QUALITY EVALUATION OF BISCUITS PRODUCED FROM PLANTAIN (*Musa balbisana*), CHARA PONA FISH (*Labeorohita*) AND ACHA (Digiteria exiles) FLOUR BLENDS

ABSTRACT

Plantain (*Musa balbisiana,)*, charapona (*Labeorohita*) fish flour and acha (*Dititaria exilis*) based biscuits were produced. Plantain and acha flours were substituted in acha flour at 5:5, 10:5, 15:5, 15:10 and 15:15% with 100% wheat, acha and plantain flours respectively as controls. The biscuits were then evaluated for the proximate composition, minerals and vitamins and sensory properties. The result of the study indicates the break strength (1390-1417kg) and thickness (0.28-0.38mm) increases while diameter (3.95-3.71cm), volume (12.0-9.0 cm^3), weight (7.82-6.60 g) and density (0.78-0.62 g/cm^3) of the biscuits samples decreased as the level of plantain and fish flour blends increases. The bulk density (2.33-1.39 %) decreased whereas the foaming capacity (3.36-4.88%), water absorption capacity (2.90-3.85%) and oil absorption capacity (1.95-3.05%) of the blend flours increased with increasing level of inclusion. The crude protein, fat, ash and crude fibre content increased from 7.31-11.90%, 11.46-16.02% 0.3-0.42 % and 0.2-0.38% respectively while moisture and carbohydrate decrease from 3.27-3.72% and 77.46-67.76 with increase substitution of plantain and fish flour. The potassium and calcium increased from 208.17-325 mg/100g while magnesium decreased from 34.06 to 33.97 with addition of plantain and fish flour. Vitamin A, vitamins B1, and B2, of the flour blends biscuits increased from 0.61-0.86, 0.43-0.65 and 0.12-0.18 mg/100g respectively with increase in the level of plantain and fish flour. The acha-plantain and charapona fish blends biscuits were generally accepted up to 15:15%, but most preferred at 75:15:10% added plantain, charapona fish and acha flours blends. The plantain and charapona fish flour could be used to enrich the quality of food products.

Key Words: Quality, plantain, chara pona, acha, biscuits

1.0 INTRODUCTION

Biscuits, a widely consumed and convenient snack, offer varying nutritional values depending on the flour used (Gbenga et al., 2018). In Nigeria, especially among children, biscuits are a staple food item, commonly made from flour, fat, sugar, and water, with optional ingredients to enhance flavor and texture. The selection of ingredients and production methods, such as roll and cut, shape and slice, and scoop and bake, play a crucial role in biscuit quality (Kumar *et al.*, 2021). Acha (Digitaria exilis), a nutrient-rich cereal from West Africa, is underutilized despite its high protein and amino acid content (Ayo *et al*., 2018). It is traditionally grown in regions like Central Nigeria and has significant nutritional benefits, including essential minerals like iron, calcium, and phosphorus (Patalano (2019). Acha is versatile, often used in local dishes and could be incorporated into biscuits and other products (Ayo *et al*., 2018). Plantain (Musa balbisiana), another underexploited crop, is rich in carbohydrates, fiber, vitamins, and minerals. Widely produced in sub-Saharan Africa (Nafack *et al.*, 2023), plantain flour is a valuable ingredient for biscuits due to its nutritional profile and health benefits, such as lowering cholesterol and reducing disease risks (Gómez *et al.*, 2021). Fish, particularly Chara Pona (Labeo rohita), offers high-quality proteins and omega-3 fatty acids, making it a valuable nutritional component. Despite its benefits, the use of fish in biscuit production is limited by challenges in processing and maintaining quality. The high cost and demand for wheat flour necessitate exploring alternative ingredients like acha and plantain (Ayo and Atondo, 2020). Combining these with Chara Pona fish flour could enhance the nutritional value of biscuits while promoting the utilization of underused crops. This study aims to evaluate the quality and acceptability of biscuits made from blends of acha, plantain, and Chara Pona fish flours, potentially offering a nutritious and cost-effective alternative to traditional wheat flour biscuits.

2.0 MATERIAL AND METHOD

2.1 Materials

The material used in this study include Acha grains (*Digitaria exilis*), plantain (*Musa balbisiana*), chara pona fish, wheat flour, baking powder (double-acting), salt (palm salt), baking fats, sugar (Dangote), water (portable water) all was purchase in Wukari New Market , Wukari Local Government Taraba State.

2.1.1 Preparation of acha flour

Cream coloured acha was washed with portable water to remove dirts, de-stoned (sedimentation method) and sun dried (3 days). The dried acha was milled into flour (attrition mill) and sieve (0.2mm screen size) to produce acha flour (Tanko *et al., 2023*)

2.1.2 Preparation of plantain flour

Plantains (*Musa paradisiaca)* was peeled manually(using stainless steel kitchen knives), pulp was sliced (1.5mm thickness), oven dried(50°C), milled (hammer mill) and sieved (0.2mm) to produce plantain flour(Adanse*et al.*, 2021).

