ASSESSMENT OF THE NUTRITIONAL QUALITY OF BAMBARA GROUNDNUT CONDIMENT (BGNC) AND CONSUMER ACCEPTABILITY OF BGNC IN OKRO SOUP

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ABSTRACT

Food insecurity is a major problem in African countries. Increasing food diversity will improve the availability of food, thereby reducing food insecurity. A dadawa-like product (Bambara groundnut condiment-BGNC) was made from Bambara groundnut. Nutritional composition, protein quality and consumer acceptability of the product were assessed using standard methods. Consumer acceptance of BGNC compared favourably with dadawa (DDW), a popular fermented condiment (made from Parkia biglobosa) in South-West, Nigeria. The protein content of BGNC (21.69 %) compared to that of dadawa (21.41 %). Magnesium, phosphorus and potassium concentrations were higher in BGNC than in DDW (69.04 vs 28.23, 189.13 vs 78.22, 82.26 vs 19.43) mg/100g for BGNC vs DDW respectively. The protein quality of Bambara groundnut condiment-based feed compared fairly well with that of other protein sources like fish and casein. The possibility of making condiment from Bambara groundnut was ascertained in this study. Bambara groundnut condiment was well accepted by consumers. The acceptance compared favourably well with dadawa; as there was no significant difference ($p>0.05$) in appearance, taste and overall acceptability of BGNC and DDW when used to garnish okro soup. Consumers of the Bambara groundnut condiment will benefit from its high nutritional value.

Keywords: ***Bambara groundnut, condiment, consumer acceptability, mineral content, protein quality, proximate analyses.***

INTRODUCTION

Bambara groundnut is a legume that is generally believed to be a bean. Its seeds are however dug from the ground like groundnuts. Bambara groundnut is a herbaceous plant that grows annually, its stems creep on the soil or very close to the soil when raised, but there is also an erect form.It is a leguminous plant with plenty of nitrogen-fixing nodules on the roots (Bamishaye *et al*., 2011).Bambara groundnut is grown for its seeds, however, the stem and leaves are used as forage for feeding animals. The seeds are within the pods and are beneath the soil. The pods are large and round, they bear one or two seeds that are round, smooth, and very hard when dried, they vary in size and may be up to about 1.5cm in diameter (Ibrahim *et al*., 2018). The seeds are shaped more like peas than groundnuts. The Bambara groundnut seeds are very tasty and highly nutritious, they come in varying colours (white, cream, dark brown, red, black and speckled) and patterns but the shape is always round regardless of the variety. Bambara groundnut is the legume with the greatest ability to withstand drought of high intensity, it survives well in areas where annual rainfall is below 500 mm, therefore when grown at the peak of the dry season, it will still survive and bear seeds during the rainy season when it will be enabled by rainfall to accomplish its vegetative cycle (Mubaiwa *et al*., 2018). The seeds of

Bambara groundnut are complete food in themselves, they contain a complimentary and balanced amount of the major food nutrients, i.e., carbohydrates, fat and protein (Bamisaye *et al*., 2011). Bamabara groundnut seeds are rich in minerals and vitamins (Ijarotimi & Esho, 2009; Muimba-Kankolongo, 2018). On average, the per centage composition of carbohydrates, protein and fat in Bambara groundnut seeds are 63 per cent, 19 per cent and 6.5 per cent respectively (Adebowale, 2011). Hence, the consumption of the Bambara groundnut diet only will give a diet that is fairly balanced in nutrients (Jideani & Diedricks, 2014). Generally, legumes are higher in protein than other plants, past works (Ijarotimi & Keshinro, 2013; Rotimi *et al*., 2013; Ewuola *et al.*, 2015) have established that the protein quality of Bambara groundnut seeds is high in comparison with other legumes. The essential amino acids in Bambara groundnuts were reported to be higher than that of other legumes, for example, Bambara groundnut was reported to have a protein score of 80 percent while groundnut had a protein score of 65 percent and cowpea had a protein score of 64 percent (Yao *et al*., 2015). In addition, the predominant fatty acids identified in Bambara groundnut seeds were linolenic acid, linoleic acid and palmitic (Adeleke *et al*., 2018). Bambara groundnut seeds were also found to be fairly rich in carotene, niacin, riboflavin and thiamine; the content of ascorbic acid in it was, however, low (Muimba-Kankolongo, 2018).

