NUTRITIONAL QUALITY, PHYSICOHEMICAL PROPERTIES AND SENSORY EVALUATION OF AMARANTH-*KUNU* PRODUCED FROM FERMENTED GRAIN AMARANTH (*AMARANTHUS HYBRIDUS)*

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ABSTRACT
Kunu is a refreshing non-alcoholic beverage which is usually produced from fermented cereal grains, consumed by children and adults and sometimes used as a weaning food in Nigeria. The current global trend in exploiting underutilized species for producing indigenous foods necessitated this study which exploited standard methods to assess the proximate composition, physicochemical properties, anti-nutrient constituents, and sensory qualities (10 semi-trained panelists) of Amaranth-Kunu developed from grain amaranth (Amaranthus hybridus), an underutilized pseudo-cereal, which was fermented for 24, 48 and 72 h at 30 - 30.5^{o}C, in comparison with kunu from Sorghum. The percentage proximate composition results: moisture content (10.24 – 91.87), Crude protein (1.42 – 16.86), Crude fibre (0.11 – 2.50), Crude fat (0.85 – 5.77), Total ash (0.05 – 2.90) and Carbohydrate (2.84 – 61.77) were significantly different (p<0.05).There was no significant difference (p<0.05) in the temperature which ranged from 30 – 30.5^{o}C but the pH (4.49 – 5.79) decreased significantly while Total titratable acidity (2.30 – 6.40) and total solids (4.90 – 8.90) increased significantly (p<0.05) as fermentation period increased. The Oxalate (0.1108 – 0.3151), Phytate (3.4900 – 17.4000), and Saponin (0.4900 – 4.8100), contents decreased significantly (p<0.05) with increased fermentation time while Tannin was not detected in all. Sensory evaluation results showed that Amaranth-kunu was significantly more acceptable (p<0.05) than sorghum kunu. Amaranth-Kunufermented for 48 h had the best mean sensory scores (1.0 - 1.2) which depicted 'like extremely' and was mostly acceptable by the panellists.Amaranth-kunu developed from grain amaranth possessed potentials for commercialization to combat malnutrition and used for food security in Africa.

Keywords: Fermentation, grain amaranth, Amaranth-*Kunu*, underutilized species, pseudo-cerealfood security, malnutrition, *Amaranthus hybridus*, non-alcoholic beverage

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INTRODUCTION

Kunu is a popular, indigenous, fermented, cereal-based, non-alcoholic beverage often consumed throughout Nigeria, but mostly in the north, by children and adults, especially, those whose religions restrict alcohol consumption (Adejuyitan *et al*., 2008). It has a sweet-sour taste, creamy appearance, low viscosity and is sometimes used as a weaning beverage for infants (Adebayo *et al*., 2010). It is available all-year-round and also often consumed after meals (as an alternative to carbonated beverages), especially, in the Northern parts of Nigeria, for its thirst-quenching properties, especially in dry season (Elmahmood and Doughari, 2007). It is usually flavored with black pepper, ginger or red pepper to boost the taste and aroma, serve as purgatives, antidotes to flatulence and regarded as a lactation-enhancer in nursing mothers. *Kunu*is relatively cheap and more nutritious when compared with carbonated beverages (Adejuyitan *et al*., 2008). Its cheapness is owed to the ready availability of its locally-sourced raw materials, especially, the cereals which grow abundantly in West Africa (Elmahmood and Doughari, 2007).

Amaranth is a multi-useful crop with grains that possess high nutritional quality and leafy vegetables for food and animal feed (Grobelnik-Mlakar, 2009). It is a pseudo-cereal, highly resistant to drought, can be produced in a short time with high yield and utilized as a good source of protein and non-saturated fatty acids owing to its high nutritional value (Andrasofszky *et al*., 1998). Amaranth has been described to possess excellent nutritional composition of protein

content higher and of better quality and lipid or fat content higher than in cereals grains. Pisankova *et al*., 2005 reported that the biological value of untreated amaranth expressed by essential amino acid index character as 90.4%, depicting favourable nutritional quality of its protein content. The availability of cheap, and highly nutritious alternative underutilized species such as grain amaranth, a pseudo-cereal, could be exploitedfor producing indigenous foods to alleviate malnutrition, poverty and food insecurity in the developing nations, like Nigeria, especially among children and women of child bearing age group(Oshundahunsi and Aworh, 2003).This study therefore, exploited standard methods to assess the proximate composition, physicochemical properties, anti-nutrient constituents, and sensory qualities of Amaranth-*Kunu* developed from fermented grain amaranth (*Amaranthus hybridus*).

