Quality Evaluation of Biscuits Made from Amaranthus Seed (*Amaranthus spp*) and Tiger Nut (*Cyperus esculentus lativum*) Flour Blend.

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the production of flour and biscuit from blends of amaranth grain and tiger nut flours. The blend biscuits produced were analyzed for chemical composition properties. The tiger nut was substituted into amaranth grain flour at 5, 10, 15, 20 and 25% to produce amaranth grain-tiger nut flour blend which was used with other ingredients (fat, salt, baking powder and sugar) baked at 160°C to produce amaranth grain-tiger nut biscuits. The chemical composition, physical and sensory properties of the biscuit were determined [1]. The moisture, protein and carbohydrate content of the blend biscuit decreased from 9.38 to 8.58, 18.90 to 16.68 and 59.97 to 58.17 %, respectively, with the increase in added tiger nut (0 to25%). The fat, fibre and ash content of the blend biscuit increased from 6.87 to 10.41, 2.22 to 3.23 and 2.26 to 2.99% respectively with

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increase in added tiger nut flour. The flavonoids, lycopene, β-carotenoid and total carotenod content result increased from 2218.60 to 2277.60, 0.22 to 1.47, 0.93 to 2.23 and 12.79 to 27.19 mg/100g respectively, with increase in added tiger nut flour. The blend biscuit (25% tiger nut) had the highest values of fat, crude fibre and ash (10.41, 3.23 and 2.93%). The tiger nut incorporation had significant effects and could contribute to the improvement of the flour blend biscuits properties. The addition of tiger nut flour to amaranth seed flour in the production of biscuits has relatively improved the nutrient contents, particularly the fibre and phytochemicals (flavonoids, lycopene and β-carotenoid). Also the crispiness of the blend biscuit was greatly improved. The biscuit was accepted up to 25% of the tiger nut flour.

1. INTRODUCTION

"Africa and indeed most tropical and sub-tropical countries are blessed with numerous seeds and nuts, which can be converted to flour products but many are yet to be fully exploited. Cereal is any grass cultivated for the eatable component of its grain, botanically a type of fruit called caryopsis, which composes of the endosperm, germ and bran" [2]. "Example of examples includes wheat, barley, millet, oats, rye, fonio" [3]. "Cereal flour is the main ingredient of bread, which is a staple food for most cultures" [2]. "Wheat flour is unique among the cereals grain flours in that, when mixed with water, its protein component forms an elastic network capable of holding gas and developing a firm spongy structure during baking" [4].

"Biscuits are a popular foodstuff consumed by a wide range of populations due to their varied taste, long shelf life and relatively low cost. Biscuit is a well-known product categorized as miscellaneous food product. It consists of three major components: flour, sugar, and fat, which compose biscuit dough and influence the quality of the final product" [5].

"Tiger nut (*Cyperus esculentus*) is a tuber, mainly grown and harvested in Spain, West African countries like Nigeria, Senegal, or Ghana, and also in South America, as in Chile" [6,7]. "From an economic point of view, tiger nut is described as an underutilized African crop with high potential for development" [8]. "Because of its ecological plasticity and its invasive capacity, this plant is considered as a weed or a crop depending on the purpose its grown" 6]. "In West Africa, the tubers are often part of the diet as they are cheap, available all the year around, and have nutritional benefits" [8]. "Recent market changes show how innovative tiger nut based beverages are rising around the Europe and this tuber is becoming popular in the United State of America" [9].

"Three varieties (Black, brown and yellow) are cultivated in Nigeria and among these, only two varieties (yellow and brown) are readily available in the market. The yellow variety is preferred over all other varieties because of its inherent properties like its bigger size and attractive colour" [8]. "The yellow variety also yields more protein and possess less anti-nutritional factors especially polyphenols" (Okafor *et al.,* 2003). "Tiger nut is used in the production of refreshing purely natural milk. The tiger nut milk originated from Spain where it is known as *Chufa de horchata* while it is commonly called *kunnu aya* in Northern Nigeria" [10].

