

# Evaluation of Nutrient Parameters of Selected African Accessions of Bambara Groundnut (*Vigna subterranea* (L.) Verdc.)

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**Abstract** Developing countries, especially in Africa are facing challenges of malnourished conditions and food insecurity generally. Nutrients, being components of food ingredient required for survival, normal body function and satisfying the physiological and dietary requirements of the body metabolism [38]. Hence, for meaningful growth and developments in man, the type and amount of nutrients intake and its rate of absorption or level is crucial. However, much emphases and consumption pattern in Africa had been on common or routine food crops like rice, common beans, cassava, maize e.t.c., resulting in the reduced utilisation of other plant species, termed neglected and under-utilised species (NUS), like Bambara groundnut. Selected accessions of Bambara groundnut (*Vigna subterranea* (L.) Verdc), assembled at the International Institute of Tropical Agriculture, IITA, Ibadan, Nigeria were analysed for important nutrients parameters including moisture content, carbohydrate, protein, crude fibre, total sugar, fat, starch, ash and minerals, based on standard and established protocols at the Crop Utilisation laboratory, IITA, Ibadan, Nigeria. Moreso, samples were sent to the South African grain laboratory, the Willows, South Africa, for the determination of free and essential amino acids using HPLC and UPLC conditions. Results revealed that accessions TVSu – 1235, TVSu – 1231, TVSu – 1205, TVSu -729 and TVSu – 1824 could be regarded as high nutrients varieties, while TVSu – 1744, TVSu – 553 and TVSu -922 are medium nutrients type, while the remaining accessions falls below the medium nutrient range, among these lines of Bambara groundnut evaluated. The protein values has a range of  $15.88 \pm 0.005$  g / 100 g for TVSu – 1202 to  $24.91 \pm 0.011$  g / 100 g for TVSu – 1231; while their carbohydrate content ranges from  $42.77 \pm 0.001$  g / 100 g for TVSu – 1202 to  $62.76 \pm 0.223$  g / 100 g for TVSu – 1744.

**Keywords:** bambara groundnut, nutrients, evaluation, amino acids, micronutrients, dietary, food security

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## 1. Introduction

Bambara groundnut (*Vigna subterranea* (L.) Verdc) is a grain legume crop which constitute an important food in some areas of the semi-arid regions of Africa [1,14]. The crop has enormous potentials, yet a neglected and under-utilised (NUS) crop [17,28]. The plant has the ability to fix nitrogen and it is resistant to high temperatures and also drought tolerance, thus making it a valuable crop in areas where soils are too poor for other leguminous crops to thrive. It often has its fruits in the soil, thereby protecting them from insect damage, which can ravage other crops such as cowpea, common bean and soybean, whose tastiest parts are found usually above the ground. Bambara groundnut is rich in carbohydrate and protein content thus making it an important addition to the diets of people who cannot afford expensive animal protein [15].

It also has appreciable amount of minerals such as phosphorous, calcium zinc and iron, which makes it to be considered as a complete diet and people can easily survive by feeding exclusively on Bambara groundnut diet [2], for the supply of all of their nutritional requirements. Bambara is used to prepare many dishes. The seeds can be boiled, roasted or processed to make different delicious snacks or mixed with maize or plantain to serve as meal delicacies [27]. Also the seeds can be ground into flour after it has been roasted and used to prepare porridge and alternately they can also be soaked, boiled and ground into a paste and used in fried or steamed dishes or paste popularly eaten in Nigeria as ‘okpa’. Bambara groundnut flour can also be processed into soup and stew in Zambia, where it is also commonly made into bread. Milk can also be made from the seeds and can be fermented into products such as tempeh and dawadawa. However, to be able to fully understand its immense potentials in nutrition, there is a need to determine the quantities of the protein

and its qualities through amino acids quantification of the selected accessions, so as to fully utilise its genetic resources for food and agriculture [5,6,12,17,31].

## 2. Materials and Methods

### 2.1. The Source and Preparation of Bambara Groundnut Seed Materials

Twenty (20) accessions of Bambara groundnut were selected as a sub-set for nutrition studies from an initial assembly of (300) accessions, obtained from the Genetic Resources Centre (GRC) of the International Institute of Tropical Agriculture, Ibadan, Nigeria after genetic characterisation. Each of the Bambara seed accession was milled into powder in the laboratory using a grinder [19,21].

