EVALUATION OF ACHA (*Digitaria Exilis*) and MALTED BAMBARANUT (*vigna subterranean*) BASED BISCUITS

Supported by tetfund

[1]Ayo, J.A, [2]Awogbenja M.D and [2]Iliya, J.A
*[1]Department of Food Science and Technology, Federal University Wukari, Nigeria.
[2]Department of Nutrition and Dietetics, Nasarawa State University, Nigeria
*Correspondence author: jeromeayo@gmail.com,

Received: September 14, 2023 Accepted: November 28, 2023

Abstract: The aim of the study was to determine the effect of supplementation of malted Bambara nut on the quality of millet-based biscuits. The brambara nut seeds were sorted, washed, malted (48 hours), dried for 2-3 days, milled (attrition mill) and sieved for bambara nut. The millet grains were sorted, washed, dried, milled (attrition mill) and sieved. The bambara nut flour was substituted (5, 10, 15, 20, 25 and 50%) into millet flour to produce malted bambara nut-millet flour blend biscuit. Wheat (100%) flour was used as control. The proximate, minerals, vitamins, physical and sensory properties of the millet based biscuits were analyzed. The moisture, ash, protein, fat content increased from 2.07 to 3.61, 5.17 to 6.33, 1.30 to 5.87 and 21.40 to 23.38%, respectively, with increase in added malted bambara nut flour. The functional properties values range from 1.55 to 2.10g/ml, 11.05g/ml to 2.65g/ml, 20.50 to 26.50, 0.45 to 0.28 and 1.20 to 3.80 for oil absorption capacity (OAC), water absorption capacity (WAC), swelling Index (SI), bulk density (BD) and foaming capacity respectively. The average mean scores for appearance, taste, colour and aroma increased from 6.53 to 6.97, 5.00 to 6.20, 6.30 to 6.73 and 5.80 to 6.13, respectively, with increase in the added malted bambaranut flour from 0 - 20%, and further increased (above 20%) cause decrease This study showed that malted Bambara nut-millet can be used to produce biscuits preferably at 20% added malted Bambara nut.

Keywords: Bambara Nut, Proximate Analysis, Seeds, OAC method

Introduction

Biscuit is an important edible confectionary crisp product majorly consumed by human especially children and used as weaning food for infants (Ferial *et al.*, 2011). The need of production of biscuits with a suitable amount and high nutritionally balanced biscuits, is to produce high density protein biscuits (Erbas *et al.*, 2005). It is an essential food material which contain valuable quantities of 20 ppm iron, 12 ppm calcium, 100 ppm protein, 20 ppm calories, 40 ppm fibre and some of the B-vitamins to our diet and daily food requirement (Barca *et al.*, 2010). Biscuits are principally produced from mixture of wheat flour, baking fat, sugar, salt, baking powder and water and baked at 180^{o}C. The relative high cost of biscuits has been attributed to the high cost of the imported wheat flour as they are not grown in Nigeria. This has called for research into uses of other cereals crops like millet, acha, sorghum. Also, the relative low protein content of biscuits has also called for its supplementation with leguminous crops such as Bambara nut which are grown abundantly in Nigeria.

Bambara nuts (*Vigna subterranean*) are edible seed from the *Leguminosae* family (Basu *et al.*, 2007). It is high in protein and thus play important role in human nutrition which makes the crop an excellent source of supplementing dietary proteins. Bambara nut contains protein (19–28g 100g-1), carbohydrate (57–68 g 100 g-1), fat (6.3%) with relatively high proportions of lysine (6.6%) and methionine (1.3%), 18% oil and fatty acid content is predominantly linoleic, palmitic and linolenic acids (Minka *et al.*, 2000; Mahala *et al.*, 2010 and Oyeyinka *et al.*, 2015), It also has a high content of crude fibre and high level of sulphur containing amino acids (Okpala and Chinyelu, 2011). Its protein may be used as a functional ingredient in the industry due to its balanced amino acid profile (Bamshaiye *et al.*, 2011). It is a popular ingredient use in making snack in Nigeria and other West African countries in general, there are numerous traditional recipes. In the Ibo States of Nigeria, bambara nut seeds are roasted and chewed with palm kernel as a snack item, or they may be milled into flour and used to prepare bean balls (‘akara’) after frying the paste in vegetable oil Alternatively, the slurry may be used to prepare a steamed gel, also known as ‘okpa’ (Uvere *et al*., 1999).