2.1.3 Production of fish flour

The chara pona fish was washed with potable water, sun dried (3days),milled(attrition mill) and sieved(0.2mm screen size) to produce fish flour (Sabry 2021).

2.2.4 Production of acha– plantain-chara pona fish flour blend biscuits

Biscuits was prepared as described by Jagarlamudi (2022) with some modifications in the recipe. The dry ingredients (flour, sugar, salt, and baking powder baking fat etc, Table 1) were carefully mixed in a bowl by hand for 3min to produce batter. The batter was rolled and cut (biscuit cutter), arranged on oil greased baking trays, and (baked at 180^{o}C for 25min in the baking oven) to produce flour blend biscuits. The biscuits were cooled down to room temperature (38^oC) and packed hematic ally in a polyethylene material.   .

Table 1. Formulation of Acha- plantain, acha- Chara pona fish composite biscuit

Sample	Acha flour (%)	Plantain flour (%)	Fish flour (%)	Wheat (%)
A	100	-	-	-
B	-	100	-	-
C	90	5	5	-
D	85	10	5	-
E	80	15	5	-
F	75	15	10	-
G	70	15	15	-
H	-	-	-	100

2.2 ANALYTICAL METHODS

2.2 .1 Determination of functional properties of acha– plantain-chara pona fish flour blends

2.2.1.1 Determination of Bulk density

A 5 g flour sample was put into 100ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g cm-3) was calculated as weight of flour (g) divided by flour volume (cm3) (Donaldben *et al*., (2020)

$$\text{Bulk density} = \frac{\text{weight of sample (g)}}{\text{Volume of sample (ml)}} \quad \ldots\ldots (1)$$

2.2.1.2 Water Absorption Capacities

Oil and water absorption capacity was determined as described by Oyet and Chibor, (2020).. One gram of the sample was added to 3ml of water/corn oil in a 15ml conical graduated centrifuge tube. The emulsion was mixed with a vortex mixer for 2 min, incubated at room temperature for 30 min and later centrifuge at 4896 x g for 25 min. After centrifuging, the supernatant was decanted, dried and weighed and calculated as in Equ, 2.

$$\text{Water absorption capacity (g / g)} = \frac{\text{Density of water x volume absorbe}}{\text{Weight of sample}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

2.2.1.3 Determination of Oil Absorption Capacity (OAC)

Oil absorption capacity of samples was determined as described by Makanjuola, and Adebowale (2020) .One (1 g) of sample was mixed with vegetable oil (specific gravity 0.9092) and allowed to stand at room temperature (30±2 ºC) for 30 minutes, then centrifuged for 30 minutes at 3000 rpm. Oil absorption was calculated as Equ.3

$$\text{OAC (mL/g)} = \frac{m2}{m1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

2.2.1.4 **Determination of emulsion capacity Emulsion capacity and stability**

Emulsion capacity and stability was determined as described by Zidani and Boudraa, (2020).. Emulsions were formed inside a 600 ml beaker using a continuous stirring apparatus. The sample (0.25, 0.5, 0.75, 1.00 and 1.25 g) was dissolved in 25 ml of distilled water making 1, 2, 3, 4 and 5% slurries (w/v), respectively. pH adjustment was made to ensure maximum solubilisation of the protein. The mixture was stirred for 30 min in order to disperse the sample. Oil was then added at a rate of 1.00 ml/s from a burette until emulsion collapsed indicated by a sharp fall in motor current. The volume of oil added up to inversion point was noted and the emulsion capacity expressed as ml oil per g of sample. The emulsion stability was determined by allowing the emulsion prepared to stand in a graduated cylinder and the volume of oil separated at time of 0.00, 0.5, 1, 2, 3 up to 24 h was noted in each case and calculated using Equs. 4 and 5.

$$EC\ (\%) = \frac{V2}{ME} \times 100 \quad \ldots\ldots (4)$$

$$ES\ (\%) = \frac{\text{Height of the emulsified layer}}{\text{Height of the total content}} \times 100 \quad \ldots\ldots (5)$$

2.2.1.5 **Foam capacity and foam stability**

The method described by Mshayisa, (2021**) w**as used for the determination of foaming capacity (FC) and foaming stability (FS). Two grams of flour sample was added to 50 ml distilled water at 30 ± 2ºC in a 100 ml measuring cylinder. The suspension was mixed using glass rod and was properly shaken to foam and the volume of the foaming capacity after 30 s was recorded. The foaming capacity was expressed as the percentage was increased in volume mixed thoroughly and was analysed using the RapidVisco Analyser (RVA) using the manufacturer recommended parameters**.**

