32^{ab}±.01	1.10 ^{b}±.06	1.21^{cd}±.00
75	25	17.47^{a}±.06	663.86^{b}±.19	1.36 ^{g}±.00	.28$^{a\ b}$±.02	1.21. ^{b}±.07	1.28 ^{d}±.16
100% wheat	0	30.71^{g}±.07	140.45^{b}±.52	1.69 ^{d}±.01	1.97 ^{a}±1.27	1.28 ^{b}±08	2.76 ^{a}±.56

** Average mean score with the same letter(s) on the same column are not significantly different if P=o.05*

Minerals and phytochemical composition of ripe banana peel-acha flour blend biscuit

The minerals, and phytochemical composition of ripe banana peel-acha flour blend biscuit are shown in Table 2. Magnesium, carotenoid, flavonoid and zinc increased from 17.25 to 17.47 (mg/l), 0.75 to 1.36 mg/100g, 0.83 to 1.21 mg/100g, and .99 to 1.28 mg/100g respectively, while potassium and total phenol decreased from 668.62 to 663.86 and 2.91 to 0.28 ppm with increase in percentage of added banana peel flour. The effect of adding ripe banana peel to acha are significant, p=0.05. The 75:25% ripe banana peel-acha samples had the highest value for magnesium, carotenoid, flavonoid and zinc. Magnesium and zinc increased as the levels of substitution of ripe banana peel-acha flour with acha increased (75-25%). The findings agreed with that of Igbabul *et al*. (2014). Carotenoids are abundant in the red, yellow, orange, and green colored vegetables and fruits. They are, the second most widely occurring plant pigment found in nature (MacDougall 2002). The high degree of hydration and long carbon chain length of these molecules makes them hydrophobic and therefore fat soluble molecules. The major purpose of carotenoids in the human diet is to serve as precursors to provitamin A, a required nutrient for humans (MacDougall, 2002).

Physical composition of ripe banana peel-acha blend biscuits

The physical properties of the ripe banana peel-acha flour blend biscuits is shown in Table 3. Break strength and spread ratio in the below biscuit ranged from 2.15 to 2.25 kg and 3.90 to 3.70 respectively, as a result of the increase in level of banana peel-flour substitution. The reverse was observed for the thickness, volume and weight of the biscuit which ranged from 1.20-1.10 cm, 3.62-3.41 cm^3, and 17.45-18.80 g, respectively. The 85:15% ripe banana peel-acha samples had the highest spread ratio and weight, 75:25% had lower values in volume, thickness and spread ratio, and 90:10% samples had the highest in thickness and volume respectively. The effect of adding banana peel powder are significant, p=0.05, for weight. The increased spread ratio observed in ripe banana peel-flour substituted biscuit samples could be due to the difference in the particle sizes and characteristics of the constituent flours of banana peel and acha (Agu *et al.*, 2007). Joel *et al*. (2014) and Olapade *et al*. (2011) reported similar trend in biscuits from wheat and full fat soya and biscuit from acha flour supplemented with cowpea flour. The spread ratio could be an indicator of biscuit quality.

Table 3: Physical properties of ripe banana peel-acha flour blend biscuit

Acha flour %	Ripe banana Peel flour%	Break strength (kg)	Spread ratio	Thickness (cm)	Volume (cm^3)	Weight (g)
100	0	$2.15^{b}\pm.21$	$3.90^{ab}\pm.14$	$1.20^{a}\pm.14$	$3.62^{ab}\pm.02$	$17.45^{c}\pm.21$
95	5	$2.10^{b}\pm.14$	$3.95^{ab}\pm.21$	$1.20^{b}\pm.14$	$3.64^{ab}\pm.04$	$18.05^{b}\pm.21$
90	10	$2.15^{b}\pm21$	$3.80^{ab}\pm.14$	$1.25^{a}\pm.21$	$4.05^{a}\pm.14$	$17.20^{c}\pm.14$
85	15	$2.65^{ab}\pm.21$	$4.15^{b}\pm.21$	$1.15^{a}\pm.07$	$3.46^{ab}\pm.05$	$19.20^{ad}\pm.14$
80	20	$3.25^{a}\pm35$	$4.0^{ab}\pm.28$	$1.20^{a}\pm.14$	$3.65^{ab}\pm.06$	$16.80^{a}\pm.14$
75	25	$2.25^{a}\pm.35$	$3.70^{ab}\pm.14$	$1.10^{b}\pm.14$	$3.41^{b}\pm.41$	$18.80^{a}\pm.14$
100% wheat	0	$2.30^{b}\pm.42$	$3.60^{a}\pm.28$	$1.40^{a}\pm.14$	$2.15^{c}\pm49$	$18.80^{b}\pm.14$