MATERIALS AND METHODS

Production of amaranth-kunu

Fresh grain amaranth wasobtained from National Institute of Horticultural Research and Training (NIHORT) and chemical reagents of analytical grade were purchased fromlocal stores in Ibadan and Akure.The Amaranth-*kunu* was produced using the modified method of Fapohunda and Adeware, (2012) as presented in Figure 1. The grain amaranth was manually cleaned to remove sand and dirt.

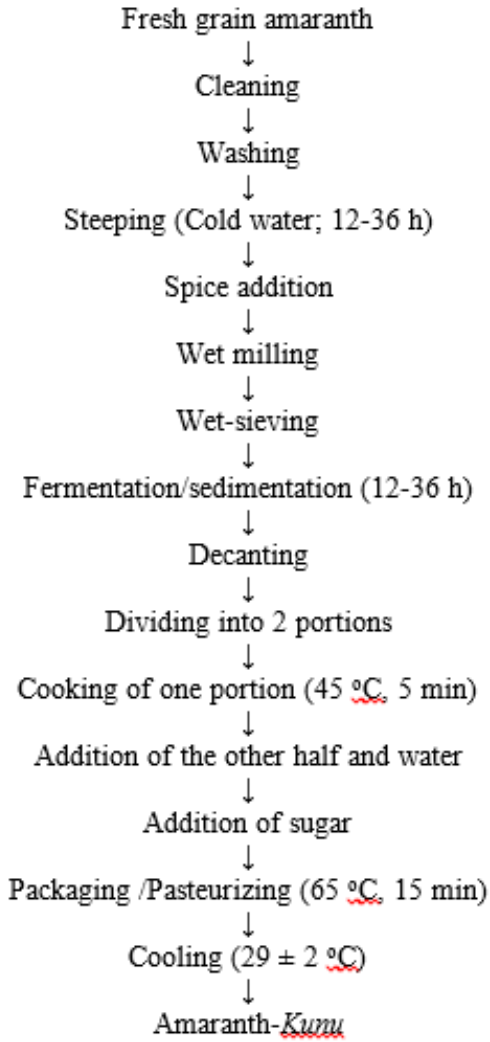

Fig. 1: Production of amaranth-*Kunu*.
Source: Fapohunda and Adeware, (2012) (Modified)

About 500 g each of the cleaned grains was weighed into transparent plastic containers, washed with water, and steeped in 1litre of water for 12, 24 and 36 h, respectively, to obtain three fermented samples (24AK, 48AK and 72AK), respectively. At the end of each fermentation period, the samples were washed with water, before addition of clean, pre-measured spices - ginger (*Zingiber officimals*), black pepper (*Piper guineense*), red pepper (*Capsicum* species), Alligator pepper (*Afromoniummelegueta*) and cloves (*Syzygieae aromaticum*). The samples were wet-milled, wet-sieved with a white muslin cloth to remove bran, hulls, germs and coarse spice residue, left to sediment and further ferment for 12, 24 and 36 h, respectively and the souring water was decanted. The three slurry samples obtained were weighed, packaged in transparent plastic containers and labelled as 24AK, 48AK and 72AK, respectively. Each sample was divided into two portions (3:1v/v), the first portion was cooked at 45^{o}C for about 5 min, the other 1/4 portion was added with water to dilute to the appropriate consistency, 50 g of sugar was also added, and the sample was packaged and pasteurized at 65^{o}C for 15 min in plastic bottles, cooled to and stored at room temperature and 4^{o}C for further analyses.

Production of sorghum *kunu*

Sorghum *kunu* was produced using the modified method of Fapohunda and Adeware(2012) as presented in Fig. 2.