In South-West, Nigeria, Bambara groundnut is an underutilized food crop due to a lack of knowledge of its health benefits and availability (Olanipekun *et al*., 2017). Part of the efforts being made at promoting the utilization of Bambara groundnut is the development of products from the seeds. One such product is the Bambara groundnut condiment flour, which can be used as food additive to enhance the flavour and taste of food. The need therefore arises to assess the nutritional quality of the processed Bambara groundnut condiment flour through proximate, mineral and protein quality analyses.

MATERIALS AND METHODS

Collection and authentication of Bambara groundnut seeds

Bambara groundnut seeds were obtained from Bodija Market in Ibadan, Oyo State, Nigeria (7.2535°N, 3.5439°E). The seeds were authenticated at the Grain Legumes Improvement Program, Institute of Agricultural Research and Training, Moor Plantation, Ibadan (7.3612°N, 3.8497°E).

Processing of Bambara groundnut condiment flour

The Bambara groundnut condiment was prepared according to the modified method in Farinde *et al.* (2007). Clean Bambara groundnut seeds (3 kg) were soaked overnight, then de-hulled on the kitchen sink railings using a flat wooden spatula specially made for that purpose. The de-hulled seeds were then cooked in a pressure cooker for about 25 minutes; the pressure knob of the pot was released and the cover was removed. The remaining cooking water was allowed to get dried on the seeds by continuous heating at low heat, to retain nutrients. The boiled seeds were immediately poured into calabash already lined with banana leaves, covered properly with cloth and placed in a warm place to ferment for 72 hrs. After fermentation, the samples were dried in an oven at 50 °C for 24 hours. The dried fermented seeds were milled into fine flour using an attrition mill. The milled flour was kept in an airtight container and kept in the freezer (- 4 °C) for subsequent use.

Processing of dadawa (DDW) flour

Dadawa (ready to use) was bought from Apata market, Ibadan. The DDW sample was spread thinly in a tray and dried in the oven

at 50 °C for 24 hours. The dried fermented seeds were milled into fine flour using a kitchen mill (Philip HR2106/01). The milled flour was kept in an airtight container and kept in the freezer (- 4 °C) for subsequent use.

Sensory evaluation vs consumer acceptability test of Bambara groundnut condiment (BGNC)

Bambara groundnut condiment (BGNC, 5g) and 5g of dadawa (DDW) were separately added to two different portions of okro soup (OkrB and OkrD). Another sample of okro soup was made without condiment (OkrN); that served as control. The samples were served to a twenty-man taste panel that comprise purposively selected panelists who were familiar with the dadawa taste in soup. Panelists scored the soup samples for properties of condiments used in soup preparation. Evaluation was done using 9-point hedonic scale where 9 was maximum (like extremely) and 1 was minimum (dislike extremely)**.** Samples were scored for appearance, flavour, taste and overall acceptability. The panelists were instructed to rinse their mouth before tasting each sample. This was done to prevent taste interference.

Proximate analysis of Bambara groundnut condiment (BGNC) and dadawa (DDW)

The proximate analyses were carried out according to the Association of Official Analytical Chemists (2005) methods. Moisture content was determined using the hot air circulating Gallenkamp oven; samples were dried at 105°C until constant weight was achieved. Ash was determined by incineration of known weights of the samples at 550°C, using a muffle furnace. Crude fat was extracted over petroleum ether (boiling point, 42°C – 62 °C), using the Soxhlet extraction apparatus. Protein content was determined using the Kjeldahl method (N X 6.25). The crude fibre was determined after digesting a known weight of fat-free sample in refluxing 1.25 % tetra oxo sulphate (vi) acid (H_2SO_4) and 1.25 % sodium hydroxide (NaOH). Carbohydrate content was estimated by difference, i.e., removal of the summation of values obtained for moisture, ash, crude fat and crude fibre, from 100.

