IJSAR
ISSN: 2504-9070

# VARIATIONS IN NUTRIENT AND ANTINUTRIENT CONTENT OF SOME NIGERIAN BAMBARA GROUNDNUT ACCESSIONS

Okereke, Agbonma Chioma[a]; Edugbo, Richmond Emuohwo[b*]; Nwofia, Godson Emeka[c] and Okocha, Peter Iwunor[c]

**[a]National Institute for Oil Palm Research (NIFOR), Benin City, Edo State Nigeria.**
**[b]Federal University of Technology, Babura, Jigawa State, Nigeria.**
**[c]Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.**

[*] Corresponding Author: richmondedugbo@gmail.com

## ABSTRACT

Proximate and nutrient analysis of edible plants plays a crucial role in assessing their nutritional significance. Biochemical analysis of the carbohydrate, fat, protein and mineral content reveals that Bambara groundnut produces an almost balanced diet. However, the nutritional attributes may vary among samples of different genotypes. This study evaluated the variations in the proximate, mineral and antinutrient characters of thirteen Bambara groundnut accessions planted across three locations. The results showed that the Bambara groundnut accessions varied significantly for all the proximate, mineral and antinutrient traits evaluated. These significant genotypic variations in nutrient attributes may be attributed to differences in the genetic architecture of the accessions and suggest the potential for improvement of any of these nutrient traits through breeding programmes. Location also played a critical role in influencing these nutritional traits, further impacted by genotype-environment interactions. PCA showed substantial contributions of nutrient traits to the total observed variation. This study highlights the influence of environmental factors, such as agro-climatic and soil conditions, on Bambara groundnut's nutritional quality. The study also showed evaluated accessions are rich in nutrients, underscoring their potential as valuable dietary components in sub-Saharan Africa, particularly Nigeria. These genotypes offer promising breeding material for improving the nutritional characteristics of Bambara groundnut.

Key words: Accessions, nutritional analysis, proximate composition, minerals, phytochemicals

## Introduction

Bambara groundnut (Vigna subterranea L. Verdc) is a herbaceous annual plant characterized by creeping stems. It is an indigenous African legume that remains underutilized (Unigwe et al., 2016). The crop is especially valued for its high protein content and is primarily grown by small-scale farmers for subsistence purposes (Unigwe et al., 2016). Most cultivated Bambara groundnut genotypes are landraces, which are derived directly from their wild relatives (Unigwe et al., 2016). These landraces have adapted to local environmental conditions and are favored by farmers for their yield stability across various environments (Massawe et al., 2005). As a result, they provide an essential source of genetic diversity that can be further exploited. Conducting proximate and nutrient analysis of edible plants is critical for understanding their nutritional value (Pandey et al., 2006). There is need for more research to focus on the nutritional and phytochemical properties of crops like Bambara groundnut, which are important but often neglected. Nutritionally, Bambara groundnut represents an affordable, protein-rich food source that could help improve food and nutrition security, particularly in rural households. Biochemical analysis of its carbohydrate, fat, protein, and mineral content reveals that it provides a nearly balanced diet. However, the nutritional and phytochemical properties may vary among different genotypes (Adeleke et al., 2018), possibly due to differences in genetic makeup and the influence of environmental factors such as agro-climatic conditions and crop management practices. Consequently, this study aims to investigate the variation in nutritional traits among different Bambara groundnut accessions across various locations.

## Materials and methods

### Experimental site

Field experiments were carried out across 2017 and 2018 cropping seasons in three field locations. The locations were: (i) The substation of National Cereals Research Institute (NCRI) Amakamma, in humid Rainforest agro- ecological zone of South East Nigeria (lat.$5^0$ $28^1$ N, Long.$7^0$ 29 $^1$ E; The Research station of the Nigerian Institute For Oil Palm Research (NIFOR), Benin city, Edo State, Nigeria. The location lies in the rainforest agro-ecological zone of Nigeria with latitude $6^0$ $33^1$N and longtitude $5^0$ $37^1$ E and lies 156m above sea level. (iii) The third location is the substation of National Root Crops Research Institute (NRCRI), Igbariam; which falls in the derived savannah agro-ecological belt of Nigeria. It lies in Latitude $06^0$ $14^1$ N and longititude $06^0$ $45^1$ E.

