



Influence of processing method on the proximate composition and anti-nutrient content of bambara nut (*Vigna subterranea* L.)

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Abstract

*This study was carried out to investigate the effect of various processing methods on the proximate and anti-nutritional composition of Bambara nut (*Vigna subterranea* L.). Traditional processing methods namely; soaking, steaming, roasting and boiling were employed. The seeds were procured and divided into five portions of 500 g each as treatments. The treatments were coded as A, B, C, D, and E for raw, soaked, steamed, roasted and boiled Bambara nut seeds respectively. The chemical analysis and determination of anti-nutritional factors of the seeds were carried out in the Nutrition and Biochemistry laboratories of Bayero University, Kano. The Data collected were subjected to One-way analysis of variance (ANOVA) using Minitab 17 Statistical package. Results revealed that the values for moisture content ranged from 5.77 - 13.23% while the dry matter content ranged from 86.78 to 94.23%. The values for crude protein (14.50 - 18.37%), ether extract (3.89 - 4.44%), crude fiber (4.20 - 5.02%), ash (2.89 - 3.78%) and nitrogen free extract (69.18 - 73.97%) were recorded. The results of anti-nutrient composition indicate that processing significantly ($p < 0.05$) reduced the content of anti-nutritional factors (Tannin, Oxalate and Phytate) in the seeds. This study demonstrated that traditional methods such as boiling have an impact on the nutritional value of Bambara nut with some nutrient losses. Thus, processing enhanced the nutritional value of the nut and could be used as an important ingredient in animal feed.*

Keywords: Bambara Nut, Processing, Proximate Composition, Anti-Nutrient Content.

Introduction

Bambara nut is economically important as a low-cost source of high-quality protein. It is highly valuable among the Eastern and Northern states of Nigeria (Oloyede *et al.*, 2010). Bambara nut is processed into consumable food and taken in various forms as source of protein to Nigerians. Report showed that in Nigeria, Bambara nut is widely produced in Borno, Anambra, Plateau, Taraba, Sokoto, Bauchi, Benue, Kano, Yobe, Adamawa, and Gombe States. It is the third most important legume after peanut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*) (Mkandawire, 2007). Research by Brough and Azam-Ali (1992) and Mazahib *et al.* (2013) indicated that bambara nut have high content of carbohydrate (65%) and relatively high protein content (18%) (with relatively high proportions of lysine and methionine as percentage of the protein) as well as

sufficient quantity of fat (6.5%). This makes the crop to be ranked as a complete staple food. The seeds of Bambara nut are also known for their high content of minerals like calcium, iron, potassium and sodium (Aremu and Ibrahim, 2014). Despite its nutrient composition, Bambara nut is still among the lesser known and under-utilized crops in Nigeria.

There exist limited works on processing and nutritious value of Bambara nut flour (Abiodun and Adepeju, 2011). *Vigna subterranea* (Bambara nut) is a promising commodity which needs more research works to be done on, both its raw and processed state. In tropical Africa, very few people in the forest zones are aware of its nutritional benefits. Investigating the effect of processing on the nutritional and the anti-nutritional components of *V. subterranea* will help to increase the awareness of not

only this crop but also its nutritional capabilities. Ndidi *et al.* (2014) reported that boiling and roasting reduced the anti-nutritional factors of Bambara nut below the permissible limits. They also contain anti-nutrients most of which are reduced during boiling and de-hulling of the seeds, thus improving nutritional value and making dehulled flour safe for consumption (Abiodun *et al.*, 2011). The different processing steps applied to Bambara nuts, on a small and large scale, have positive and negative impacts on their food and nutrition security (Tan *et al.*, 2020). The presence of various ANFs and the indigestible nature of the raw seeds mean that processing is an essential stage for all legumes. Processing methods, such as soaking, cooking or fermentation can improve the quality of legume protein (Habiba, 2001, Adebowale and Maliki, 2011). Therefore, the objective of this study was to investigate the effect of processing method (Soaking, Steaming, Roasting and Boiling) on the nutritive value of Bambara nut (*Vigna subterranea* L.) with the emphasis on proximate and anti-nutrient compositions.

Materials and Methods

Experimental location

The experiment was conducted at the Nutrition and Biochemistry Laboratory of the Animal Science Department, Faculty of Agriculture, Bayero University, Kano, Nigeria. Kano lies between Longitude 9°30' and 12°30' North and Latitude 9°30' and 8°42' East on an elevation 468 m (NiMet, 2014).

