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NUTRITIONAL DIVERSITY OF TWO *PHASEOLUS* ACCESSIONS FROM NORTHERN NIGERIA

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ABSTRACT

Malnutrition is still prevalent in Nigeria as a result of the decline in protein intake owing to scarcity and un-affordable price of animal protein. *Phaseolus* species is an underutilised crop in Nigeria with potentials as a good source of protein, nutrients and minerals, and with high medicinal value. This study was aimed at investigating the nutritional diversity of twenty-nine accessions of *Phaseolus vulgaris* and four accessions of P. *lunatus* collected from growing regions in Northern Nigeria using the AOAC methods. The result of proximate composition showed that moisture content was lowest in KD-06 (3.79 %); KD-08 had the highest protein content (27.08 %); carbohydrate content was highest in KD-05 (70.03 %). Pl- 10 had the highest crude fat (8.37 %) while crude fibre was highest in KD-10 (10.15 %). PL-14 had the highest energy value (392.44 kcal/100 g). Mineral composition also varied across the accessions studied. Calcium was highest in KD-10 (570 mg/100 g); magnesium was highest in KD-08 (43 mg/100 g); potassium was highest in PL-05 (55.30 mg/100 g) while phosphorus was highest in PL-02 (532.00 mg/100 g). *Phaseolus* species present in Northern Nigeria possess a great diversity which can be harnessed by plant breeders to produce varieties of *Phaseolus* with better nutritional qualities in the future.

Key words: Malnutrition; proximate; mineral; nutritional; accession
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INTRODUCTION

Beans (*Phaseolus* species) as a traditional food in the human diet, has low lipid content and is rich in proteins, vitamins, complex carbohydrates and minerals. It is a source of proteins, dietary fibre (14-19%), minerals (Ca, Fe, Cu, Zn, P, K and Mg) and unsaturated fatty acids (De Barros and Prudencio, 2016). It is a nutrient-dense food crop that is particularly important in Sub-Saharan Africa (SSA), where it provides both rural and urban households with critical minerals, vitamins, carbohydrates and proteins. It is estimated that the crop meets more than 50% of dietary protein requirements of households in SSA (Namugwanya *et al*., 2014, Onkgolotse *et al*., 2022).

Members of the *Phaseolus* genus belong to the leguminous family Fabaceae. Legumes are staple food in human diets around the world (Ndidi *et al*., 2014; Onkgolotse *et al*., 2022), hence their wide cultivation in most countries, with total world production rates of more than 17 million tonnes, led by China, Indonesia, India and Turkey as the largest producers and consumers of beans (FAOSTAT, 2010; Richardson, 2012). *Phaseolus* is one of the most adaptable legumes; it can withstand heat, drought, and it grows on marginal soils. These days, the bulk of crop genetic diversity and attractive features remain unused in elite varieties, causing a simultaneous degradation in nutritional quality due to the loss of genetic resources and crop diversity (Gouveia *et al*., 2011).

Malnutrition is one of the leading causes of death globally (WHO, 2013). In Nigeria, more than half of children under five years of age are stunted (Owolabi *et al*., 2020). About six out of the seventeen million Nigerians who lack access to food currently reside in Borno, Adamawa, Yobe, Sokoto, Katsina and Zamfara states and are under the age of five. When acute malnutrition is the cause, children are at the grave risk of dying.

Between 2022 and 2023, there were 1.74 million more children suffering from acute malnutrition than there were in 2022. The northwest area, which includes the states of Katsina, Zamfara and Sokoto, is becoming a hotspot of malnutrition and food insecurity. If immediate action is not taken, the estimated 2.9 million individuals who are currently experiencing critical food insecurity are expected to increase to 4.3 million in the coming years (FAO, 2023).

Nigeria is a populous country with a high prevalence of nutritional deficiency varying widely across its borders owing to high cost and inadequate supply of animal protein (Adekunmi *et al*., 2017). As at 2019, Nigeria’s per capital daily protein intake (45.4 g) was lower than both the Food and Agriculture Organisation (FAO) recommended minimum per capita daily protein intake (53.8 g) and the global daily intake (64 g), indicating that the country is faced with protein deficiency (De Vries *et al*., 2020). Protein-energy malnutrition is still prevalent in Nigeria as a result of the decline in protein intake owing to scarcity and unaffordable price of animal protein food sources (Metu *et al*., 2016; Akerele *et al*., 2017).

Food-based strategies are vital to stop the crippling effects of malnutrition by encouraging the consumption of foods that are naturally rich in micronutrients. One such strategy is dietary diversification, which is defined as household access to a variety of foods and can also act as a proxy for individuals’ nutrient adequacy (Owolabi *et al*., 2020).

Phaseolus species are underutilised crops in Nigeria with a protein content that ranges between 20 and 30% and possess numerous health benefits which include reduction of cholesterol level and coronary heart diseases, favourable effects against cancer, decrease of diabetes and obesity and a high anti-oxidant capacity (Xu and Chang, 2012; Nwadike *et al*., 2018). This study was aimed at unravelling the proximate and mineral compositions of accessions of *Phaseolus* species collected from growing regions in Northern Nigeria. These can serve as a useful source of nutrients.

MATERIALS AND METHODS

Collection of Germplasm

A total of thirty-three (33) landraces of *Phaseolus* were obtained from local farmers in the four states (Kaduna, Plateau, Taraba and Kogi) where they are cultivated in Northern Nigeria and assigned accession number Twenty-nine accessions are *Phaseolus vulgaris* (KD-01, KD-02, KD-03, KD-06, KD-07, KD-08, KD-09, KD-10,KD-11, KD-12, KD-13, KD-14, KD-15, PL-01, PL-05, PL-06, PL-07, PL-08, PL-09, PL-10, PL-11, PL-12, PL-13, PL-14, TA-01, YA-02, TA-03 and KG-01) and four are *Phaseolus lunatus* (KD-04, PL-02, PL-03 and PL-04).