Pre-planting soil analysis:

Pre-planting soil sample analysis was done to determine the physico-chemical properties of the planting sites. Soil samples from depth of 0-20 cm were randomly collected from different points of planting sites, using a soil extractor (augar) before field preparation. The collected sample were bulked and taken to soil science laboratory for analysis.

**Planting materials:**

Thirteen accessions of Bambara groundnut were collected from different areas in Northern and South eastern Nigeria and used for the study.

Table 1 Bambara groundnut accessions used in this study and their sources of collection

| S/No. | Accessions | State of origin |
|---|---|---|
| A1 | Kano | Kano state |
| A2 | Zuru11 | Kebbi state |
| A3 | Ankpa | Kogi state |
| A4 | Jos11 | Plateau state |
| A5 | Zuru1 | Kebbi state |
| A6 | Nkanu | Enugu state |
| A7 | Jos111 | Plateau state |
| A8 | Agwu | Enugu state |
| A9 | Jos1 | Plateau state |
| A10 | Aniri | Enugu state |
| A11 | Ezeagu | Enugu state |
| A12 | Nsukka | Enugu state |
| A13 | Lafia | Nasarawa |

**Data collection**

Harvested grains of 13 Bambara groundnut accessions from each location were packaged, appropriately labelled and taken to the laboratory for determination of the proximate, mineral, vitamins and anti-nutrient contents

Proximate analysis:

The moisture, crude fibre, crude protein, ash, crude fat and carbohydrate of the samples were determined using methods of the Association of Official Analytical Chemists (AOAC, 1984). All determinations were done in triplicates. Determination of moisture content was done by weighing the sample in crucible and drying in oven at 105$^{o}$C, until a constant weight was obtained. Determination of ash content was done by ashing at 550$^{o}$C for about 3hrs. The Kjeldhal method was used to determine the protein content by multiplication of the nitrogen value with a conversion factor of 6.25. The crude fibre content of the samples was determined by digestion method and the crude fat was done by Soxhlet extraction method. Total soluble carbohydrate was determined by the difference of the sum of all the proximate composition from 100%.

**Mineral element analysis:**

The mineral contents - potassium and sodium were determined using flame photometer, while calcium, magnesium, iron, zinc and manganese was determined using atomic absorption spectrophotometer as described by the Association of Official Analytical Chemists (AOAC, 1990) after appropriate digestion by acids. All the determinations were done in triplicates.

Phytochemical analysis

Qualitative phytochemical analyses of the Bambara groundnuts were determined using the methods of Sofowora (1993) and Harborne (1999). All determinations were done in triplicates.

**Data analysis**

Data obtained from the biochemical analyses were subjected to analysis of variance (ANOVA) using GenStat for Windows, 12th edition (2009). Principal component analysis was used to decompose the total variation in order to determine the nutrient variables that contribute the most of the total variation.

## RESULTS

The result showed that the proximate composition (table 2 and table 3) of the bambara groundnyut accessions was significantly affected by genotype variations and location ($P < 0.05$). Among the accessions, Ankpa had the highest ash content (2.619%), highest protein fraction (2.291%) and highest fat cntent (6.753%) while the highest carbohydrate fraction was recorded in Aniri (61.279%). Nkanu recorded the highest crude fibre (2.127%) and moisture contents (7.480%) while Agwu had the highest dry matter content (93.56%). Across locations, Bbambara groundnut grown at Amakama had the highest ash (3.081%), crude fibre (2.0397%) and fat contents (6.318%). The highest carbohydrate (60.218%) and dry matter contents were recorded in bambara groundnut grown at Igbariam while those grown at Benin recorded the highest protein (22.705%) and moisture contents (7.136%).