### 2.2. Moisture Content Determination

5g of the sample was placed in a dish, and put in an oven of 105°C for 16hrs. The weight was taken at an hourly interval until it becomes constant.

$$\% \text{ Moisture (wt / wt)} = \frac{(\text{wt wet sample} - \text{wt of dry sample}) \times 100}{\text{wt of wet sample}}$$

#### 2.2.1. Protein Determination

The protein content was estimated by determining the Nitrogen content using the micro Kjeldahl N distillation followed by a subsequent multiplication of the nitrogen content value by 6.25, the universally accepted protein content estimation factor. 0.2g of each of the powdered sample was weighed into digestion tubes and added to them were 4ml of concentrated 98% H<sub>2</sub>SO<sub>4</sub> and 4 ml hydrogen peroxide using Cu tablet as a catalyst. The tubes were now heated to 420°C at the digestion block for 1 hour until a clear solution was obtained. After cooling, the procedures using the Kjeltec 2300 automated protein analyser having valves containing NaOH and 0.2 M HCl with Boric acid as an indicator was then used for the titration, until colour changes from green to pink end point.

#### 2.2.2. Fat Content Determination

The procedure in Official Methods of Analysis (AOAC, 1990) was followed using Soxtec Tm 8000 fat extraction and auto-analyser equipment. 3.0g of powdered sample was put in a n – hexane extracting tube and heated between 100 – 145°C; the reflux continues until the oil in the samples is leached out of the paper into a cup, leaving the water to evaporate. The oil was now allowed to cool down and the volume of oil (fat) was obtained by the differential weight after evaporation as compared with the initial weight before evaporation occurred.

#### 2.2.3. Crude fibre Content Determination

Powdered materials of the Bambara groundnut samples were weighed and used for the digestion using 1.25 % of

H<sub>2</sub>SO<sub>4</sub> and NaOH. This digestion allows for the organic materials to be burnt – off, leaving only the fibre material. Then 1g of each of the sample was weighed into a crucible, filtered by allowing the sample to stay on top using celite 545. The samples were now brought into the Foss fibertec Tm 2010 chamber and reagent one (H<sub>2</sub>SO<sub>4</sub>) was introduced to start the acid digestion for 30 mins at boiling point temperature. After washing with hot water, alkaline digestion was done using reagent two (NaOH) for 30 mins before finally washing with hot water and left in the oven overnight at 105°C. After cooling the weight is taken before ashing at 520°C for 3 hours, this weight is again noted.

#### 2.2.4. Ash Content Determination

The procedure for the ash content determination involves weighing 5g of powdered sample into already known weighed crucible. They were then oven dried for 4hrs at 105°C after which they were put in a muffle furnace at 500°C, until white ash was obtained. Then the samples were cooled and reweighed to estimate the amount of ash.

#### 2.2.5. Carbohydrate Determination

This was done by the normal scientific deduction:

$$\% \text{ Carbohydrate} = 100 - \left( \begin{array}{l} \% \text{ moisture} + \% \text{ crude protein} \\ + \% \text{ fat} + \% \text{ ash} + \% \text{ crude fibre} \end{array} \right)$$

#### 2.2.6. Total Sugar Content

To 0.02g of the powdered sample was added 1ml ethanol and later diluted with 2 ml of ultra – pure water. Then 10 ml of hot 95% ethanol was added before centrifuging at 2,500 rpm for 15 mins. The supernatant was now decanted into a separate tube and further diluted with 20 ml of ultra – pure water. Out of this, 0.2ml of the solution was taken with another 0.8ml of water in a clean test – tube and was added 0.5ml of 5 % phenol solution from the stock was added. Thereafter, 2.5ml of concentrated H<sub>2</sub>SO<sub>4</sub> was added, vortex and left at room temperature before taking the absorbance at 490 nm using a solution of D – glucose as the standard. The absorbance read was now intrapolated from the standard curve to give the sugar content.

#### 2.2.7. Total Starch Content

For starch determination, the procedure precedes that of the sugar determination. To the residue from the sugar content is added 7.5ml of perchloric acid so as to hydrolyse or break down the starch. The reaction was stopped after 1 hour of hydrolysis with the addition of ultra – pure water to make up to 25ml volume. The solution was then filtered after which 0.05ml was taken into another test – tube and added to it is 0.95 ml of water, 0.5ml of 5 % phenol and 2.5ml of H<sub>2</sub>SO<sub>4</sub> to give room for colour formation and development. This was now vortex and allowed to cool to room temperature before taken the absorbance at 490 nm using D – glucose as the standard. The starch content was now extrapolated from the standard curve plot.