"Tiger nut produces high quality oil of up to about 25.5% fat content and 8% of protein" (Adejuyitan, 2011). "The protein in tiger nut is of high biological value 5.04–6.67% wet matter considering the many essential amino acids it contain" [7]. "These amino acids ranged from 29% for leucine to 87% for methionine plus cysteine for infant's/pre-school children, and 31% to 102%, respectively, for adults are higher than those proposed in the standard by the FAO/WHO and satisfy amino acid requirements of adults" [11,12]. "Tiger nut has been reported to be an excellent source of some useful minerals (iron, calcium phosphorus, potassium, sodium, magnesium, zinc and traces of copper) and vitamin E that are essential for body growth and development" [13].

"Tiger-nut was also reported to have high content of oleic acid with positive effect on cholesterol level due to high content of vitamin E. The nut was found to be ideal for children, elderly and sports person" [14]. "They have been reported to be used in traditional medicine for treatment of indigestion, flatulence, diarrhea, dysentery and excessive thirst" [15].

"Amaranth (*Amaranthus)* is a herbaceous annual plant with upright growth habit, cultivated for both its seeds which are used as a grain and its leaves which are used as a vegetable or green. Both leaves and seeds contain protein of an unusually high quality" [16]. "Amaranth is a self-pollinated crop with wide variation in genotype due to varying amounts of out crossing and frequent interspecies and inter-varietal hybridization" [17]. "It was rediscovered a most promising plant genus that may provide high-quality protein, unsaturated oil, and various other valuable constituents" [18]. "Leaves of both the grain and the vegetable types may be eaten raw or cooked" [16]. "A partial replacement for wheat flour in food formulations with amaranth flour15% amaranth flour in the blend revealed the significant positive difference compared with wheat flour alone" [19].Owing to their significant starch, protein and lipid content, amaranth seeds can be considered as a promising raw material for the production of flour, starch and protein.

Amaranth contains 62% starch, 17% protein [20], 9-16% dietary fiber [21] and are considered to be a good source of B vitamins and minerals [22]. "Amaranth seeds being a good source of high-quality proteins are a valuable raw material for the preparation of protein concentrates. Considering the amino acid profile, amaranth contains a high content of the amino acid lysine" (Garuda, 2004). "Crude fat content in amaranth seed varies greatly as different scholars have reported different ranges, all these range from 4 - 19.3%" [18,23,24], However, it has more protein than maize, and the protein is of an unusually high quality (high in the amino acid lysine, which is the limiting one in cereals like maize, wheat and rice).

In recent years, researchers have investigated the physical, chemical and functional properties of various seeds and flours. This study is aimed at determining the physical and sensory properties of three varieties of amaranth grain flour-tiger nut flour blend biscuit. The objective of this study was to determine the quality evaluation of biscuits from cream coloured amaranth seed and tiger nut flour blend.

2. MATERIALS AND METHODS

Amaranth grains (*Amaranthus spp*) were purchased from a local market in Kaduna, while tiger nut (*Cyperus esculentus lavitum*) were purchased from Wukari new market in Taraba state, Nigeria. Baking powder, baking fat, sugar and salt were also purchased from Wukari new market in Taraba state.

2.1 Preparation of Raw Materials

2.1.1 Amaranth and tigernut flour

According to the description by Ayo et al. [25], amaranth 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 3hours and then milled using milling machine (model R175A). The flour was sieved using (0.3mn aperture) sieve, packed (polyethylene) and stored under room temperature.

The tiger nuts were cleaned, sorted, washed, drained, dried in an oven and grounded into flour. The flour samples were passed through a 45 µm mesh size sieve and stored at 4ºC until further use.

2.1.2 Composite flour preparation

Tiger nut and amaranth flours were mixed at different proportions (5, 10, 15, 20, 25 and 30 %) while one hundred percent (100%) amaranth flour and wheat was used as the control. The flours were thoroughly mixed using a Kenwood blender into a uniform blend [26].