2.2.1.6 **Swelling capacity**

This was determined by the method described by (Heydari *et al.*,2020) with modification for small samples. One gram of the flour sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80ºC for 30 min. This was continually shaken during the heating period, the suspension was centrifuged at 10,000 rpm, decanted and the paste was weighed. The swelling power was calculated as indicated Equ. 6

Swelling power =weight of the paste/weight of dry flour.

$$\text{Swelling index (ml/ g)} = \frac{\text{water absorbed (ml)}}{\text{Weight of dry sample (g)}} \quad \ldots\ldots (6)$$

2.2.2 **PHYSICAL PROPERTIES OF COMPOSITE BISCUITS**

2.2.2.1 Spread ratio

The spread ratio was calculated as diameter of biscuits divided by height (Doğan and Meral 2019). Two rows of five well-formed biscuits were made and the height was measured, arranged horizontally edge to edge and the sum of the diameters was also measured as well.

2.2.2.2 Break strength

Oyet and Chibor (2020).method was used. Biscuit of known thickness was placed centrally between two parallel metal bars (3 cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

2.2.2.3 Thickness and Weight

Thickness of the biscuit sample was determined using a venire calliper, while the weight of the sample was determined with a top loading balance Oyet and Chibor (2020). .

2.2.3 DETERMINATION OF CHEMICAL COMPOSITION

2.2.3.1 Proximate Composition analysis

Nutrient composition of the food samples was determined in triplicate using the standard procedures of Association of Official Analytical Chemists as follows:

2.2.3.1.1 Determination of Moisture Contents

Determination of Moisture Content Two (2g) of each sample was weighed inside a clean dried crucible (W1) and was dried at 60°C in a hot stimulating oven for 24 hours to a constant weight. It was cooled in desiccators for 30minutes and weighed (W2). The crucible was washed, dried in the oven and the weight was recorded (W0) (Bello *et al.*, 2020).

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1 - w_0} \times \frac{100}{1} \quad \ldots\ldots (7)$$

Where;

W1 = weight of sample + empty crucible

W0 = weight of empty crucible

W2 = weight of dried sample + empty crucible

2.2.3.1.2 Determination of crude protein

Determination of Crude Protein The crude protein content (N x 6.25) was determined as described by D'Hooghe *et al.,* (2023). A quantity(0.5 g) of each sample was added to 10 ml of conc. sulphurics acid and 1g of the catalyst mixture. It was then heated cautiously on digestion rack under fume hood until a greenish clear solution appeared, cooled and then made up to 50 ml with distilled water. The digested sample was transferred into distillation apparatus and distilled. 10 ml of the distillate was titrated with 0.1M HCL to first pink colour. The nitrogen content was calculated and multiply by the factor to obtain the protein content.

2.2.3.1.3 Determination of crude fiber

Two(2g) gram of the sample was defatted with 99% ethanol, boiled under reflux for 30 minutes with 200 ml of a solution containing 1.25 g of H2SO4 per 100 ml of solution (Ganesan, *et at.*, 2023). And was filtered with Whatmann No 1 filter paper, washed with boiled water until the washing was no longer acid. The residue was transferred to a beaker and boiled for 30 minutes with 200ml of a solution containing 1.25g of carbonate free sodium hydroxide per 100ml. It was filtered and transferred into a crucible. The residue was dried in the oven at 600C in a muffle furnace and the dried weight recorded.

$$\text{Crude fiber (\%)} = \frac{W_1 - W_2}{W_0} \times 100 \quad \ldots\ldots (8)$$

Where; W_0 = weight of sample (g)

W_1 = weight of dried sample (g)

W_2 = weight of ash sample (g)

2.2.3.1.5 Determination of Crude Fat

Crude fat was determined by exhaustively extracting each sample in petroleum ether in a soxhlet extractor. The weighed sample (W0) was poured into a thimble and covered with a clean white cotton wool. 99% ethanol (200 ml) was poured into a 250 ml extraction flask which was previously dried in the oven at 1050C for 30 minutes and weighed (W2). Extraction was done for 5 hours. And was cooled in desiccators and reweighed (W1)(Ganesan,*et al.*, 2023).

$$\text{Crude fat (\%)} = \frac{W_1 - W_2}{W_0} \times 100 \quad \text{…} \quad (9)$$

2.2.3.1.6 Determination of ash content

Two(2 g) gram sample was transferred into a previously heated, cooled and weighed crucible (W0) and then weighed (w1). It was placed into a Gallenkamp muffle furnace(550°C for 3 hours), cooled(in desiccators) and weighed (W2)(Ikala,*et al.*, 2020).

$$\% \text{ Ash} = \frac{W_2 - W_0}{W_1 - W_0} \times \frac{100}{1} \quad \text{…} \quad (10)$$

2.2.3.1.7 Determination of carbohydrate content

Carbohydrate content was determined by difference using the method described by (Ikala,*et al.*, 2020). Total carbohydrate content of the samples was calculated by difference (subtracting the sum of percent moisture, crude protein, crude fibre, crude fat, and ash from 100%).