## 2.3. Mineral Analyses

The method described by Association of Official Analytical Chemists (AOAC, 2005) was used for the analysis of the minerals. Aqua regia solution was prepared in a 2litre volumetric flask as follows, 1.2 litre of distilled water was added to the flask, followed by the addition of 400ml of Concentrated Hydrochloric acid and 133ml of 70% nitric acid. The solution is diluted to 2 litres. 0.52 g of the powdered Bambara groundnut samples in clean ceramic crucibles were placed in a cool muffle furnace and ramp temperature to 500°C over a period of 2 hours. They were allowed to remain at 500°C for an additional 2 hours before cooling down. The samples were later transferred to a desiccator. Each sample was now poured into already labeled 50ml centrifuge tube. The crucibles were first rinsed with 5ml of distilled water into the centrifuge tubes and later with 5ml aqua regia solution. The process was repeated, so as to make a total volume of 20ml. The samples were then vortex for proper mixing before centrifuging for 10mins at 3000rpm. The supernatants were now decanted into clean vials and micronutrient analysis for zinc, iron, copper, magnesium, phosphorous and calcium were determined using flame atomic absorption spectrophotometer, AAS, using model Acusys 211 from Buck Scientific, USA.

## 2.4. Amino Acids Analysis

The amino acids analysis was done at the Southern African Grain Laboratory, the Willows, South Africa. Each of the 20 Bambara groundnut samples was analysed by the AccQ-Tag method using a Waters Acquity H-Class UPLC with Empower software (Waters, Millipore Corp., Milford, MA). The seed samples of each were milled into powder and (400 mg) of each were later hydrolysed with 6 N HCl for 24 hours and then derivatized with 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate (AQC) to produce stable derivatives. These amino acids are then analysed by reverse phase UPLC [3,8,10,11].

### 2.4.1. Tryptophan Analysis

The determination of the amino acid tryptophan was done as a separate analysis, due to its differing hydrolysis

condition. The samples (400 mg) are hydrolysed under alkaline conditions with a saturated barium hydroxide solution heated to 110°C for 20 hours. The hydrolysate is analysed by reverse phase liquid chromatography with UV detection at 285 nm, using a Waters Breeze HPLC with Empower software (Waters, Millipore Corp., Milford, MA) [4,7].

## 2.5. Statistical Analysis

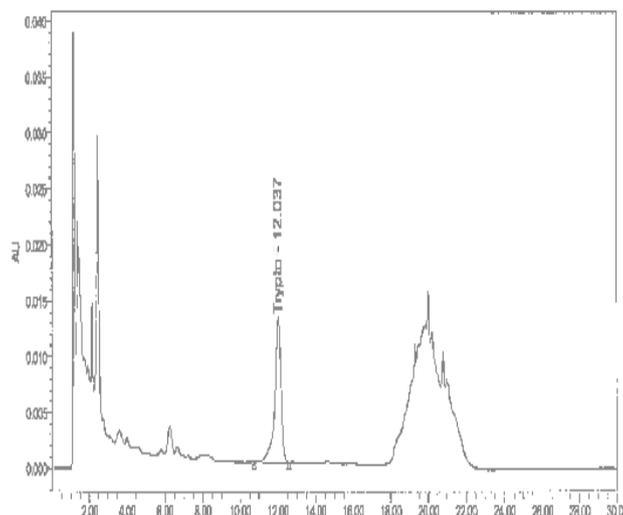
The data were analysed using Statistical Application System (SAS) software, version 9.3. The mean and standard error of means (SEM) of the triplicate analyses of the samples were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means of all the nutrients and amino acid parameters using the tukey's multiple range test at  $p < 0.05$ .

## 3. Results

**Table 1. Summary of the mean values for the 16 amino acids evaluated in Bambara groundnut**

Amino acid	N	Mean $\pm$ Sem	Maximum	Minimum
Alanine	60	0.814 $\pm$ 0.006	0.9100	0.7100
Arginine	60	1.421 $\pm$ 0.039	2.4200	1.0800
Aspartate	60	2.047 $\pm$ 0.015	2.2700	1.8000
Glutamate	60	3.111 $\pm$ 0.027	3.5100	2.6600
Glycine	60	0.770 $\pm$ 0.009	0.9700	0.6500
Histidine	60	0.638 $\pm$ 0.011	0.8800	0.5000
Isoleucine	60	0.768 $\pm$ 0.010	0.9400	0.6300
Leucine	60	1.543 $\pm$ 0.019	1.9000	1.2600
Lysine	60	1.307 $\pm$ 0.011	1.4700	1.1200
Phenylalanine	60	1.136 $\pm$ 0.019	1.5700	0.8300
Proline	60	0.849 $\pm$ 0.011	1.0800	0.7000
Serine	60	1.121 $\pm$ 0.015	1.4500	0.9100
Threonine	60	0.701 $\pm$ 0.008	0.8500	0.5800
Tryptophan	60	0.165 $\pm$ 0.001	0.2000	0.1400
Tyrosine	60	0.520 $\pm$ 0.010	0.7700	0.4100
Valine	60	0.880 $\pm$ 0.010	1.0600	0.7300