Source and sample preparation

The Bambara nut seeds were procured from Dawanau International Grains Market of Kano-State, Nigeria. The seeds were authenticated at the Agronomy Department of the Bayero University, Kano. The stones and other foreign materials were removed and was put inside sack to de-shell manually by using stick then winnowed to remove the chaff in order to have pure Bambara nut grain. A portion of the raw dried seeds of

Bambara groundnut devoid of insect pests and debris were ground into fine powder using pestle and mortar. They were then sieved through 20mm mesh iron to obtain the flour. The flour samples were kept in screw – capped jars and stored in a deep freezer for two days until needed for analysis. This was to prevent spoilage by microorganisms. A digital scale was used to measure 4 separate portions of 500 g of Bambara nut, the beaker was used to measure the water, the hot plate and pot was used for boiling, steaming and roasting, the thermometer was used to measure temperature of the water during boiling and steaming, the plastic strainer was used to drain the Bambara nut after boiling, steaming and soaking and a stopwatch was used to measure the time for all the processes.

Processing Techniques

The processing was performed according to the modified method of Fernandez *et al.* (1996). The following processing methods were employed:

Soaking

A second portion of the raw seeds (500 g) was soaked for nine hours in distilled water. After the seeds were soaked, they were dehulled by mechanical scrubbing between both hands and the excess solution was drained. The proportion of seed to soaking solution was 1/3 (wt: vol). After the soaked Bambara nut seed was dried off, it was then milled into a fine powder and stored in an air-tight plastic container until used.

Steaming

A third portion of Bambara nut (500 g) was processed by steaming at 100°C for 1hour. After steaming the seed was rinsed with water and drained in rubber sieve. And then shade-dried for one day and milled using laboratory milling machine (FW80-I high speed universal disintegrator grinding mill). Thereafter, the dried, steamed, and milled Bambara nut seed was stored in air tight container until used.

Roasting

The fourth portion of Bambara nut seeds (500 g) placed on frying pan was roasted for 30 min using electric plate with temperature at about 100 °C. Thereafter, the roasted seed was allowed to cool and then milled with laboratory milling machine (FW80-I high speed universal disintegrator grinding mill) and stored in air-tight plastic container until used.

Boiling

The fifth portion of Bambara nut seeds (500 g) was boiled in distilled water (100°C) in a seed to water ratio of 1:6 (w/v) for 35 min. After boiling the water was drained off with plastic strainer and the boiled seed was shade-dried for 24 hours. Thereafter, the boiled seed were pulverized to fine powder using the laboratory milling machine (FW80-I high speed universal disintegrator grinding mill) and then stored in an air-tight plastic container until used.

Analytical Techniques**Proximate analysis of Bambara nut seeds**

The proximate analysis was carried out at Nutrition Laboratory of the Department of Animal Science, Bayero University, Kano. It was performed according to methods described by AOAC (1990). In these methods, Dry matter, ether extract (EE), crude protein (CP), crude fiber (CF) and ash were determined while nitrogen free extract (NFE) was calculated using the formula: $NFE = 100 - (\%EE + \%CP + \%Ash + \%CF)$.

Anti-nutritional factors analysis

Anti-nutritional factors analysis was carried out at the Department of Biochemistry Laboratory of Bayero University, Kano to determine the tannin, phytate and oxalate contents. The tannin content was determined using Dennis spectrophotometric methods described by Pearson (1976). The oxalate determination involved three major processes; digestion, precipitation and permanganate titration as outlined by Jonsyn (1985) while phytate was determined using the methods of Lucas Markakes (1975).

Statistical analysis

Data obtained from proximate analysis of Bambara nut seeds (*Vigna subterranean* L.) were entered into Microsoft excel spread sheet and imported to Minitab 17 Statistical package and subjected to One-way analysis of variance (ANOVA), where significant differences were observed, means were separated using Tukey's test.

Results and Discussion**Proximate composition**

The results of the proximate composition of differently processed (raw, soaked, steamed, roasted and boiled) Bambara nut is shown in Table 1. There were significant differences ($p < 0.05$) in all the parameters measured across the processing methods. The result indicates that most of the values obtained did not follow any definite trend except for NFE which increased across the processing methods.

The values for moisture content ranged from 5.77 - 13.23%. Moisture content increased significantly ($p < 0.05$) with boiling and soaking methods. The moisture content values of the raw sample were generally low but are within the range expected of most legumes. Moisture content is important as it has a significant role in determining the shelf-life of the sample (Webb, 1985). The moisture content of raw Bambara nut was within the range reported by Ndidi *et al.* (2014). However, the values obtained for all the different processing methods were within the reported range in available literature. The moisture content of Bambara nut was significantly ($p < 0.05$) improved by boiling and soaking this was in agreement with the finding of Ndidi *et al.* (2014) who stated that moisture content was significantly improved by boiling but significantly reduced by roasting. The value obtained from moisture content were within the range found by Abiodun and Adefeju (2011).