2.2.4 **MICRONUTRIENTS ANALYSIS**

2.2.4.1 **Determination of minerals**

2.2.4.1.1 Calcium

Calcium was determined by titrimetric method after precipitation as calcium oxalate as outlined by Stanković*et al.*, (2020). About 5 mL of samples was mixed with 1 mL of ammonium oxalate solution. pH was adjusted to 8 using ammonium hydroxide solution and adjusted again to 5 using dilute acetic acid. The mixtures was allowed to stand for 4 hours, centrifuged and decanted.

About 2 mL dilute sulphuric acid was added and heated. Titration was then carried out using 0.02 N potassium permanganate (1 mL = 0.0004 g Ca) until colour changes. Calcium was calculated using Equ. 11

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Where A_s is absorbance of sample, C_{ss} is concentration of standard solution, D_f is Dilution factor, A_{ss} is aborbance of standard solution and S_v is sample volume.

2.2.4.1.2 Magnesium

Colourimetric method was used to determined magnesium content as described by Stanković *et al.*, (2020). About1 mL of magnesium buffer and 2.5 mL of eriochrome blue black tea was added to 5 mL of sample. This was allowed to stand for 10 minutes. Absorbance was taken at 520 nm using a colourimeter. Magnesium was calculated using Equ.12.

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Where A_s was absorbance of sample, C_{ss} was concentration of standard solution, D_f was dilute on factor, A_{ss} was absorbance of standard solution and S_v was sample volume.

2.2.4.1.3 Potassium

Potassium stock solution and standard dilute potassium solution was prepared with the method for sodium solution as described by Stanković*et al.*, (2020). A calibration graph was prepared from the reading obtained. About 2 mL of sample was mixed with 2 mL of sodium cobaltonitrate and allowed to stand for 45 minutes. About 2 mL of water was added to the mixture and centrifuged for 15minutes. The supernatant was obtained and mixed with 2 mL of 99 % ethanol. The mixture was centrifuged for 5 minutes and the supernatant boiled in a water bath for 10 minutes. About 1 ml of 1 % chlorine hydrochloride, 1 ml potassium fericyanide and 2 mL of distilled water was added to the extract. Absorbance was determined at 620 nm using a colorimeter. The sample solution was then read and potassium content was calculated using Equ 13

$$\text{Potassium} = \frac{A_s \times C_{ss} \times D_f}{A_{ss} \times S_v} \times 100 \quad \text{……………………………………………………………… (13)}$$

Where A_s= absorbance of sample, C_{ss}= concentration of standard solution, D_f= Dilution factor, A_{ss}=aborbance of standard solution and S_v=sample volume.

2.2.4.2 DETERMINATION OF VITAMINS

Vitamin A, Thiamine (B1) Riboflavin (B2) was the vitamins analysed for the food formulation by the method described by Choi and Row (2023). This was performed at the optimum separation condition by High Performance Liquid Chromatography (HPLC) with isocratic binary mobile phase consisting of methanol: water (65:35 v/v) with flow rate of 1ml.min-1. The pH was measured using pH meter combined with a glass electrode. A 320R Hettich centrifuge and a digital 10P ultrasonic bath was used. A calibration curve was prepared for each vitamin and the correlation coefficient based on the concentration curve was obtained**.**

2.2.5 SENSORY EVALUATION

Sensory evaluations of the biscuits was determined using twenty-member panellist consisting of staff and students of the Department of Food Science and Technology, Federal University of wukari Taraba state. The biscuits samples prepared from each flour blend was presented in coded white microwavable plastic container. The order of presentation of samples to the panellists was randomized. Potable water was provided to rinse the mouth between evaluations. The panellists was instructed to evaluate the coded samples for taste, aroma, colour, texture, crispiness and overall acceptability. Each sensory attribute was rated on a 9-point Hedonic scale (for taste, aroma and overall acceptability, 1 = disliked extremely, 5 = neither like nor dislike, while 9 = liked extremely. For colour, 1 = extremely white, 5 = neither brown nor white, while 9 = extremely brown. For texture:

2.2.6 Statistical Analysis

All the analyses was carried out in duplicate. Data obtained was subjected to Analysis of Variance (ANOVA); differences between means was evaluated using Turkey's multiple comparison tests with 95% confidence level. The statistical package in Minitab software version

16 was used. Means was separated with Duncan Multiple Range Test (DMRT) at 95% confidence level (p=0.05)