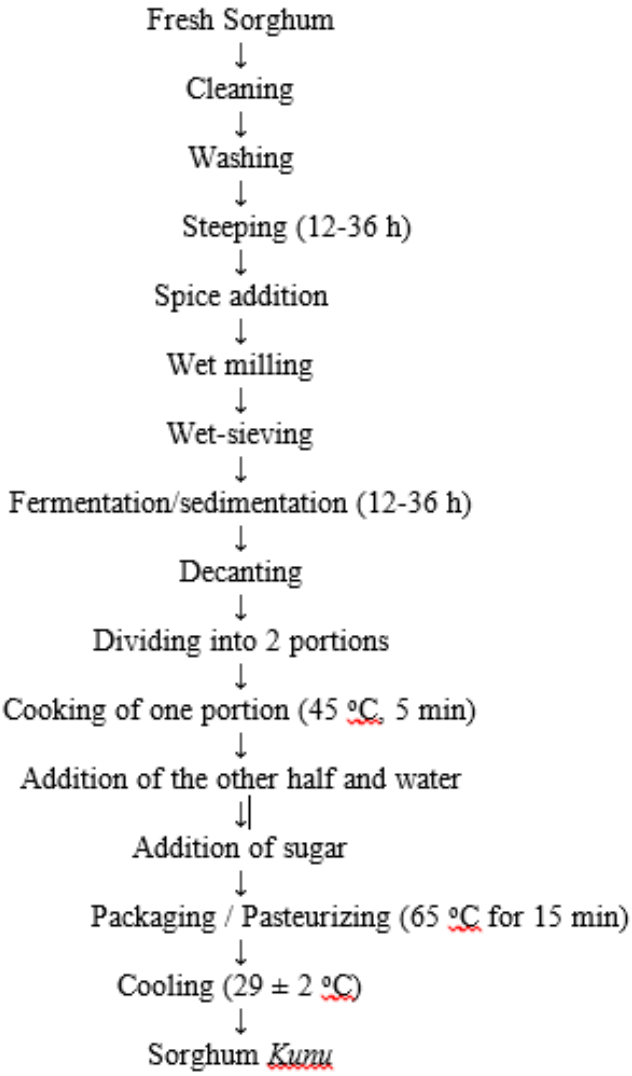

Fig. 2: Production of sorghum *Kunu*
Source: Fapounda and Adeware (2012) (Modified)

The sorghum was manually cleaned to remove sand and dirt. About 500 g was weighed into a transparent plastic container, washed with water and steeped in 1 litre of water for 24 h after which it was washed with water, before addition of clean, pre-measured spices - ginger (*Zingiber officimals*), black pepper (*Piper guineense*), red pepper (*Capsicum* species), Alligator pepper (*Afromoniummelegueta*) and cloves (*Syzygieae aromaticum*)). The sample was wet-milled, wet-sieved with a white muslin cloth to remove bran, hulls, germs and coarse spice residue, left to sediment and further ferment for 24 h, and the souring water was decanted. The slurry obtained was weighed, divided into two portions (3:1v/v), the first portion was cooked at 45^{o}C for about 5 min and the other 1/4 portion was added with water to dilute to the appropriate consistency. Sugar (50 g) was added to the sample which was packaged and pasteurized at 65^{o}C for 15 min in plastic bottles, labelled as SK, cooled to and stored at room temperature and 4^{o}C for further analyses.

Physicochemical Analyses

The pH of each sample was determined using the method described by Nwachukwu *et al.*, (2010). Sample (10 ml) was shaken with 100 ml of water and allowed to stand for 30 min. The material was filtered and the pH of the filtrate was determined with a pH meter (pH meter - Surgifield medical England Sm - 6021A) and the reading was recorded.

Determination of total titratable acidity (TTA)

Water extracts method (AOAC, 2005) was used in the determination. Sample (18 ml) was measured and shaken with 200 ml of CO_2 free water in a conical flask and placed in a water bath at 40ºC for one hour with the flask loosely corked. It was filtered and 100 ml of the clear filtrate was titrated with 0.05M of NaOH solution with phenolphtalein indicator. The acidity of water extract increased during storage and is calculated as lactic acid or potassium dihydrogen phosphate (1 ml of 0.05M of NaOH = 0.0068 g of KH_2PO_4).