The metabolizable energy (ME) content of the treatments ranged from 3213.70 – 3237.60 kcal/kg. It significantly ($p < 0.05$)

increased across the treatments. The increase in ME content in treatments especially in roasting and boiling agrees with the report of Mazahib *et al.* (2013) who reported that cooking as domestic processing increased the total energy content of Bambara nut.

The crude protein content of the treatments ranged from 14.50 - 18.37%. In all treatments, protein content was slightly decreased. Mazahib *et al.* (2013) reported similar findings. The decrease in protein content in treatments especially in roasting and boiling was possibly due to solubilisation of protein by heating or might be attributed to denaturation during heating (Deman, 1999) or could be as a result of leaching of soluble protein into the boiling water. A similar observation was made by Adeparusi (2001) when boiling Lima beans (*Phaseolus lunatus*). However, processing by soaking and steaming supported higher protein content.

The crude fiber content of the treatments ranged from 4.20 - 5.02%. Crude fiber content of the raw Bambara nut variety was significantly ($p < 0.05$) higher than that of the treatments. Fiber content in both raw and processed Bambara groundnut were significantly ($P < 0.05$) decreased after processing. These findings are in line with reports by Rehman and Salariya (2005) for Bambara groundnut.

The ether extract content of Bambara nut ranged between 3.89 and 4.44%. The ether extract content of Bambara nut found in this experiment was similar to the value reported by Anhwange and Atoo (2015). The ether extract content was significantly ($p < 0.05$) reduced by soaking, steaming, roasting and boiling (4.19, 3.96, 3.89 and 4.03%, respectively), this was contrary to the observations of Mazahib *et al.* (2013) who stated that processing of Bambara nut seeds increased fat content after soaking and cooking. This is in agreement with Ndidi *et al.* (2014) who stated that lipid and crude fibre were significantly reduced by both boiling and roasting, with boiling causing

more significant reduction than roasting. The values were within the range reported by Ndidi *et al.* (2014) but were lower than the reported value of 6 - 14% for Bambara nut (Brough and Azam-ali, 1992; Stephen, 2009). This may be due to the species difference and methods of analysis used to determine the ether extract. Similarly, the values obtained in this work are lower than those reported by Mune *et al.* (2007). However, this ether extract content does not describe the Bambara nut as an oil-rich legume compared to others such as soy bean with 22.8 - 23.5% (Salunkhe *et al.*, 1985; Paul and Southgate, 1980) and *C. vulgaris* with 47.9 - 51.1% (Ige *et al.*, 1984).

The ash content of both raw and processed Bambara nut ranged from 2.89 - 3.78%. The ash content significantly ($P < 0.05$) decreased after roasting, which could be an indicator of the decrease in especially the mineral components of the seeds as a consequence of roasting. However, soaking, steaming and boiling increased the ash content. Ndidi *et al.* (2014) stated that ash content was not significantly affected by roasting but significantly reduced by boiling. That could probably be explained by the difference between the species and the method of analysis used.

The nitrogen free extract content of raw and processed Bambara nut seeds ranged from 69.18 - 73.97% (Table 1). Nitrogen free extract was significantly ($p < 0.05$) improved by processing methods. It increased linearly across the raw and differently processed methods, this is in agreement with the observation of Mazahib *et al.* (2013) who stated that carbohydrate content was significantly increased after cooking but slightly decreased after soaking. The values obtained were within the range reported by Ndidi *et al.* (2014).

Anti-nutrient analysis

The results of anti-nutrient analysis are presented in Table 2. In both raw and

processed Bambara nut, processing led to significant ($p < 0.05$) decrease in tannin, phytate and oxalate. The tannin content of raw and processed Bambara nut ranged between 3.4 and 18.6 mg/g.

Anti-nutrients are substances that are produced in the natural ingredients of foods by the normal metabolism of plant species and the interaction of different mechanisms. These factors hinder the optimal utilisation of the food (Apata and Ologhobo, 1997). In the present study, processing significantly ($p < 0.05$) decreased the tannin content. This decrease was in agreement with the findings of Abiodun and Adepeju (2011) who reported that the tannin content was reduced drastically after boiling and dehulling. Also, cooking and dehulling have been reported to reduce the tannin content in beans (Deshpande *et al.*, 1982; Rehman and Salariya, 2005). The reduction in tannin content of Bambara nut after processing agrees with the report of Adeparus (2001) and Nyachoti *et al.* (1997). The anti-nutritional effect of tannin include interference with the digestive processes either by binding enzymes or food components like protein or minerals (Elkin *et al.*, 1990). It also has the ability to complex with vitamin B₁₂ (Ene-Obong *et al.*, 1996).