Mineral analyses of Bambara groundnut condiment (BGNC) and dadawa (DDW)

Determination of calcium, potassium and sodium concentrations in BGNC and dadawa (DDW)

Determination of calcium, potassium and sodium concentration was done by the method of Association of Official Analytical Chemists (2005).5 ml of 2 M HCl was added to the ash of the sample for digestion. This was followed by heating to dryness on a heating mantle. Another 5 ml of 2 M HCl was added to the dried digested sample; this was brought to boil and then filtered into a 100 ml volumetric flask, using Whatman No 1 filter paper. The filtrate was made to mark with distilled water, stoppered and made ready for reading of concentration on the Jenway Digital Flame Photometer (PFP7 model) using the standard corresponding to each mineral element. Different concentrations of calcium chloride ($CaCl_2$), potassium chloride (KCl_2) and sodium chloride (NaCl) were used as standards for the mineral elements calcium (Ca), potassium (K) and sodium (Na) determined respectively. The concentration of each of mineral element was calculated using the formula:

$$Mineral\ element\ (\frac{mg}{kg}) = \frac{MR \times slope \times dilution\ factor}{100}$$

where,

MR = Meter reading

Determination of phosphorus concentration in Bambara groundnut Condiment (BGNC) and dadawa (DDW)

Phosphorus was determined by the Vornado-molybdate spectrophotometric method as described by the Association of Official Analytical Chemists (2005). The ash of the BGNC sample was treated with 2 M HCl solution as described for calcium, potassium and sodium concentration above. 10 ml of the filtrate was pipetted into a 50 ml standard flask and 10 ml of Vornado-molybdate solution was added, the flask was made up to mark with distilled water, stoppered and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the optical density (OD) on a Metrohm Spectronic 21D spectrophotometer at a wavelength of 470nm.

The concentration of phosphorus was calculated as:

$$\text{Phosphorus}\left(\frac{mg}{kg}\right) = \frac{\text{Absorbance} \times slope \times dilution\ factor}{100}$$

Determination of micro-mineral concentration in BGNC and DDW

The micro mineral elements (iron, zinc, copper, selenium, manganese) in the Bambara groundnut condiment (BGNC) were analyzed as described by Omenna *et al.* (2016). Different concentrations of the chloride salts of each mineral element were prepared. The optical density of each standard solution was measured at 540 nm. A graph of absorbance against concentration was obtained for the salt of each micro-mineral, and the slope was found for each graph. The diluent of digested ash sample of BGNC obtained above was aspirated into the Buck 200 atomic absorption spectrophotometer through the suction tube provided, and the optical density of the sample was also read at 540nm. The corresponding concentration of each micromineral element in the sample was taken as follows:

$$Mineral\ element\ \left(\frac{mg}{kg}\right) = \frac{\text{Absorbance} \times slope \times dilution\ factor}{100}$$

Protein quality studies of BGNC

The protein quality studies were done as described by Ijarotimi & Keshinro (2013). Twenty Wistar rats, (weanling, 2 weeks old); with weight range 40-42 g were used for the study. Rats were divided into 4 groups (n = 5). The cages were labelled 1 to 4. Rats in group 1 were fed on a casein meal as the protein source and served as the control group. Group 2 rats were fed on fish meal as a protein source; group 3 rats were fed on Bambara groundnut condiment as protein source, while group 4 rats were fed on nitrogen free diet. Each rat was kept in a separate cage made especially for the study. The rats were fed for 28 days, they were given feed and water *ad libitum.* Urine samples were collected daily from each cage into a small urine container which contained about $1cm^3$ conc. H_2SO_4. Faecal samples were also collected daily from each cage. The faecal samples were weighed, dried, and milled. Samples of the diet, faeces and urine of the rats were then analyzed for Nitrogen by the Kjeldahl method (Association of Official Analytical Chemists, 2005).