3. ANALYTICAL METHODS

3.1 Determination Proximate Composition

The flours and the most acceptable biscuits were analyzed for proximate :- moisture, crude protein, ash, crude fat, carbohydrate content and crude fiber.

3.1.1 Moisture content

Determined as described by AOAC [1] 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°C for 18 hours. The glass crucibles were removed and transferred into desiccators for cooling and weighed. Moisture content was determined by difference and expressed as a percentage.

% Moiture content (M) = W2-W3 x 100 / W2 - W1

W1 = Initial weight of crucible
W2 = Weight of crucible + sample before drying
W3 = Weight of crucible + sample after drying

3.1.2 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 hours at 600^oC. After ashing, the crucibles were cooled below 200^oC in a furnace for 20 minutes 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" [1].

% Ash (dry basis) = W3-W1 x 100. / W2 - W1

Where:

W1 = Initial weight of empty crucible
W2 = Weight of crucible + sample before Charring and ashing
W3 = Weight of crucible + white ash

3.1.3 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 5min at 110°C then cooled and weighed. The fat was extracted with petroleum ether for 2-3hours 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" [1].

$$\% \text{ Fat} = \frac{(W2 - W1)}{W} \times 100$$

3.1.4 Crude fibre content

"The sample from the crude fat determination was transferred into a digestion flask. A 200ml 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 minutes. The content were again filtered through linen cloth in a funnel and washed thoroughly with boiled water, then with 15ml of 95% ethanol. The residue was transferred into previously dried and weighed porcelain, in an oven at 110^oC 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 550^oC for 30 min until the carbonaceous matter has been consumed. Cooled in a desiccator and weighed" [1].

% Crude fibre = the loss in weight after incineration x 100.

3.1.5 Protein content

The protein content of the samples was determined according to AOAC([1]. "Half (0.5) gram of a finely grounded samples were weighed into a digestion flask and one kjeldahl catalyst tablet was added, 10ml of conc. H_2SO_4 was added and digested for 4 hours until a clear solution is obtained. The digest was cooled and transferred into 100ml volumetric flask and made up to mark with distilled water. 20ml of boric acid were dispensed into a conical flask and 5 drops of indicator and 75ml 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 20ml 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 minutes and the distillate was titrated with 0.05NHCl" [1].

%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.

3.1.6 Carbohydrate content

Carbohydrate content was obtained by the difference: 100 - (MC + Ash + Crude protein + Fat + Crude fibre [27].

3.2 Determination of Phytochemical Compositions

3.2.1 Flavonoids

The total flavonoids content of sample was estimated by aluminium chloride colorimetric method as described by Hossain et al. [28].0.5mL of sample was taken in a test tube and added water (10mL) and 5% sodium nitrate (0.5mL) were mixed together then 10% aluminium chloride (0.3mL) was added into the test tube and kept for 10 min for complete reaction. Finally, 5% sodium hydroxide (1 mL) and distill water (10 mL) was added to the test tube. The absorbance was measured at a fixed wavelength 510 nm (UV/VIS spectrophotometer T60U, Leicestershire, UK). The estimation of

total flavonoid content in sample was carried out in duplicate and the results was averaged. The total flavonoids were calculated using equation6.

$$X= (A. mo) / (Ao. m)............ \qquad 6$$

Where "X" is the flavonoid content, mg/g plant extract, "A" is the absorption of plant crude extract solution, "Ao" is the absorption of standard quercetin solution, "m" is the weight of crude drug extract in mg and "mo" is the weight of quercetin in the solution in mg.