Table 4 and 5 show the mineral content of 13 bambara groundnut accessions grown across three locations. Genotype and location had significant effects on the mineral contents of the bambara groundnut accessions ($P < 0.05$). Among the accessions, Ezeagu recorded the highest iron (5.29mg100g) and phosphorus (36.52mg/100g) contents while Jos III recorded the highest potassium (197.709mg/100g) and zinc (4.859mg/100g). Nkanu had the highest calcium content (292.36mg100g), Zuru had the highest copper content (0.3944mg100g), Agwu recorded the highest sodium content (40.531mg100g) while Ankpa had the highest magnesium content (52.788mg100g). Bambara groundnut grown at Igbariam had the highest calcium (273.85mg/100g), copper (0.3408mg/100g), iron (5.706mg/100g) and zinc (4.788mg/100g) contents while those grown at Benin had the highest potassium (198.716mg/100g), sodium (38.51mg/100g) and phosphorus (36.518mg/100g) contents. Babara groundnut grown at Amakama had the highest magnesium (51.756mg/100g) content

Variations in genotype and location had significant effects on the antinutrient contents of the bambara groundnut accessions ($p < 0.05$). Table 6 and 7 show the antinutrient content of 13 bambara groundnut accessions grown across three locations. Among the accessions, Lafia recorded the highest alkaloid (0.4678mg/100g) and T.I. (20.272mg/100g) contents. Jos I and Jos II recorded the highest phytate (0.6428mg/100g) and tannin (0.7506mg/10g) contents respectively. Agwu had the highest HCN content (3.047mg/100g), Nkanu had the highest hemaglutinin content (1766.8mg/100g) while Ezeagu had the highest saponin content (0.5022mg/100g). Across locations, Bambara groundnut grown at Benin recorded the highest alkaloid (0.4751mg/100g), HCN (2.9026mg/100g), T.I. (17.412mg/100g) and saponin (0.4817mg100g) contents while those grown at Amakama had the highest hemaglutinin (1717.5mg/100g), phytate (0.5438mg/100g) and tannin (0.7299mg/100g) contents.

Table 2: The Proximate content of thirteen Bambara groundnut accessions

| Accession | Ash content | Crude fibre | Carbo--hydrate | Crude protein | Fat content | Dry Matter | Moisture content |
|---|---|---|---|---|---|---|---|
| Kano | 2.496 | 2.0889 | 59.555 | 22.514 | 5.964 | 92.73 | 7.266 |
| Zuru II | 2.563 | 2.0406 | 60.040 | 22.466 | 6.381 | 93.33 | 6.508 |
| Ankpa | 2.619 | 2.0250 | 58.168 | 23.291 | 6.753 | 92.83 | 7.122 |
| Jos II | 2.406 | 1.9178 | 59.657 | 22.806 | 6.534 | 93.37 | 6.625 |
| Zuru I | 2.572 | 1.8483 | 60.109 | 21.713 | 6.342 | 92.62 | 7.382 |
| Nkanu | 2.479 | 2.1272 | 59.255 | 22.157 | 6.513 | 90.33 | 7.480 |
| Jos III | 2.525 | 1.9278 | 61.183 | 21.499 | 6.245 | 93.40 | 6.621 |
| Agwu | 2.567 | 1.9756 | 60.904 | 22.302 | 5.765 | 93.56 | 6.456 |
| Jos I | 2.552 | 2.0733 | 60.095 | 22.080 | 6.234 | 93.03 | 6.937 |
| Aniri | 2.387 | 2.0039 | 61.279 | 21.408 | 6.172 | 93.21 | 6.749 |
| Ezeagu | 2.599 | 1.8911 | 60.586 | 22.547 | 5.468 | 92.93 | 7.069 |
| Nsukka | 2.396 | 1.9939 | 59.390 | 22.993 | 6.247 | 93.04 | 7.036 |
| Lafia | 2.288 | 2.0628 | 58.047 | 23.436 | 6.544 | 92.55 | 7.454 |
| Mean | 2.496 | 1.9982 | 59.867 | 22.401 | 6.243 | 92.84 | 6.977 |
| $LSD^{(0.05)}$ | 0.1108 | 0.08931 | 0.4864 | 0.3342 | 0.1285 | 0.9159 | 0.2561 |
| | *** | *** | *** | *** | *** | *** | *** |

