NUTRITIONAL EVALUATION OF BAMBARA GROUNDNUT (*Vigna subterranea* (L.) Verdc) FROM LAPAI, NIGERIA

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ABSTRACT: *The nutritional constituents of seeds of Bambara groundnut (Vigna subterranean) were analyzed for their nutritional compositions using standard analytical methods. Results of proximate analysis obtained were moisture content (9.20 ± 0.12 %), ash (3.40 ± 0.09 %), carbohydrate (21.10 ± 0.05 %), crude fibre (4.60 ± 0.07 %) and calorific value (185.79 ± 0.03 kcal/100 g). Mean concentrations of mineral elements were the order: zinc (139.00 ± 0.04 mg/100 g) > potassium (31.50 ± 0.12 mg/100 g) > copper (30.00 ± 0.01 mg/100 g) > phosphorus (17.40 ± 0.11 mg/100 g) > magnesium (3.90 ± 0.07 mg/100 g) > calcium (3.50 ± 0.17 mg/100 g) > sodium (0.11 ± 0.03 mg/100 g) > iron (0.10 ± 0.01 mg/100 g). Measured values for bulk density, water absorption capacity, oil absorption capacity, foaming capacity and foaming stability were 0.85 ± 0.07 g/cm³, 1.65 ± 0.13 %, 0.70 ± 0.03 %, 16.00 ± 0.12 % and 7.50 ± 0.22 % respectively. The amino acid profile revealed that glutamic acid had the highest value (12.56 g/100 g) while tryptophan had the lowest concentration (0.87 g/100 g). Results obtained indicate that the consumption of V. subterranean can contribute to the nutritional requirements of the body.*

KEYWORDS: *Vigna Subterranean,* Nutritional, Carbohydrate, Minerals, Amino Acids.

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INTRODUCTION

The last decade has witnessed increased food shortage and hunger in Nigeria (especially in the North) occasioned by grave insecurity, climate change, cost of fertilizer, communal conflicts, increase in population and changes in dietary pattern of the populace. These situations have heightened the competition for conventional foodstuff needed for adequate supply of nutrients required for good health and development of the body (Musah *et al*., 2020). Lack of sufficient food supply with necessary nutrients could lead to malnutrition especially in young children. To mitigate the effect of nutrient inadequacy and improve sustainable food security, it is important to explore affordable and readily available plant-based food such as fruits, vegetables, roots and tubers, nuts and seeds for their nutritive values. One such plant-based food is the Bambara groundnut (*Vigna subterranean* (L.) Verdc).

Bambara groundnut (*V. subterranea* (L.) Verdc) is a legume indigenous to Africa; it is cultivated in semi-arid regions of Africa. It is associated with small-scale, subsistence farming and relatively unpopular compared with major cash crops like rice, yam, beans and cocoa. *V. subterranea* is a member of the family *Fabaceae*; it is an annual, creeping legume with glabrous, trifoliate leaves. It has a deep taproot surrounded by lateral profuse roots bearing N-fixing nodules. It ripens its pods underground like the peanut but gives superior yield to the peanut in poor soil. Seeds of *V. subterranea* are round, smooth and hard when dry, used in different forms as food for humans while the leaves are fed to ruminants. The seeds are converted into different forms, milled into powder and paste for making cake.

The seeds can be consumed in different forms either in the immature green state or mature form. But at maturity, the seeds become very hard and therefore require boiling before any specific preparation can be carried out. However, it is common knowledge that legume seeds generally require a long cooking time for tenderization (Omoikhoje, 2008). The nut can be eaten raw when immature because it is soft and pleasant. Bambara groundnut is also consumed as a salt-boiled snack food beside maize and cowpea (Iyayi *et al*., 2005). The extracts from plant nuts, particularly protein extracts, can be used directly in cosmetic formulations and they provide specific properties and notable particular effects (Aburjai & Natsheh, 2003).

The present study will help to authenticate the already existing database for the study of plant resources among the rural dwellers of Niger State, and probe into their likely nutritional potential to ascertain if they could help to complement the nutritional needs from other food sources.

MATERIALS AND METHODS

Sample collection

Mature and dried *Vigna subterranean* (L.) Verdc seeds used for this research were obtained from *Sabon Kasuwa* market in Minna, Nigeria. They were dried under the sun and carefully removed from their hulls, ground into powder using mortar and pestle and stored in a plastic container ready for analysis.