3.2.2 Total carotenoids

The chlorophyll*a*, chlorophyll*b* and total carotenoids will be determined by the method described by Branisa et al. [29]. Acetone-water mixture (4:1,v/v) will be used as a solvent. The absorbance maxima were read at 663.6 nm for chlorophyll*a*, 646.6 nm for chlorophyll*b*and470.0 nm for carotenoids. Contents of chlorophyll*a*, chlorophyll*b* and total carotenoids will be calculated using Equations 1, 2 and 3 respectively

$$\text{chlorophyll a} \; (\mu g/ml) = 12.25A_{663.6} - 2.25A_{646.6} \dots\dots\dots\dots\dots\dots 1$$

$$\text{chlorophyll b} \; (\mu g/ml) = 20.31A_{646.6} - 4.91A_{663.6} \dots\dots\dots\dots\dots 2$$

$$\text{total carotenoids} \; (\mu g/ml) = \frac{1000A_{470} - 2.27\,(\text{chl a}) - 81.4\,(\text{chl b})}{227} \dots\dots\dots 3$$

3.2.3 β-carotene and lycopene

The β-carotene and lycopene contents of the blend biscuit were determined according to the methods described by Branisa et al. [29]. One gram weight of the blend biscuit will be homogenized with 10 mL of an acetone–hexane mixture (2:3) for 2 mm to uniform mass. Homogenates will be centrifuged at 5000 rpm for 10 minutes at 20 °C. The absorbance spectrum of each supernatant will be measured and the absorption maxima will be read at 453, 505, 645 and 663 nm (UV/VIS spectrophotometer Cary 50 Scan).β-carotene and lycopene content will be calculated using Equations: 4 and 5

$$\beta - \text{carotene} \; \frac{mg}{100ml} = 0.216A_{663} - 1.22A - 0.304A_{505} - 0.452A_{453} \dots\dots\dots\dots 4$$

$$l\text{ycopene} \; (\mu g/100ml) = -0.0485A_{663} + 0.372A_{505} - 0.086_{453} \dots\dots\dots\dots 5$$

where A = absorbance.

3.3 Determination of Anti-nutritional Factors

3.3.1 Alkaloids

This was done by the alkaline precipitation gravimetric method as described by Harbone [30]. Five grams (5 g) of the samples was weighed into 50 ml of 10% acetic acid solution in ethanol in a 250 ml beaker. The mixture was shaken and allowed to stand for 4 hours. The mixture was then filtered with Whatman No.42 filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation using a steam bath.

Alkaloid in the extract was precipitated by drop-wise addition of ammonium hydroxide (NH_4OH) until full turbidity was obtained. The alkaloid precipitate was recovered by filtration using a weighed filter paper, and washed with 1% ammonia solution (NH4OH), dried in the oven at 80ºC for 1 hour. It was later cooled in a desiccator and reweighed. By weight difference, the weight of alkaloid was determined and expressed as a percentage of the sample analyzed, using the formula.

$$\% \text{ Alkaloid} = \frac{W2-W1}{W} \times \frac{100}{1}$$

Where:

W = weight of sample
W1 = weight of empty filter paper
W2 = weight of paper + alkaloid precipitate

3.3.2 Phytates

The phytate content was determined according to the method described by Latta and Eskin [31] later modified by Vaintraub and Lapteva [32].0.5g of sample was extracted with 10ml 2,4% HCL for 1hr at ambient temperature and centrifuged (3000 rpm) for 30min. The clear supernatant was used for phytate estimation.1ml of wade reagent (0.03% solution of $FeCl_3$. $6H_2O$ containing 0.3% sulfosalicylic acid in water) was added to 3ml of the sample solution and the mixtures were centrifuged. The absorbance at 500nm was measured using UV-VIS spectrophotometer. The phytate concentration was calculated from the difference between the absorbance of the control (3ml of water + 1ml wade reagent) and that of assayed sample. The concentrated of phytate was calculated using phytic acid standard curve and result were expressed as of phytic acids in mg per 100g dry weight. To prepare the phytic

acid standard curve, a series of standard solution were prepared containing 5-40mg/ml phytic acid in water. 3ml of standards was pipetted into 15ml centrifuge tubes with 3ml of water used as a zero level. To each tube 1ml was added of the wade reagent, and the solution was mixed using a vortex mixer for 5s. The mixture was centrifuged for 10min and the supernatant read at 500nm by using water as a blank. By plotting the calibration curve (absorbance vs concentration) and one can find out the slope and intercept. The phytate content of the blend biscuit were calculated using the following relation:

$$\text{Phytate (mg/100g)} = \frac{(Absorbance-intercept)\times 10}{(Slope \times density \times wt.sample)\times 3}$$

3.4 Physical Properties

3.4.1 Spread ratio

The spread ratio was calculated by method described by Ayo et al. [25].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.