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Table 3: The proximate content of thirteen Bambara groundnut accessions grown across three locations in Southern Nigeria

| Nutrient trait | Amakanma | Location Igbariam | Benin | Mean |
|---|---|---|---|---|
| Ash content | 3.081 | 2.296 | 2.111 | 2.496 |
| Crude fibre content | 2.0397 | 2.0258 | 1.9290 | 1.9982 |
| Carbohydrate content | 59.449 | 60.218 | 59.933 | 59.867 |
| Crude protein content | 22.173 | 22.325 | 22.705 | 22.401 |
| Fat content | 6.318 | 6.255 | 6.156 | 6.243 |
| Dry matter content | 92.99 | 93.16 | 92.38 | 92.84 |
| Moisture content | 6.955 | 6.841 | 7.136 | 6.977 |

Table 4: The mineral content (mg/100g) of thirteen Bambara groundnut accessions

| Accession | Calcium content | Copper content | Iron Content | Potassium content | Magnesium Content | Sodium content | Phosphorus Content | Zinc Content |
|---|---|---|---|---|---|---|---|---|
| Kano | 262.20 | 0.3089 | 4.977 | 194.306 | 50.209 | 33.251 | 33.235 | 4.1039 |
| Zuru II | 258.95 | 0.2983 | 4.712 | 190.537 | 51.325 | 36.406 | 32.454 | 4.4717 |
| Ankpa | 255.37 | 0.3844 | 5.014 | 182.788 | 52.788 | 33.284 | 32.581 | 4.2328 |
| Jos II | 243.46 | 0.3367 | 4.203 | 178.152 | 50.947 | 36.496 | 34.961 | 4.8039 |
| Zuru I | 268.27 | 0.3944 | 5.210 | 178.106 | 50.202 | 32.767 | 33.043 | 4.6950 |
| Nkanu | 292.36 | 0.3378 | 4.534 | 195.528 | 51.654 | 36.893 | 32.804 | 4.4489 |
| Jos III | 277.11 | 0.3017 | 4.736 | 197.709 | 49.815 | 39.729 | 33.353 | 4.8594 |
| Agwu | 276.70 | 0.3661 | 4.522 | 176.659 | 51.219 | 40.531 | 34.296 | 4.2244 |
| Jos I | 269.53 | 0.3267 | 4.933 | 171.821 | 51.199 | 40.498 | 35.662 | 4.2544 |
| Aniri | 285.54 | 0.3550 | 4.816 | 164.812 | 51.749 | 40.342 | 34.582 | 4.2750 |
| Ezeagu | 267.43 | 0.3489 | 5.279 | 164.468 | 50.518 | 39.439 | 36.542 | 3.9583 |
| Nsukka | 267.53 | 0.2939 | 4.939 | 174.335 | 51.342 | 34.438 | 35.289 | 4.3000 |
| Lafia | 272.51 | 0.3189 | 4.658 | 196.313 | 50.020 | 34.771 | 33.176 | 4.1922 |
| Mean | 268.23 | 0.3363 | 4.810 | 181.964 | 50.999 | 36.850 | 33.998 | 4.3708 |
| LSD$^{(0.05)}$ | 2.156 *** | 0.0126 *** | 0.1352 *** | 0.5628 *** | 0.3895 *** | 0.2930 *** | 0.6161 *** | 0.0843 |

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Table 5: The mineral nutrient content of thirteen Bambara groundnut accessions grown across three locations in Southern Nigeria

| Nutrient trait | Amakanma | Location Igbariam | Benin | Mean |
|---|---|---|---|---|
| Calcium content | 267.05 | 273.85 | 263.78 | 268.23 |
| Copper content | 0.3340 | 0.3408 | 0.3341 | 0.3363 |
| Iron content | 4.793 | 5.106 | 4.531 | 4.810 |
| Zinc content | 4.0944 | 4.7888 | 4.2291 | 4.3708 |
| Sodium content | 37.400 | 34.638 | 38.510 | 36.850 |
| Potassium content | 165.556 | 181.621 | 198.716 | 181.964 |
| Magnesium content | 51.756 | 49.882 | 51.359 | 50.999 |
| phosphorus content | 32.779 | 32.698 | 36.518 | 33.998 |