Millet is a cereal crop plant belonging to the grass family, Graminae (FAO, 2001). Millets are major energy source and staple foods for people living in the dry and arid regions of the world. The Stover after harvest of grains is a source of nutritive fodder to animals apart from its industrial use as bird feed, brewing and potable alcohol. Millets contain high amount of essential amino acids, minerals, and vitamins, niacin B6 and folic acid, and calcium, iron, potassium, magnesium and zinc. Finger millet is the richest source of calcium (300-350 mg/100 g) and other small millets are good source of phosphorous and iron, easy to digest, high amount of lecithin and are excellent for strengthening the nervous system, it also contains 12% protein, 25% fat, 65-75% carbohydrates and 15-20% dietary fibre as well as unique in phenolic compounds and phytochemicals having medicinal properties (Venkatesh *et al.*, 2018).

With increase in biscuit consumption, high cost of importation of wheat flour and its relative low level of protein content there is need for its substitution with other locally available cereals (millet) and supplementation with other abundant leguminous crops (Bambara nut) though with the problem of antinutrients. The acceptance of the malted Bambara nut-millet flour blend biscuits will improve the nutrient intake of the consumers, make biscuits available at cheaper price as well as improve commercial production of Bambara nut.

The aim of the study was to determine the effect of supplementation of malted Bambara nut on the quality of millet-based biscuits.

Materials and Methods

Materials

The millet and bambara nut seeds used for this study was purchased from the market in Lafia, Nasarawa State, Nigeria. Other ingredients such as: granulated sugar, fortified milk, baking powder, whole eggs, butter, salt and vanilla etc. used in the production of the biscuits formulation was also obtained from the same market.

Bambara nut flour: Bambara nut seeds were cleaned manually to remove all foreign materials such as dust, dirt, small branches and immature seeds. The cleaned sample were sorted and steeped in water for 12 hrs spread on jut bag, covered and watered at 4hrs interval for 6 days to allow germination. The germination was terminated and sun dried, dehulled and oven dried using oven, at 60 °C for 3 hours and finely grand to powder (0.60 mm) form with a high speed grinding machine and sieved using 500 µm sieve to obtain fine flour (Nwosu, 2013).

Millet flour : Millet (Panicum milliarae) was clean and extraneous materials were removed. The cleaned millet was milled into fine flour in milling machinery and whole millet flour was used in the study to retain the fiber content.

Composition of flour: Standardization of product will be carried out by formulating five trials (T1, T2, T3and T4) including the reference one (control) (T0) as shown in Table 1. The ingredients required for the preparation were weighed according to the recipe. millet flour and bamabara nut flour.

Table 1: Recipe for Malted Bambara nut-millet flour blend biscuits

Ingredients(%)	T1	T2	T3	T4	T5	T6	T7	T8
Malted Bambara nut	0	10	20	30	40	50	100	0
Millet	200	190	180	170	160	150	100	0
Material	T1	T2	T3	T4	T5	T6	T7	T8
Malted Bambara nut	0	10	20	30	40	50	100	0
Millet	200	190	180	170	160	150	100	0
Baking Fat	60	60	60	60	60	60	60	60
Suagr	40	40	40	40	40	40	40	40
Water	50	50	50	50	50	50	50	50
Baking Powder	2	2	2	2	2	2	2	2
Salt	2	2	2	2	2	2	2	2
Wheat flour	-	-	-	-	-	-	-	200

A: 100% Millet, B: 95% Millet +5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Production of malted Bambara nut-millet flour blend biscuits

Biscuit making was carried out according to the method described in Mohammed (2000).The sugar powder and shortening will be mixed together for 10 min at slow speed with a dough mixer and then dissolved sodium and ammonium bicarbonate in 50 ml water. During the mixing at slow speed, malted Bambara nut-millet flour blend, vanillia, fructose syrup and sodium meta bisulphate was added. The skimmed milk, the flour and other ingredients will be mixed together at slow speed for 10 min and water was added, mixed with other ingredients at high speed for 20 min. The mixing of the dough was continue until it reached full development. The biscuits was baked in a conventional electric oven at 220°C for 7 min. Immediately after cooling, samples was evaluated for both physical and sensory characteristics.

Methods

Determination of Chemical Composition of malted Bambara nut-millet flour blend

Proximate Composition : The proximate composition (moisture, crude protein, crude fat, ash, crude fibre and carbohydrate) Content was determined using the procedure described by AOAC (2012).

Determination of Functional Properties

Water Absorption Capacity: The water absorption capacity was determined using the method described by Onwuka, (2005). Ten millilitres (10 ml) of distilled water was added to 1g of cha-amaranth composite flour sample in a weighed centrifuge tube. The tube was agitated on a vertex mixer for 2min and then centrifuged at 4000rpm for 20min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then weighed. Water absorption capacity was expressed as the weight of water bound by 100g of dried flour.

Oil Absorption Capacity : The oil absorption capacity was determined using the method described by Onwuka, (2005). One gram (1g) of acha-amaranth composite flour sample was mixed with 10ml of refined vegetable oil and allowed to stand at ambient temperature for 30min. it was then centrifuged for 30min at 2000rpm. The oil and adhering drops of oil was decanted and discarded. Oil absorption capacity was expressed as percent oil bound per gram flour.