Feed intake of rats

The amount of feed given to each rat was recorded daily. Before giving feed the following day, the amount of feed left in the feed tray was weighed and recorded. The feed intake of rat was calculated as:

$$Feed\ intake/day = Quantity\ of\ feed\ given/day - Quantity\ of\ feed\ left\ in\ feed\ tray/day$$

Table 1: Composition of experimental diet for protein quality study of Bambara groundnut condiment

Ingredients	Group 1	Group 2	Group 3	Group 4
Corn-starch (%)	81	81	81	91
Salt/mineral mixture (%)	4	4	4	4
Fat (%)	5	5	5	5
Casein (%)	10	-	_	_
Fish meal (%)	_	10	_	_
BGNC (%)	_	_	10	_

Salt/mineral mix contains the following (in g/100 g): *calcium phosphate, 49.50; sodium powder, 11.80; potassium sulfate, 5.20; sodium chloride, 7.40;magnesium oxide, 2.40; potassium citrate, 22.40; ferric citrate, 0.60; mangnesium carbonate, 0.35; cupric carbonate, 0.03; zinc carbonate, 0.16; chromium potassiumsulfate, 0.055; potassium iodate, 0.001; sodium selenate, 0.001; choline chloride, 0.50; thiamine HCl, 0.06; riboflavin, 0.06; niacin, 0.30; calcium pantothenate, 0.16;biotin, 0.01; vitamin B12, 0.10; vitamin D3, 0.025; vitamin E acetate, 1.00; pyridoxine, 0.07; folic acid, 0.02; vitamin A acetate, 0.08.*
BGNC is Bambara groundnut condiment.

Body weight determination

Body weights of the rats were taken before and after feeding trial. Each rat was put in a pre-weighed small container that has been designed for that purpose. Rat and container were placed on a digital balance (Camry model EK8022). The body weight before feeding on experimental diet (initial body weight) and after feeding on experimental diet (final body weight) were taken and recorded. The weight gain of each rat was determined by subtracting the initial body weight from the final body weight.

Protein quality parameters of BGNC

After the feeding trial, samples of faecal drops, urine and feed were taken to the laboratory for nitrogen analysis. Nitrogen values of rat faeces, urine and feed as well as the weight gain in the rats were used to calculate the following parameters for protein quality:

1. $Nitrogen\ retention\ (NR) = Ni - (Nf - Nef) - (Nu - Neu)$

2. $Biological\ value\ (BV) = \frac{Ni - (Nf - Nef) - (Nu - Neu)\ x\ 100}{Ni - (Nf - Nef)}$

3. $Feed\ efficiency\ (FE) = \frac{Weight\ gained}{Feed\ intake}$

4. $Net\ protein\ utilization\ (NPU) = \frac{Ni - (Nf - Nef) - (Nu - Neu) x\ 100}{Ni}$

5. $Protein\ efficiency\ ratio\ (PER) = \frac{\text{Weight gained}}{protein\ intake}$

6. $True\ digestibility\ (TD) = \frac{\text{Ni} - (\text{Nf} - \text{Nef})\ \text{x}\ 100}{Ni}$

7. $Protein\ rating\ (PR) = PER\ x\ daily\ protein\ intake$

Where
Ni = Nitrogen intake from the food
Nf = Faecal Nitrogen Nef = Endogenous faecal Nitrogen

Nu = Urine NitrogenNeu = Endogenous urine Nitrogen

Statistical analyses

Data were analysed by SPSS (version 20). Values were expressed as Mean ± S.E.M. Mean values were evaluated by one-way analysis of variance (ANOVA) and means were separated by Duncan's multiple range test (DMRT). Differences were considered significant at $p < 0.05$

RESULTS

Proximate analysis of Bambara groundnut condiment flour and dadawa flour

Table 2 is the mean proximate analysis value of Bambara groundnut condiment flour and dadawa flour. The result revealed that Bambara groundnut condiment is rich in protein, it also has an appreciable amount of carbohydrates and other nutrients.