Legend: Data were analysed in triplicates; Data = Mean  $\pm$  SEM, n=60. Showing also the maximum and minimum values for each of the amino acid analysed. Mean values are expressed as g / 100g.



**Figure 1.** Chromatogram of Tryptophan peak of TVSu-1727

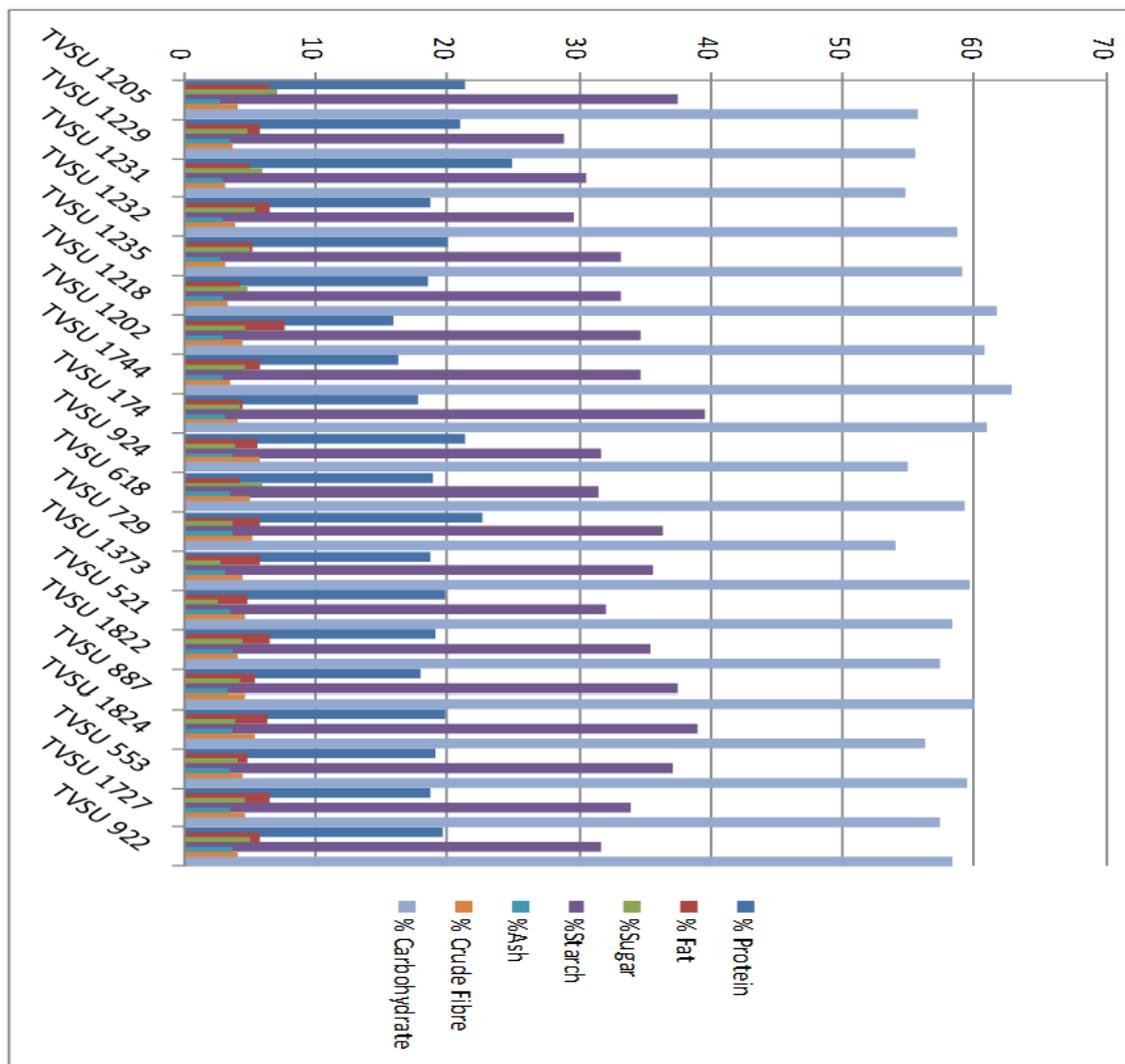


Figure 2. Proximate Composition in African Bambara groundnut accessions

Table 2. Summary values of the minerals content in Bambara groundnuts accessions evaluated