3.4.2 Weight

The weight of the tiger nut-amaranth seed composite biscuit was determined by weighing on an electronic weighing balance (Mettler PF160 Balance, Switzerland) Ayo et al. [25].

3.4.3 Diameter and thickness

The tiger nut-amaranth seed composite biscuit diameter and thickness were determined using venire calipers Ayo et al. [25].

3.4.4 Breaking strength

Breaking strength of tiger nut-amaranth seed composite biscuit was determined using the method described by Ayo et al. [33]. Biscuit sample of 0.4cm and 5-20mm thickness respectively was placed centrally between two parallel metal bars (3cm 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 and bread.

3.4.5 Volume

The volume of the amaranth-tiger nut composite biscuit was determined using the formula.

$V=\pi r^2 h$

3.5 Sensory Evaluation

The sensory evaluation of the tiger nut-amaranth seed biscuits was carried out by twenty 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 (MVP, RPG, DMX, 3PG, HTM, CDS, 3ML and 2DX) and of the same size and temperature (29 ± 30°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" [33].

3.6 Statistical Analysis

Data will be expressed as mean ± standard deviations of triplicate scores. The significant differences between the groups will be assessed by two-way analysis of variance (ANOVA) and Duncan Multiple Range Test will be used to separate the means at $p < 0.05$. These will be done using the Statistical Package for Social Science (SPSS) software version 20. Microsoft excel (2007) will be used for plotting graphs.

4. RESULTS AND DISCUSSION

4.1 Proximate Composition of Amaranth-Tiger nut Flour Blend

The result of proximate composition is given in Table 1. The moisture content, protein content, carbohydrate ranged from 8.58 to 9.38, 16.68 to 18.90, 58.17 to 59.97 %, with decreasing amaranth substitution using tiger nut from 0 to 25%. The fat, fibre and ash contents ranged from 6.87 to 10.41, 2.22 to 2.23, and 2.66 to 2.99 and increased with increasing tiger nut flour addition from (0 to 25%). The result are significant (p=0.05).

The moisture content of the blend biscuit decreased with increase in added tiger nut flour which could be due to the low fiber content of amaranth seed flour when blended with tiger nut. The moisture content is lower than that of wheat biscuit. The moisture content of black coloured amaranth biscuit (15%) is higher than that of cream coloured amaranth biscuit. This could mean stability and shelf life quality as reported by Ayo et al. [33].

The decrease in crude protein content with increasing tiger nut flour addition, recorded were found to be similar to the report of Ayo et al. [33]; Ade-Omowaye et al. (34). The increase could be attributed to the low protein content of tiger nut as reported by Oladele and Aina [13]. The 100% amaranth flour had the highest content of protein (18.90%) while the 25% amaranth tiger nut flour blend had the least (16.68%). This finds conforms to the earlier work of by Ayo et al. [33]; Ade-Omowaye et al. [34].

The fat content of the blend biscuit increased from 6.87 to 10.41% with increase in added tiger nut flour. The increase fat may be due to the higher level of fat (32.13%) in tiger nut as reported by Oladele and Aina [13]. A fat content of 7.7 to 17.73 was reported by Ade-Omowaye et al. [34] and 13.57 to 17.54 % by Ayo et al. [33] respectively with increase in tiger nut substitution. The fat values obtained from the composite blend samples in this study are higher compared to 100% wheat. Fat is a good carrier of fat soluble vitamins promoting the absorption of vitamin A and carotenoids [35].