Table 2: Proximate analyses of Bambara groundnut condiment (BGNC) flour and dadawa (DDW) flour

Nutrient	BGNC (%)	DDW (%)
Carbohydrate	50.35 ± 0.41	48.52 ± 0.54
Protein	21.69 ± 0.05	21.41 ± 0.20
Fat	7.30 ± 0.12	5.11 ± 0.13
Fibre	2.78 ± 0.02	3.62 ± 0.31
Ash	9.35 ± 0.14	12.13 ± 0.04
Moisture	8.57 ± 0.04	9.21 ± 0.14

Values are means of three determinations ± SEM, BGNC = Bambara groundnut condiment; DDW = dadawa

Mineral analyses of Bambara groundnut condiment flour and dadawa flour

The mean mineral values of the Bambara groundnut condiment flour and dadawa flour is given in Table 3. The results showed that Bambara groundnut condiment is richer than dadawa in minerals. The most abundant mineral being phosphorus, with concentration of 189. 13 mg /100gvs 78.22 mg /100g in dadawa

Table 3: Mineral analyses of Bambara groundnut condiment (BGNC) flour and dadawa (DDW) flour

Mineral	BGNC (mg/100g)	DDW (mg /100g)
Calcium	19.62 ± 0.01	29.02 ± 0.02
Potassium	82.26 ± 0.02	19.43 ± 0.08
Magnesium	69.04 ± 0.02	28.23 ± 0.06
Sodium	27.97 ± 0.01	18.89 ± 0.13
Phosphorus	189.13 ± 0.05	78.22 ± 1.24
Selenium	0.21 ± 0.01	0.09 ± 0.01
Manganese	0.22 ± 0.03	18.17 ± 0.02
Copper	0.15 ± 0.01	1.99 ± 0.02
Zinc	0.72 ± 0.02	0.11 ± 0.01
Iron	0.63 ± 0.04	1.55 ± 0.01

Values are means of three determinations ± SEM; BGNC = Bambara groundnut condiment; DDW = dadawa

Protein quality parameters of Bambara groundnut condiment

The result of the protein quality of the Bambara groundnut condiment is given in Table 4. Feed supplemented with Bambara groundnut condiment was compared with feed supplemented with other protein sources (fish and casein), all supplementation was at a 10 % level. The result showed that the protein quality of Bambara groundnut condiment compared fairly well with that of other protein sources like fish and casein. The protein quality values for Bambara groundnut condiment-based feed were significantly lower than that of other protein sources used in this work ($p < 0.05$), except for feed efficiency ratio (FER) and protein efficiency ratio (PER), where values for Bambara groundnut condiment were not significantly different ($p > 0.05$) from that of casein meal.

Table 4: Protein quality parameters of feed supplemented with BGNC and other protein sources

Group	NR (%)	BV (%)	FER	NPU (%)	PER	TD (%)	PR
Casein meal	72.91 ± 0.31^{a}	78.81 ± 0.63^{a}	0.36 ± 0.01^{a}	75.87 ±1.24^{a}	2.48 ±0.13^{a}	84.95 ± 2.11^{a}	4.50 ±0.12^{a}
Fish meal	72.53 ±0.42^{a}	77.36 ± 0.56^{b}	0.38 ± 0.02^{a}	75.17 ± 3.24^{a}	1.67 ± 0.09^{b}	84.31 ± 1.19^{a}	3.06 ± 0.13^{b}
BGNC meal	71.64 ±0.12^{b}	61.74 ± 0.97^{c}	0.39 ± 0.04^{a}	69.50 ± 1.18^{b}	2.38 ± 0.06^{a}	62.50 ±1.14^{b}	2.94 ± 0.24^{c}
NFD	0.00 ±0.00^{c}	0.00 ±0.00^{d}	0.3 ±0.00^{b}	0.00 ±0.00^{c}	0.00 ±0.00^{c}	0.00 ±0.00^{c}	0.00 ±0.00^{d}

Values are means of five determinations ± SEM. Means with different superscripts along the same column are significantly different at $p<0.05$

NR= Nitrogen retention; BV= Biological value; FER= Feed efficiency ratio; NPU= Net protein utilization; PER=Protein efficiency ratio; TD= True digestibility; PR= Protein rating; NFD= Nitrogen free diet

Sensory evaluation vs consumer acceptability of Bambara groundnut condiment (BGNC) compared to dadawa (DDW) in okro soup

Bambara groundnut condiment was well accepted by consumers. The acceptance compared favourably well with dadawa. Table 5 shows no significant difference ($p>0.05$) in appearance, taste and overall acceptability of BGNC and DDW when used to prepare okro soup.