Table 6: The antinutrient content of thirteen Bambara groundnut accessions

| Accession | Alkaloid content | HCN content | Hemaglutinin content | T.I Content | Phytate content | Saponin content | Tanin content |
|---|---|---|---|---|---|---|---|
| Kano | 0.3300 | 2.2239 | 1657.1 | 12.158 | 0.4506 | 0.3444 | 0.7261 |
| Zuru II | 0.3522 | 2.3656 | 1592.0 | 13.039 | 0.5111 | 0.4083 | 0.7161 |
| Ankpa | 0.3261 | 3.0133 | 1565.4 | 12.528 | 0.5583 | 0.4511 | 0.7033 |
| Jos II | 0.3561 | 2.6983 | 1732.4 | 14.270 | 0.4922 | 0.4189 | 0.7506 |
| Zuru I | 0.4072 | 3.0283 | 1743.6 | 12.531 | 0.4622 | 0.3439 | 0.6983 |
| Nkanu | 0.3744 | 2.8744 | 1766.8 | 14.493 | 0.4906 | 0.3400 | 0.6278 |
| Jos III | 0.3950 | 2.6617 | 1744.2 | 16.644 | 0.4750 | 0.3383 | 0.7078 |
| Agwu | 0.4400 | 3.0472 | 1542.4 | 16.103 | 0.6256 | 0.4039 | 0.7178 |
| Jos I | 0.3139 | 2.9406 | 1699.9 | 16.051 | 0.6428 | 0.4250 | 0.6544 |
| Aniri | 0.4622 | 2.7783 | 1584.4 | 13.844 | 0.5222 | 0.4294 | 0.6867 |
| Ezeagu | 0.3650 | 2.3517 | 1549.2 | 14.066 | 0.5439 | 0.5022 | 0.7144 |
| Nsukka | 0.3739 | 2.1028 | 1627.7 | 18.202 | 0.4928 | 0.4411 | 0.7078 |
| Lafia | 0.4678 | 2.7161 | 1654.1 | 20.272 | 0.5144 | 0.4172 | 0.6722 |
| Mean | 0.3818 | 2.6771 | 1650.7 | 14.939 | 0.5217 | 0.4049 | 0.6987 |
| $LSD^{(0.05)}$ | 0.02084 *** | 0.04486 *** | 14.09 *** | 0.5080 *** | 0.01605 *** | 0.01432 *** | 0.0.014 *** |

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Table 7: The antinutrient content of thirteen Bambara groundnut accessions grown across three locations in Southern Nigeria

| Genotype | Amakanma | Location<br>Igbariam | Benin | Mean |
|---|---|---|---|---|
| Alkaloid content | 0.3542 | 0.3162 | 0.4751 | 0.3818 |
| HCN content | 2.4973 | 2.6314 | 2.9026 | 2.6771 |
| Hemaglutinin content | 1717.5 | 1578.2 | 1656.4 | 1650.7 |
| Phytate content | 0.5438 | 0.5290 | 0.4922 | 0.5217 |
| Saponin content | 0.3249 | 0.4082 | 0.4817 | 0.4049 |
| T.I. content | 13.822 | 13.582 | 17.412 | 14.939 |
| Tanin content | 0.7299 | 0.7201 | 0.6462 | 0.6987 |

Principal component analysis

The eigenvector values for principal components of nutritional traits of thirteen Bambara groundnut accessions grown across three locations in Southern Nigeria in 2017 and 2018 are shown in Table 8. The total variation in the measured nutritional traits of the Bambara groundnut accessions was partitioned into twelve principal components (PCs), with the first three PCs accounting 54.2% of the total variation in the nutritional character of the accessions. The first principal component (PC1) captured 21.5% of the total variation. It had an eigen value of 4.731 and had crude protein content, carbohydrate content, calcium content, sodium content, and phytate content as its major contributing attributes. PC2 with an eigen value of 3.862 represented 17.6% of the total variation had moisture content, dry matter content, and tannin content as the major contributing factors. PC3 which captured 15.1% of the variation with eigen value of 3.321 had high loadings for potassium, zinc, hydrogencyanide and T.I.