Determination of total solid

Five gram of each sample was weighed into a flat-bottomed metal dish and placed on boiling water for about 30 minutes until the liquid evaporated leaving the solid. It was then transferred into an oven maintained at 100ºC for 2½ h as W_2. It was then transferred to a dessicator, cooled and weighed. It was heated in the oven again for 1 h, cooled and weighed. The process was continued until constant weight W_3, was obtained (AOAC, 2005). The total solid is calculated from Eqn. (1):

$$\text{Total solid} = \frac{W_3 - W_1}{W_2 - W_1} x100 \qquad \text{Eqn.(1)}$$

Determination of ash content

The crucible dish was cleaned, dried ignited, cooled and weighed as W_1. About 24.4 g of each sample was weighed accurately and directly in the dish i.e. W_2. The substance was dried on a boiling water bath and then charred over a hot plate in fume cupboard until no more soot was given out. Then, it was then ashed with a muffle furnace at 500ºC to obtain W_3 (AOAC, 2005). Percentage ash was calculated from Eqn. (2):

$$\text{Ash (\%)} = \frac{W_3 - W_1}{W_2 - W_1} x\ 100 \qquad \text{Eqn.(2)}$$

Determination of protein content

The mole titration method (Pirie, 1975; Akoh, 1981) was used for the determination. 10 ml of each sample was added to 0.05 ml of 0.5% phenolphthalein indicator. It was mixed and allowed to stand for a few minutes and neutralized with 0.1M NaOH to the standard pink colour. 2 ml of formalin was added, mixed and allowed to stand for few minutes. The new acidity produced was titrated with 0.1M NaOH to the same pink colour. Then 2 ml of the formalin +10 ml of H_2O were titrated separately with 0.17M NaOH as blank.

Note: 1.95 (a-b) % where: a- titre value, b-blank value (Adebayo *et al.*, 2010).

Determination of moisture content

This method is based on loss on dry at an oven temperature at 105ºC. Besides water, the loss will include other matter volatile at 105 ºC (AOAC, 2005; Akoh, 1981). Five grams of

each sample was weighed into a pre-weighted flat dish (W_1) and dried at an oven temperature of 105 °C for 3 h as W_2. It was allowed to cool in an airtight desiccator and reweighed. It was heated in the oven again for half an hour, cooled and weighed. The process was repeated until constant weight was obtained W_3 (AOAC, 2005). The percentage moisture was calculated from the equation 3:

$$\text{Moisture}(\%) = \frac{W_3 - W_1}{W_2 - W_1} x\ 100 \qquad \text{Eqn.(3)}$$

Determination of crude fibre content

About 1g of the sample was weighed into the conical flask (W_1) and boiled with 1.25% H_2SO_4 (150 ml) for 30 min. The mixture was filtered through a poplin cloth and rinsed with distilled water; the sample was then scraped back into the flask and boiled with 150 ml of 1.25% NaOH for 30 min. The residue was collected again and rinsed with distilled water, 10% HCL and lastly with ethanol. The residue was later scraped into a crucible, oven dried, cooled in the desiccator, weighed (W_2), and ashed in the muffle furnace. It was placed in desiccator, allowed to cool to room temperature and then we re-weighed (W_3)(AOAC, 2005).

$$\%\ \text{Crude fibre} = \frac{W_2 - W_3}{W_1} x\ 100 \qquad \text{Eqn.(4)}$$

Determination of fat content

Filter paper was weighed (W_1) and 0.5 g of each of the oven dried samples was put into it and weighed (W_2). The filter paper with the content was neatly folded, tied using threads arranged in the thimble. Round bottom flask (500 ml capacity) was filled with n-hexane up to ¾ of the flask.

