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Quality evaluation of "Kangu" produced from bambara nut (Vigna subterranean) and yellow maize (Zea mays) composite flour

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Abstract

Legumes play a very important nutritional role in the diet of millions of the populace around the world as major sources of protein and minerals (FAO, 2016). In developed countries, plant proteins are now considered as important component than major nutrients. The aim of this study is to produce 'kangu' from bambara nut and maize composite flour. This study examined the chemical properties of 'Kangu,' a value added snack produced using composite flour of Bambara groundnut and maize. Four composite flours were prepared by homogenously mixing Bambara flour and maize flour in the proportions of 90:10, 80:20, 70:30, and 60:40 and evaluated for functional properties and chemical composition. Value-added snacks produced were evaluated for colour properties, water absorption ability and sensory acceptability using 100% Bambara flour as a control. The loose bulk density, packed bulk density, dispersibility, water and oil absorption of the composite flour increased when compared with 100% Bambara flour. At 70°C, 80°C and 90°C, the swelling power of composite flour was nearly the same, with only a little differential at 50°C, and 60°C. The moisture content, ash, fat and crude fibre of the composite flours significantly increased when compared to 100% Bambara flour with the exception of protein and carbohydrate. Sensory evaluation by semi-trained panelist indicated consumer acceptability. However, the sample that contained 60% Bambara flour and 40% maize flour scored the highest for crunchiness, taste and overall acceptability, while 100% Bambara flour scored the highest for appearance and colour. Composite flour with 30% maize substitution absorbed the highest moisture (0.76 g) among other stored snacks. Maize is rich in the amino acid methionine and deficient in lysine which is readily available in bambara groundnut, where as methionine is limited in bambara nut, this suggested that products from bambara and maize flour should be encourage so as to solve the problem of malnutrition

Keywords: bambara groundnut, yellow maize, "Kangu", composite flours, snack, deep-fat frying, sensory evaluation

Introduction

Protein-Energy Malnutrition (PEM) is a serious public health problem in some parts of the globe, including Nigeria and West Africa sub-region. This is due to the fact that diets in this area are majorly carbohydrate-rich foods; based on the major crops which are mainly cereals, roots and tubers (Olapade and Aworh, 2012). Undernutrition in Nigeria is a long-standing problem which has persisted since the 1960s and whose magnitude is on the increase. This is because food consumption, both quality and quantity, has decreased appreciably. The prevalence of PEM can be attributed to many factors, such as the high price of animal protein (eggs, meat and milk), the staple cereal-based diet and increasing price of food commodities, which are becoming unaffordable to the lower income groups. Although high-protein legumes such as soybean and cowpea are available to consumers, their consumption rate surpasses their production rate; thus, an ever increasing demand has been observed (Nedumaran et al., 2015). Furthermore, cereals in their natural, unprocessed, whole grain form, are rich source of vitamins, minerals, carbohydrates, fats, oils, and protein. In developed countries, cereal consumption is moderate and varied but still substantial, primarily in the form of refined and processed grains (Mundell, 2019).

Bambara groundnut (Vigna subterranea) is a leguminous crop grown in many parts of Africa. The name, Bambara groundnut was derived from the name of a Mali tribe called "Bambara" (Murevanhema and Jideani 2015, Yao et al., 2015). The crop is a legume species of African origin and is widespread south of the Sahara (Ocran et al., 1998; Atiku et al., 2004). In West Africa, Bambara groundnut was for a long time at par with, or slightly ahead of cowpea (Vigna uniguiculata) in terms of production (market availability) and utilisation. In Ghana, over 40,000 cans (various sizes) of Bambara groundnut were produced annually throughout the 1960's and early 1970's. The canned product was very popular throughout West Africa and competed favourably with Heinz baked beans. The status of the nut however, started to decline from 1970's with introduction of high yielding varieties of groundnut (Arachis hypogaea) and pest control methods for cowpea (Doku, 1996). With respect to all the nutritive quality of Bambara nut, it remains an underutilized crop both locally and industrially. Food legumes have a major role to play in the fight against malnutrition. The protein of Bambara groundnut is of good quality and has surplus lysine which complements cereals in the diet (Ocran et al., 1998). From the point of view of human nutrition, the composition of the seeds is very well balanced, as they contain 20% soluble carbohydrates and 8% fats (Messiaen, 1992). It is high in protein, but unlike ordinary groundnuts, it contains very little oil (Tweneboah, 2000). Bambara groundnut has been ranked as the third most important grain legume, after groundnut and cowpea in semi-arid Africa (Murevanhema and Jideani, 2013), but has not been accorded due attention in research (Bamishaiye et al., 2011). Bambara groundnut research has been done till date to improve its utilisation. The usefulness of grain legume in developing high-protein foods in meeting the needs of vulnerable groups of the population is now well recognized, and several high-protein energy foods have been developed industrially from Bambara in different parts of the world (Olapade et al., 2014).