Table: 8: eigenvector values for principal components nutritional traits of thirteen Bambara groundnut accessions grown across three locations in Southern Nigeria in 2017 and 2018.

| | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 |
|---|---|---|---|---|---|---|
| Eigen Values | 4.731 | 3.862 | 3.321 | 2.659 | 2.174 | 1.461 |
| Proportion of Variance (%) | 21.5 | 17.6 | 15.1 | 12.1 | 9.9 | 6.6 |
| Cumulative Proportion (%) | 21.5 | 39.1 | 54.2 | 66.2 | 76.1 | 82.8 |
| | | | | | | |
| Moisture content | 0.069 | 0.324 | 0.189 | -0.208 | 0.186 | 0.009 |
| Dry matter | 0.028 | -0.434 | -0.045 | -0.065 | -0.052 | 0.388 |
| Ash | -0.210 | 0.130 | 0.001 | -0.373 | 0.151 | -0.062 |
| Crude protein | 0.373 | 0.066 | 0.201 | -0.011 | -0.105 | -0.098 |
| Crude fibre | -0.165 | 0.194 | 0.221 | 0.342 | -0.099 | 0.094 |
| Carbohydrate | -0.338 | -0.250 | -0.176 | -0.006 | 0.091 | 0.015 |
| Calcium | -0.302 | 0.197 | 0.180 | -0.111 | -0.095 | -0.005 |
| Magnesium | 0.156 | 0.231 | -0.133 | -0.022 | -0.417 | 0.000 |
| Phosphorus | -0.294 | -0.135 | -0.052 | -0.020 | -0.116 | -0.335 |
| Potassium | -0.100 | 0.022 | 0.359 | 0.223 | 0.260 | 0.027 |
| Iron | -0.051 | 0.193 | 0.047 | -0.320 | 0.103 | 0.532 |
| Zinc | 0.087 | -0.137 | -0.406 | 0.303 | 0.034 | 0.065 |
| Copper | -0.025 | 0.097 | -0.283 | -0.338 | -0.322 | 0.156 |
| Sodium | -0.370 | -0.212 | 0.005 | 0.023 | -0.152 | -0.202 |
| Tannin | 0.156 | -0.353 | -0.085 | -0.126 | 0.186 | 0.268 |
| Phytate | -0.301 | 0.000 | -0.010 | 0.083 | -0.366 | 0.208 |
| Alkaloid | -0.327 | 0.200 | -0.052 | 0.138 | -0.071 | 0.332 |
| Hydrogecyanide | -0.072 | 0.297 | -0.358 | -0.089 | 0.125 | -0.058 |
| T.I | -0.048 | -0.069 | 0.339 | 0.237 | -0.065 | 0.318 |
| Haem | -0.115 | 0.245 | -0.270 | 0.317 | 0.211 | -0.008 |
| Saponin | 0.044 | -0.135 | 0.253 | -0.162 | -0.436 | -0.128 |