The extractor was fitted with the reflux condenser and heated to allow the solvent boil gently and siphon several times within 4 h. Samples were then removed, dried in the oven for 1 h at 105 °C, cooled in the desiccator and weighed (W_3)(AOAC, 2005).

$$\%\ \text{Ether extract (fat)} = \frac{W_2 - W_3}{W_2 - W_1} x\ 100 \qquad \text{Eqn.(5)}$$

Determination of carbohydrate content

The carbohydrate content of the samples was calculated by difference, rather than analyzed directly. All the other constituents in the food (protein, fat, water, alcohol, ash) were determined individually, summed and subtracted from the total weight of the sample (AOAC, 2005).

$$\text{Carbohydrate} = 100 - (\text{Weight in grams [protein} + \text{fat} + \text{water} + \text{ash} + \text{alcoholin 100 g of sample} \qquad \text{Eqn.(6)}$$

Determination of Anti nutrients

Determination of tannin content

About 0.2 g of finely ground sample was weighed into a 50 ml sample bottle. 10 ml of 70% aqueous acetone was added and properly covered. The bottle was put in an ice bath shaker and shaken for 2 h at 30°C. The solution was then centrifuged and the supernatant stored in ice. Exactly 0.2 ml of each solution was pipetted into the test tube and 0.8ml of distilled water was added. Standard tannin acid solutions were prepared from a 0.5 mg/ml of the stock and the solution made up to 1 ml with distilled water. 0.5 ml of Folin Ciocateau reagent was added to the sample and standard. Accurately 2.5 ml of 20% Na_2CO_3 the solution was then vortexed and allowed to incubate for 40 min at room temperature. The absorbance was read at 725 nm against a reagent blank and the concentration of the solution from a standard tannic acid curve was obtained (Makkar and Goodchild, 1996).

Determination of saponin content

The spectrophotometric method of Brunner (1984) was used for Saponin determination. Accurately 2 g of the finely ground sample was weighed into a 250 ml beaker and 100 ml of Isobutyl alcohol or (But-2-ol) was be added. The mixture was shaken with a shaker for 5 h to ensure uniform mixing, filtered with a No 1 Whatman filter paper into 100 ml beaker containing 20 ml of 40% saturated solution of magnesium carbonate ($MgCO_3$). The resulting mixture was also filtered through a No.1 Whatman filter paper to obtain a clean colourless solution. Exactly 1 ml of the colourless solution was put into a 50 ml volumetric flask using a pipette, 2 ml of 5% iron (iii) chloride ($FeCl_3$) solution was added and made up to the mark with distilled water.

The mixture was allowed to stand for 30 min for development of colour. The absorbance is read against the blank at 380 nm.

$$\text{Saponin} = \frac{\text{Abs of sample}}{\text{Concentration of sample}}, \text{Saponin} = \text{Conc. of sample} = \frac{\text{Abs of sample x conc .of STD}}{\text{Abs of STD}} \quad \text{Eqn.(7)}$$

Determination of phytate content

Phytate content was determined according to the method of described by Ajayi *et al.*, 2018. Exactly 4 g of sample was soaked in 100 ml of 2% HCl for 3 h and filtered through a No 1 Whatman filter paper. 25 ml of the filterate was pipetted into a conical flask, 5 ml of 0.3% of ammonium thiocyanate solution was added as indicator and 53.5 ml of distilled water was added for proper acidity. The mixture was titrated against 0.00566 g/ml of standard iron (iii) chloride solution that contained about 0.00195 g of iron per ml, until a brownish yellow colouration persisted for 5 min.

Oxalate content

Oxalate determination was carried out by soaking 1 g of the sample in 75 ml of 1.5N H_2SO_4 for 1hr and filtered through a No 1 Whatman filter paper. About 25 ml of the filtrate was pipetted into a conical flask and titrated against 0.1 M $KMnO_4$ until there was a pink colour that persisted for 15 sec (Day and Underwood, 1986).

Sensory Evaluation

The consumer acceptability and sensory quality in terms of aroma, appearance, taste, mouth feel and overall acceptability of the Amaranth-*Kunu* was assessed and evaluated in comparison with the traditional *kunu*made from Sorghum using 10 semi-trained panellists.The samples were served in clean cups, presented randomly and one at a time to each panellist. A 9-point Hedonic scale was used in the scoring, with 1 being 'like extremely' and 9 being 'dislike extremely' ((1 = Like extremely, 2 = Like very much, 3 = Like moderately, 4 = Like slightly, 5 = Neither like nor dislike, 6 = Dislike slightly, 7 = Dislike moderately, 8 = Dislike very much, 9 = Dislike extremely). The mean scores were subjected to analysis of variance (ANOVA) at 5% and separated using New Duncan's Multiple Range Test (NDMRT) (Fapohunda and Adeware, 2012).