Maize is one of the most abundant food crops in Nigeria (Doebley, 2004). About 80% is consumed by man and animals, while 20% is utilised in variety of industrial processes such as production of starch, oil, high fructose, corn sweetener, ethanol, and alkaline. Maize can be boiled or roasted; the grains can be cooked fresh or dry; and the dry grain can be made into 'egbo', popcorn 'guguru' and eaten with roasted groundnuts (Doebley, 2004). 'Kangu', which is also similar to 'akara' Ogbomoso, derived its name from its main center of production, Ilorin, an ancient town in Kwara

State, Nigeria, and may be consumed alone or in combination with cereal porridge and soaked 'garri' (Falade et al., 2003). The technology of 'kangu' production involves crushing of the Bambara nut to facilitate winnowing of the seed coat, followed by a short soaking period in water to condition the cotyledons. Wet-milling of the conditioned cotyledon is done with the addition of a small amount of water to produce a paste of low moisture content (Vasal, 2005). The paste is seasoned with salt, pepper, onion and flattened with the palm and fried in hot vegetable oil to produce reddish brown, hard textured, and low moisture product. Constraints on the wider use of Bambara as food or snacks beyond the West Africa region are the tedious, labor intensive and time-consuming task of preparation. However, through the use of improved technology, Bambara paste may now be prepared from processed Bambara flour (Oyeyinka et al., 2017). The purpose of this work is to develop and examine the characterize 'Kangu'; produced using composite flour of Bambara groundnut and maize.

Materials and methods

Source of materials

The fresh Bambara nut, maize (yellow variety) and other ingredients such as salt, vegetable oil, dry pepper and onion was purchase from local market in Ibadan, Nigeria.

Preparation of bambara nut flour

The Bambara nuts were processed into flours using the earlier reported method (Olapade et al., 2014) with slight modifications. The Bambara nuts were first thoroughly cleaned by picking up all stones and other foreign materials while sorting out the bad ones. The clean seeds were soaked in water for 2 hours and parboiled (100°C) for 20 minutes. The seeds were dehulled manually and dried at 60°C in the oven (DHG-9123, INESA Drying oven) for 48 hours. The dried seeds were then dry milled into flour in a hammer mill (8 LAB MILL, Serial Number 50681, 8000 rpm, CHRISTY AND NORRIS LIMITED PROCESS ENGINEERS CHELMSFORD, ENGLAND). The milled cotyledon was sieved through a fine 300 µm mesh sieve to obtain the Bambara flour, which was packaged in a ziplock bag until used.

Preparation of maize flour

The maize grains were processed into flour according to the method of Echendu et al. (2004) with slight modifications. The maize grain was sorted to remove all the bad ones, stones and other foreign materials. The clean grain was sundried for 5 days. The dried grain was then dry milled into flour in a hammer mill (8 LAB MILL, Serial Number 50681, 8000 rpm, CHRISTY AND NORRIS LIMITED PROCESS ENGINEERS CHELMSFORD, ENGLAND). The milled grain was later sieved through 300 µm mesh sieve to obtain fine maize flour, which was packaged in a ziplock bag until used.

Formulation of flour composite

The blends of Bambara and maize flours were prepared by mixing the flours in the following ratios: 90:10, 80:20, 70:30 and 60:40, respectively, while 100:0 Bambara nut flour serve as the control. The mixing of the flour composite was done in a food mixer (Kenwood Electronic UK, Unified National Inventory Database 060377) for proper mixing to form a homogenous product. After mixing, it was transferred into a ziplock bag and kept until used.