CODE	N	P		Ca		Mg		Cu		Fe		Zn	
		Mean	±Sem	Mean	±Sem	Mean	±Sem	Mean	±Sem	Mean	± Sem	Mean	± Sem
TVSu 1202	3	0.18	±0.005 <sup>b</sup>	0.69	±0.005 <sup>a</sup>	0.19	±0.005 <sup>d</sup>	5.78	±0.005 <sup>c</sup>	87.58	±0.011 <sup>f</sup>	10.49	± 0.005 <sup>h</sup>
TVSu 1205	3	0.35	±0.005 <sup>d</sup>	0.28	±0.005 <sup>e</sup>	0.23	±0.005 <sup>b</sup>	6.37	±0.005 <sup>b</sup>	180.19	±0.005 <sup>a</sup>	10.55	± 0.005 <sup>h</sup>
TVSu 1218	3	0.21	±0.005 <sup>e</sup>	0.43	±0.005 <sup>c</sup>	0.21	±0.005 <sup>c</sup>	6.37	±0.005 <sup>b</sup>	78.97	±0.005 <sup>e</sup>	9.03	± 0.005 <sup>k</sup>
TVSu 1229	3	0.42	±0.005 <sup>b</sup>	0.61	±0.005 <sup>b</sup>	0.25	±0.005 <sup>a</sup>	6.36	±0.005 <sup>b</sup>	142.05	±0.005 <sup>c</sup>	12.17	± 0.005 <sup>b</sup>
TVSu 1231	3	0.40	±0.005 <sup>b</sup>	0.29	±0.005 <sup>e</sup>	0.22	±0.005 <sup>c</sup>	6.37	±0.005 <sup>b</sup>	176.09	±0.005 <sup>b</sup>	9.80	± 0.011 <sup>j</sup>
TVSu 1232	3	0.21	±0.005 <sup>e</sup>	0.29	±0.005 <sup>e</sup>	0.19	±0.005 <sup>d</sup>	5.83	±0.005 <sup>c</sup>	133.74	±0.005 <sup>d</sup>	9.79	± 0.005 <sup>j</sup>
TVSu 1235	3	0.27	±0.005 <sup>e</sup>	0.70	±0.011 <sup>a</sup>	0.23	±0.005 <sup>b</sup>	6.49	±0.663 <sup>b</sup>	109.66	±0.034 <sup>e</sup>	9.73	± 0.034 <sup>j</sup>
TVSu 1373	3	0.27	±0.005 <sup>e</sup>	0.36	±0.005 <sup>d</sup>	0.19	±0.005 <sup>d</sup>	5.24	±0.005 <sup>c</sup>	56.47	±0.011 <sup>m</sup>	9.77	± 0.005 <sup>j</sup>
TVSu 1727	3	0.27	±0.005 <sup>e</sup>	0.69	±0.005 <sup>a</sup>	0.21	±0.005 <sup>c</sup>	8.01	±0.005 <sup>a</sup>	39.96	± 0.005 <sup>f</sup>	11.07	± 0.005 <sup>f</sup>
TVSu 174	3	0.26	±0.011 <sup>e</sup>	0.36	±0.005 <sup>d</sup>	0.20	±0.005 <sup>d</sup>	5.77	±0.005 <sup>c</sup>	74.39	± 0.005 <sup>i</sup>	11.90	± 0.005 <sup>d</sup>