Bulk Density : The bulk density was determined using the method described by Onwuka, (2005). Fifty grams (50g) of ach-amaranth composite flour sample was poured into a 100ml measuring cylinder. The cylinder was tapped fifty (50) times on a laboratory bench to constant volume. The volume of sample was recorded.

Bulk density (g/cm^3) = $\frac{weight\ of\ sample}{volume\ of\ sample\ after\ tapping}$

Foaming Capacity :The foaming capacity and stability were determined using the method described by Onwuka, (2005). Two grams (2g) of acha-amaranth composite flour sample was added to 50ml of distilled water at 30 ± 2ºc in a 100ml graduated cylinder. The suspension was mixed and shaken manually for 5min to foam. The volume of foam at second after whipping was expressed as foaming capacity using the formula;

Foam capacity = $\frac{volume\ of\ foam\ after\ whipping}{volume\ of\ mixture} \times 100$

The volume of foam was recorded at different time intervals (5, 10, 15 and 20 seconds) after whipping to determine the foam stability as per cent of the initial foam volume.

Swelling Capacity :The swelling capacity was determined using the method described by Olapade *et al.* (2003). One gram (1g) of acha-amaranth composite flour sample was mixed with 10ml of water in a weighed centrifuge tube. The tube was heated in water bath at 85ºc for 15min and then centrifuged at 2000rpm for 30min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then weighed. Swelling capacity was expressed as percent swelled per gram flour.

Determination of Mineral of malted Bambara nut-millet flour blend Biscuits

Determination of Phosphorous: Determination of phosphorous was done according to the method of AOAC (2012). Twenty-five grams (25g) of ammonium molybdate and 1.25g of ammonium metavanadate were added to 300ml of distilled water, warmed to dissolve, cooled and made up to 500ml with water. Concentrated HCl (215ml) was diluted to 500ml with water and mixed with ammonium molybdate-ammonium metavanadate reagent. Phosphorous stock was prepared by dissolving 0.879g of dried phosphorous dihydrogen orthophosphate (dried at 105°C for one hour) with water and 1ml of conc. HCl added. It was diluted to 200ml with the first reagent, and 2ml of toluene was added to give 1mg/ml. The working standard was prepared by measuring 2ml of phosphorous to 0, 2, 4, 6, 8, and 10ml of standard phosphorous solution into six 200-ml volumetric flasks and diluted to mark with water. Each phosphorous standard solution (5ml) was pipetted into a 500-ml graduated flask. Molybdate mixture (10ml) was added and diluted to the mark with water. It was allowed to stand for 15 minutes for colour development, and the absorbance measured at 400nm against blank. A calibration curve relating absorbance to mg of phosphorous was used to read the phosphorus content of the sample solution in mg/ml, and the number of phosphorous equivalent to the absorbance of the sample blank determined was calculated.

Determination Iron Content: Phenanthroline method as described in AOAC (2012) was used. Phenanthroline solution was prepared by dissolving 100mg I,10-phenanthroline molybdate in 100ml distilled water by stirring and heating to 80°C. Hydroxylamine solution was prepared by dissolving 10g in 100ml of distilled water, while ammonium acetate buffer solution was prepared by dissolving 250g in 150ml distilled water. 5ml of the digested sample was added in a test-tube. Then, 3ml of phenanthroline solution and 2ml of HCl was added. Hydroxylamine solution (1ml) was added to the mixture and boiled in a steam bath at 600°C for 2 minutes. Then, 9ml of ammonium acetate buffer solution was added and 35 diluted to 50ml with water. The absorbance was taken at 510nm. Calibration curve (see appendix 2) was prepared by pipetting 2, 4, 6, 8, and 10ml standard iron solution into 100ml volumetric flasks to prepare a solution of known concentrations. The curve obtained was used to read off the value of iron.

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

Determination of Vitamins of malted Bambara nut-millet flour blend Biscuits

Vitamin B1 (Thiamin): Thiamine content was determined using the scalar analyzer method (AOAC, 2010). Five grams of each sample was homogenized in 5ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up to 100ml with the extract solution. A 10ml aliquot of the extract was dispensed into a flask and 10mls of potassium dichromate solution added. The resultant solution was incubated for 15mins at room temperature (25- 331°C). The absorption was read from the spectrophotometer at 360nm using a reagent blank to standardize the instrument at zero. The thiamine content was calculated.

Determination of Physical Property of malted Bambara nut-millet flour blend Biscuits

***Weight, diameter and thickness*:** The weight of the malted Bambara nut-millet composite biscuit was determined by weighing on an electronic weighing balance (Mettler PF160 Balance, Switzerland) (Ayo *et al.,* 2007). The Bambara nut-millet composite biscuit diameter and thickness were determined using venire calliper (Ayo *et al.,* 2007).