The crude fibre content of the flour blend biscuit increase from 2.22 to 3.23% with increase in added tiger nut flour (0 to 25%). The black coloured amaranth had 2.66 % fibre content and lower than that of cream colour (2.83%) at the same level of substitution (15%) which agreed with the findings Schnetzler and Breene [36]. The increase in in fibre content could be as a result of the high fibre content of tiger nuts reported by – Suarez *et al* (2003). Dietary fibre is reported to have some beneficial effects on the muscles of small and large intestine, which include emptying of bowl and slow glucose absorption [33].The ash content flour blend biscuit increased from 2.66 to 2.93% with increase in added tiger nut flour.

The carbohydrate content of the flour blend biscuit on the other hand slightly decreased (59.97 to58.17%) with increasing tiger nut flour (0

to 25%). Akujobi [37] reported decrease in carbohydrate from 70.23 to 59.51 for cocoa yam-tiger nut flour blend. Different products;- baggia and pan cakes could be produced from composite of amaranth and it showed decrease which may be due to composite formulation and reduction in nutrient prior to processing; baggia (39%) and pan cakes (22.65%) Muyonga et al. [38]. The high amount of carbohydrate shows that the products are good source of energy [26].

4.2 Phytochemicals Amaranth-Tiger Nut Flour Blend

The result of phytochemical composition is shown in Table 2. The flavonoid, lycopene, β-carotenoid and total carotenoid content of the blend biscuit increased from 2218.60 to 2277.60, 0.22 to1.47,0.93 to 1.04 and 12.79 to 27.19 mg/100g, respectively with increase (0 to 25%) added tiger nut flour blends respectively. The effect is significant (p=0.05).

The increasing flavonoid content could be due to the relative high content (236.17 mg/100g) of the same in the tiger nut (Oladele *et al.*, 2017). Flavonoids are anti-oxidants, and could lower cholesterol, inhibit tumor formation, and decrease tumor formation and protect against cancer and heart disease [39].

The β-carotene content of the flour blend increased (0.93 to 1.04 mg/100g) significantly with increasing amaranth substitution with tiger nut flour at $p > 0.05$ significant level. The β-carotene of tiger nut flour was 6.13μg/100g [40].

The total carotenoid of 100% amaranth is within the range similar to (1.69-17.61mg/100g) as reported by Tang and Tsao [41]. Carotenoids have been proven to improve the recovery of night blindness and loss of appetite [26].

4.3 Anti-nutrients Composition of Cream Colour Amaranth Seed – Tiger Nut Flour Blend

The alkaloid and phytate contents increased from 0.005 to 0.49 %, with increase in added tiger nut

(0 to 25%). The increase phytate content of the flour blend biscuit could be due to the relative high content of phytate in tiger nut 1.97 mg/100g tiger nut Chukwuma et al. [42].Content in light coloured seeds is lower or comparable to the quantity of growth inhibitors in common grain (trypsin inhibitor, phytates, saponins, and tannins), or are heat labile as lectins [43,44]. The relative low content of the anti-nutrient could be said to be of advantage as a phytochemical.

4.4 Physical Properties of Cream Colour Amaranth Seed – Tiger Nut Biscuits

The result of physical analysis of the amaranth-tiger nut biscuits are given in Table 4. The break strength decreased of the flour blend biscuits decreased 3.50 to 1.55 kg, while the volume, diameter and spread ratio increased from 20.40 to 23.65, 5.26 to 5.48, and 5.04 to 5.41 respectively with added tiger nut (0 to 25%). The relative reduction in the break strength though could be a problem in post handling of the biscuit (breakage), but could improve the digestibility of the product, hence the release of the nutrients to the body system.

4.5 Sensory Qualities of Cream Colour Amaranth Seed – Tiger Nut Flour Blend Biscuits

The result of the sensory evaluation is shown in Table 5. The aroma, crispiness, colour, texture, taste and general acceptability ranged from 6.43 to 6.90, 6.27 to 6.63, 5.83 to 6.07, 6.20 to 6.43, 6.60 to 6.63 and 6.37 to 7.23 for 0, 5, 10, 15, 20 and 25%amaranth tiger nut flour blends respectively. The effect is significant increase with increasing amaranth substitution with tiger nut flour at $p > 0.05$ significant level. The effect of tiger nut incorporation into the flour blend to produce biscuit had significant effects on the aroma, crispiness, colour, texture, taste and general acceptability. The increase in crispiness could be due to the increasing fibre content which agrees with Ayo et al. [7]. The biscuit having the highest spread ratio are considered more desirable [45].