** Average mean score with the same letter(s) on the same column are not significantly different if P=o.05*

Table 4 Sensory qualities of ripe banana peel-acha flour blend biscuit

Acha Flour%	Ripe banana peel powder%	Colour	Texture	Taste	Odour	Appearance	Crispiness	General acceptability
100	0	$7.55^{a}\pm1.23$	$7.60^{a}\pm1.18$	$7.80^{a}\pm1.10$	$7.70^{a}\pm1.08$	$7.70^{a}\pm.97$	$7.50^{a}\pm1.46$	$8.05^{a}\pm.94$
95	5	$5.90^{a}\pm1.55$	$6.75^{ab}\pm1.11$	$7.20^{ab}\pm1.15$	$6.55^{a}\pm1.27$	$6.30^{ab}\pm1.65$	$1.53^{ab}\pm1.53$	$6.60^{a}\pm.1.78$
90	10	$5.42^{a}\pm1.64$	$5.68^{ab}\pm1.63$	$6.52^{b}\pm1.21$	$6.26^{a}\pm1.14$	$5.89^{b}\pm1.88$	$6.31^{ab}\pm.88$	$6.10^{a}\pm.1.79$
85	15	$5.50^{a}\pm2.11$	$5.60^{ab}\pm2.03$	$5.75^{b}\pm1.75$	$6.40^{a}\pm1.78$	$5.60^{ab}\pm2.28$	$6.35^{ab}\pm1.34$	$5.80^{a}\pm1.76$
80	20	$5.20^{ab}\pm2.14$	$5.85^{b}\pm1.78$	$6.45^{b}\pm1.19$	$6.40^{a}\pm1.66$	$5.60^{a}\pm2.11$	$6.25^{b}\pm1.44$	$6.35^{ab}\pm.1.49$
75	25	$5.28^{b}\pm1.52$	$5.71^{b}\pm1.70$	$5.76^{b}\pm1.84$	$5.33^{a}\pm1.62$	$5.61^{b}\pm1.49$	$6.38^{b}\pm1.16$	$6.04^{b}\pm1.20$
100%Whea	0	$8.80^{a}\pm.52$	$12.95^{a}\pm20.27$	$8.60^{a}\pm.68$	$8.55^{a}\pm0.88$	$8.75^{a}\pm.55$	$8.50^{a}\pm.88$	$8.65^{a}\pm.67$

** Average mean score with the same letter(s) on the same column are not significantly different if P=o.05*

Sensory evaluation of ripe banana peel-acha flour blend biscuits

The sensory qualities of the below biscuit are presented in Table 4. The result showed that the average mean score for colour, texture, taste, odour, appearance, crispiness, and general acceptability ranged from 7.55-5.28, 7.60-5.71, 7.80-5.76, 7.70-5.33, 7.70-5.61, 7.50-6.38 and 8.05-6.04, respectively. The effect of ripe banana peel flour was significant, p=0.05, for colour, texture, taste, crispiness and general acceptability. The relative increase in the average mean scores for texture could be due to the increasing fibre content of the ripe banana peel with effect on the crispiness of the biscuit. The sample, 95:5 % ripe banana peel-acha blends with average mean score of 6.60 is the most preferred and acceptable. This effect on the sensory could be due to inherent flavor compounds in ripe banana peel. Ayo and Gidado *et al.*, (2018) reported a similar range for sensory qualities of acha-carrot biscuits and Dabels *et al*. (2016) also reported similar range of wheat, acha and mung bean composite biscuit.