The oxalate content of raw and processed Bambara nut ranged from 2.2 – 4.6 mg/g. Boiling reduced oxalate content considerably. This was in agreement with the finding of Albihn and Savage (2001) who reported that boiling results in considerable epidermal ruptures and facilitate the leaking of soluble oxalate into the cooking water. Therefore, the reduction in oxalate content by boiling may be due its solubility in boiling water (Bradbury and Nixon, 1998). The steaming methods of processing adopted partially reduced the oxalate content as compared with boiling, roasting and steaming.

The phytate content of raw and processed Bambara nut ranged from 18.5 – 28.4 mg/g. The raw Bambara nut had the highest phytate content (28.4 mg/g) and this was similar to the finding of Abiodun and Adepeju (2011) that reported Bambara nut coat had higher phytate content. The processing methods (roasting, steaming, boiling and soaking) reduced the anti-nutritional factors of Bambara nut and this was in agreement with the report of Ene-obong and Obizoba (1996) who reported reduction in phytic acid in boiled Bambara nut up to 74%. Additionally, cooking had been reported to reduced phytate level of plant feedstuffs (Badifu, 2001). Phytate decreases calcium bioavailability and forms calcium phytate complexes that inhibit the absorption of Fe and vary depending on the crop variety, climatic conditions, location, irrigation conditions, type of soil, and growing season of the plant. Phytate are known to reduce bioavailability of mineral, impair protein digestibility caused by formation of phytic-protein complexes; and hinder absorption of nutrients due the damage of phyloric caeca region of the intestine (Francis *et al.*, 2001).

Conclusion

This study demonstrated that traditional methods such as boiling have an impact on the nutritional value of Bambara groundnuts with some nutrient losses. Boiling increased the ME and nitrogen free extract content of the seeds. Thus, processing enhanced the nutritional value of the nut and could be used as an important ingredient in animal feed.

Acknowledgement

The authors gratefully acknowledge Muhammad I. A. and Technologists in the laboratories for their technical assistance.

Table 1: Proximate composition of Bambara nut seed (*Vigna subterranea* L.)

Parameters	Treatments (Processing methods)					SEM
	A(RBS)	B(SBS)	C(StBS)	D(RsBS)	E(BBS)	
ME (kcal/kg)	3225.45 ^b	3213.70 ^d	3221.85 ^c	3237.60 ^a	3235.23 ^a	0.746
Moisture (%)	5.77 ^c	12.41 ^a	10.20 ^b	8.49 ^b	13.23 ^a	0.327
Crude Protein (%)	18.37 ^a	18.26 ^a	16.52 ^b	15.81 ^c	14.50 ^d	0.089
Crude Fibre (%)	5.02 ^a	4.98 ^a	4.24 ^c	4.66 ^b	4.20 ^c	0.035
Ether Extract (%)	4.44 ^a	4.19 ^b	3.96 ^d	3.89 ^e	4.03 ^c	0.011
Ash (%)	3.00 ^c	3.22 ^b	3.78 ^a	2.89 ^c	3.37 ^b	0.033
NFE (%)	69.18 ^d	69.37 ^d	71.76 ^c	72.76 ^b	73.97 ^a	0.084

Means that do not share a letter are significantly different (p<0.05). SEM – Standard error of mean, NFE – Nitrogen Free Extract, A(RBS) – Raw Bambara nut seed, B(SBS) – Soaked Bambara nut seed, C(StBS) – Steamed Bambara nut seed, D(RsBS) – Roasted Bambara nut seed, E(BBS) – Boiled Bambara nut seed.

Table 2: Anti-nutritional composition of Bambara nut seeds (*V. subterranea* L.)

Parameters (mg/g)	Treatments (processing methods)					SEM
	A	B	C	D	E	
Tanin	18.6 ^a	9.4 ^b	3.4 ^d	3.8 ^c	9.3 ^b	0.065
Oxalate	4.6 ^a	2.2 ^e	4.4 ^b	3.4 ^d	3.6 ^c	0.009
Phytate	28.4 ^a	24.7 ^b	20.8 ^d	18.5 ^e	24.1 ^d	0.054

Means that do not share a letter superscript are significantly different (p<0.05). SEM – Standard error of mean, A – Raw Bambara nut seed, B – Soaked Bambara nut seed, C – Steamed Bambara nut seed, D – Roasted Bambara nut seed, E – Boiled Bambara nut seed.

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