Table 1. Proximate composition of Cream coloured amaranth seed – tiger nut flour blend biscuits

Materials	Proximate composition (%)					
Amaranth:Tiger nut	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate
100:0	9.38^a±1.41	18.90^a±1.41	6.87^b±1.41	2.22^a±1.41	2.66^a±1.41	59.97^a±7.07
95:5	9.15^a±1.41	18.44^a±1.41	7.98^a±2.12	2.42^a±1.41	2.68^a±1.41	58.35^a±4.95
90:10	9.222^a±1.41	17.73^a ±1.41	8.09^a±1.41	2.62^a±1.41	2.73^a±1.41	59.46^a±5.66
85:15	9.08^a±1.41	17.52^a±1.41	8.69^a±1.41	2.83^a±1.41	2.92^a±1.41	59.09^a±5.66
80:20	8.83^a±1.41	17.06^a±1.41	9.80^a±2.12	3.02^a±1.41	2.86^a±1.41	58.42^a±6.36
75:25	8.58^a±1.41	16.68^a±1.41	10.41^a±2.12	3.23^a±1.41	2.93^a±1.41	58.17^a±6.36
Wheat (100 %)	10.30^a±1.41	10.71^b±1.4	3.54^b±1.41	1.80^a±1.41	1.62^a±1.41	72.04^a±4.25
Black Amaranth(85:15)	9.38^a±1.41	17.73^a±1.41	8.09^a±1.41	2.66^a±1.41	2.99^a±1.41	59.12^a±5.66

Values are means ± standard deviation of 2 replicates. Means within a co lumn with the same superscript were not significantly different (P>0.05)

Table 2. Phytochemical composition of Cream coloured amaranth seed – tiger nut flour blend biscuits

	Materials			
Amaranth:Tiger nut	Flavonoid(mg/100g)	Lycopene(µ/100g)	β-carotenoid (mg/100g)	Total carotenoid(µ/ml)
100:0	2218.60^b±686.46	0.22^f±0.00	0.93^a±0.00	12.79^f±0.12
95:5	2232.40^b±1.41	0.61^{ec}±0.00	1.19^a±0.00	14.20^e±0.12
90:10	2241.22±0.02	0.77^d±0.00	1.45^a±0.00	17.33^d±0.10
85:15	2554.40^b±1.41	1.00^c±0.00	1.71^a±0.00	22.34^c±0.01
80:20	2265.40^b±1.41	1.19^b±0.02	1.97^a±0.56	25.99^b±0.01
75:25	2277.60^b±1.41	1.47^a±0.00	2.23^a±0.01	27.19^a±0.02
Wheat (100%)	13635.00^a±2498.92	0.37^g±0.00	1.04^a±0.00	10.06^g±0.21
Black Amaranth(85:15)	2260.12^b±1.41	0.27^{abc}±0.31	1.35^a±0.00	26.06^b±0.00

Values are means ± standard deviation of 2 replicates. Means within a column with the same superscript were not significantly different (P>0.05)

Table 3. Anti-nutrients composition of Cream colour amaranth seed – tiger nut flour blend biscuits

Blend Amaranth: Tiger nut	Phytate (mg/100g)	Alkaloid (%)
100:0	0.005[g]±0.00	0.0054[c]±0.00
95:5	0.018[f]±0.00	0.0064[c]±0.00
90:10	0.020[e]±0.00	0.0069[c]±0.00
85:15	0.029[c]±0.00	0.0078[bc]±0.01
80:20	0.034[b]±0.00	0.0162[a]±0.00
75:25	0.049[a]±0.00	0.0190[a]±0.00
Wheat (100 %)	0.0010[h]±0.00	0.004[c]±0.00
Black 85:15	0.0044[a]±0.00	0.0150[ab]±0.00