3.0 RESULTS AND DISCUSSION

3.1 Chemical Composition of acha-plantain-chara pona fish blends biscuits

3.1.1 Proximate composition of acha-plantain-chara pona fish blends biscuits

The proximate composition of acha-plantain and chara pona fish blend biscuit is presented in table 2. The moisture content of biscuits enriched with plantain flour and chara pona fish blends increased from 3.27 to 3.72% and was higher than 2.32% in wheat flour. The moisture content was significantly, $p<0.05$ lower than 17.01 to 26.23% reported by Akoja and Coker (2018) on wheat flour biscuit incorporated with okra powder and Sengev *et al.* (2015) which increased from 7.9 to 10.0% on cookies produced from sweet potato and mango mesocarp flours. The ash content of the enriched biscuits also increased on addition of plantain and fish flours with sample G (70:15:15%) The study agrees with Akoja and Coker (2018) who also observed an increased ash content on addition of okra flour (0.91 – 4.17%). Usman et al. (2015) reported similar increase in ash content (0.52 – 1.12%) as carrot extract was added at varying degrees to wheat and maize flour composite blends. Fish and plantain are rich sources of minerals in human diet.

Ash content of a food material is a measure of nutritionally essential minerals present in that food material. High ash content in the biscuits signifies higher mineral content.

The protein content of the enriched biscuit increased on addition of okra pod flour and was consistent with (Akoja and Coker (2018). Also carrot vegetable increased the protein content 11.4 to 23.2%) of biscuit (Usman et al., 2015). The protein content of the enriched biscuit ranged from 7.31 to 11.90%, the highest at sample G with 15% fish flour. This content was higher than 5.1 to 9.5% on cookies produced from mango mesocarp (Sengev *et al.*, 2015).

Table 2. Proximate composition of acha-plantain-chara pona fish blend biscuit

Sample	Moisture%	Crude protein (%)	Crude fat (%)	Crude fibre (%)	ash%	carbohydrate%
A	$2.43^{d}\pm0.03$	$9.69^{b}\pm0.04$	$8.55^{c}\pm0.16$	$3.13^{a}\pm0.02$	$3.13^{a}\pm0.02$	$73.07^{b}\pm0.24$
B	$3.18^{cd}\pm0.01$	$7.00^{c}\pm0.61$	$9.24^{c}\pm0.86$	$2.1^{b}\pm0.07$	$0.1^{d}\pm0.07$	$78.38^{a}\pm1.53$
C	$3.27^{c}\pm0.4$	$7.31^{c}\pm0.0$	$11.46^{b}\pm1.12$	$0.2^{c}\pm0.14$	$0.3^{c}\pm0.14$	$77.46^{a}\pm0.57$
D	$3.29^{c}\pm0.4$	$7.32^{c}\pm0.1$	$11.81^{b}\pm0.24$	$0.05^{d}\pm0$	$0.06^{e}\pm0$	$77.77^{a}\pm0.74$
E	$3.39^{c}\pm0.42$	$7.39^{c}\pm2.03$	$12.91^{b}\pm2.28$	$0.28^{c}\pm0.11$	$0.27^{c}\pm0.11$	$75.76^{b}\pm3.79$
F	$3.99^{a}\pm0.29$	$10.2^{a}\pm0.21$	$15.79^{a}\pm0.76$	$0.21^{c}\pm0.04$	$0.33^{c}\pm0.04$	$70.48^{b}\pm0.23$
G	$3.72^{b}\pm0.21$	$11.9^{a}\pm0.21$	$16.02^{a}\pm1.7$	$0.18^{c}\pm0.11$	$0.42^{c}\pm0.11$	$67.762^{c}\pm1.17$
H	$2.32^{d}\pm0.01$	$9.11^{b}\pm0.12$	$9.91^{c}\pm0.11$	$1.82^{b}\pm0.01$	$1.83^{b}\pm0.01$	$75.01^{b}\pm0.12$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly($p<0.05$) different from each other using Duncan multiple range test.

Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF

AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

The difference in the protein content could be attributed to the high protein content in fish used. Protein is needed in the body for the growth and repair of worn out tissues, forms major enzymes and hormones and boosts the immune system The fat content of the biscuits increased on addition of fish flour. This shows that fish flour is also high in protein. The result agrees with Akoja and Coker (2018) and Kinn-Kabiari *et al*. (2017) reported fat content of 17.90 to 20.79% but their results were significantly ($p<0.05$) higher than that obtained from the present study. The difference may be as a result of recipe used. The use of margarine and fat in bakery also predisposes consumers to high intake of fat. However, Ajibola *et al*. (2015) who worked on whole wheat biscuits incorporated with moringa flour and cocoa powder reported fat content 13.19 to 15.00% which agreed with that obtained from the present study. Fat is required for the metabolism of fat soluble vitamins such as vitamin A, D, E and K and it also forms hormones systems in the body.