Proximate Composition

Crude Protein

Nitrogen content was determined by the Kjeldahl procedure. The method which involves a three-step approach to the quantification of protein: digestion, distillation and titration, was used to determine the nitrogen content of the bean seeds. Following the determination of total nitrogen, a specific conversion factor was used to convert the measured nitrogen content to the crude protein content. A nitrogen-to-protein conversion factor of 6.25 was used to obtain the protein content (AOAC, 2016).

$$Percentage\ Protein\ Content = \%\ Nitrogen \times 6.25$$

Moisture content

Moisture content was determined using the air-oven method. About 100 g of bean samples was transferred into crucibles and dried at 103-105 ºC. The dry bean samples were cooled in a desiccator and its weight noted. This process was repeated until constant weight was obtained. Moisture content was calculated using the formula of the Association of Official Analytical Chemists (AOAC, 2016):

$$Percentage\ Moisture\ Content = \frac{\text{weight loss}}{weight\ of\ bean\ sample} \times \frac{100}{1}$$

Ash content

Ash content was determined by weighing finely ground bean sample into clean, dried previously weighed crucible with lid. The sample was ignited over a low flame to char the organic matter without the lid. The crucible was placed in muffle furnace at 600 ºC for 6 hrs until it ashed completely. It was then transferred directly into a desiccator to cool and weighed immediately using a weighing balance (AOAC, 2016).

$$Percentage\ Moisture\ Content = \frac{\text{weight loss}}{weight\ of\ bean\ sample} \times \frac{100}{1}$$

Crude fat

Crude fat was determined using the Soxhlet apparatus. About 100 g of bean sample was weighed into a weighed filter paper, neatly folded and placed in a pre-weighed thimble. The thimble with the sample was inserted into the Soxhlet apparatus and extraction under reflux was carried out with petroleum ether (40 – 60 ºC boiling range) for 6 hrs. The thimble was oven-dried at 100ºC for 30 minutes to evaporate off the solvent and allowed to cool in a desiccator before weighing again. The amount of fat extract was calculated using the formula below (AOAC, 2016)

$$Percentage\ Crude\ Fat = \frac{\text{loss in weight of bean sample}}{original\ weight\ of\ bean\ sample} \times \frac{100}{1}$$

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Crude fibre

Crude fibre was determined by taking the fat-free extract obtained after determining ether extract and weight. This was serially heated with dilute acid and alkali to hydrolyse the digestible portion. (AOAC, 2016).

$$Percentage\ Crude\ Fibre = (\text{weight of dried residue after fat extraction}) - (weight\ of\ ash) \times \frac{100}{1}$$

The percentage carbohydrate content

The carbohydrate content of bean seeds was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100%. (AOAC, 2016).

$$Percentage\ Carborhydrate = 100 - \sum(\%\ moisture, ash, fat, protein\ and\ cudefibre)$$

Energy value

The energy value of bean samples was calculated using the Atwater formula:

$$Energy\ value\ (kcal) = [(4\ \times\ \%\ \text{CHO}) + (4\ \times \%\ CP) + (9\ \times \%\ CF)]$$

Where,

CHO, CP and CF stand for carbohydrate, crude protein and crude fat, respectively (Ndayankpa *et al*., 2024).

Mineral Composition Analysis

The accessions were analysed for Ca, Mg, Na, K, P, Fe, Mn and Zn by flame atomic absorption spectrometry. Bean seed samples were ground to fine powder using a pestle and mortar. The samples were concentrated by evaporating 100 ml of sample to about 20 ml. They were thereafter aspirated through the nebulizer into the air-acetylene flame where atomisation took place (AOAC, 2016).

Data Analyses

Data obtained were subjected to one-way Analysis of Variance (ANOVA) using R software (version 4.05) for windows. Statistical testing was carried out using Tukey's Honest Significant Difference (HSD) at $p \leq 0.05$.

RESULTS

Proximate Composition of 33 accessions of *Phaseolus* species

The proximate composition of the 33 accessions of *Phaseolus* species used in this study is presented in Table 1.

Moisture content varied significantly ($p<0.05$) among the different accessions studied. The highest moisture content was observed in PL-04 (10.81 %) which was followed closely by KD-13 with a value of 10.08 %. The lowest value was in observed KD-06 with a moisture content of 3.79 %. Percentage ash content varied significantly ($p<0.05$); the highest value was observed in KD-15 (7.83 %), followed by KD- 10, KD- 11, KD-03 and KD-02 with values of 7.76, 7.80, 7.78 and 7.69 %, respectively. The lowest ash content was observed in PL-14 with a value of 3.21 %. Crude fat content showed significant ($p<0.05$) variation across the accessions; PL-10 and PL-07 had the highest crude fat of 8.37 % and 8.36 %, respectively. The lowest values were observed in KD-04 (1.48 %), PL-03 (1.48 %) and PL-02 (1.49 %).

Crude protein was highest in KD-08 with a value of 27.10 %, followed by KG-01 and PL-14 with values of 23.27 % and 23.07 %, respectively. The lowest protein content was observed in KD-05 (10.64 %). Other accessions which had significantly ($p<0.05$) low protein content were PL-02 (10.74 %), PL-03 (10.75 %) and KD-04 (10.86%). Crude fibre was highest in KD-10 (10.15 %) and followed by KD-11 (10.03%). The lowest value was observed in TA-02 (2.28 %). Other accessions that showed low crude fibre content were KD-06 (2.30 %), KD-09 (2.30 %) and PL-04 (2.30 %). Carbohydrate content was significantly ($p<0.05$) high across several accessions; the highest was observed in KD-05 (70.03 %), followed by PL-03 (69.89 %), KD-04 (69.88 %), PL-02 (69.88 %) and KD-07 (66.06 %). The lowest value was observed in KD -08 with a value of 49.70 %.

Dry matter content was highest in KD -06 with a value of 96.22 %; a similar value of 96.17 % was observed in PL-14. The lowest dry matter content was observed in PL-04 at 89.12 %. Calculated energy value was highest in PL-14 (392.44 Kcal/100 g), which was followed by PL-10 with an energy value of 391.02 Kcal/100 g. The lowest value of 308.80Kcal/100 g was observed in KD-11.