Preparation of "Kangu"

"Kangu" was produced according to the method described by (Falade et al., 2003; Oyeyinka et al., 2017) with slight modifications. Bambara and maize flours were weighed and mixed in the ratios of 100:0, 90:10, 80:20 70:30 and 60:40. To 100 g of each of the flour mixtures, 3 g of common salt, 15 g of grated red onion, 10 g of grated dry red chilli pepper and 30 mL of water were added and stirred to form stiff pastes. The thick paste formed was flattened (1.00±0.10 cm thickness) on a flat surface using a roller. These were deep fried in a refined palm oil olein vegetable oil (specific gravity 0.918, refractive index 1.464) at a temperature of 170±5°C for 7±0.5 min (Oyeyinka et al., 2017), and cooled for 20 min (Falade et al., 2003). The "kangu" pieces was then drained, packaged, until it is needed for sensory and colour analysis.

Storage of snacks

Freshly prepared snacks were kept in ziplock bags in a low-density polyethylene for a period of 10 weeks at room temperature (25±2 °C) under a light atmospheric condition. Appearances of the samples stored at room temperature were determined at an interval of 1 week for the period of storage.

Water absorption of stored snacks

The amount of water absorbed by the stored samples was estimated by determining the weight gain in g for a period of 10 weeks. The weight gain was measured by subtracting the initial weight of the samples before storage from the final weight after storage, which could result during storage.

Instrumental colour measurement

Instrumental colour measurement (L*, a*, b*, Δ E* and hue angle) of the composite flour and fresh "kangu" samples were obtained with a Konica Minolita Chroma Meter CR-410 (Sensing, Japan). L* stands for lightness and ranges from 0 (black) to 100 (white), with 50 representing 'middle gray', a* (red-green) axis-positive value are red; negative values are green, and 0 is neutral. On the b* (yellow-blue) axis, positive values are yellow, negative values are blue, and 0 is neutral. ΔE* is known as total colour differences, which are calculated as values. Hue angle ($\tan^{-1}$ b* / a*) and 180 + ($\tan^{-1}$ b* / a*) was calculated from +a* (redness), -a* (greeness), +b* (yellowness) and –b* (blueness). It is expressed in radian (0-360) and if this factor reveals 0-90, 90-180, 180-270 the colour signified is red-yellow, yellow-green, and green-blue respectively. The instrument was standardized, and the samples were placed in the sample holder. Colour measurement was determined in triplicates for each sample, and their means were recorded.

Functional properties

The method described by Emeje et al., (2012) was used to determine the bulk density of the flour blends. Two gram of the powdered sample was measured in a 10 mL measuring cylinder and the volume (V0) occupied without tapping was noted. After 100 taps on the table, the filled volume (V100) was noted. The bulk loose and packed density was calculated as the ratio of the weight to volume (V0 and V100, respectively). Oil absorption capacity was carried out using the procedure as describe by Emeje et al. (2012). Two grams of the sample was added to 20 mL of vegetable oil in a weighed 25 mL centrifuge tube. The suspension was stirred occasionally with a glass rod over 30 minutes at 25°C. The supernatant was decanted and discarded, the adhering top of oil is removed, and the tube with the content was reweighed. The oil absorption capacity is expressed as the weight of oil bound by 100 g dry flour. Water absorption capacity was determined according to method describe by Olapade et al. (2003). A flour sample (1.5 g) was measured into a centrifuge (Eppendorf 5804 with F-34-6-38 fixed-angle rotor); the sample was mixed thoroughly with 10 mL of distilled water for 30 seconds, after which it was allowed to stand for 10 minutes at room temperature and then centrifuged at 3000 rpm for 30 minutes. Water absorption capacity was expressed as the mass of water bound by a sample. The dispersibility (%) was determined according to method described by Olapade et al. (2003). 10 g of flour samples were weighed into 100 mL measuring cylinder, and distilled water was added to reach a volume of 100 mL. The set up was stirred vigorously and allowed to settle for 3 hours. The volume of the settled particles was recorded and subtracted from 100. The difference was taken as % dispersibility.