TVSu 1744	3	0.23	±0.005 <sup>e</sup>	0.36	±0.005 <sup>d</sup>	0.21	±0.005 <sup>c</sup>	6.37	±0.005 <sup>b</sup>	78.15	±0.005 <sup>h</sup>	10.55	± 0.005 <sup>h</sup>
TVSu 1822	3	0.28	± 0.00 <sup>e</sup>	0.43	±0.005 <sup>c</sup>	0.22	±0.005 <sup>c</sup>	5.79	±0.005 <sup>c</sup>	47.74	±0.005 <sup>n</sup>	9.76	± 0.005 <sup>j</sup>
TVSu 1824	3	0.29	±0.005 <sup>e</sup>	0.43	±0.005 <sup>c</sup>	0.25	±0.005 <sup>a</sup>	7.97	±0.005 <sup>a</sup>	44.03	±0.005 <sup>o</sup>	11.46	± 0.005 <sup>e</sup>
TVSu 521	3	0.34	±0.005 <sup>d</sup>	0.35	±0.005 <sup>d</sup>	0.23	±0.005 <sup>b</sup>	4.73	±0.005 <sup>d</sup>	39.23	±0.005 <sup>i</sup>	10.95	± 0.005 <sup>e</sup>
TVSu 553	3	0.32	±0.005 <sup>d</sup>	0.43	±0.005 <sup>c</sup>	0.19	±0.005 <sup>d</sup>	6.91	±0.005 <sup>b</sup>	66.09	±0.005 <sup>k</sup>	10.33	± 0.05 <sup>i</sup>
TVSu 618	3	0.29	±0.005 <sup>e</sup>	0.43	±0.005 <sup>c</sup>	0.22	±0.005 <sup>b</sup>	6.33	±0.005 <sup>b</sup>	60.74	± 0.005 <sup>l</sup>	10.86	± 0.00 <sup>e</sup>
TVSu 729	3	0.33	±0.005 <sup>d</sup>	0.43	±0.005 <sup>c</sup>	0.27	±0.005 <sup>a</sup>	6.34	±0.005 <sup>b</sup>	43.70	±0.005 <sup>q</sup>	12.35	± 0.005 <sup>a</sup>
TVSu 887	3	0.23	±0.005 <sup>e</sup>	0.42	±0.011 <sup>c</sup>	0.19	±0.005 <sup>d</sup>	4.71	± 0.00 <sup>d</sup>	43.92	±0.005 <sup>p</sup>	10.90	± 0.005 <sup>e</sup>
TVSu 922	3	0.48	±0.005 <sup>a</sup>	0.43	±0.005 <sup>c</sup>	0.21	±0.005 <sup>c</sup>	2.61	±0.005 <sup>e</sup>	39.60	±0.005 <sup>s</sup>	12.04	± 0.005 <sup>c</sup>
TVSu 924	3	0.43	±0.005 <sup>b</sup>	0.44	±0.005 <sup>c</sup>	0.19	±0.005 <sup>d</sup>	6.92	±0.005 <sup>b</sup>	73.77	± 0.005 <sup>j</sup>	7.03	± 0.005 <sup>l</sup>