Spread Ratio and Breaking Strength : 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 and bread. The spread ratio was calculated as diameter divided by height. Break strength of malted Bambara nut- millet composite biscuit and bread was determined using the method described by Ayo *et al.,* (2010). Biscuit sample of 0.4cm and 5-20mm was placed centrally between two parallel metal bars (3cm apart) and weights were applied until the biscuit.

Evaluation of Sensory Quality

The sensory evaluation of malted Bambara nut-millet flour blend biscuit was carried out by twenty untrained panel lists, randomly selected from Home Science, Nasarawa State University, Lafia based on their familiarity with the biscuit. The biscuits, appropriately coded (ABP, BPF, AJD, and BAF) 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 panel lists were instructed to evaluate the coded samples for colour, crispiness, aroma, taste, texture, and general acceptability. The panel lists rinsed their mouths with bottled water after tasting each sample and were not allowed to make comment during evaluation to prevent influencing other panel list. 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 Iwe (2018).

Statistical Analysis.

All the analyses were conducted in duplicates. The data were subjected to Analysis of Variance using Statistical Package for Social Science (SPSS) software version 23.0. Means were significantly different and separated by the least significant difference (LSD) test. Significance was accepted at $p<0.05$.

Results and Discussions

Effect of Malted Bambara nut (Vigna subterranean) on Physical Properties of Millet Based Biscuit

The effect of added malted Bambara ground nut flour on the quality of millet based biscuit is shown in the Table.2. The weight of the samples increased from 48.00 to 51.30g with increase in quantity of malted bambara nut flour from 0 to 25% with increase in the added malted Bambara nut flour. Diameter of samples increased from 4.00 to 4.75cm^3. The spread ratio of the samples increased from 15.00 to 17.10 with increase in the percentage of Bambara groundnut flour (0 to 100%). The effect of added malted bambara groundnut flour increased the break strength of the biscuit from 2.31g to 10.35 g (Table 4). The relatively increase in the spread ratio could be due to the increase in the fiber and oil content in the added bambara groundnut flour (Mazahib *et al.*, 2013) which could enhance the same attribute. The increase in weight, density and break strength could be due to the rigid structure formed from the high protein content of Bambara groundnut and carbohydrate content from millet. This could be an advantage as it will prevent breaking of the biscuit during transportation and post handling of the biscuit (Ayo *et al.,* 2010; Nwosu, 2013).

Table 2: Physical properties of Bambara nut, millet and wheat composite biscuit.

MB:millet	**100:0**	**95:5**	**90:10**	**85:15**	**80:20**	**75:25**	**0:100**
Weight (g)	48.00^{d}±1.41	48.75±^{d}1.06	48.25^{d}±0.35	45.60^{e}±0.00	48.15^{c}±0.07	50.60^{a}±0.14	51.30^{b}±1.80
D (cm^3)	4.00^{e}±0.00	4.15^{e}±0.07	4.15^{e}±0.21	4.40^{c}±0.00	4.35^{d}±0.07	4.45^{b}±0.07	4.75^{a}±0.07
Spread ratio D/h)	15.00^{f}±0.00	15.25^{e}±0.07	15.30^{e}±0.07	15.85^{c}±0.07	16.55^{d}±0.07	16.85^{b}±0.07	17.10^{a}±0.14
Break strength(g)	2.31^{e}±1.41	4.55^{f}±7.07	7.08^{e}±0.07	8.15^{c}±7.07	8.55^{b}±7.07	9.75^{a}±7.07	10.35^{g}±7.07

Values are mean ± standard deviation of 15 panelists Means within each rows not followed by the same superscript are significantly different (p < 0.05) . A: 100% Millet, B: 95% Millet + 5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Effect of Malted Bambara nut (*Vigna* subterranean) on Functional Properties of Millet Based Biscuit.

The results of the functional properties of the samples is shown in Table 3. The values ranges from 1.55 to 2.10g/ml, 11.05g/ml to 2.65g/ml, 20.50 to 26.50, 0.45 to 0.28 and 1.20 to 3.80 for Oil Absorption Capacity (OAC), Water absorption Capacity (WAC), Swelling Index (SI), Bulk Density (BD) and foaming capacity respectively. The findings in this report is close to 3.65 g oil g-^{1} (Adegbanke *et al.,* 2019) but slightly lower than 3.80 g water g-1 of malted bambara nut flour (Ayo and Andrew 2016). The low OAC and WAC of BGN products flour might be due to low levels of hydrophobicity of proteins which show superior binding of lipids. The bridge caused by protein in fat and water emulsion may not make malted bambara nut flour products a suitable ingredient in the cold meat industry particularly for sausages. The swelling index increased (1.05–1.31) significantly, p≤0.05 as the malted Bambara nut flour increased (0% - 50%), while no significant difference (p≤0.05) was observed in bulk density (0.62 g ml-1) of substituted blend samples of malted bambara nut flour from 20%–100%. This result were comparable to 0.56 and 0.62 g ml-1 as reported by previous findings (Adegbanke *et al.,* 2019). The presence of relatively high proportion of carbohydrate in the samples may be responsible for the high BD demonstrated. Starch polymer structure has been seen to influence BD and loose starch polymer could result in low bulk density (Ayo and Andrew, 2016; Adegbanke *et al.,* 2019).