Effect of temperature on swelling power of composite flour

The method of Abayomi et al. (2013) was used in this study. One gram of the flour sample was weighed into a 25 mL plastic centrifuge tube. 10 mL of distilled water was added to the sample and mixed gently. The slurry was heated in a water bath at 50°C, 60°C, 70°C, 80°C and 90°C, respectively, for 30 minutes. The solution was gently shaken during heating to prevent clumping of the starch; the gelatinized sample was cooled at room temperature and centrifuged at 6000 rpm for 15 minutes. Then the supernatant was decanted and the weight of the sediment was recorded. The swelling power was represented as the ratio of the weight of the wet sediment to the weight of the initial dry sample.

Proximate composition

The composite flour samples were analyzed chemically according to the official methods of analysis (AOAC, 2010). Moisture content, crude fat, crude protein, crude fibre, total ash, and carbohydrate were determined. Total carbohydrate was obtained by difference.

Sensory evaluation

Sensory evaluation of the samples was carried out as described by Oyeyinka et al. (2017). Using 100% Bambara flour as the control, the following parameters: taste, colour, crunchiness, texture and general acceptability were evaluated on the coded "kangu" samples. A semi trained panel of twenty (20) selected from student of the University of Ibadan, Department of Food Technology was used to carry out the analysis. The rating of the product was based on overall acceptability and sensory attributes of appearance, flavour, colour, taste and crunchiness (Oyeyinka et al., 2017). Prior to the sensory analysis, panelists were screened with respect to their interest and ability to differentiate between food sensory properties. The panelist were asked to record their observation on the sensory sheet based on 9-point hedonic scale where "Like extremely" = 9, "Dislike extremely" = 1 and neither "like nor dislike" = 5. Drinking water was provided for the respondents to clean their palates between samples.

Statistical analysis

Analysis of variance (ANOVA) was performed on all data using SPSS (Statistical Package for Social Science) version 20, and the means were separated by a post hoc test (Duncan Multiple range test) at 5% level of significance to determine the significant differences between the means.

Results and discussion

Proximate composition of bambara-maize blends

The proximate composition of Bambara-maize blends is presented in Table 1. The fat, moisture, fibre, and ash increased from 6.33%, 7.67%, 0.74% and 2.00% at 10% level of substitution to 7.83%, 10.66%, 1.85%, 3.83% at 40% level of substitution, respectively, while the protein and carbohydrate content decreased from 21.11% and 61.96% at 10% level of supplementation to 18.05% and 57.77% at 40% level of supplementation, respectively. These values were significantly different ($p < 0.05$) compared with the values obtained for the control at 5.67%,7.33%, 0.56%, 1.67%, 22.78% and 61.99%, respectively. Although, the protein content of 100% Bambara nuts flour was higher than that of 10% to 40% level of maize flour inclusion.

The composition of protein in the Bambara nut flour is in agreement with the values (21-28 g/100 g), earlier reported (Adebowale et al., 2002; Arise et al., 2015). Moisture, fat, fibre and ash composition of the Bambara flour were not generally low relative to composite blends. Low fat composition in Bambara nut flours is expected since these seeds are pulses. Pulses generally have a low contents of oil usually below 10 g/100 g (Oyeyinka et al., 2017) when compared to oil seeds such as soybean. It is thus obvious that Bambara nut flour is the major source of protein in the composite flour, while maize flour provided the bulk of moisture, fat, fibre, and ash. Also, it was observed that the protein content of the blends decreased significantly with the increase in the supplementation level with maize flour, thus confirmed that maize originally contains more carbohydrate than bambara nut.