Table 1: Proximate composition of 33 accessions of *Phaseolus* species

ACC. I.D	MC (%)	AC (%)	CF (%)	CP (%)	CFI (%)	CHO (%)	DM (%)	E V (Kcal/100g)
KD-01	5.35±0.45^{efghij}	4.71±0.01^{f}	3.95±0.01^{fgh}	16.80±0.01^{j}	6.11±0.01^{cd}	68.09±0.44^{bcdefgh}	94.65±0.45^{abcdef}	355.18±3.54^{f}
KD-02	8.53±0.29 ^{abc}	7.69±0.08^{a}	4.37±0.44^{ef}	12.70±0.25^{m}	6.58±0.08^{c}	60.10±0.12^{hijkl}	91.45±0.23^{hij}	330.51±2.45^{i}
KD-03	6.70±0.17^{cdefgh}	7.76±0.06^{a}	4.30±0.25^{fg}	12.42±0.13^{m}	6.52±0.11^{c}	62.31±0.60^{efghij}	93.30±0.17^{bcdefgh}	337.35±0.04^{ghi}
KD-04	5.67±0.18^{defghij}	5.34±0.00^{d}	1.48±0.01^{l}	10.86±0.13^{n}	6.90±0.01^{c}	69.88±0.07^{a}	94.31±0.16^{abcdefg}	334.62±0.54^{hi}
KD-05	5.57±0.09^{defghij}	4.80±0.33^{ef}	1.51±0.03^{kl}	10.64±0.02^{n}	6.94±0.02^{c}	70.03±0.30^{a}	93.91±0.60^{abcdefgh}	336.25±1.02^{ghi}
KD-06	3.79±0.54^{j}	3.50±0.01^{hi}	3.98±0.05^{fgh}	22.42±0.12^{c}	3.42±1.59^{fg}	62.91±1.22^{cdefghi}	96.22±0.54^{a}	377.07±5.85^{bcde}
KD-07	4.91±0.98^{fghij}	3.49±0.00^{hi}	4.96±0.01^{d}	18.26±0.18^{g}	2.30±0.00^{g}	66.06±0.83^{a}	95.07±1.03^{abcdef}	383.64±0.05^{abcde}
KD-08	5..65±0.29^{defghij}	6.54±0.00^{c}	2.46±0.00^{ij}	27.10±0.06^{a}	8.51±0.01^{b}	49.70±0.28^{n}	94.30±0.33^{abcdefg}	329.34±0.89^{i}
KD-09	4.10±0.11^{hij}	3.49±0.00^{hi}	3.73±0.05^{h}	20.82±0.09^{d}	2.30±0.00^{g}	65.58±0.15^{bcd}	95.91±0.11^{abc}	379.20±0.83^{abcde}
KD-10	6.87±0.45^{cdefg}	7.80±0.13^{a}	2.14±0.08^{j}	15.61±0.16^{k}	10.15±0.04^{a}	57.45±0.38^{lm}	93.14±0.45^{cdefgh}	354.35±0.40^{f}
KD-11	7.57±2.92^{bcdef}	7.78±0.20^{a}	2.06±0.08^{jk}	16.63±0.18^{k}	10.03±0.14^{a}	56.94±2.99^{m}	92.44±2.92^{efghi}	308.80±13.49^{j}
KD-12	4.46±0.05^{ghij}	3.38±0.20^{hi}	3.78±0.06^{gh}	19.50±0.11^{e}	3.15±0.19^{g}	65.70±0.06^{bc}	95.50±0.00^{abcd}	375.12±0.76^{cde}
KD-13	10.08±0.82^{ab}	5.20±0.01^{d}	5.99±0.01^{c}	12.66±0.06^{m}	6.76±0.12^{c}	59.31±0.70^{jklm}	89.90±0.29^{ij}	341.76±3.17^{fghi}
KD-14	7.66±0.04 ^{bcde}	7.71±0.04^{a}	4.06±0.04^{fgh}	12.24±0.15^{m}	6.59±0.08^{c}	61.81±0.25^{fghijk}	92.40±0.04^{fghi}	332.68±0.11^{hi}
KD-15	8.19±0.05^{abcd}	7.83±0.01^{a}	4.41±0.54^{def}	12.73±0.13^{m}	6.59±0.12^{c}	59.98±0.20^{ijkl}	91.53±0.35^{ghij}	328.24±0.42^{i}
PL-01	4.75±0.00 ^{ghij}	6.93±0.00^{b}	2.06±0.10^{jk}	18.79±0.06^{fg}	4.57±0.00^{ef}	62.90±0.17^{cdefghi}	95.25±0.01^{abcde}	345.26±0.48^{fgh}
PL-02	5.60±0.11^{defghij}	5.33±0.01^{d}	1.49±0.02^{l}	10.74±0.08^{n}	6.94±0.00^{c}	69.88±0.04^{a}	94.37±0.05^{abcdef}	336.29±0.09^{ghi}
PL-03	5.56±0.20^{defghij}	5.35±0.02^{d}	1.48±0.03^{l}	10.75±0.24^{n}	6.90±0.01^{c}	69.89±0.09^{a}	94.36±0.09^{abcdefg}	335.56±0.94^{ghi}
PL-04	10.81±0.21^{a}	3.49±0.00^{hi}	2.96±0.02^{i}	14.85±0.06^{l}	2.30±0.00^{g}	65.76±0.04^{bc}	89.12±0.31^{j}	348.99±0.08^{fg}
PL-05	6.55±0.06^{cdefghi}	5.10±0.02^{de}	4.95±0.01^{d}	17.54±0.04^{h}	6.63±0.04^{c}	59.26±0.09^{klm}	93.46±0.06^{abcdefgh}	351.69±0.44^{f}
PL-06	4.50±0.02^{ghij}	3.54±0.01^{hi}	3.77±0.04^{gh}	19.10±0.14^{ef}	3.01±0.04^{g}	64.84±0.96^{bcde}	94.55±0.33^{abcdef}	369.65±2.96^{e}
PL-07	5.06±0.43^{efghij}	3.60±0.01^{h}	8.36±0.02^{a}	17.56±0.06^{h}	4.68±0.01^{e}	60.76±0.47^{ghijk}	94.95±0.43^{abcdef}	388.52±1.79^{abc}
PL-08	4.01±0.05^{hij}	3.46±0.05^{hi}	3.73±0.04^{h}	20.83±0.01^{d}	2.32±0.01^{g}	65.66±0.03^{bc}	95.99±0.04^{ab}	379.03±0.65^{abcde}
PL-09	5.89±0.30^{cdefghij}	4.64±0.08^{f}	3.95±0.04^{fgh}	16.76±0.07^{j}	6.12±0.05^{cd}	62.64±0.08^{defghi}	93.85±0.67^{abcdefgh}	353.98±3.88^{f}
PL-10	5.17±0.90^{efghij}	3.61±0.01^{h}	8.37±0.03^{a}	17.51±0.04^{h}	4.55±0.10^{ef}	60.86±0.81^{ghijk}	94.84±0.90^{abcdef}	391.02±6.83^{ab}
PL-11	5.95±0.70^{cdefghij}	4.09±0.00^{g}	6.98±0.01^{b}	17.39±0.06^{hi}	5.32±0.01^{de}	60.30±0.63^{hijkl}	94.06±0.70^{abcdefgh}	373.50±2.92^{de}
PL-12	5.74±0.04^{defghij}	3.41±0.01^{hi}	3.67±0.11^{h}	20.55±0.18^{d}	2.39±0.01^{g}	64.25±0.04^{bcdef}	94.27±0.04^{abcdefgh}	372.19±0.39^{e}
PL-13	4.05±0.04^{hij}	3.49±0.01^{hi}	4.02±0.01^{fgh}	22.45±0.10^{c}	2.34±0.06^{g}	63.65±0.10^{bcdefg}	95.95±0.04^{abc}	380.58±0.13^{abcde}