Table 3: Functional properties of malted Bambara nut, millet and wheat composite biscuit.

MB:Millet	100:0	95:5	90:10	85:15	80:20	75:25	0:100
Swelling capacity	20.50^{d}±0.70	20.50^{f}±0.70	22.50^{e}±0.70	22.50^{e}±0.70	24.50^{c}±0.70	25.50^{b}±0.70	26.50^{a}±0.70
Water absorption	11.05^{a}±12.65	2.10^{f}±0.14	2.25^{e}±0.70	2.30^{d}±0.14	2.30^{d}±0.14	2.40^{c}±0.14	2.65^{b}±0.14
Oil absorption	1.55^{f}±0.70	1,60^{g}±0.14	1.65^{e}±0.07	1.70^{d}±0.14	1.75^{c}±0.07	1.80^{b}±0.14	2.10^{a}±0.14
Foaming	1.20^{g}±0.14	1.95^{f}±0.07	2.45^{e}±0.07	2.65^{d}±0.07	2.75^{c}±0.07	3.45^{b}±0.07	3.80^{a}±0.14
Bulk density	0.45^{b}±0.01	0.47^{a}±0.04	0.36^{c}±0.04	0.34^{d}±0.00	0.31^{e}±0.01	0.30^{f}±0.00	0.28^{g}±0.00

Values are mean ± standard deviation of 15 panelists Means within each column not followed by the same superscript are significantly different (P < 0.05).. A: 100% Millet, B: 95% Millet +5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Effect of Malted Bambara nut (Vigna subterranean) on Proximate Composition of Millet Based Biscuit

The effect of added malted Bambara groundnut on the quality of millet based biscuit is presented in Table 4. The moisture content of the biscuit increased from 2.07% to 3.61% with increasing concentration of Bambara groundnut flour. The ash content of the product increased significantly (p < 0.05) from 5.17% to 6.33% with an increase in the percentage of added malted Bambara groundnut flour. The protein content increased significantly (p < 0.05) from 1.30% to 5.87% with increase in the percentage (0 to 100%) of malted Bambara groundnut flour. The fat content increased from 21.40% to 23.38% with increasing concentration of Bambara groundnut flour. The crude fibre of the product increased from 0.95% to 2.40% with increasing Bambara groundnut. The carbohydrate content of the product decreased from 60.50% to 67.35% with increase in the percentage of Bambara groundnut flour. The increase in protein contents of the samples could be due to the added Bambara groundnut which from former work has been observed to contain high protein content (Boateng *et al.,* 2013; Alozie *et al.,* 2009). The protein has been confirmed to contain some essential amino acids of great importance to the body. The increase in fat content though relatively low, could be a good source of energy supply to the body when eaten since in human body (Alozie *et al.,* 2009). The relative low increase in the fat content of the product could be an advantage in extending the shelf life of the product as the level of rancidity could be minimal. The increase in moisture is relatively low (not significant) and could be due to the decrease in the carbohydrate content (Ayo and Andrew, 2016). The low moisture content of the product agreed with other composite biscuits- acha-soybean, amaranths-wheat, acha-malted acha, Bambara groundnut-wheat flour, acha-beniseed, Wheat-African bread fruit (Ayo *et al.,* 2010). This relatively low moisture content could be an advantage in extending the keeping quality (shelf life) of the product as most spoilage organism may not be able to thrive, and the biochemical and enzymatic reactions could be minimal (Ayo *et al.,* 2010).

The increase in the ash content could be due to the added malted Bambara groundnut which has been noted to be high in the same. High ash content has been related to high mineral content (Ayo and Andrew, 2016) hence could improve the mineral level of the product and invariably that of the consumer. High ash content is usually as a result of high mineral which apart from the nutritional value are good for bone development and functionality (Ayo *et al.,* 2007). The increase in the fibre content could help to improve the digestion and could aid waste elimination in the body and guide against anthracite (Ayo and Okoliko, 2003). The decrease in carbohydrate content could be due to relatively low carbohydrate content of added malted bambara groundnut (Ayo and Okoliko, 2003).