Functional properties of bambara/maize composite flour

The results obtained for the functional properties of Bambara/maize and Bambara flours are presented in Table 2. There was a significant difference ($p < 0.05$) in the bulk density, dispersibility, oil and water absorption capacity and swelling power of the flour samples compared with the values obtained for the control (Table 2). The result of the loose bulk density and packed bulk density ranged from 0.46 g/ml to 0.49 g/ml of maize/Bambara flour, while Bambara flour had 0.38 g/ml. Likewise, the packed bulk density ranged from 0.67 g/ml to 0.74 g/ml, and Bambara flour had 0.68 g/ml. The loose bulk density values of the composite flours were higher than 100% Bambara flour. Processed samples that yield high bulk density indicate heavy weight and, hence, occupy little space and require a small amount of packaging material per unit weight, which attract a low cost of packaging (Padmashree et al., 1987). There was increase in the bulk density of Bambara/maize flour. The increase in the bulk density could be due to heavy weight of maize flour. This implies that composite flour (60/40% Bambara/maize) had the highest bulk density as a result of the high supplementation of maize flour. Ajanaku et al. (2012) reported that flour density and size influence the bulk density; hence, it is very important in determining raw material

Table 1. Proximate composition of bambara-maize flour (%)

Samples	Protein	Moisture	Fat	Crude fibre	Ash	CHO
100:0	22.78±0.72a	7.33±0.58c	5.67±0.76b	0.56±0.01b	1.67±0.76d	61.99±1.27a
90:10	21.11±0.55ab	7.67±0.58bc	6.33±0.58b	0.74±0.32b	2.00±0.50cd	61.96±1.52a
80:20	19.88±2.03bc	9.33±0.58ab	6.67±1.04ab	1.30±0.32ab	2.67±0.29bc	59.99±3.32ab
70:30	18.84±0.23c	10.00±1.00a	6.83±0.29ab	1.67±0.56a	3.33±0.29ab	59.32±0.83ab
60:40	18.05±0.90c	10.66±1.53a	7.83±0.29a	1.85±0.64a	3.83±0.29a	57.77±0.76b

Values are mean ± SD of triplicate determination. Values for samples in the same column with different superscripts are significantly different at 5% probability level ($p< 0.05$).

handling and packaging requirements.

This implies that the dispersibility of 100% Bambara flour was lower than composite blends samples. Sample 60:40 had the highest dispersibility among flour samples and were significantly higher than other samples ($p < 0.05$). This result was in agreement with Olapade et al. (2014) in Bambara/fufu flour blends. The values of dispersibility of Bambara/maize flour samples are comparatively high, and this implies that the samples can be reconstituted easily to give fine consistency dough during mixing. There was a significant decrease ($p < 0.05$) in water absorption capacity between Bambara/maize flour with substitution ≥ 30% and 100% Bambara flour. Samples with 20% maize flour had the highest water absorption capacity of 0.80 g/g among all flour samples and were significantly higher than other samples ($p < 0.05$). The presence of high fat content in flours might have adversely affected the OAC of composite flours. The OAC was found to be insignificant to each other at (p >< 0.05) at 10 and 20% also at 30 and 40% level of substitution. Therefore, the possible reason for increase in the OAC of composite flours after incorporation of maize flour is the variations in the presence of non polar side chain which might bind the hydrocarbon side chain of the oil among the flours. Low fibre content can also cause a reduction in oil capacity as earlier reported by (Aletor et al., 2002).

The dispersibility of 100% Bambara flour was lower than Bambara/maize composite flour samples (Table 2). Sample 60:40 had the highest dispersibility among flour samples and were significantly higher than other samples ($p < 0.05$). This result was in agreement with Olapade et al. (2014) in Bambara/fufu flour blends. The values of dispersibility of Bambara/maize flour samples are comparatively high, and this implies that the samples can be reconstituted easily to give fine consistency dough during mixing.

Effect of temperature on swelling power of composite flours

The results of the swelling power of the flour samples at different temperatures are presented in Table 3. The result shows that there were significant differences ($p < 0.05$) from each other at 50 to 60°C but significantly the same at 70 to 90°C. Kim et al. (1996) also report an increase in the swelling power capacities of potatoes noodles as temperature increases. The result showed that swelling power increases in direct proportion to the increase in temperature. At the highest temperature of 90°C, the flour has the highest value.

There was a gradual swelling at 50 to 60°C, thereafter increased steadily with increase in temperature from 70 to 90°C (Table 3). These results are in agreement with the previous study (Baguma et al., 2011). Swelling power is a factor ratio of the amylase and amylopectin, the characteristics of each fraction in terms of molecular distribution, degree or length of branching and confirmation.