Discussion

This research examined the differences in proximate, mineral, and antinutrient properties across thirteen Bambara groundnut accessions planted in three locations. The findings revealed significant variations in all the evaluated nutritional traits among the accessions. These differences in nutrient content could be attributed to genetic diversity among the accessions, indicating the potential for enhancing these traits through breeding programs. Previous studies, such as those by Unigwe et al. (2018), Adeleke et al. (2018), Anhwange and Atoo (2015), and Amarteifio et al. (2006), have also documented considerable nutritional variation based on genotype. Location significantly impacted all nutritional traits except copper, suggesting that environmental factors, such as agro-climatic conditions and soil quality, influence the nutrient composition of Bambara groundnuts. Significant year-to-year variations were observed in all traits, except crude fiber and phosphorus content. Additionally, the results indicated significant genotype × environment interactions, emphasizing the role of environmental factors in shaping the nutritional qualities of grain crops. According to Halimi et al. (2019), both genetic and environmental factors, along with their interaction, account for the variation in the nutritional composition of grain crops within and between species. The ash content of the accessions was lower than the 4.36% and 3.53% reported by Olaleye et al. (2013) and Anhwange and Atoo (2015), but consistent with values reported by Yao et al. (2015) and Akaninwor and Okechukwu (2004). The crude fiber content content observed in this study aligns with the findings of Olaleye et al. (2013) but is lower than the values reported by Adeleke et al. (2018), Yao et al. (2015), and Anhwange and Atoo (2015). Carbohydrate levels in the accessions were high, ranging from 58.05% in Lafia to 61.28% in Aniri, which is at the upper end of previously reported ranges for Bambara groundnut (Udeh et al., 2020). The mean crude protein content across both years was 22.4%, with values ranging from 21.4% in Aniri to 23.4% in Lafia, surpassing the values reported by Adeleke et al. (2018), Yao et al. (2015), Olaleye et al. (2013), and Anhwange and Atoo (2015). According to Mwale et al. (2007), Bambara groundnut's protein content is comparable to other legumes, making it a valuable complement to cereal-based diets. Although the protein content of Bambara groundnut is often reported to be below 25%, Halimi et al. (2019) suggested that selective breeding could enhance its protein concentration, contributing more significantly to food and nutrition security, particularly in sub-Saharan Africa.The fat content of the accessions ranged from 5.5% in Ezeagu to 6.8% in Ankpa, with an overall mean of 6.2%. These values exceed those reported by Yao et al. (2015) but align with those by Adeleke et al. (2018). Although Bambara groundnut's fat content is low compared to oilseeds like groundnut or soybean, it falls within the expected range for pulses, making it unsuitable for oil extraction (Duranti and Gius, 1997; Mudryj et al., 2014;

The mineral levels in this study exceeded those reported by Adeleke et al. (2018), Olaleye et al. (2013), and Amarteifio et al. (2006) but fell short of the values reported by Halimi et al. (2019). The levels of ANFs observed in this study were lower than those in previous studies (Halimi et al., 2019; Yao et al., 2015; Olaleye et al., 2013; Mazahib et al., 2013; Akaninwor and Okechukwu, 2004). Antinutritional factors (ANFs) in pulses, such as enzyme inhibitors, tannins, and phytic acid, limit their broader use and consumption (Rochfort and Panozzo, 2007; Soetan and Oyewole, 2009). ANFs reduce protein digestibility and nutrient absorption, with phytates hindering mineral absorption (Gilani et al., 2012). Reducing ANFs through breeding is a priority for improving digestibility and taste (Wang et al., 2003). PCA showed substantial contributions of nutrient traits to the total observed variation.

## Conclusion

The nutritional analysis of Bambara groundnut accessions across three locations demonstrated significant genetic variation in proximate, mineral, and antinutrient traits. Location also played a critical role in influencing these nutritional traits, further impacted by genotype-environment interactions. PCA showed substantial contributions of nutrient traits to the total observed variation. This study highlights the influence of environmental factors, such as agro-climatic and soil conditions, on Bambara groundnut's nutritional quality. The evaluated accessions are rich in nutrients, underscoring their potential as valuable dietary components in sub-Saharan Africa, particularly Nigeria. These genotypes offer promising breeding material for improving the nutritional characteristics of Bambara groundnut.

REFERENCE

Adeleke O.R.; Adiamo O.Q. and Fawale, O.S. (2018). Nutritional, physicochemical, a functional properties of protein concentrate and isolate of newly developed Bambara groundnut (Vigna subterreneaL.) cultivars. Food Science and Nutrition. 2018;6:229–242. https://doi.org/10.1002/fsn3.552

Akaninwor, J.O. and Okehchuwu, P.N. (2004). Comparative nutrient and anti-nutrient levels in commercial and formulated weaning mixtures. Biokemistri 16(1):15-21

Akinyeye, R.O.; Adeyeye, E.I.; Fasakin, O. and Agboola, A. (2011).Physicochemical properties and anti-nutritional factors of oil palm fruit products (Elias guineensis Jacq.) from Ekiti State. Electronic Journal of Environmental Agriculture and Food Chemistry. 10(5) 2190-2198

Anhwange, B.A. and Atoo, G.H. (2015). Proximate Composition of Indigenous Bambara nuts (Vigna subterranean (L.) Verdc). SCSR Journal of Pure and Applied Sciences (SCSR-JPAS) 2(1): pp 11 - 16

AOAC. Association of Official Analytical Chemists. (1990). Official methods of analysis of the association of official analytical chemists. 16th ed. Gaithersburg (MD): AOAC International.