Table 4: Proximate composition of malted bambaranut (*vigna subterranean)* and millet based biscuit

MB: millet	**100:0**	**95:5**	**90:10**	**85:15**	**80:20**	**75:25**	**0:100**
Moisture (%)	$2.07^{g}\pm0.14$	$2.40^{f}\pm0.00$	$2.65^{e}\pm0.01$	$2.70^{d}\pm0.00$	$2.90^{c}\pm0.14$	$3.30^{b}\pm0.00$	$3.61^{a}\pm0.14$
Ash (%)	$5.17^{g}\pm0.01$	$4.18^{f}\pm0.02$	$5.59^{e}\pm0.01$	$5.70^{d}\pm0.01$	$5.75^{c}\pm0.07$	$6.25^{b}\pm0.35$	$6.33^{a}\pm0.01$
Cude Protein (%)	$1.30^{g}\pm0.01$	$4.37^{f}\pm0.01$	$4.59^{e}\pm0.00$	$4.85^{d}\pm0.00$	$5.15^{c}\pm0.00$	$5.54^{b}\pm,0.01$	$5.87^{a}\pm0.00$
Ether Extract (%)	$21.40^{g}\pm0.00$	$22.24^{f}\pm0.01$	$22.71^{e}\pm0.09$	$22.79^{d}\pm0.02$	$23.09^{c}\pm0.0$	$23.35^{b}\pm0.01$	$23.38^{a}\pm0.01$
Crude Fibre (%)	$0.95^{g}\pm0.01$	$0.64^{f}\pm0.01$	$1.47^{e}\pm0.55$	$1.88^{d}\pm0.00$	$2.09^{c}\pm0.01$	$2.10^{b}\pm0.14$	$2.40^{a}\pm0.00$
NFE(%)	$60.50^{g}\pm0.00$	$61.16^{f}\pm0.00$	$63.46^{e}\pm0.08$	$63.55^{d}\pm0.01$	$64.51^{c}\pm0.01$	$67.29^{b}\pm0.28$	$67.35^{a}\pm0.02$

Values are mean ± standard deviation of 15 panelists Means within each rows not followed by the same superscript are significantly different ($p < 0.05$) . A:100% Millet, B: 95% Millet +5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Effect of Malted Bambara nut (Vigna subterranean) on Mineral Composition of Millet Based Biscuit

The mineral element composition of the composite flours and biscuit are presented in table 5. The mineral elements tested for in the study included Ca, Mg, Zn and Fe. For the composite flour and biscuit most of the mineral elements were relatively above the recommended daily allowance. The most predominant are iron magnesium. The high concentrations of these minerals in the biscuit may be due to the inclusion of seed coat during processing. Generally, the individual mineral content of all the samples differed significantly, $p< 0.05$. The values reported in this study were relatively lower than those in previous studies (317.90 mg/100g) of Adegbanke *et al., (2020*). The addition of malted bambara nut flour generally increased the mineral content levels of all the biscuits samples. The values of minerals in this report were within the FAO, (2003) recommended value.

Table 5: Mineral composition ((mg/l) of malted Bambara nut (*vigna subterranean)* and millet based biscuit

Minerals	**100:0**	**95:5**	**90:10**	**85:15**	**80:20**	**75:25**	**0:100**
Calcium	$7.62^{d}\pm3.53$	$7.09^{g}\pm0.70$	$7.17^{f}\pm3.53$	$7.42^{e}\pm3.35$	$7.67^{c}\pm3.35$	$7.75^{b}\pm7.07$	$8.15^{a}\pm7.07$
Magnesium	$49.50^{e}\pm0.70$	$55.50^{d}\pm0.70$	$59.50^{c}\pm0.70$	$62.50_{a}\pm0.70$	$62.50^{a}\pm0.70$	$64.50^{b}\pm0.07$	$47.50^{f}\pm0.10$
Zinc	$1.52^{c}\pm0.03$	$1.01^{g}\pm0.01$	$1.15^{f}\pm0.07$	$1.35^{e}\pm0.07$	$1.84^{d}\pm0.07$	$1.85^{b}\pm0.07$	$2.85^{a}\pm0.07$
iron	$0.65^{f}\pm0.70$	$0.51^{g}\pm0.01$	$0.77^{e}\pm0.03$	$0.87^{d}\pm0.03$	$1.15^{c}\pm0.07$	$1.25^{b}\pm0.07$	$1.37^{a}\pm0.17$

Values are mean ± standard deviation. Means within each column not followed by the same superscript are significantly different ($P < 0.05$). A: 100% Millet, B: 95% Millet +5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Effect of Malted Bambara nut (Vigna subterranean) on Sensory Properties of Millet Based Biscuit

The effect of added malted Bambara groundnut flour on the sensory quality of millet based biscuit is summarized in Table .6. The average mean scores for appearance, taste, colour and aroma increased from 6.53 to 6.97, 5.00 to 6.20, 6.30 to 6.73 and 5.80 to 6.13, respectively, with increase in the added malted bambara nut flour from 0 -20%, and further increased (above 20%) cause decrease The average means scores for general acceptance increased from 5.39 to 6.23 with increase in the added malted Bambara nut up to 20% and further increase caused decrease in the means scores. The observation agreed with that of Ayo and Andrew, (2016) who worked on the effect of added Bambara nut on date acha-palm based biscuit. Generally, the average means scores compared favorably with the of 100% wheat four based biscuits. The malted bambara nut-millet based biscuits are generally acceptable but most preferred at 20% added malted Bambara nut flour.