Statistical Analysis

The results obtained were subjected to statistical analysis using one-way analysis of variance (ANOVA) and the means were separated by using New Duncan's Multiple Range Test (NDMRT).

RESULTS AND DISCUSSIONS

Proximate composition

The proximate composition of grain amaranth, sorghum *kunu*and amaranth-*kunu* is as shown in Table 1. All the proximate parameters analysed were significantly different ($p<0.05$) in all the samples. There were changes in moisture, crude protein, crude fibre, crude fat, crude ash and carbohydrate contents of amaranth-*kunu* this agreed with Okafor *et al.*, (2017) there was decrease in crude protein content as fermentation time increased. Oly-Alawuba and Ibe, (2018) reported 89.82 % to 94.24 % of Kunun-zaki from sorghum, rice and tiger-nut. The values decreased significantly ($p<0.05$) when *kunu* was produced from the grain amaranth with respect to steeping time; and lower than the one obtained from *kunu* made from sorghum (Ikpoh *et al.*, 2013). This trend is similar to what was observed by Ayo and Okeke (2008) who reported that *kunu* was rich in carbohydrates but low in protein. The protein content ranged from 1.77% to 2.87% with significant difference($p<0.05$). The crude fibre ranged 0.17% to 0.31%. The fibre content increased with increase in fermentation. The ash content is an indication of the quantity of mineral elements present in the sample while ash content value also denotes the quality assessment of certain edible materials (Adebayo *et al.*, 2010). There was no significant difference ($p<0.05$) in fibre content. There was significant difference ($p<0.05$) in fat content of amaranth-*kunu* with fermentation time. There was decrease in fat content has fermentation time increased in agreement with Adejuyitan *et al.*, (2008) who reported that fat content decreased with fermentation period from 14.41% to 11.21% for tiger-nut milk.

Table 1: Percentage proximate composition of grain amaranth, Sorghum *kunu* and Amaranth-*Kunu* (%)

Sample	Moisture	Crude Protein	Crude fibre	Crude Fat	Total Ash	Carbohydrate
GA	10.24±0.20^{a}	16.86±0.3^{a}	2.50±0.01^{a}	5.77±0.20^{a}	2.90±0.03^{a}	61.77±0.20^{a}
SK	91.87±0.30^{a}	1.42±0.20^{e}	0.11±0.01^{e}	0.85±0.13^{e}	0.21±0.01^{b}	5.47±0.20^{c}
24AK	90.97±0.20^{b}	2.87±0.22^{b}	0.17±0.01^{d}	3.28±0.72^{b}	0.06±0.01^{c}	2.84±0.16^{e}
48AK	90.97±0.20^{b}	2.60±0.57^{c}	0.21±0.04^{c}	2.53±0.34^{c}	0.05±0.02^{c}	4.16±0.67^{d}
72AK	88.65±0.10^{d}	1.77±0.01^{d}	0.31±0.02^{b}	1.59±0.16^{d}	0.07±0.02^{c}	6.69±0.32^{b}

Values are mean ± standard deviation, mean values followed by different subscripts within columns are significantly different by Duncan's multiple range tests ($p<0.05$; n=3)

Key:
GA = Raw grain amaranth;
SK = Sorghum-*Kunu* fermented for 48 h;
24AK = Amaranth *kunu* fermented for 24 h;
48AK = Amaranth *kunu* fermented for 48 h and
72AK = Amaranth *kunu* fermented for 72 h.

The carbohydrate content increased with increase in fermentation time. The carbohydrate content ranged from 2.84% to 6.69% with significant difference ($p<0.05$).