PL-14	3.82±0.44^{ij}	3.21±0.03^{i}	6.42±0.01^{bc}	23.07±0.16^{b}	2.88±0.06^{g}	60.60±0.59^{hijk}	96.17±0.45^{a}	392.44±1.60^{a}
TA-01	5.20±0.79 ^{efghij}	4.74±0.00^{ef}	3.97±0.01^{fgh}	16.90±0.13^{ij}	6.16±0.00^{cd}	62.98±1.02^{cdefghi}	94.79±0.81^{abcdef}	355.19±3.54^{f}
TA-02	4.00±0.47^{hij}	3.32±0.12^{hi}	3.67±0.11^{h}	20.74±0.23^{d}	2.28±0.04^{g}	66.00±0.74^{b}	95.99±0.46^{ab}	379.10±0.69^{abcde}
TA-03	6.64±0.06^{cdefgh}	5.08±0.08^{de}	4.90±0.04^{de}	17.61±0.30^{h}	6.67±0.21^{c}	59.20±0.15^{klm}	92.86±0.37^{defgh}	351.69±0.44^{f}
KG-01	4.29±0.65^{ghij}	3.49±0.00^{hi}	6.44±0.00^{bc}	23.27±0.10^{b}	2.93±0.06^{g}	59.58±0.69^{jklm}	95.71±0.65^{abc}	387.19±5.42^{abcd}
P- value	1.08e-11 ***	<2e-16***	<2e-16***	<2e-16 ***	<2e-16 ***	<2e-16 ***	2.69e-11 ***	<2e-16 ***

KEY: MC: Moisture Content, AC: Ash Content, CF: Crude Fat, CP: Crude Protein, CFI: Crude Fibre, CHO: Carbohydrate, DM: Dry Matter, EV: Energy Value, ***: Highly significant. Means with different letter(s) are significantly different

Mineral Composition of 33 Accessions of *Phaseolus* species

The mineral composition of the 33 accessions of *Phaseolus* species is shown in Table 2.

Calcium (Ca) varied significantly ($p<0.05$) across the accessions. The highest amount of calcium was observed in KD-10 (570 mg/100 g) and this was followed by KD-09, TA-02 and PL-08 with values of 563, 562 and 559 mg/100 g, respectively. The lowest value was observed in TA-03 (120 mg/100 g). PL-05, PL-03, PL-02, KD-04, KD-05 and KD-11 had low values of 122.00, 136.50, 138.00, 138.50, 139.00 and 142.00 mg/100 g, respectively.

Magnesium (Mg) content differed significantly ($p<0.05$). The highest value of 43.00 mg/100 g was observed in KD -08; KG – 01 followed with a value of 42.50 mg/100 g. The lowest value of magnesium was observed in PL -10 (14.50 mg/100 g). Sodium (Na) was highest in PL-05 and TA-03 with both having the same value of 15.50 mg/100 g while the lowest value was observed in TA-01 and KD-09 at 4.50 mg/100 g and 4.60 mg/100 g, respectively.

The potassium (K) content of the accessions varied significantly at $p\leq0.05$. The highest value was observed in PL-05 (55.30 mg/100 g), which was followed by TA-03 (48.15 mg/100 g). The lowest value of 38.95 mg/100 g was observed in PL-12. Phosphorus (P) content was high in PL-02, PL-03, KD-01, KD-04 and KD-05 with values of 532, 530, 524, 530 and 531.50 mg/100 g, respectively.

Significant differences were also observed in iron (Fe) content of *Phaseolus* species. KD- 10 had the highest value of 8.45 mg/100 g while KD-13 and KD-15 had the lowest value of 2.30 mg/100 g each. Manganese (Mn) content was generally low across the accessions studied. The highest value was observed in PL-11 (2.10 mg/100 g) and this was followed by KD-03 (2.00 mg/100 g). The lowest value of manganese was observed in KD-13 (0.10 mg/100 g).

There was no significant difference in the zinc (Zn) content of all the accessions studied, although the highest value of 4.00 mg/100 g was observed in KD-03 while the lowest value of 1.50 mg/100 g was observed in KD-04, KD-11, PL-02 and PL-06.