Legend: Data were analysed in triplicates; Data = Mean ± SEM, n=3. Values with different superscripts along a column are significantly different (p < 0.05). P, Ca and Mg are in (%); while Fe, Zn and Cu are in ppm.

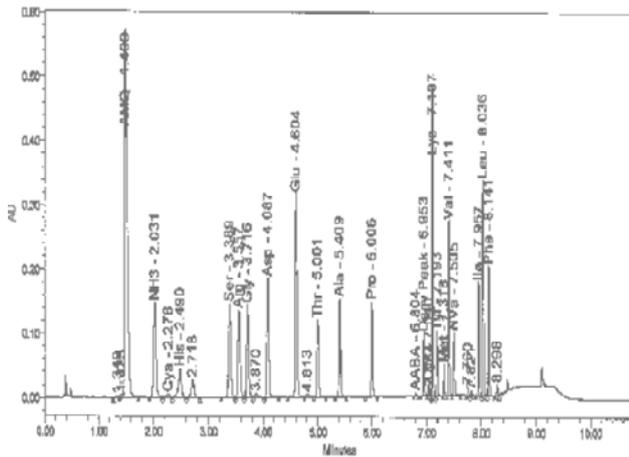


Figure 3. Chromatogram of Amino acid peaks in sample TVSu-1235

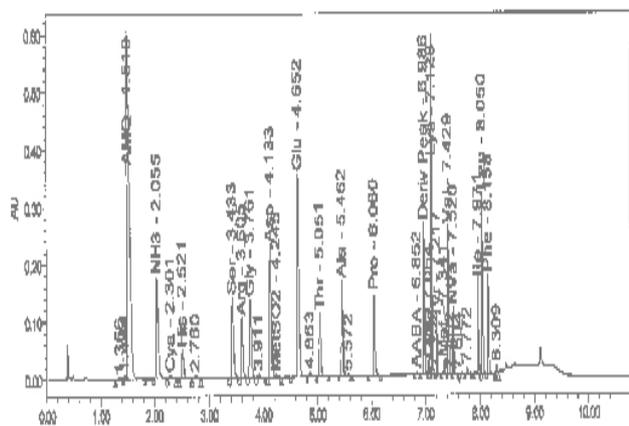


Figure 4. Chromatogram of Amino acid peaks in sample TVSu-1218

## 4. Discussion

The Figure 2 Bar chart shows the display of the proximate analysis mean values. The Table 2 and Table 1 show the summary of the minerals parameters (Phosphorous (P), Calcium (Ca), Magnesium (Mg), Copper (Cu), Iron (Fe) and Zinc (Zn) for all the 20 Bambara groundnut accessions evaluated, as well as the summary of the results of the 16 amino acids analysed. Also showing are figures 1,3, and 4 are the chromatograms showing amino acids and tryptophan peaks in selected Bambara groundnut accessions. The results of the proximate analysis reveal that the Bambara groundnut accession (TVSu – 1231) has the highest protein mean value of 24.91 g / 100 g; while (TVSu – 1202) has the least value of 15.88 g / 100 g. The Tukey's test for protein shows that the means of TVSu – 1231 and TVSu – 729 are however significantly different, while those of TVSu – 1205 and TVSu – 924 are not significantly different. Also protein mean values of accessions TVSu – 1824, TVSu – 1235, TVSu – 521 are not significantly different, while those of TVSu – 174, TVSu – 1202 and TVSu – 1744 are significantly different. The carbohydrate value was highest for TVSu – 1744 at 62.76 g/100g; and lowest for TVSu – 1202 at 42.77 g / 100 g. The tukey's test of comparison shows that the carbohydrate mean values for all the 20 Bambara groundnut accessions evaluated are not significantly

different from one another. Among all the Bambara groundnut accessions evaluated, the amount of total sugar was highest for TVSu – 1205, with a value of 7.01 g/100g; and least for TVSu – 521 with a value of 2.57 g/100g. Using turkey's classification; the mean values for total sugar for accessions TVSu – 1205, TVSu – 618, TVSu – 1231, TVSu – 1232, TVSu – 1235, TVSu – 922, TVSu – 1229, TVSu – 1218 and TVSu – 1744 are all significantly different; while those of TVSu – 1202 and TVSu – 1727 are not. Also, the total sugar mean values of TVSu – 887, TVSu – 174, TVSu – 553, TVSu – 1824, TVSu – 924, TVSu – 729, TVSu 1373 and TVSu – 521 are all significantly different. The mean amount of fat in the accession TVSu – 1202 was highest with 7.68 g/100g and least for TVSu – 618 with 4.35 g/100g. The mean fat values for accessions TVSu – 1202 and TVSu – 1232 are significantly different, while those of TVSu – 1232 and TVSu – 1822 are not significantly different from each other. Also the mean amount of fat for TVSu – 1822, TVSu – 1727, TVSu – 1205, TVSu – 1824 are not significantly different, so also those of TVSu – 922, TVSu – 729, TVSu – 1229, TVSu – 1373, TVSu – 1744 and TVSu – 924.

The summary results of the 16 amino acids analysed for the 20 Bambara groundnut was shown earlier, and revealed from the chromatograms displayed in the figures. For the semi-essential amino acids (Histidine, Serine, Arginine, Tyrosine), as well as the essential amino acids (Lysine, Threonine, Isoleucine, Leucine, Phenylalanine, Valine) analysed showed interesting results. The mean values obtained for Threonine shows the highest value of 0.843 g/100g for TVSu – 1231, while the least amount of 0.593 g/100g was obtained for TVSu – 1744. The mean values obtained for Lysine was highest with an amount of 1.69 g/100g in TVSu – 521, while it was the least with 1.23 g/100g in TVSu – 1218. For Phenylalanine, the mean amount was highest with 1.536 g/100g in TVSu – 1231; and the lowest in TVSu – 1744 with an amount of 0.830 g/100g. Histidine values obtained was highest for TVSu – 1231 with 0.88 g/100g and lowest for TVSu – 1373 with 0.57 g/100g. For Isoleucine, highest mean amount of 0.933 g/100g was in TVSu – 1231; while TVSu – 1744 shows the least amount of 0.630 g/100g; while Leucine for accessions TVSu – 1231 and TVSu – 1744 were the highest and the lowest respectively with mean of 1.90 g/100g and 1.273 g/100g respectively.