The crude fiber content of the enriched biscuit increased plantain and fish flour addition with highest value at sample F (15:10%) plantain and fish flour inclusion. This was consistent with previous studies (Akoja and Coker 2018; Kinn-Kabiari et al., 2017; Grah *et al.*, 2014). Fiber increases bulk of food and aids digestion of food. It is very essential component of food and can help stop constipation. Carbohydrate content of the enriched biscuit reduced on addition of and fish flour. The present study was consistent with (Akoja and Coker 2018; Ajibola *et al*., 2015) but lower than 62.32 – 70.01% reported by Omah and Okafor (2015) on legume based cookies. This shows that animal sources have lower carbohydrate contents compared to plants. (Akoja and Coker 2018)

3.1.2 Minerals composition of acha-plantain-chara pona fish flour blends

Calcium, magnesium, potassium and content of the enriched biscuit increased on plantain and fish flour substitution and were highest in sample G compared to the control samples (Table 3). This shows that plantain and fish flour blends are good sources of micronutrients. The study was similar with (Usman et al., 2015; Ajoka and Coker, 2018). However, some studies reported lower values on addition of legumes (Ndife *et al.*, 2014), vegetables (Kinn-Kabiari *et al.*, 2017), and nuts (Nzeagu and Onwudiwe, 2016).

Table 3. Minerals composition of acha-plantain-chara pona fish flour blends

SAMPLE	Potassium (mg/100g)	Magnesium (mg/100g)	Calcium (mg/100g)
A	$31.95^{g}\pm0.71$	$29.06^{c}\pm0.69$	$39.55^{f}\pm0.01$
B	$705.63^{a}\pm2.52$	$38.91^{a}\pm0.6$	$101.8^{e}\pm1.28$
C	$208.17^{e}\pm1.51$	$34.06^{b}\pm0.54$	$150.32^{c}\pm9.92$
D	$254.78^{cd}\pm0.0$	$30.83^{c}\pm0.81$	$169.74^{c}\pm4.34$
E	$256.19^{c}\pm3.02$	$29.67^{c}\pm0.83$	$176.07^{c}\pm3.87$
F	$260.83^{c}\pm0.51$	$30.18^{c}\pm1.1$	$223.45^{b}\pm4.88$
G	$325.95^{b}\pm1.0$	$33.97^{b}\pm0.11$	$290.11^{a}\pm4.86$
H	$171.93^{f}\pm0.0$	$31.58^{bc}\pm0.01$	$140.96^{d}\pm0.69$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly ($p<0.05$) different from each other using Duncan multiple range test.
Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF
AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

3.1.3 Vitamins content of acha-plantain-fish flour blends bread

The vitamin contents of biscuit samples are presented in Table 4. Vitamin A, vitamin B1 and B2 ranged from 0.31 to 0.86, 0.11 to 0.65 and 0.11 to 0.18 mg/100 g respectively. The maximum level of vitamin A content of biscuit (0.86 mg/100 g) was observed in the 70:15:15% substitution levels of acha-plantain-fish flour blends biscuit and significantly higher than the values obtained from other samples. Lowest value of vitamin A (0.31 mg/100 g) observed in 100% acha biscuit which could be attributed to non-incorporation of plantain and fish flour blends which are rich sourcse of vitamin A (Olakunle and Olalekan, 2020). There are significant differences ($p \leq 0.05$) in vitamin B2 (riboflavin) and B1 (thiamin) contents of the samples. Vitamin B2 and B1 helps to break down proteins, fat and carbohydrates band plays a vital role in maintaining of body's energy supply. This result is in agreement with the work of Olakunle and Olalekan, (2020).that reported 0.157 mg/100 g to 0.477 mg/100 g for ready to eat snacks.

Table 4. Vitamins content of acha-plantain-fish flour blends

Sample	Vitamin A (mg/100g)	Vitamin B1 (mg/100g)	Vitamin B2 (mg/100g)
A	$0.31^{f}\pm0.01$	$0.11^{d}\pm0.14$	$0.11^{c}\pm0.07$
B	$0.42^{e}\pm0.02$	$0.36^{c}\pm0.0$	$0.12^{c}\pm0.01$
C	$0.61^{c}\pm0.0$	$0.43^{c}\pm0.01$	$0.12^{c}\pm0.0$
D	$0.65^{c}\pm0.0$	$0.41^{c}\pm0.01$	$0.12^{c}\pm0.01$
E	$0.71^{b}\pm0.01$	$0.43^{c}\pm0.02$	$0.13^{c}\pm0.0$
F	$0.79^{b}\pm0.01$	$0.56^{ab}\pm0.0$	$0.16^{b}\pm0.0$
G	$0.86^{a}\pm0.01$	$0.65^{a}\pm0.01$	$0.18^{a}\pm0.0$
H	$0.51^{d}\pm0.14$	$0.47^{bc}\pm0.06$	$0.13^{c}\pm0.01$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly($p<0.05$) different from each other using Duncan multiple range test.
Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF
AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