Sensory evaluation of fresh snacks

The sensory scores of freshly kangu prepared from Bambara flour supplemented with maize flour were presented in Table 4. It is interesting to note that there were no significant differences (p><0.05) in appearance, colour, flavour, taste, crunchiness and overall acceptability. The sensory score for overall acceptability of kangu ranged from 6.45 at 10% level of maize supplementation to 6.95 at 40% level of maize supplementation, while 100% Bambara flour was 6.60, although there was no significant difference (p>< 0.05) in the rating, "kangu" made from 60:40 was the most preferred to the panelists.

Appearance and water absorption of freshly prepared and stored snack

The appearance of the snack made from Bambara/maize and Bambara flour is shown in Figure 1. Snacks prepared from Bambara flour had a similar appearance to those made from Bambara/maize flour. The colour of the samples varied from golden brown to dark brown, which may be due to Maillard browning resulting from the reaction between the carbonyl group of carbohydrate and amino groups of amino acids. After 10 weeks of storage, no mould growth was evidenced on all the samples except for the sample that contained (80% Bambara flour and 20% maize flour) (Figure 2). Furthermore, the ability of the snacks to absorb water,

Table 2. Functional properties of composite flours

Samples	WAC (g/mL)	OAC (g/mL)	Dispersibility (%)	BDL (g/g)	BDP (g/g)
60:40	0.53 ± 0.09bc	0.55 ± 0.07ab	76.50 ± 0.71a	0.49 ± 0.02a	0.74 ± 0.04a
70:30	0.47 ± 0.09c	0.60 ± 0.00ab	74.50 ± 0.71ab	0.49 ± 0.02a	0.71 ± 0.00ab
80:20	0.80 ± 0.09a	0.40 ± 0.14b	73.00 ± 0.00abc	0.46 ± 0.03a	0.65 ± 0.03b
90:10	0.73 ± 0.00ab	0.40 ± 0.00b	72.00 ± 2.82bc	0.47 ± 0.01a	0.67 ± 0.01ab
100:0	0.60 ± 0.09abc	0.70 ± 0.14a	69.50 ± 2.12c	0.38 ± 0.01b	0.68 ± 0.05ab

Values are mean ± Standard deviation of duplicate determination. Values for samples in the same column with different superscripts are significantly different at 5% probability level ($p < 0.05$). WAC – Water Absorption Capacity; OAC – Oil Absorption Capacity; BDL - Bulk Density Loose; BDP – Bulk Density Package.

Table 3. Swelling power of bambara/maize flours and bambara flour (°C)

Sample	50°C	60°C	70°C	80°C	90°C
60:40	1.50 ± 0.00ab	1.55 ± 0.71cd	1.90 ± 0.14a	4.70 ± 0.14a	4.75 ± 0.21a
70:30	1.35 ± 0.71b	1.50 ± 0.14d	1.95 ± 0.35a	4.80 ± 0.14a	4.80 ± 0.14a
80:20	1.50 ± 0.14ab	1.75 ± 0.71bc	1.90 ± 0.14a	4.80 ± 0.00a	4.70 ± 0.01a
90:10	1.70 ± 0.01a	1.85 ± 0.71b	2.00 ± 0.14a	4.55 ± 0.35a	4.90 ± 0.14a
100:0	1.65 ± 0.71a	2.35 ± 0.71a	2.25 ± 0.71a	4.90 ± 0.14a	5.00 ± 0.00a

Values are mean ± Standard deviation of duplicate determination. Values for samples in the same column with different superscripts are significantly different at 5% probability level ($p < 0.05$).

which was assessed over a 10-week period, show that the snacks absorbed water differently (Figure 3). Changes in temperature and relative humidity in the environment of the stored snacks results in moisture build up among the samples. The relatively high amount of moisture absorbed by sample labeled C may explain why the sample alone had mould growth after 10 weeks of storage. The results were in agreement with those reported on storage changes by (Oyeyinka et al., 2017).