Looking at the values for the micronutrients [22,23,24], the accession TVSu – 1205 had the highest mean amount of Iron (Fe), with a value of 180.19 ppm, while TVSu – 521 had the least amount of 39.23 ppm. Using tukey's grouping; the mean Iron (fe) values obtained for all the 20 Bambara groundnut accessions are significantly different from one another. The highest amount of Zinc (Zn) was found in TVSu – 1229, with a value of 12.17 ppm, while it was the least for TVSu – 1218, with a value of 9.03 ppm. The mean values for Zinc, obtained for accessions TVSu – 729, TVSu – 1229, TVSu – 822, TVSu – 174, TVSu – 1824 and TVSu – 1727 are significantly different by tukey's grouping. But the Zinc mean values of TVSu – 521, TVSu – 887 and TVSu – 618 are not significantly different, as well as those of TVSu – 1205, TVSu – 1744 and TVSu – 1202 [36,40]. For Copper (Cu), the highest amount of its mean was 8.01 ppm in TVSu – 1727 as

against the least amount of 4.73 ppm in TVSu – 521. The mean values obtained for copper for accessions TVSu – 1727 and TVSu – 1824 are not significantly different; while that of TVSu – 1824 are significantly different from those of TVSu – 924 and TVSu – 553. For Magnesium (Mg), the highest amount of 0.25 g/100g were obtained for TVSu – 1229 and TVSu – 1824; while the least value of 0.19 g/100g were obtained for TVSu – 1232, TVSu – 1373 and TVSu – 553. The mean values obtained for magnesium in accession TVSu – 1229 and TVSu – 1824 are not significantly different; as well as those for TVSu – 1235 and TVSu – 618; but those for accessions TVSu – 1202 and TVSu – 1822 are significantly different from each other.

## 5. Conclusion

Nutrient parameters are important pre-requisite, not only in breeding for genetic improvements or improved varieties of crops, but also in the utilisation of certain lines or accessions of germplasm to meet specified conditions, especially of health challenges [9,13,14]. Developing countries, especially those mostly in Africa are suffering diverse malnourished conditions, resulting in loss of life, especially in infancy [32,33,37]. These are sometimes as a result of micronutrient deficiencies; however, Bambara groundnut had been discovered to be able to have the potentials to alleviate these challenges [15,27]. Some of these African accessions of Bambara groundnut, which has the ability to alleviate majority of these nutrition challenges were randomly selected for evaluation in this study after the initial screening; to be able to discover those that can best be recommended for certain nutrition and health-related challenges. These could be used in a complementary food or as ready-to-use food (RTUF) [25,26,34]. Among these 20 African accessions of Bambara groundnut evaluated, TVSu – 1231 can be recommended for conditions that can ameliorate protein deficiency due to its highest amount of energy. This could also be supported by its essential amino acids values. This serves importance to combat increased risk of venous thrombosis and the activation of protein c cofactor activity in the human plasma [16]. Thus protein deficiency diseases such as marasmus, kwashiorkor and cachexia can easily be curtailed thus assisting in the overall prevention against protein – energy under-nutrition. Also food supplementation with TVSu – 1231 can be useful in the supply of these essential amino acids in our diet [18], thus making it to serve as potential building block materials for the maintenance of body functions and metabolism. Also the essential amino acid contributes to cellular growth and protein synthesis. It also has potentials to serve as precursors for the body, in the production of the remaining non-essential amino acids. This makes food that contains all the essential amino acids to be a complete protein, while those missing in one or more essential amino acids to be an incomplete protein. The result obtained also shows that the Bambara groundnut accession TVSu – 1744 among all the 20 evaluated has the highest amount of carbohydrate. This makes its consumption to be a ready supply of glucose to the body systems, thus making it efficient in the protection against ketone and keto-acidosis

conditions. Hence the consumption of Bambara groundnut, especially the TVSu – 1744 as recommended has the ability to supply this important dietary nutrient, which is a key source of caloric energy. Important micronutrients such as Iron analysed was found to be enormous in accession TVSu – 1205. Iron plays a role in serving as a co-factor in hemoglobin and myoglobin formation by acting as an oxygen transporter, thus preventing diseases such as anaemia, body weakness, tiredness and fatigue. Dietary iron is also a key components of many proteins and enzymes; and thus helping to regulate a lot of reactions in the body. Conclusively, among all the African accessions of Bambara groundnut evaluated for nutrition parameters, TVSu – 1231, TVSu – 1235, TVSu – 1205, TVSu – 729 and TVSu – 1824 could be regarded to belong to the category of the high – nutrient type. Also, the accessions TVSu – 1744, TVSu – 553 and TVSu – 922 could be regarded to belong to the category of the medium – nutrient type; while the rest are found to be below the medium nutrient category. Hence, some of these accessions can be utilised to eradicate endemic diseases and also enhance food security [28,29,30].

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