Values are means ± standard deviation of 2 replicates. Means within a column with the same superscript were not significantly different (P>0.05)

Table 4. Physical properties of Cream coloured amaranth seed – tiger nut flour blend biscuits

Materials	Physical properties				
Amaranth:Tiger nut	Weight (g)	Height (cm)	Diameter(cm)	Spread ratio	Break strength (Kg)
100:0	20.40[b]±0.28	1.05[d]±0.02	5.26[c]±0.06	5.04[c]±0.06	3.50[d]±1.06
95:5	20.65[b]±0.21	1.08[d]±0.03	5.57[c]±0.02	5.16[c]±0.14	3.29[d]±1.06
90:10	20.45[b]±0.70	1.03[d]±0.04	5.33[c]±0.03	5.18[c]±0.18	2.85[d]±1.06
85:15	21.35[b]±0.49	1.02[d]±0.02	5.21[c]±0.04	5.21[c]±0.05	2.37[d]±0.28
80:20	20.65[b]±0.70	1.08[d]±0.03	5.55[c]±0.00	5.39[c]±0.22	1.75[d]±1.03
75:25	23.65[b]±0.77	1.05[e]±0.02	5.48[c]±0.04	5.41[c]±0.21	1.55[d]±0.00
Wheat (100 %)	19.90[b]±0.57	1.03[d]±0.00	5.15[c]±0.07	5.19[c]±0.70	3.00[d]±0.28
Black Amaranth (85:1)	13.50[b]±0.21	0.85[e]±0.23	5.06[d]±0.56	5.96[c]±0.98	0.90[f]±0.00

Values are means ± standard deviation of 2 replicates. Means within a column with the same superscript were not significantly different (P>0.05)

Table 5. Sensory properties of Cream colour amaranth seed – tiger nut flour blend biscuits

Blend Amaranth:tiger nut	Aroma	Crispiness	Colour	Texture	Taste	General Acceptability
100:0	6.43[a]±1.72	6.27[a]±1.98	6.03[a]±1.92	6.23[a]±1.74	6.63[a]±1.78	6.37[a]±1.43
95:5	6.67[a]±1.18	6.07[ab]±1.76	5.50[b]±1.98	6.23[ab]±1.72	6.60[a]±1.57	6.40[ab]±1.40
90:10	6.53[a]±1.68	6.03[a]±1.88	5.83[a]±1.80	6.10[a]±2.03	6.37[a]±1.87	6.53[a]±1.18
85:15	6.87[ab]±1.25	6.33[ab]±1.94	6.07[b]±1.96	6.43[ab]±1.92	6.87[ab]±1.80	7.10[a]±1.63
80:20	6.88a±1.71	6.53a±1.97	5.90a±1.69	6.20a±1.75	6.60a±1.69	7.17a±9.68
75:25	6.90[a]±153	6.63[ab]±1.35	5.83[b]±1.84	6.42[ab]±1.82	6.59[ab]±1.95	7.23[ab]±2.12
Wheat (100 %)	7.77[a]±1.41	7.20[a]±1.49	7.93[a]±1.28	7.57[a]±1.70	7.55[a]±1.70	8.03[a]±1.27
Black Amaranth 85:15	5.33[a]±2.35	5.12[a]±2.17	4.40[a]±2.31	5.10[a]±2.17	4.87[a]±2.49	5.23[a]±2.65

Values are means ± standard deviation of 2 replicates. Means within a column with the same superscript were not significantly different (P>0.05)

5. CONCLUSION

The present study highlights about the physical and sensory properties of three varieties of amaranth grain flour-tiger nut flour blend biscuit. The addition of tiger nut flour to amaranth seed flour in the production of biscuit has improved its nutritional particularly with regard to its fat, minerals, fibre and phytochemicals (flavonoids, lycopene and β-carotenoid) content. Also the crispiness of the blend biscuit was greatly improved. The biscuit with 25% tiger nut flour was the most prefered.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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