Physicochemical properties

The physicochemical properties of sorghum *kunu* and amaranth-*Kunu* are as showed in Table 2. The temperature of all the samples ranged from (30.0 – 30.5^{o}C). The pH values ofsorghum *kunu* and amaranth-*Kunu* which ranged from (4.49 – 5.79) decreased significantly ($p<0.05$)with increased fermentation period. These pH valuesare within the acidic range as reported by Oladeji *et al.*, (2018) but at variance with Braide *et al.*, (2018) who reported a range of 6.83-7.13. Amaranth-*Kunu*had pH values (4.49 – 4.86) which were significantly lower ($p<0.05$)than sorghum *kunu*(5.79). The difference could be due to difference in raw materials (millet and sorghum), sizes of the grains, rate and time of fermentation and presence of some organic acids produced as a result of fermentation. Conversely, the Total Titratable Acidity (TTA) of all the samples which ranged from 2.30 and 6.40%increased significantly ($p<0.05$)with increased fermentation time and temperature and imparted sour taste on the samples due to the organic acids. The increase in TTA with respect to increased temperature agreed with the findings of Braide *et al.*, (2018) for *kunu* but higher than those reported by Ahmad *et al.*, (2018) for indigenous beverages in Nigeria. The total solidsof all the samples ranged from 6.19 - 8.9 mg/ml with significant difference($p<0.05$) and increased as fermentation period increased and the Amaranth-*Kunu*samples had significantly higher total solids than *kunu* produced from sorghum ($p<0.05$). This implied that the Amaranth-*Kunu* would be more filling, nourishing and economical to fight malnutrition and enhance food security.

Table 2: pH, titratable acidity and total solid contents of Sorghum *kunu* and Amaranth-*kunu*

	Temperature (° C)	pH	Total Titratable Acidity (%)	Total Solids (mg/ml)
SK	30.0^{a}	5.79±0.01^{a}	2.30±0.01^{a}	4.90±0.01^{a}
24AK	30.0^{a}	4.86±0.01^{b}	4.20±0.01^{b}	6.19±0.01^{b}
48AK	30.5^{a}	4.60±0.01^{c}	5.80±0.01^{c}	7.20±0.01^{c}
72AK	30.5^{a}	4.49±0.01^{d}	6.40±0.02^{d}	8.90±0.01^{d}

Values are mean ± standard deviation, mean values followed by different subscripts within columns are significantly different by Duncan's multiple range tests ($p<0.05$; n=3)

Key:
SK = Sorghum-*Kunu* fermented for 48 h;
24AK = Amaranth *kunu* fermented for 24 h;
48AK = Amaranth *kunu* fermented for 48 h and
72AK = Amaranth *kunu* fermented for 72 h.

Anti-nutrient constituents

The anti-nutrient constituents of grain amaranth, sorghum *kunu* and amaranth-*kunu* are as presented in Table 3. There was a significant decrease ($p<0.05$) in all the anti-nutritional constituents (oxalate: 0.3151 – 0.1108, phytate: 17.4000 – 3.4900 and saponin: 4.8100 – 0.4900) as fermentation time increased. The results indicated that fermentation reduced all the anti-nutrients, in agreement with the report of Adegbehingbe *et al.*,(2017)that showed reduction in oxalate when breadfruit was fermented. All the anti-nutrient constituents of sorghum *kunu* (0.8100–4.2310) was significantly higher ($p<0.05$)than those in amaranth-*kunu* samples (0.1108 – 4.1200). Amaranth-*kunu* which was fermented for 48 h even had a significantly lower ($p<0.05$) anti-nutrient constituents than sorghum *kunu*, thereby, indicating that the former was of a better quality than the latter. The lower anti-nutrients in amaranth-*kunu* samples might be due to the faster rate of fermentation of the smaller grains of amaranth than sorghum whose grains are about 4 times bigger. Oxalate content (0.1108 – 0.1961) of all the *kunu* samples were the least, followed by the saponin (0.4900 – 0.8100) while phytate (3.4900 – 4.2310) was the highest of all the anti-nutrients.

Sensory evaluation

The sensory evaluation of all the attributes examined in the samples were significantly different ($p<0.05$) as shown in Table 4. All the Amaranth-*kunu* samples fermented at 24 h, 48 h and 72 h had sensory scores (1.0 – 4.4), were significantly better ($p<0.05$), more acceptable and preferred to Sorghum *kunu* (sensory scores of 5.5 – 7.1) by the panellists. Amaranth-*kunu* sample that was fermented for 48 h had the best scores for aroma (1.0), mouth feel (1.1), taste (1.0) and overall acceptability (1.2). The 24 h fermented sample had scores ranging from 1.4 - 2.7 and possessed the most acceptability for appearance (1.4) which indicated 'like extremely'. The sample which was fermented for 72 h scored 4.0 – 4.4 which depicted 'like slightly' and was still significantly better ($p<0.05$) than Sorghum *kunu* with sensory scores that indicated 'Neither like nor dislike and dislike moderately'. The sensory evaluation results, therefore implied that even at the longest fermentation time (72 h) employed for fermentation during this study, the aroma, appearance, mouth feel, taste and overall acceptability of the Amaranth-*kunu*