3.2 Functional properties of acha-plantain-chara pona fish flour blends

The functional properties of the flour are shown in Table 5. A significant variation was observed among the samples where the bulk density ranged from 1.89 – 2.33g/ml. Bulk density is a measure of the heaviness of the flour and it is generally affected by the particle size. The low value of the bulk density observed in this study facilitates easy packaging and transportation, which improves overall cost efficiency of the end bakery product (Oladipo and Nwokocha, 2011) Foam capacity ranged from 3.33–4.88%. Samples differ significantly. Foaming capacity contributes to dough formation and stability of the flour. A high foaming capacity is a criterion for good quality product (Ukpong et al., 2021). The water and oil absorption capacities of the blends ranged from 2.45 – 3.85% and 1.85 – 3.05%. It increased progressively as the level of the fish flour increased in the flour blend. Sample G had the highest values both for oil and water absorption capacities. Both the water and oil absorption capacities are reported to be influenced by the nature and behavior of the micro molecules, especially protein and the nature of starch

(Upong *et al*., 2021).. For the OAC, a significant variation ($p<0.05$) existed among the blends, while for WAC, no significant difference ($p < 0.05$) existed among the blends.

Table 5: Functional properties of acha-plantain-chara pona fish flour blends

Sample	Bulk density (%)	Foaming capacity (%)	Water absorption capacity (%)	Oil absorption capacity (%)
A	$1.89^{c}\pm0.05$	$3.33^{c}\pm0.00$	$2.45^{a}\pm0.64$	$1.85^{a}\pm0.07$
B	$1.41^{e}\pm0.03$	$3.36^{c}\pm1.03$	$2.85^{a}\pm0.07$	$2.05^{a}\pm0.07$
C	$2.33^{a}\pm0.08$	$3.36^{c}\pm0.04$	$2.90^{a}\pm0.00$	$1.95^{a}\pm0.07$
D	$1.9^{c}\pm0.03$	$3.46^{d}\pm0.02$	$3.00^{a}\pm0.14$	$1.95^{a}\pm0.07$
E	$1.82^{cd}\pm0.05$	$3.61^{b}\pm0.06$	$3.15^{a}\pm0.07$	$2.05^{a}\pm0.21$
F	$1.42^{b}\pm0.12$	$4.65^{d}\pm0.02$	$3.74^{a}\pm0.00$	$2.95^{a}\pm0.21$
G	$1.39^{e}\pm0.05$	$4.88^{b}\pm0.06$	$3.85^{a}\pm0.07$	$3.05^{a}\pm0.21$
H	$1.7^{d}\pm0.04$	$3.79^{a}\pm0.21$	$2.90^{a}\pm0.00$	$1.9^{a}\pm0.00$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly($p<0.05$) different from each other using Duncan multiple range test.
Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF
AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

3.3 Physical properties of acha-plantain-chara pona fish flour blends

The physical properties of the acha-plantain-fish flour blend biscuits is shown in Table 6. There was an increase in break strength and thickness ranging from 277.5 to 2222.5kg and 0.27 to 0.38cm respectively, as a result of the increase in level of plantain and fish flour substitution. The reverse was observed for the volume, diameter, weight and density of the biscuit which ranges from 10.5-8.0cm, 4.00- 3.68cm, 8.48-5.54 g and 8.48 – 0.55g/ml respectively. Sample G had the highest breaking strength and thickness, but had lower values in volume, diameter and density. The effects of adding plantain and fish flour blends are significant, ($p<0.05$). The increased break strength and thickness observed in plantain and fish flour substituted biscuit samples could be due to the difference in the particle sizes and characteristics of the constituent flours Joel *et al.*, (2014), Olapade *et al.*, (2011) reported similar trend in biscuits from wheat and full fat soya and biscuit from acha flour supplemented with cowpea flour.