Table 2: Mineral composition of 33 accessions of *Phaseolus* species

ACC. I.D	Ca (mg/100 g)	Mg (mg/100 g)	Na (mg/100 g)	K (mg/100 g)	P (mg/100 g)	Fe (mg/100 g)	Mn (mg/100 g)	Zn (mg/100g)
KD-01	187.00±1.41^{h}	27.50±2.12^{bcdefghi}	6.00±1.41^{e}	40.80±0.00^{bcd}	524.00±38.18^{a}	3.45±0.35^{ghijk}	1.00±0.00^{de}	3.00±1.41^{a}
KD-02	420.00±2.83^{d}	26.50±6.36^{cdefghi}	6.00±0.00^{e}	41.60±0.57^{bcd}	166.00±8.49^{l}	4..30±0.28^{cdefgh}	0.10±0.00^{g}	3.50±0.71^{a}
KD-03	372.00±19.80^{e}	20.50±0.71^{efghi}	6.35±0.07^{de}	41.75±0.64^{bcd}	331.50±28.99^{gh}	3.00±0.28^{ijk}	1.85±0.07^{ab}	4.00±0.00^{a}
KD-04	138.50±3.54^{i}	18.50±3.54^{ghi}	12.00±0.00^{abc}	41.35±0.21^{bcd}	530.50±0.71^{a}	3.70±0.42^{efghij}	2.00±0.00^{a}	1.50±0.71^{a}
KD-05	139.00±1.41^{i}	27.00±11.31^{bcdefghi}	12.50±0.71^{ab}	40.20±0.14^{bcd}	531.50±0.71^{a}	5.50±0.14^{cd}	1.00±0.00^{de}	3.50±0.71^{a}
KD-06	202.00±2.83^{h}	36.00±2.83^{abcd}	8.75±0.35^{bcde}	46.95±0.21^{bc}	437.50±0.71^{de}	4.30±0.14^{cdefgh}	1.20±0.00^{cd}	2.50±0.71^{a}
KD-07	204.00±0.00^{h}	39.00±1.41^{abc}	8.05±0.64^{bcde}	41.45±0.07^{bcd}	494.50±0.71^{abc}	4.85±0.07^{cde}	1.10±0.14^{ce}	2.50±0.71^{a}
KD-08	335.00±1.41^{f}	43.00±1.41^{a}	5.95±0.35^{e}	41.55±0.07^{bcd}	437.00±1.41^{de}	3.70±0.14^{efghij}	0.25±0.07^{g}	2.50±0.71^{a}
KD-09	563.00±1.41^{a}	25.00±1.41^{defghi}	4.60±0.57^{e}	40.70±0.14^{bcd}	173.50±2.12^{l}	4.10±0.14^{cdefghi}	0.45±0.07^{fg}	2.00±1.41^{a}
KD-10	570.00±14.14^{a}	30.00±1.41^{abcdefgh}	8.25±0.35^{bcde}	40.90±0.00^{bcd}	169.50±0.71^{l}	8.45±0.50^{a}	0.25±0.07^{g}	3.50±0.71^{a}
KD-11	142.00±2.83^{i}	34.00±2.83^{abcde}	8.25±0.35^{bce}	41.20±0.00^{bcd}	510.50±0.71^{ab}	6.80±0.85^{b}	0.30±0.14^{fg}	1.50±0.71^{a}
KD-12	436.50±20.51^{d}	33.00±1.41^{abcdef}	7.00±0.28^{de}	42.05±0.21^{bcd}	186.50±4.95^{kl}	4.60±0.28^{cdefg}	0.20±0.00^{g}	2.50±0.71^{a}
KD-13	484.00±5.66^{c}	23.00±2.83^{defghi}	8.40±0.14^{bcde}	40.30±0.00^{bcd}	177.00±1.41^{kl}	2.30±0.14^{k}	0.10±0.00^{g}	3.00±0.00^{a}
KD-14	565.00±15.56^{a}	29.50±2.12^{abcdefgh}	7.80±0.28^{cde}	40.50±0.42^{bcd}	166.00±11.31^{l}	4.55±0.35^{cdefg}	0.15±0.07^{g}	3.50±0.71^{a}
KD-15	353.50±12.02^{ef}	27.50±0.71^{bcdefghi}	6.25±0.07^{e}	42.15±0.21^{bcd}	339.00±15.55^{fgh}	2.30±0.14^{k}	1.50±0.14^{bc}	3.50±0.71^{a}
PL-01	490.00±2.83^{c}	25.50±3.53^{cdefghi}	8.85±0.35^{bcde}	39.70±0.00^{cd}	230.00±1.41^{jk}	5.15±0.35^{c}	1.10±0.14^{ce}	2.50±0.71^{a}
PL-02	138.00±2.83^{i}	17.50±4.95^{hi}	7.90±1.56^{cde}	41.70±0.00^{bcd}	532.00±1.41^{a}	3.60±0.42^{ghij}	0.15±0.07^{g}	1.50±0.71^{a}

PL-03	136.50±6.36^{i}	17.50±4.95^{hi}	8.10±1.27^{bcde}	41.25±0.07^{bcd}	530.50±0.71^{a}	3.80±0.42^{efghij}	0.20±0.00^{g}	2.00±0.00^{a}
PL-04	342.00±2.83^{f}	27.00±1,41^{bcdefghi}	5.70±0.14^{e}	40.05±0.07^{cd}	289.50±0.71^{hi}	3.30±0.14^{hijk}	0.45±0.07^{fg}	2.50±0.71^{a}
PL-05	122.00±0.00^{i}	25.00±1.41^{defghi}	15.50±0.70^{a}	55.30±0.42^{a}	265.50±0.71^{ij}	4.00±0.14^{cdefghi}	0.30±0.00^{fg}	3.00±0.00^{a}
PL-06	436.50±7.78^{d}	33.00±1.41^{abcdef}	6.85±0.49^{de}	42.75±0.92^{bcd}	173.00±35.36^{l}	4.20±0.14^{cdefgh}	0.25±0.07^{g}	1.50±0.71^{a}
PL-07	337.00±1.41^{f}	19.50±2.12^{fghi}	7.50±2.12^{cde}	41.15±0.07^{bcd}	463.00±1.41^{bcd}	3.90±0.14^{defghi}	0.35±0.07^{fg}	2.50±0.71^{a}
PL-08	559.00±0.71^{a}	23.50±0.71^{defghi}	4.75±0.64^{e}	40.30±0.14^{bcd}	175.50±0.71^{kl}	4.05±0.07^{cdefghi}	0.35±0.07^{fg}	2.50±0.71^{a}
PL-09	182.00±0.00^{h}	26.00±2.83^{cdefghi}	7.50±2.12^{cde}	40,25±0.07^{bcd}	526.00±39.60^{a}	3.65±0.21^{fghij}	1.00±0.00^{de}	3.00±1.41^{a}
PL-10	331.50±0.71^{f}	14.50±0.71^{i}	12.50±3.54^{ab}	40.50±0.71^{bcd}	450.00±2.83^{cd}	2.65±0.21^{jk}	0.25±0.07^{g}	3.00±0.00^{a}
PL-11	250.00±2.83^{g}	39.00±1.41^{abc}	10.85±1.63^{bcd}	40.80±0.00^{bcd}	498.00±1.41a^{bc}	4.80±0.28^{cdef}	2.10±0.14^{a}	2.50±0.71^{a}
PL-12	523.00±1.41^{b}	31.50±4.95^{abcdefg}	5.15±0.07^{e}	38.95±1.63^{d}	162.00±9.90^{l}	3.80±0.14^{efghij}	0.35±0.07^{fg}	3.00±1.41^{a}
PL-13	203.00±1.41^{h}	23.00±2.83^{defghi}	8.65±0.21^{bcde}	44.15±0.49^{bcd}	430.00±2.83^{de}	3.85±0.21^{defghi}	1.20±0.00^{cd}	3.00±1.4^{1a}
PL-14	189.50±0.71^{h}	40.50±2.12^{ab}	8.65±0.35^{bcde}	40.50±0.42^{bcd}	372.00±5.66^{fg}	3.60±0.14^{ghij}	0.70±0.42^{ef}	3.50±0.71^{a}
TA-01	181.00±1.41^{h}	27.00±1.41^{bcdefghi}	4.50±2.12^{e}	40.50±0.14^{bcd}	494.00±1.41^{abc}	3.50±0.14^{ghij}	1.00±0.00^{de}	3.00±1.41^{a}
TA-02	562.00±2.83^{a}	24.00±0.00^{defghi}	4.80±0.28^{e}	40.90±0.00^{bcd}	178.00±0.00^{kl}	3.95±0.07^{defghi}	0.40±0.00^{fg}	2.50±0.71^{a}
TA-03	120.00±0.00^{i}	23.50±3.54^{defghi}	15.50±0.71^{a}	48.15±10.82^{b}	264.50±2.12^{ij}	4.15±0.21^{cdefghi}	0.30±0.00^{fg}	3.50±0.71^{a}
KG-01	195.00±4.24^{h}	42.50±0.71^{a}	8.65±0.49^{bcde}	41.80±0.00^{bcd}	392.00±0.00^{ef}	3.30±0.14^{hijk}	0.20±0.00^{g}	3.50±0.71^{a}
P- value	<2e-16 ***	9.4e-10 ***	1.31e-11 ***	7.73e-06***	<2e-16 ***	<2e-16***	<2e-16 ***	0.225