Proximate Composition

Moisture content was determined by drying 5 g of the powdered sample to constant weight in an oven at 105 °C. The difference in weight before and after drying was recorded as the moisture content of the seed (AOAC, 2006). Ash content was quantified according to the method described by Ceirwyn (1998), which involved dry ashing in a muffle furnace at 600 °C until grayish white ash was obtained. Crude lipid content was determined using soxhlet apparatus and n-hexane as solvent, according to the AOAC (2006) method. Crude protein of the sample was determined by multiplying the value obtained from Kjeldahl's nitrogen analysis by a protein factor of 6.25 (AOAC, 2006). Available carbohydrate was estimated by difference where the sum of the percentage ash, crude lipid, crude protein, and crude fiber was subtracted from 100 % as shown in equation 1 (AOAC, 2006). Calorific value was calculated using expression described in equation 1 by Asibey-Berko and Taye (1999).

$$Available\ Carbohydrate\ (\%) = 100 - (\%\ ash + \%\ protein\ + \%\ lipid\ \%\ fibre) \quad ..(1)$$

$$Energy\ (kcal/100g) = (crude\ protein\ x\ 2.44) + (crude\ lipid\ x\ 8.37) + (available\ carbohydrate\ x\ 3.57) \quad ....(2)$$

Determination of Amino Acids

The amino acids profiles of the seed sample was determined using methods described by Barakat *et al.* (2017) with modifications as described in AOAC (2006). The sample was defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Technicon sequential multi-sample Amino Acid Analyser (TSM).

Mineral Quantification

Oven dried powdered sample (6 g) was put into a dry crucible and ignited in a muffle furnace at 600 °C until greyish white ash was obtained. The sample was removed and cooled in a desiccator. 5 cm^3 of 1.0 mol dm^{-3} HNO_3 was added and the sample was evaporated to dryness on a steam bath and reheated in a muffle furnace until the formation of greyish white ash was observed. The ash was cooled in a desiccator and 10 cm^3 of 1.0 mol dm^{-3} HCl was added and filtered into a 100 cm^3 volumetric flask. The concentrations of Cu, Fe, Mg, Zn and Ca were determined using Atomic Absorption Spectrophotometer (AAS Model SP9) while Na and K were evaluated using flame photometer. Phosphorus concentration was quantified using the Jenway 6100 spectrophotometer at 420 nm (Ceirwyn, 1998).

Functional Properties

Bulk density was determined by gently filling a 10 cm^3 graduated measuring cylinder with the sample and its bottom was gently tabbed until the volume of the sample stopped decreasing (Yoshiyuki & Yukata, 2003). Foam capacity and stability were determined according to the method described by Abbey and Ibeh (2006) while water and oil absorptions capacities were determined using the methods in Musah *et al.* (2021).

RESULTS AND DISCUSSION

Proximate Composition

The results of the proximate composition in Table 1 showed high moisture content in *V. subterranea* seeds (49.20%). The value was found to be higher than 2.86 ±0.22 obtained for *V. subterranea* seeds from Maikunkele market (Mathew *et al*., 2014). The high moisture content of these seeds indicates that they will be susceptible to microbial growth and will not have a long shelf life (Ndamitso *et al*., 2014). The carbohydrate content (44.10±0.05 %) obtained was lower than the 58.09 % and 66.45 % reported for *Cola acuminate* and *Cola nitida* respectively (Dewole *et al*., 2013). Dietary carbohydrates supply the bulk of calories in an average diet.

Table 1: Proximate composition of Bambara nuts (*Vigna subterranea*) (% Dry weight)

Parameter	Content
Moisture	49.20±0.12
Ash	3.40±0.09
Crude fibre	4.60±0.07
Crude protein	19.20±0.11
Crude lipid	7.60±0.21
Available Carbohydrate	44.10±0.05
Calorific value (kcal/100g)	185.79±0.03

Values are means of triplicate determination ± standard deviations. Calculated energy value was 185.79 ± 0.03 kCal 100 g^{-1}. This value was higher than the 155.04 ± 1.60 kCal 100 g^{-1} reported for *V. subterranea* seeds (Mathew *et al.,* 2014). The results showed a moderately high protein content of 19.20±0.11 %, although the value was low compared to the 32.40±0.02 % reported for Bambara groundnut by Nwodo and Nwinyi (2012). The protein content of the seeds revealed that they could be considered a good source of protein for humans. The fat content value was relatively high (7.60%) while total ash content of the seeds was low (3.84%). These values were within the range of 6–8 % ash content reported for *V. subterranea* seeds (Ojimelukwe, 1999). The low ash content of *V. subterranea* seeds indicates the low total level of inorganic components in the sample. It has been reported that a diet providing 1–2% of its caloric energy as fat is sufficient for humans (Shaba *et al*., 2015). Excess fat consumption may contribute to certain cardiovascular disorders.

Mineral Composition

Table 2 presents the result of mineral composition of *V. subterranea* seeds. The results revealed that potassium and phosphorus were the most abundant minerals present in the seeds. Similarly, potassium and phosphorus were reported as the most abundant minerals in *V. subterranea* seeds (Belewu *et al*., 2008). Phosphorus helps in bone growth, proper kidney function and cell growth. Potassium also plays a role in maintaining the body's acid-alkaline balance (Ndamitso *et al*., 2017). Mathew *et al*. (2014), in a related study, reported high potassium content of 122.91±1.02 for *V. subterranea* obtained from Kure Market. The results showed the low contents of calcium (3.50±0.17 mg/100g) and magnesium (3.90±0.07 mg/100g), whereas Belewu *et al*. (2008) recorded these minerals in relatively high concentrations in *V. subterranea* seeds.