Conclusion

The result of this study showed that addition of ripe banana peel flour improved the fat, fibre, magnesium, carotenoid and flavonoid content, respectively. The ripe banana peel-acha flour blend biscuits was generally accepted up to 15%, however the 95:5% ripe banana peel flour blend was the most preferred corresponding to a relatively high improvement in the ash, fat, fibre, magnesium, carotenoid and flavonoid content of the acha based biscuits. The break strength appearance and crispiness of the ripe banana peel-acha biscuit were greatly improved and the acceptability of ripe banana peel-acha flour blend biscuits could be said to have added variety to diabetes meals and other individuals that are non-tolerant to gluten. The result shows that there is a great opportunity for the use of ripe banana peel in various food products.

References

Agu HO, Ezeh GC & Jideani AIO 2014. Quality assessment of Acha-based biscuit improved with bambara nut and unripe plantain. *Afri. J. Food Sci.*, 8(5): 278-289.

AOAC 1995. Official Methods of Analysis (16th ed.), Association of Official Analytical Chemists. Arlington, VA, USA.

Ayo *et al*. 2010. Evaluation of nutritional quality of soyabean-Acha composite biscuits. *Nigeria Food Journal- Ajol. Info*., 28(2).

Ayo JA & Nkama I 2003. Effects of acha (*Digitaria exilis* Staph) grain flour on the physical sensory quality of biscuit. *J. Nutr. & Food Sci.*, 33(3): 125-135.

Ayo JA, Ibrahim A & Nkama I 2003. Effect of acha (*Digitaria exilis*) on the Body Weight, Glucose Blood Level, Haemoglobin and Packed Column Cell of Rabbit. Proceedings, National Conference of the Application of science for National Development, Mubi, Adamawa state, p. 56.

Ayo JA, Ikuomola DS, Sanni TA, Esan YO & Ayo VA 2006. Evaluation of nutritional quality of soybean acha composite biscuit. *NigerianFood Ajol. Info.*, 28(2).

Ayo JA, Ayo VA, Nkama I & Adewori R 2007. Physicochemical, in-vitro digestibility and organoleptic evaluation of acha wheat biscuit supplementation with soybean flour. *Nigeria Food Journal*, 25(1): 77-89.

Ayo JA & Gidado FE 2017. Physiochemical, phytochemical and sensory evaluation of acha-carrot flour blends biscuit. *Curr. J. Appl. Sci. and Techn.*, 25(5): 1-15.

Bori MO, Adebusoye SA Lawal AK & Awotiwon A 2007. Production of biogas from banana and plantain peels. *Advanced Environmental Biology* 1: 33-38.

Chukwu O & Abdul-kadir AJ 2008. Proximate chemical composition of acha (*Digitaria exilis*and *Digitaria iburua*) grains. *J. Food Techn.*, 6: 214-216.

Dabels Nanyen, Igbabul Bibiana Dooshima, Amove Julius, Iorliam Benbella 2016. Nutritional composition, physical and sensory properties of cookies from wheat, acha and mung bean composite flours. *Int. J. Nutr. and Food Sci.*, 5(6): 401-406.

FAO 2001. Amino Acid Content of Foods and Biological Data on Proteins. FAO Nutritional Studies, Food and Agriculture Organization of the United Nations, Rome, p: 285.

Fatemeh SR, Saifullah R, Abbas FMA& Azhar ME2012. Total phenolics, flavonoids and Antioxidant activity of banana pulp and peel flours: Influence of variety and stage of ripeness. *Int. Food Res. J.*, Selangor, 19(3): 1041-1046.

Ferreira MSL, Santos MCP, Moro TMA, Basto GJ, Andrade RMS & Goncalves ECB 2013. Formulation and characterization of functional foods based on fruit and vegetable residue flour. *J. Food Sci. and Tech.*, 52(2): 822-830.

Guti´errez RMP, Mitchell S & Solis RV 2008. *Psidium guajava:* A review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, 117: S1–27.

González R-Montelongo, MG Lobo& González M 2010. Food Chemistry/Antioxidant activity in banana peel extracts: Testing extraction conditions and related bioactive compounds. Review article: safe amounts of gluten for patients with wheat allergy or coeliac disease. *Aliment Pharmacol. Ther.*, 23(5): 559–75.