KEY: ***: highly significant. Means with the same letter(s) are not significantly different.

DISCUSSION

Proximate Composition of thirty-three Accessions of *Phaseolus* species

Food analysis is the resolution of the components of food into its proximate or ultimate parts (Onwuka, 2005). Proximate analysis involves the determination of the major components of food such as moisture, ash, crude fat, crude protein, crude fibre and carbohydrate (Ekwumemgbo *et al*., 2014; Aja *et al*., 2015). Moisture content estimates directly the water content and indirectly the dry matter content of the sample. It is also an index of storage stability of a grain and its susceptibility to microbial attack. At a moisture level below 10 %, respiration in most food grain almost stops, increasing the grain storage life (Sujeetha, 2014). The moisture contents of accessions used in this study were low (3.79 %- 10.81 %), indicating that these accessions could have a longer shelf-life. The moisture content was within the range (5-14 %) reported by Prolla *et al*. (2010) and Herrera- Hernández *et al.* (2018).

The ash content of the accessions is an indication of the amount of inorganic minerals present in a genotype. The higher the ash content, the higher the minerals a particular genotype might contain. The ash content reported in this study was in line with the report of Saulawa *et al*. (2014) and Siulapwa and Mwambungu (2014) in baobab and soya bean, respectively. Muktar *et al*. (2022) have also reported a similar trend in kidney bean ranging from 4.14-4.81%. The findings of this study were contrary to the reports of other authors, where lower ash content ranging between 1.01 and 1.67% for three varieties of soyabean was reported (Eshun, 2012). The difference in ash content might be because of the difference in the genetic composition of the genotypes.

Crude fat was significantly different in all the accessions studied. This could be because of the genetic variation that exists in the germplasm. The percentage crude fat in some accessions used for this study was higher than that of Muktar *et al.* (2022) that reported a lipid content of 1.03% in kidney bean. This could be due to genetic differences in the germplasm used as well as environmental differences. A similar percentage fat (1.15 %) was reported by Palupi *et al*. (2022) in lima bean. Lipids play an important role in diet as an important energy source, and also aid the transportation of fat-soluble vitamins A, D, E and K (Inobeme *et al*., 2014).

Beans are an important source of vegetable protein. Legumes are an excellent source of dietary proteins that play an important role in human nutrition by complementing other foods such as wheat and other cereals (Hall *et al*., 2017). Protein is very important in the growth and replacement of worn-out tissues in the human body (Gemede *et al*., 2016). The different accessions used in this study showed significantly high amount of protein, suggesting that the protein obtained from *Phaseolus* can serve as a good dietary supplement in both humans and animals. The percentage protein reported in the different accessions agrees with the findings of Florvil *et al.* (2022) and Pineda *et al*. (2023), that reported that common bean is a good source of protein and has protein content ranging from 21.2-26.4 % dry weight.

Crude fibre is an indigestible plant material. It lowers blood cholesterol level in humans, prevents cancer and reduces the risk of developing diabetes, hypertension and hypercholesterolemia (Oboh and Omofoma, 2008). Dietary fibre promotes growth and protects the beneficial intestinal flora. A high intake of fibre reduces the risk of colon cancer (Gemede *et al*., 2016). The crude fibre content varied across the accessions; this suggests that consumption of beans with a higher crude fibre content can help in improving digestibility and absorption process in the large intestine, thereby preventing constipation. The results obtained in this study is in line with the findings of Herrera-Hernández *et al.* (2018), Rezende *et al.* (2018) and Florvil *et al.* (2022) but contrary to the findings of Pineda *et al*. (2023) that reported a fairly higher fibre content in *Phaseolus vulgaris.* The difference in the value may be due to genetic variation in germplasm, environmental differences or the analytical method used in handling the samples.

Carbohydrates play an essential role in human nutrition, with starch representing a major source of calories, and dietary fibre contributing to gut health (Chibbar *et al*., 2010). Almost all accessions used in this study had a relatively higher percentage of carbohydrate compared to the reports of Pedrosa *et al.* (2015); Rezende *et al.* (2018) and Pineda *et al*. (2023) that reported the carbohydrate content of *Phaseolus vulgaris* of between 34.5 and 43.1% dry weight. This difference might be due to variation in the genome of the germplasm and environment. The high carbohydrate content of the genotypes suggests that the genotypes could be used in managing protein-energy malnutrition since there is enough quantity of carbohydrate to derive energy from so as to spare protein, which could be used solely for its primary function of building the body and repairing worn-out tissues rather than as a source of energy (Nwosu *et al*., 2019). The high amount of carbohydrate obtained in most accessions is in agreement with the findings of Adamu *et al*. (2016) in common beans.

Dry matter was high in all the accessions, an indication of how nutrient-dense the accessions are. The dry matter is the weight of the sample after all moisture has been removed. The high percentage of dry matter observed in all the accessions is in line with the findings of Gouveia *et al*. (2014) in common bean and Nwosu *et al*. (2019) in soybean,

The gross energy value obtainable from each accession was significantly high in all accessions, an indication that these accessions could serve as a good source of energy for the body. The results obtained in this study is significantly higher than the report of Gemede *et al*. (2016) in okra but similar to the findings of Nwosu *et al*. (2019) in soybean. The differences in the energy contents are the result of the differences in protein content, carbohydrate and fat contents.