Colour parameters of composite flour and snacks

The results of the colour measurement of the flour samples are presented in Table 5. The L* and a* values were insignificantly different (p>< 0.05) between samples. The b* value showed the degree of yellowness of the snack sample which was observed to increase with increase in bambara substitution with maize. The degree of yellowness increased as the supplementation with maize increased from 10 to 40%. This was expected because yellow maize variety was used for this study, which explains why the sample with the highest maize concentration has the highest degree of yellowness. Δ E* is often employed in pass/fail colour production application and all samples except for 60/40% bambara/maize are insignificantly different (p><0.05). however, the values obtained for hue angle showed that the composite flour were yellow-green and was observed to increase as the level of maize substitution increases.

The results of the colour measurement of the snacks are presented in table 6. The a* and b* values were observed to decrease with an increase in bambara substitution with maize. It was observed that the hue angle increase with an increase in substitution of bambara with maize. The hue angle values obtained showed that the snacks were orange yellow tending towards yellow.

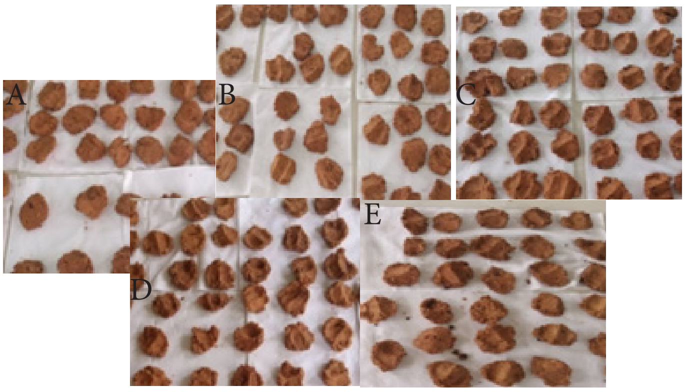

Figure 1. Snacks prepared from bambara and maize flour
Remarks:
A: Fresh snacks prepared from 100% Bambara groundnut flour
B: Fresh snacks prepared from Bambara groundnut flour/maize flour (9 0/10)
C: Fresh snacks prepared from Bambara groundnut flour/maize flour (80/20)
D: Fresh snacks prepared from Bambara groundnut flour/maize flour (70/30)
E: Fresh snacks prepared from Bambara groundnut flour/maize flour (60/40)

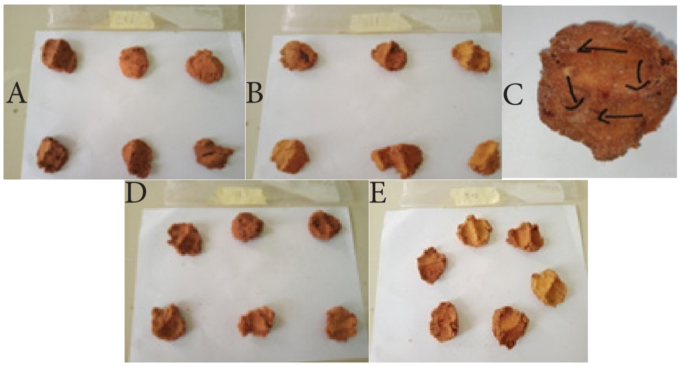

Figure 2. Appearance of stored snacks at room temperature 25°c after 10 weeks

Arrows indicate mould growth on snacks

Remarks:
A: Stored snacks prepared from 100% Bambara groundnut flour
B: Stored snacks prepared from Bambara groundnut flour/maize flour (90/10)
C: Stored snacks prepared from Bambara groundnut flour/maize flour (80/20)
D: Stored snacks prepared from Bambara groundnut flour/maize flour (70/30)
E: Stored snacks prepared from Bambara groundnut flour/maize flour (60/40)

Table 4. Sensory qualities of "kangu" made from bambara/maize and bambara flour

Samples	Appearance	Colour	Flavor	Taste	Crunchiness	Overall acceptability
60:40	6.40±1.27a	6.60±1.19a	6.55±1.23a	6.85±1.14a	7.00±1.26a	6.95±0.89a
70:30	6.50±1.28a	6.40±0.99a	6.35±1.35a	6.45±1.19a	6.90±1.62a	6.75±1.75a
80:20	6.40±1.19a	6.15±1.14a	6.50±1.00a	6.15±1.09a	6.65±1.18a	6.60±0.75a
90:10	6.65±1.27a	6.30±1.56a	6.30±1.63a	6.30±1.26a	6.35±0.75a	6.45±1.05a
100:0	6.65±1.31a	6.65±1.09a	6.35±1.42a	6.20±1.24a	6.15±1.31a	6.60±1.05a

Mean values ± Standard deviation (n=20). Mean values for samples in the same column with the same superscripts are significantly the same at 5% probability level (p< 0.05).