Table 3: Anti-nutrients constituents of grain amaranth, Sorghum *kunu* and Amaranth-*kunu*

	Oxalate (Mg/g)	Phytate (Mg/g)	Saponin (Mg/g)	Tannin (Mg/g)
GA	0.3151 ± 0.030^{e}	17.4000 ± 0.033^{e}	4.8100 ± 0.003^{d}	0.0000
SK	0.1961 ± 0.015^{d}	4.2310 ± 0.001^{d}	0.8100 ± 0.003^{c}	0.0000
24AK	0.1808 ± 0.001^{c}	4.1200 ± 0.003^{c}	0.6250 ± 0.001^{b}	0.0000
48AK	0.1304 ± 0.001^{b}	3.7100 ± 0.001^{b}	0.6050 ± 0.001^{b}	0.0000
72AK	0.1108 ± 0.001^{a}	3.4900 ± 0.001^{d}	0.4900 ± 0.003^{a}	0.0000

Values are mean ± standard deviation, mean values followed by different subscripts within columns are significantly different by Duncan's multiple range tests ($p<0.05$; n=3)

Key:
GA = Raw grain amaranth;
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48AK = Amaranth *kunu* fermented for 48 h and
72AK = Amaranth *kunu* fermented for 72 h

Table 4 Sensory qualities of Sorghum *kunu* and Amaranth-*kunu*

	Aroma	Appearance	Mouth feel	Taste	Overall acceptability
SK	7.1 ± 0.60^{d}	6.8 ± 0.60^{d}	6.2 ± 0.50^{d}	5.5 ± 0.50^{d}	6.7 ± 0.30^{d}
24AK	2.1 ± 0.10^{b}	1.4 ± 0.40^{a}	2.1 ± 0.20^{b}	2.7 ± 0.60^{b}	2.0 ± 0.30^{b}
48AK	1.0 ± 0.00^{a}	2.7 ± 0.30^{b}	1.1 ± 0.10^{a}	1.0 ± 0.00^{a}	1.2 ± 0.20^{a}
72AK	4.4 ± 0.20^{c}	4.1 ± 0.40^{c}	4.0 ± 0.30^{c}	4.2 ± 0.40^{c}	4.1 ± 0.20^{c}

Values are mean sensory scores by panellists ± standard deviation, mean values followed by different subscripts within columns are significantly different by Duncan's multiple range tests ($p< 0.05$; n = 10).

Key:
SK = Sorghum-*Kunu* fermented for 48 h;
24AK = Amaranth *kunu* fermented for 24 h;
48AK = Amaranth *kunu* fermented for 48 h and
72AK = Amaranth *kunu* fermented for 72 h.

samples were not impaired to affect their acceptability by the consumers, hence, could be produced at commercial level to meet the nutritional, economic and health needs of Nigerians, in order to reduce malnutrition, poverty and health disorders in the society.

CONCLUSION

The potentials of grain amaranth for the production of Amaranth-*kunu* with higher nutritional qualities and overall acceptability at 48 h fermentation, in comparison with the usual traditional *kunu* prepared with sorghum. All the Amaranth-*kunu* samples produced at fermentation periods 24 h, 48 h, and 72 h had higher acceptability than *kunu* prepared with sorghum.

This study has established that the non-alcoholic Amaranth-*kunu* possessed thrice as much fat, twice as much crude protein and about twice as much crude fibre protein than in Sorghum *kunu*, which suggests the possibility of increasing the usefulness of underutilized, grain Amaranth as a new raw material for alleviating food and nutrition insecurity, poverty and health issues in adults and children at household and commercial levels, in Nigeria and Africa, at large.

Further studies are therefore recommended for antioxidant potentials, mineral and vitamin composition, microbiological safety and storage stability of Amaranth-*kunu*, in order to make its commercialization a worthwhile venture.

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