Table 2: Mineral composition of Bambara nut (*Vigna subterranea*)

Mineral	Concentration (mg/100 g)
Sodium	0.10±0.09
Potassium	31.50±0.12
Calcium	3.50±0.17
Iron	0.10±0.01
Zinc	139.00±0.04
Phosphorous	17.40±0.11
Magnesium	3.90±0.07
Copper	30.00±0.01

Values are means of triplicate determination ± standard deviations. The daily requirement of sodium for males and females between 9 and 50 years is 1500 mg, which has been recommended as an adequate intake, while after the age of 59 years, 1300 mg has been considered as adequate by the U.S. Food and Drug Administration (Carol, 2011). As observed in the present study, iron and sodium were detected in very low concentrations. Therefore, suggesting consumption of the seeds could be effective and useful for people with high blood pressure (Ogbuagu *et al.,* 2011; Dzomeku *et al*., 2006).

Amino Acid Profile

The results of the amino acids profile of the *V. subterranea* seed are shown in Table 3. The result revealed the presence of essential and non-essential amino acids in the study seeds. The total essential amino acid was 57.60 g/100 g, while total non-essential amino acid was 42.40 g/100 g. The value of total essential amino acid was higher than 27.90 g/100 g, though in the case of total non-essential amino acid, the value was lower than 51.11 g/100 mg reported for *X. americana* seed by Tanko *et al.* (2017).

Table 3: Amino acid profile of Bambara nuts (*Vigna subterranea*)

Amino Acid	Concentration (g/100 g)
*Leucine	7.12
*Lysine	6.26
*Isoleucine	4.06
*Phenylalanine	4.43
*Tryptophan	0.87
*Valine	4.29
*Methionine	1.33
*Arginine	6.79
*Histidine	2.55
*Threonine	4.16
Proline	3.14
Tyrosine	3.09
Cystine	1.33
Alanine	3.71
Glutamic acid	12.56
Glycine	3.70

Serine	3.29
Aspartic acid	9.67
Total amino acid (TAA)	72.68
Total Essential Amino Acid (TEAA)	41.86
Total Non Essential Amino Acid (TNEAA)	30.82
% TEAA	57.60
% TNEAA	42.40

* = Essential amino acid (EAA)

The minimum amino acid intake of 1.5 g/kg/day is reported to be necessary in preventing negative nitrogen balance, a minimum amino acid intake of 1.0 g/kg/day is recommended to avoid a negative nitrogen balance, and an intake higher than 2.5 g/kg/day is not advisable (ESPGHAN, 1987).

Functional Properties

The functional properties of *Vigna subterranea* are presented in Table 4. The water absorption capacity (WAC) content was 1.65±0.13 % which is lower than the 201.7 % obtained for raw groundnut seeds reported by Mustapha *et al*., (2015). The high water absorption capacity may be due to the high polar amino acid residues of raw groundnut proteins having strong affinity for water molecules (Narayana & Narasinga, 1985).

Table 4: Functional Properties of Bambara Nuts (*Vigna subterranea*)

Parameter	Value
Water Absorption Capacity (%)	1.65±0.13
Oil Absorption Capacity (%)	0.70±0.03
Bulk Density (g/cm³)	0.85±0.07
Foaming Capacity (%)	16.00±0.12
Foaming Stability (%)	7.50±0.22

Values are means of triplicate determination ± standard deviations. The foam stability of the study sample is 7.50±0.22 %. This was high compared to 5.88±0.41 % reported for *Bombax buonopozense* Calyx by Musah *et al*. (2021). Foam stability is dependent on protein content and environmental temperature. The higher the protein content, the higher the foam stability (Ocloo et al., 2012). Bulk density (BD) was 0.85±0.07 g/cm^3. This value is higher than the value of 0.52±0.71 0.24±0.04 g/cm^3 reported for *Bombax buonopozense* Calyx (Musah *et al*., 2021). Higher bulk density is advantageous since it helps to reduce the paste thickness which is an essential factor in child feeding (Mustapha *et al.,* 2015). However, the groundnut *V. subterranea* seed could be used as a food supplement for children.

CONCLUSION

The nutritional potential of *V. subterranea* seeds is linked to the presence of proximate amino acids and essential minerals such as calcium, magnesium, potassium, sodium, iron, and manganese. The low anti-nutrient content of these seeds shows that it could be exploited as a good dietary supplement for both human and animal feed formulation. As a good source of nutrients and non-nutrients, the crops can be recommended for inclusion in the food system of Nigeria to improve human health care. The physicochemical contents attributed to the study sample will enable the wider use and application of the crop in numerous food products, for instance, as alternative flour, modified starch, or protein isolate.

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