Table 6: Sensory evaluation and general acceptability of Bambara nut and millet composite biscuit.

	Appearance	Taste	Colour	Aroma	Mouth feel	After taste	Overall Acceptability
0:100	$6.53^{a}\pm1.25$	$5.00^{d}\pm0.93$	$6.30^{c}\pm1.40$	$5.80^{b}\pm1.02$	$6.10^{b}\pm1.01$	$5.50^{b}\pm0.77$	$5.39^{b}\pm0.80$
5:95	$6.67^{a}\pm1.45$	$5.27^{a}\pm1.10$	$6.47^{a}\pm1.10$	$5.13^{ab}\pm1.55$	$6.13^{a}\pm1.56$	$5.63^{a}\pm1.67$	$5.60^{a}\pm1.91$
10:90	$6.77^{a}\pm0.83$	$5.50^{a}\pm2.81$	$6.67^{a}\pm1.35$	$5.43^{a}\pm2.40$	$6.23^{a}\pm2.40$	$5.70^{a}\pm2.41$	$5.66^{a}\pm2.35$
15:85	$6.80^{a}\pm1.50$	$5.90^{a}\pm1.91$	$6.70^{a}\pm1.30$	$5.77^{ab}\pm2.67$	$6.37^{a}\pm2.66$	$5.73^{a}\pm2.10$	$5.73^{a}\pm2.71$
20:80	$6.97^{a}\pm2.12$	$6.20^{ab}\pm2.32$	$6.73^{ab}\pm1.03$	$6.13^{ab}\pm2.03$	$6.47^{ab}\pm2.00$	$5.80^{a}\pm2.51$	$6.23^{a}\pm1.84$
25:75	$6.77^{a}\pm2.12$	$6.13^{ab}\pm2.13$	$6.60^{ab}\pm1.30$	$5.80^{a}\pm2.41$	$6.60^{a}\pm2.20$	$5.63^{a}\pm2.41$	$5.93^{a}\pm2.06$

50:50	$6.50^{a}\pm1.41$	$6.10^{abc}\pm1.80$	$7.13^{abc}\pm1.13$	$5.73^{a}\pm2.58$	$6.40^{ab}\pm1.92$	$5.33^{a}\pm2.41$	$5.73^{a}\pm2.52$
0:100	$7.33^{a}\pm2.83$	$6.33^{c}\pm1.84$	$7.47^{c}\pm0.92$	$6.27^{a}\pm2.60$	$6.20^{ab}\pm2.20$	$6.33^{a}\pm2.70$	$6.13^{a}\pm2.00$

Values are mean ± standard deviation. Means within each column not followed by the same superscript are significantly different ($P < 0.05$). A: 100% Millet, B: 95% Millet +5%Malted Bambara nut, C: 90% Millet + 10%Malted Bambara nut, D: 85% Millet + 15%Malted Bambara nut, E: 80% Millet +20%Malted Bambara nut, F: 75% Millet + 25%Malted Bambara nut, G: 50% Millet+50%Malted Bambara nut, H: 100% Wheat

Conclusion

This study characterized the functional properties of Bambara groundnut flour and their blends with wheat flour for the production of good quality biscuits. This study showed that malted Bambara nut-millet can be used to produce biscuits. However, it is most acceptable and preferred at 20% added malted Bambara nut which correspondence to increase in protein (60%), calcium (2.0%), magnesium (30%), zinc (20%) and iron (50%) content. The contents of calcium, Zinc, Magnesium and iron improved the biscuit produced, showing that malted bambara groundnut can be used to substitute wheat flour in the production of biscuit. This study has opened up new possibilities of application for malted bambara groundnut and millet flours.

References

Adegbanke R, Omolara DO, Timilehin DO 2019. Application of Bambara Groundnut in the Production of Cookies. *Fd. Sci and Qlty Mangt.*83: 56-60.

Adegbanke OR, Osundahunsi OF, Enujiugha VN 2020. Chemical and Mineral Composition of Biscuit Produced from Wheat and Bambara Groundnut Flour. *Acta Sci. Nutri. Health.* 4(10)

Alozie YE, Iyami MA, Lawal O, Udofia U, AniI F 2009. Utilization of Bambara groundnut flour blends in bread production. *J. Fd. Technol. 7(4):111-114.*

AOAC 2012. Official Methods of Analysis of the Association of Official Analytical Chemists International 17th Ed. Association of Official Analytical Chemists International, Suite 400 2200 Wilson Boulevard, Arlington, Virginia 22201-3301, USA.