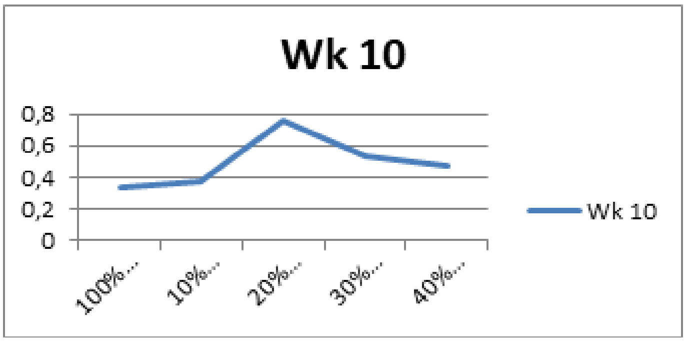

Figure 3. Water absorbed (g) by snacks prepared from bambara groundnut and maize flour (N=6)

Table 5. Bambara/maize flour and bambara flour colour determination (%)

Colour	**60:40**	**70:30**	**80:20**	**90:10**	**100:0**
L	82.67±0.70a	84.66±1.22a	83.64±1.85a	84.55±1.42a	85.60±1.22a
a*	-5.81±0.77a	-5.37±0.36a	-5.06±0.33a	-5.52±0.05a	-5.32±0.07a
b*	27.59±0.62a	25.17±0.38c	22.98±0.19c	19.53±0.25d	16.38±0.41e
Δ E	72.50±0.66a	69.74±1.09b	68.42±1.74b	68.32±1.46b	69.58±2.00b
Hue angle	101.90±1.73b	102.05±0.95b	102.41±0.21b	105.89±0.21a	107.44±0.22b

Values are mean ± SD of triplicate determination. Values for samples in the same row with different superscripts are significantly different at 5% probability level ($p < 0.05$).

Table 6. Colour determination of fresh "Kangu" on day 0 (%)

Colour	**60:40**	**70:30**	**80:20**	**90:10**	**100:0**
L*	31.31±0.02e	40.96±0.06b	38.11±0.23c	47.94±3.25a	35.37±0.04d
a*	4.20±0.09c	7.56±0.07b	8.20±0.26b	12.63±1.34a	7.30±0.36b
b*	10.73±0.02c	15.54±2.84b	15.17±0.09b	22.02±1.74a	14.43±0.35b
Δ E	16.15±0.02d	28.20±0.01b	25.03±0.28bc	37.95±4.04a	22.27±0.57c
Hue angle	68.13±0.05a	66.29±0.13b	61.57±0.39d	60.20±0.70e	63.17±0.64c

Values are mean ± SD of triplicate determination. Values for samples in the same row with different superscripts are significantly different at 5% probability level ($p < 0.05$).

Conclusions

This study has determined the chemical and functional properties of Bambara nut and maize flour that are essential for production of good quality 'kangu'. Bambara is a good source of protein and carbohydrate. This shows that it is possible to substitute bambara nut flour with maize up to 40% level of substitution to produce kangu without any adverse effect on the sensory attributes. The lightness value of the snacks slightly decreases while the samples pick up moisture during storage. The storage study of snacks packaged in ziplock bags stored at ambient conditions (25±3°C) could keep the samples for less than 10 weeks as one of the samples showed onset evidence of mould growth. The ready-to-eat snacks produced from Bambara and maize composite flours contained 18-23% protein content. Therefore, kangu produced from the composite flour could be a good source of protein for children, vegetarians or people who are accustomed to fried foods. Bambara nut is a good source of protein but are underutilize because of inconvenience and lack of new, innovative form of use. Kangu represent a unique way of using bambara as a primary ingredient.

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