Mineral Composition of thirty-three Accessions of *Phaseolus* Species

Calcium content in most of the genotypes was observed to be very high. High calcium suggests that genotypes could be used in complementary foods to help build the bones and teeth since calcium is one of the main components of teeth and bones. Calcium also plays a role in blood clotting (Nwosu *et al*., 2019). The calcium content reported in this study is higher than the reports of Rasool *et al.* (2019) and Pineda *et al*. (2023). This difference could be due to the environment where the seeds were sown or existing genetic differences in the germplasm.

Magnesium varied significantly across the accessions used in this study. Magnesium is crucial for proper functioning of the nervous system and muscles. The report in this study is in line with the findings of Nwosu *et al*. (2019) but different from the report of Herrera-Hernández *et al.* (2018) and Rasool *et al.* (2019). This difference might be as a result of variation in the properties of the soil where seeds were sown or the differences that exist in the genotypes used.

The relatively high amount of sodium in some accessions suggests that such accessions could serve as a good source of sodium in diets. However, the differences that were observed in the various accessions could be an indication of the existing genetic variation. Sodium is needed in diets in small amounts to help maintain normal blood pressure, function of the muscles and nerves. The accessions had a moderate amount of sodium compared to other studies where a higher concentration (1757-2044 mg/100 g dw) of sodium was reported. The high amount of sodium in the seeds was attributed to the presence of relatively high amount of sodium in the culture soil of the island (Pineda *et al*., 2023). The findings of this study are in line with the findings of Herrera-Hernández *et al.* (2018) and Florvil *et al.* (2022).

Potassium is nutritionally important in the maintenance of cellular water balance, pH regulation in the body and lipid, protein and carbohydrate metabolism. A diet rich in potassium seems to lower blood pressure. Adequate potassium in the diet is beneficial to the bones (Onibon *et al*., 2007). Phosphorus helps build and protect bones and teeth, serves as a part of DNA and RNA and helps in the conversion of food into energy. The recommended daily allowance for both men and women is about 700 mg (Yellavila *et al*., 2015)**.** Some accessions in this study had relatively high amount of phosphorus while some were low and this could be as a result of the genetic variations that exist in the germplasm. High amount of phosphorus (486-622 mg/100 g) has also been reported by Martinez *et al*. (2013). A similarly high value (55.3 – 587 mg/100 g) has been reported by Pineda *et al*. (2023) in land races of *Phaseolus vulgaris*. The findings in this study are contrary to the reports of Herrera-Hernández *et al.* (2018), Rasool *et al.* (2019) and Florvil *et al. (*2022) in common beans where lower levels of phosphosrus were reported. These differences could be due to genetic variation in the germplasm used, environmental and analytical methods used in analysing the germplasm.

Iron, manganese and zinc which are micro-minerals were also present in a reasonable amount in the accessions studied. Iron is actively involved in oxygen in human tissues as it aids the formation of haemoglobin. Manganese, on the other hand, is essential for the synthesis of some enzymes in the body while zinc plays an important role in insulin action, carbohydrate and protein metabolism (Navarra, 2004). The results obtained for iron, manganese and zinc are in line with the findings of Florvil *et al. (*2022) and Pineda *et al*. (2023), that reported iron as the trace element with the highest concentration (5.4-8.3 mg/100), followed by zinc (2.60-3.21 mg/100) and manganese (0.91-1.05 mg/100 g) in common bean.

CONCLUSION

Moisture content was low in most accessions with the highest in PL-04 (10.81 %) and the least in KD-06 (3.79%). The highest protein content (27.08 %) was observed in KD-08. Carbohydrate content was highest in KD-05 (70.03 %). PL-14 had the highest energy value (392.44 kcal/100 g). Mineral composition also varied across the accessions studied. Calcium was highest in KD-10 (570 mg/100 g), magnesium was highest in KD-08 (43 mg/100 g), potassium was highest in PL-05 (55.30 mg/100 g) and phosphorus was highest in PL-02 (532.00 mg/100 g). Other minerals such as iron, manganese and zinc were also present in small quantities in the accessions studied. The observed variability in nutritional composition of the different accessions studied can be harnessed by plant breeders to produce varieties with better nutritional qualities in the future.

REFERENCES

Adamu, A. S., Ajayi, M. G. and Oyetunde, J. G. (2016). Inorganic and Proximate Nutritional Composition of Common Beans in Nigeria. *European Journal of Pure and Applied Chemistry,* 3(2): 25-28.

Adekunmi, A. O., Ayinde, J. O. and Ajala, A. O. (2017). An assessment of animal protein consumption patterns among rural dwellers in Osun State, Nigeria. *Ife Journal of Agriculture*, 29: 84–94.

Aja, P. M., Offor, C. E. and Orji, O. U. (2015). Proximate and anti-nutrient compositions of *Parkia biglobosa* fruits in Abakaliki, Ebonyi state, Nigeria. *International Journal of Current Microbiology and Applied Sciences*, 4: 394–398.**6**10.5897/IJGMB2023.0226**.**

Akerele, D., Sanusi, R. A., Fadare, O. A. and Ashaolu, O. F. (2017). Factors influencing nutritional adequacy among rural households in Nigeria: How Does Dietary Diversity Stand among Influencers? *Ecology of Food and Nutrition*, 56: 187–203. DOI: 10.1080/03670244.2017.1281127

Association of Official Analytical Chemists, AOAC (2016). (20th edition). Benjamin Franklin Station, Washington D. C. USA

Chibbar, R. N., Ambigaipalan, P. and Hoover, R. (2010). Review: molecular diversity in pulse seed starch and complex carbohydrates and its role in human nutrition and health. *Cereal Chemistry*, 87(4): 342–352. https://doi.org/10.1094/CCHEM-87-4-0342

De Barros, M. and Prudencio, S. (2016). Physical and chemical characteristics of common bean varieties. *Semina: C iências Agrárias, Londrina*, 37(2),751-762 DOI: 10.5433/1679-0359.2016v37n2p751

De Vries, J., Owolabi, A., Steijns, J., Kudla, U. and Melse-Boonstra, A. (2020). Protein intake adequacy among Nigerian infants, children, adolescents and women and protein quality of commonly consumed foods. Nutrition Research Reviews, 33: 102–120. DOI:10.1017/S0954422419000222

Ekwumemgbo, P. A., Sallau, M. S., Omoniyi, K. I. and Zubairu, S. Y. (2014). Proximate and anti-nutritional Constituents of *Abelmoschus esculentus* grown in Fadaman Kubanni, Zaria, Kaduna State, Nigeria. *Journal of Scientific Research and Reports*, 3: 2015 - 2027.