Guylène, P. Berthe, F. Louis 2008**.** Bananas, raw materials for making processed food products. *Trends of Food Science and Techn*., 20(2): 1-3.

Igbabul BD, Num G & Amove J 2014. Quality evaluation of composite bread produced from wheat, maize and orange fleshed sweet potato flours. *Amer. J. Food Sci. Techn.*, 2(4): 109-115.

Jideani IA 1990. Acha-*Digitaria exilis*- The neglected cereal. *Agriculture International*, 42: 132-143.

Jideani IA 2012. *Digitaria exilis* (acha/fonio), Digitaria iburua (iburu/fonio) and Eluesine coracana (tamba/finger millet) – Non-conventional cereal grains with potentials. *Scientific Research and Essays*, 7(45): 3834-3843.

Jideani VA & Podgorski SC 2000. In vitro starch digestibility and glycemic. *Food Science and Technology*, 2(1): 19-28.

Joel Ndife, Fatima Kida & Stephen Fagbemi 2014. Production and quality assessment of enriched cookies from whole wheat and full fat soya. *European Journal of Food Science and Techn.*, 2(1): 19- 28.

Kulkarni 1997. Enrichment of Egyptian "Balady" bread. Part 1 baking studies, physical and sensory evaluation of enrichment with decorticated cracked broadbean flour (*Viciafaba* L.). *Nahrung.*, 44(6): 418-421.

Krishnaiah, D., Devi, T., Bono, A. and Sarbatly, R. (2009). Studies on phytochemical constituents of six Malaysian medicinal plants. *J. Med. Plant Resou.*, 3(2): 67-72.

Lasekan DO 1994. Chemical composition of acha (*Digitaria exilis*) flour. *J. Food Sci. and Agric.*, 14: 177-179.

Macdougall D 2002. *Colour in Food.* Woodhead Publishing. Abington, Cambridge, p. 190-211, 278-286.

Mariana SL Ferreira, Monica CP Santos, Thaisa MA Moro, Gabriela J Basto, Roberta MS Andrade & Edira CBA Goncalves 2013. Formulation and characterization of functional foods based on fruit and vegetable residue flour. *J. Food Sci. Techn*., 13197-013-1061 4.

McWatters KH, Ouedrago JB, Resurreccion AVA, Hung YC & Phillips RD 2004. *Baking performance of wheat, fonio and cowpea flours*. Abstract research programs on cowpeas. Dept. of Food Science and Technology, University of Georgia, 1109 Experiment Street, Griffin, GA 30223

Olapade AA, Awoh OC & Oluwole OB 2011. Quality attribute of biscuit from acha (*Digitaria exilli*) flour supplement with cowpea (*Vigna unguiculate*) flour. *Afri. J. Food Sci. and Techn.*, 2: 198 – 203.

Pate PL, Ellis K, Sunkara R, Shackelford L, Ogutu S, Lloyd TW, Herring J, Verghese M 2016. Development of a functional food product using guavas. *J. Food and Nutr. Sci.*, 7:927 - 937.

Shewry PR,& Hey 2015.The contribution of wheat to human diet and heart. Food and energy security. 4(3)**:175**–**202**

Shelton DR & Appolonia BI 1985. Carbohydrate functionality in baking process cereal food. *World Journal*, 30: 437 – 442.

Singleton VL, Orthofer R & Lamuela-Raventos RM 1999. Analysis of total phenol sand other oxidation substrates and antioxidants by means of Folin-Ciocalteua reagent. *Methods Enzymol*., 299: 152-178.

Thompson James F Meng Li 1997. Optical chlorophyll sensing system for banana ripening, 12(3): 273-28.

Villanueva-Suárez A, Redondo-CuencaMD, Rodríguez-Sevilla &M de las Heras Martínez2003. Characterization of nonstarch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: Comparative study. *J. Agric. and Food Chem.*, 51(20): 5950–5955.

McWatters KH, Phillips RD, Walker SL, McCullough SE, Mensa-Wilmot Y, Saalia FK, Hung YC & Petterson SP 2004. Baking performance and consumer acceptability of raw and extruded cowpea flour breads. *Journal of Food Quality*, 27(5): 337-351.