Ayo JA, Okololiko A 2003. Effect of Spray Drying temperature of Egg-white powder on the quality of Meringue. *J. Arid Agric. 13:181- 187.*

Ayo JA, Ayo VA, Nkama I, Adewori R 2007. Physicochemical, invitro digestibility and organoleptic evaluation of acha-wheat biscuit supplemented with soybean flour. *Nig. Fd. J. 25:77-79.*

Ayo JA, Ikuomola DS, Esan YO, Onuoha OG, Ayo VA, Ekele V 2010. Effect of Added defatted benniseed on the quality of acha based biscuit. Continental *J. Fd. Sci. Technol. 4:7-13.*

Ayo JA, Andrew E 2016. Effect of added Bambara groundnut on the quality of acha- date palm based biscuit. *Inter. J. Biotech. Fd. Sci.* 4(3): 34-38.

Bamisaiye AH 2011. Bambara groundnut: an Under-Utilized Nut in Africa. *Adv. Agric. Biotech..* 1, 60-72.

Barca de la AMC, Rojas ME, Islas AR 2010. Plant Foods for Human Nutrition. *J. Fd Nutri.* 65 (5): 241-6

Basu S, Mayes S, Davey M, Roberts JA, Azam-Ali SN, Mithen R, Pasquet RS 2007. Inheritance of ‘domestication’traits in bambara groundnut (Vigna subterranea (L.) Verdc.). *Euphytica*, *157*(1-2), 59-68.

Boateng MA, Addo JK, Okyoro H, Adu-Dapaah H, Borohio JN, Tottoh A 2013. Physiochemical and functional properties of proteinates of two Bambara groundnut (*Vigna substerranean*) land races. *African J. Food Sci. Technol. 4(4):64-70.*

Erbas M, Certel M, Uslu MK (2005). Some chemical properties of white lupin seeds (*Lupinus albus L.*). *J. Food Chem. 89: 341-345*

FAO (2001). millet- Post-Harvest Compendium. http://www.suanet.ac.tz

Ferial M. Abu-Salem MN, Azza A. Abou-Arab B 2010. Effect of supplementation of Bambara groundnut (Vigna subterranean L.) flour on the quality of biscuits. *Afr. J. Fd . Sci.* 5(7), pp. 376-383.

Iwe MO, Michael N, Madu NE, Obasi NE, Onwuka GI. 2017. Physicochemical and Pasting Properties High Quality Cassava Flour (HQCF) and Wheat Flour Blends. *Agrotechnology.;6:167.*

Mahala, AG, Mohammed, AAA 2010. Nutritive evaluation of bambara groundnut (Vigna subterranean) pods, seeds and hull as animal feeds. *J Appl Sci Res*, *6*(5), 383-386.

Mohamed, RI (2000). Comparative studies about using some plant proteins in food processing. *Ph.D. Thesis.* Department of Food Science and Technology, Faculty of Agriculture Al-Azhar, University. Cairo, Egypt.

Minka, SR, Brunetea M 2000. Partial Chemical Composition of Bambara Pea (*Vigna subterranean* (L) Verdc). *Fd. Chem.* 68: 273-6.

Nwosu JN 2013. “Production and Evaluation of Biscuits from Blends of Bambara Groundnut and Wheat Flours.” *Inter. J. Fd. Nutri Sci.* 2 (1): 4-9.

Okpala LC, Chinyelu VA 2011. Physicochemical, nutritional and organoleptic evaluation of cookies from pigeon pea (Cajanus cajan) and cocoyam (Xanthosoma sp) flour blends. *Afr. J. Fd. Agric. Nutri. and Devt. 11*(6): 34-40.

Olapade AA, Akingbala JO, Oguntunde AO, Falade KO 2003. Effect of processing method on the quality of cowpea (Vigna unguiculata) flour for akara preparation. *Plants Foods for Hum Nutri.* 58:1-10

Onwuka GI 2005. Soaking, boiling and antinutritional factors in Pigeon Peas. (Cajanus Cajan) and Cowpeas (Vigna. Unguiculata). *J. Fd Proc.and Preser*. 30(5): 616-630.

Oyeyinka, SA, Singh S, Adebola PO, Gerrano AS, Amonsou EO 2015. Physicochemical propertiesnof starches with variable amylose contents extracted from Bambara groundnut genotypes. *Carbohydrate Polymers* 133: 171–178.

subterranean L.) Flour on the Quality of Biscuits.” *Afr. J. Fd. Sci.* 5 (7): 376-83.

Uvere, PO, Uwaegbute AC, Adedeji EM 1999. Effects of malting on the milling performance and acceptability of bambara groundnut (Voandzeia subterranea Thouars) seeds and products. *Plt Fd Hum. Nutri.* 54: 49–57