Duranti, M., Gius, C., 1997. Legume seeds: protein content and nutritional value. Field Crops Res. 53, 31–45

Gilani, G.S., Xiao, C.W., Cockell, K.A., 2012. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. Br. J. Nutr. 108, S315–S332.

Halimi, A.R.; Mayes, S. Barkla, B. and King, G. (2019). The potential of the underutilized pulse bambara groundnut (Vigna Subterranea (L.) Verdc.) for nutritional food security. Journal of Food Composition Analysis. 77:47–59.

Massawe, FJ, Dickson, M, Roberts, JA, Azam – Ali, SN. (2002), Genetic diversity in Bambara groundnut (Vigna Subterranean [L.] Verdc.), landraces revealed by AFLP markers. Published on NRC Research Press Website http//:www.genome.nrc.ca, Canada

Mazahib, A.M.; Nuha, M.O.; Salawa, I.S. and Babiker E.E. (2013). Some nutritional attributes of bambara groundnut as influenced by domestic processing. International Food Research Journal, 20:1165–71

Mudryj, A.N., Yu, N., Aukema, H.M., 2014. Nutritional and Health Benefits of Pulses 39. pp. 1197.

Mwale SS, Azam-Ali SN, Massawe FJ. (2007). Growth and development of bambara groundnut (Vigna subterranea) in response to soil moisture: 1. Dry matter and yield. European Journal of Agronomy 26, 345-353

Olaleye, A.A.; Adeyeye, E.I. and Adesina A.J. (2013). Chemical composition of bambara groundnut (V. subterranea L. Verdc) seed parts. Bangladesh Journal of Scientific And Industrial Research. 48(3): 167-178

Rochfort, S., Panozzo, J., 2007. Phytochemicals for health, the role of pulses. J. Agric. Food Chem. 55, 7981–7994

Samuel, U.N.; Unekwuojo, C.N.; Olagunju, A.; Muhammad, A.; Graham, F.B. and Okpe, O. (2014). Proximate, antinutrients and mineral composition of raw and processed (boiled and roasted) Sphenostylis stenocarpa seeds from southern Kaduna, Northwest Nigeria. Journal of International Scholarly Research Notices Nutrition 9:1–9

Sandberg, A.S., 2002. ). Bioavailability of minerals in legumes. Br. J. Nutr. 88 (Suppl 3), S281–5.

Soetan, K.O., Oyewole, O.E., 2009. The need for adequate processing to reduce the antinutritional factors in plants used as human foods and animal feeds: a review. African Journal of Food Science. 3(9):223-232

Unigwe, A.E.; Gerrano, A.S.; Adebola, P. and Pillay, M. (2016). Morphological variation in selection accessions of bambara groundnut (Vigna subterranae L. Verdc) in South Africa. Journal of Agricultural Science. vol 8, No 11. URL: http://dx.doi.org/10.5539/jas.v8n11p69

Wang, T.L., Domoney, C., Hedley, C.L., Casey, R., Grusak, M.A., 2003. Can we improve the nutritional quality of legume seeds? Plant Physiol. 886–891

Yao, D., Beket, B.S. and Zoro, I.A. (2005). Observations preliminaries de variabilite entre quelquesmorphotypes de voandzou (Vigna subterranea L. Verdc.) de Côte d'Ivoire. Biotechnologie, Agronomie, Society of Environmental Sciences. 9, 249 – 258.

Acknowledgement:
No funding was received for this work. However, the authors would like to thank the National Cereal research Institute and the National Institute for Oil Palm Research (NIFOR) for providing land for setting up of the field experiment.

Authurs' contribution:
All authors collaborated in this work. Okereke, A. C. and Nwofia G. E. designed the study. The field work, data collection and statistical analysis were done by Okereke, A.C. under the supervision of Nwofia, G.E. and Okocha, P. I. Writing of initial draft, editing and formating was carried out by Edugbo, R.E.. The final draft was read by all authors.