Table 5: Sensory evaluation/consumer acceptability of BGNC compared to DDW in okro soup

Sample	Appearance	Flavour	Taste	Overall acceptability
OkrB	8.9±0.1^{a}	8.1 ± 0.1^{b}	8.9 ±0.1^{a}	8.8 ±0.2^{a}
OkrD	9.0 ±0.1^{a}	8.6 ± 0.2^{a}	9.1 ±0.1^{a}	9.0 ± 0.1^{a}
OkrN	8.0 ±0.2^{b}	4.0 ±0.0^{c}	4.2 ±0.1^{b}	4.2 ±0.1^{b}

Values are means of twenty determinations ± SEM; Means with different superscripts along the same column are significantly different at p<0.05; OkrB is Okro soup prepared with Bambara groundnut condiment; OkrD is Okro soup prepared with dadawa; OkrN is plain okro soup

DISCUSSION

The nutritional content of the Bambara groundnut condiment flour revealed that it is rich in protein (21.69 %) and carbohydrate (50.35 %); this result corroborates past reports on the nutrient composition of Bambara groundnut seed flour. Studies have reported that Bambara groundnut seed flour made a complete food as an almost balanced diet which contained enough amount of macro-nutrients like protein, fat and carbohydrate (Bamisaye *et al*., 2011; Jideani & Diedricks, 2014; Mubaiwa *et al*., 2018). The importance of a balanced diet cannot be over-emphasized in human nutrition, especially in relation to growing children. Consumption of a diet that is not balanced will lead to a low intelligence quotient in young children (Ijarotimi & Ijadunola, 2007). The study revealed that Bambara groundnut condiment flour is rich in macro and micro minerals. The result obtained is similar to that reported by Ijarotimi & Esho (2009) for Bambara seeds. However, the values obtained in this work were lower than the values reported by Muimba-Kankolongo (2018) for Bambara groundnut seeds with red seed coat. The difference in the reported values may be varietal. Minerals are very important in human nutrition as they serve as co-factors in many metabolic reactions. For example, in the glycolytic pathway, magnesium ion (Mg^{2+}) acts as a cofactor in the conversion of 2-phospho glyceric acid to phospho enol pyruvate, a reaction catalysed by the enzyme enolase. Another mineral, zinc (Zn) is important for the normal functioning and growth of the immune system while iron (Fe) supports growth and improves haematology parameters in females generally (Lim *et al*., 2013). The protein quality of food depends on the bioavailability and digestibility of the food (Meir *et al*., 2015). In this study, the protein quality of Bambara groundnut condiment compared fairly well with that of other protein sources like fish and casein. This indicates that the protein quality will sustain growth. However, True digestibility (TD) values calculated for the rats that were fed on a Bambara groundnut condiment-based diet was lower than the 85 % value recommended for growth by Ewuola *et al*. (2015); this suggests that consumption of Bambara groundnut condiment alone will not be able to support full growth without the intake of sources of animal proteins. Plant proteins have been known to be of lower quality to animal proteins (Ritcher *et al*., 2015). The protein quality study in this work agrees with past works (Ijarotimi and Keshinro, 2013; Rotimi *et al*., 2013; Ewuola *et al*., 2015) where legumes were reported to be of good quality proteins that can be used to improve growth, especially among the low-income earners. It should however be noted that the protein quality of animal-based food is better than that of plant-based foods because plant-based foods do not have the complete range of amino acids (Ritcher *et al*., 2015).

CONCLUSION AND RECOMMENDATION

The results obtained in the study revealed that Bambara groundnut condiment is rich in nutrients. The study, therefore recommends that Bambara groundnut condiment be included in the family menu to assess its rich phytonutrients.

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