Table 6: Physical properties of acha-plantain-chara pona fish flour blends

Sample	Break stength (g)	Diameter (cm)	Thickness (cm)	Volume (cm)	Weight (g)	Density (g/cm)
A	$227.5^{d}\pm3.54$	$3.81^{c}\pm0.01$	$0.27^{c}\pm0.01$	$10.50^{a}\pm0.71$	$6.86^{e}\pm0.00$	$0.69^{e}\pm0.00$
B	$3020^{a}\pm7.07$	$4.00^{a}\pm0.00$	$0.27^{a}\pm0.01$	$10.00^{a}\pm0.00$	$8.48^{a}\pm0.04$	$0.85^{a}\pm0.00$
C	$1390^{ab}\pm7.07$	$3.95^{c}\pm0.07$	$0.28^{c}\pm0.01$	$12.00^{a}\pm0.00$	$7.82^{c}\pm0.03$	$0.78^{c}\pm0.00$
D	$2225^{abc}\pm0.00$	$3.92^{b}\pm0.03$	$0.29^{b}\pm0.03$	$11.00^{a}\pm0.00$	$7.21^{d}\pm0.01$	$0.73^{d}\pm0.00$
E	$850.00^{bcd}\pm7.07$	$3.86^{bc}\pm0.03$	$0.30^{bc}\pm0.01$	$10.00^{a}\pm0.00$	$7.04^{b}\pm0.08$	$0.71^{b}\pm0.01$
F	$930.00^{d}\pm7.07$	$3.81^{bc}\pm0.04$	$0.34^{bc}\pm0.00$	$9.50^{a}\pm0.00$	$6.79^{e}\pm0.01$	$0.68^{e}\pm0.00$
G	$1417.5^{bcd}\pm10.61$	$3.71^{bc}\pm0.06$	$0.36^{bc}\pm0.01$	$9.00^{a}\pm0.71$	$6.60^{e}\pm0.03$	$0.62^{e}\pm0.00$
H	$2222.5^{cd}\pm3.54$	$3.84^{a}\pm0.03$	$0.38^{a}\pm0.03$	$8.00^{a}\pm1.41$	$5.54^{f}\pm0.03$	$0.55^{f}\pm0.00$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly($p<0.05$) different from each other using Duncan multiple range test.
Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF
AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

3 .4 Sensory evaluation of acha-plantain-fish flour blends biscuits

The results of Sensory evaluation of acha-plantain-fish flour blends biscuit are presented in Table 7. The mean scores of aroma ranged from 5.0 of sample, A (100% acha flour) to 6.50 of sample H. There was no significant difference ($p>0.05$) in samples. The mean scores for texture ranged from 4.65 to 6.75 with sample H (100%) having the highest rating for texture

There was a significant difference in samples. Mean scores of colour and taste ranged from 5.20 to 7.10 and 5.15 to 7.40 respectively. All the samples were accepted however, sample H containing 100% wheat flour was most preferred followed by sample E with 75:15:10% acha-plantain-fish flour substitution level.

Table 7 Sensory evaluation of acha-plantain-fish flour blends biscuits

Sample	Aroma	Texture	Colour	Taste	Overall Acceptability
A	$5.90^{a}\pm1.8$	$5.30^{ab}\pm2.62$	$6.45^{ab}\pm1.64$	$5.85^{bc}\pm1.98$	$5.75^{ab}\pm2.22$
B	$5.80^{a}\pm2.24$	$4.65^{b}\pm2.56$	$5.85^{ab}\pm1.95$	$6.05^{b}\pm2.14$	$6.30^{ab}\pm1.78$
C	$6.40^{a}\pm2.09$	$6.15^{ab}\pm2.08$	$6.15^{ab}\pm1.98$	$6.15^{b}\pm2.13$	$5.90^{ab}\pm2.22$
D	$5.05^{a}\pm2.42$	$4.60^{b}\pm2.11$	$6.20^{ab}\pm2.35$	$5.60^{bc}\pm1.98$	$5.10^{b}\pm2.07$
E	$6.55^{a}\pm2.35$	$5.80^{ab}\pm2.59$	$5.60^{b}\pm2.11$	$6.50^{c}\pm2.14$	$6.10^{ab}\pm1.77$
F	$5.45^{a}\pm2.56$	$6.35^{a}\pm2.5$	$5.95^{ab}\pm1.99$	$5.15^{bc}\pm1.90$	$5.50^{ab}\pm2.44$
G	$5.75^{a}\pm2.20$	$6.10^{ab}\pm2.27$	$6.90^{ab}\pm1.65$	$5.90^{b}\pm2.15$	$5.80^{ab}\pm2.09$
H	$6.50^{a}\pm1.91$	$6.75^{a}\pm1.92$	$7.10^{a}\pm1.33$	$7.40^{a}\pm1.39$	$6.90^{a}\pm1.59$

*Values are means ± standard deviation of triplicate determinations. Means differently superscripted along the vertical columns are significantly($p<0.05$) different from each other using Duncan multiple range test.
Key: A= 100% AF, B= 100% PF, C= 90:5:5 % APFF, D= 85:10:5% APFF, E= 80:15:5 APFF, F= 75:15:10 APFF, G= 70:15:15% APFF, H= 100% WF
AF= Acha flour, PF= Plantain flour, APFF= Acha-Plantain-Fish flours, WF= Wheat flour

CONCLUSION

The result of this study showed that addition of plantain and fish flour blends improved the functional properties, fibre, ash, minerals and vitamins content. The acha-plantain- fish flour blend biscuits was generally accepted up to 15:15% of plantain-fish flour inclusion however the 75:15:5% acha-plantain-fish flour blends was the most preferred. There were also corresponding improvement in the fibre content and minerals of the blend biscuits. The break strength which directly determines the texture of the biscuit was improved.

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