Eshun, G. (2012). Nutrient composition and functional properties of bean flours of three soya bean varieties from Ghana. *African Journal of Food Science and Technology,* 3(8): 176-181.

FAOSTAT. (2010). Food and Agricultural Commodities Production. Retrieved from https://faostat .fao.org

Florvil, F., Márquez-Quiroz, C., Cruz-Lázaro, E., Osorio-Osorio, R. and Sánchez-Chávez, E. (2022). Bioactive Compounds, Anti-oxidant Activity and Mineral Content of Common Bean Varieties Grown in Tabasco, com/journal/indian-journal-of-agricultural-research/A-5Mexico. *Indian Journal of Agricultural Research,* 56(3): 368-372. https://arccjournals. 87.

Food and Agricuture Organisation (2023). 25 million Nigerians at high risk of food insecurity in 2023. https://www.fao.org/nigeria/news/detail-events/es/c/1630260/

Gemede, H.F., Haki, G. D., Ashagrie, F. B., Woldegiorgis, Z. and Rakshit, S. K. (2016). Proximate, mineral and anti-nutrient compositions of indigenous okra (*Abelmoschus esculentus*) pod accessions: implications for mineral bioavailability. *Food Science and Nutrition,* 4(2): 223–233.

Gouveia, C.S.S., Freitas, G. and Pinheiro de Carvalho, M. Â. A. (2011). Nutritional Analysis of Regional Varieties of Common Bean (*Phaseolus vulgaris* L.) produced under Low Input Conditions. *Actas Portuguesas de Horticultura*, 17: 131-137.

Hall, C., Hillen, C. and Robinson, J. G. (2017). Composition, nutritional value and health benefits of pulses. *Cereal Chemistry*, 94(1): 11-31. https://doi.org/10.1094/CCHEM-03-16-0069-FI

Herrera-Hernández, I. M., Armendáriz-Fernández, K.V., Muñoz- Márquez, E., Sida-Arreola, J. P. and Sánchez, E. (2018). Characterisation of bioactive compounds, mineral content and anti-oxidant capacity in bean varieties grown in semi-arid conditions in Zacatecas, Mexico. *Foods*, 7, 199. https ://doi.org/10.3390/foods7120199.

Inobeme, A., Nlemadim, A. B., Obigwa, P. A., Ikechukwu, G. and Ajai, A. I. (2014). Determination of Proximate and Mineral Compositions of White Cowpea Beans (*Vigna unguiculata*). *International Journal of Scientific Engineering and Research,* 5(8): 2229-5518.

Martinez, M. M. R., Rojas, A., Santanen, A. and Stoddard, F.L. (2013). Content of zinc, iron and their absorption inhibitors in Nicaraguan common beans (*Phaseolus vulgaris* L.). *Food Chemistry*, 136: 87-93. https://doi.org/10.1016/ j.foodchem.2012.07.105.

Metu, A.G., Okeyika, K. O. and Maduka, O. D. (2016): Achieving sustainable food security in Nigeria: Challenges and way forward. 3rd International Conference on African Development Issues (CUICADI 2016). Retrieved fromhttp:// e p r i n t s . c o v e n a n t u n iv e r s it y. e d u . n g / 6 6 5 3 / 1 / icadi16pp182-187.pdf

Muktar, B., Ibrahim, A. and Jibril, M. (2022). Proximate and Elemental Analysis of Cowpea, Kidney and Sweet Cowpea Beans sold in Kawo Market, Kaduna State, Nigeria. *Journal of Applied Science and Environmental Management*, 23(2): 243-248.

Namugwanya, M., John, S. T., Erasmus, O., Drake, N. M. and Twaha, A. (2014). Development of Common Bean (*Phaseolus vulgaris* L.) Production under low soil Phosphorus and Drought in Sub-Saharan Africa: A Review. *Journal of Sustainable Development*, 7(5): 128-139.

Navarra, T. (2004). *The Encyclopedia of Vitamins, Minerals and Supplements*. 2nd Edition, Facts on File Inc., New York, 32-192.

Ndayankpa, N.M., Falusi, O. A., Daudu, O. A. Y., Adebola, M. O. and Abubakar, A. (2024). Proximate Compositions on Leaves and Seeds of Selected Drumstick (*Moringa oleifera* lam.) from Northern Nigeria. *International Journal of Applied Agricultural Sciences*, 10(1): 1-6. doi: 10.11648/j.ijaas.20241001.11

Ndidi, C.U., Olagunju, A., Muhammad, A., Billy, F. G. and Okpe, O. (2014). Proximate, anti-nutritional and mineral composition of raw and processed (boiled and roasted) *Sphenostylis stenocarpa* seeds from Southern Kaduna, Northwest Nigeria. *International Scholarly Research Notices in Nutrition*, Article ID 280837. https://doi.org/10.1155/2014/280837

Nwadike, C., Okere, A., Nwosu, D., Okoye, C., Vange, T. and Apuyor, B. (2018). Proximate and Nutrient Composition of Some Common Bean (*Phaseolus vulgaris* L.) and Cowpea [*Vigna unguiculata (*L.) Walp.] Accessions of Jos-Plateau, Nigeria. J*ournal of Agriculture and Ecology Research International, 15(1): 1-9.*

Nwosu, D.J., Olubiyi, M. R., Aladele, S. E., Apuyor, B., Okere, A. U., Lawal, A. I., Afolayan, G., Ojo, A. O., Nwadike, C., Lee, M. C. and Nwosu, E. C. (2019). Proximate and mineral composition of selected soybean genotypes in Nigeria. *Journal of Plant Development*, 26: 67-76.

Oboh, H.A. and Omofoma, C. O. (2008). The effects of heat-treated lima bean (Phaseolus lunatus) on plasma lipids in hypercholesterolaemic rats. *Pakistan Journal of Nutrition*, 7(5):636-639.

Onibon, V.O., Abulude, F. O. and Lawal, L., (2007). Nutritional and anti-nutritional compositio of some Nigeria beans. *Journal of Food Technology*, 5(2): 120-122.

Onkgolotse, G. M., Patrick, K. M. and Odireleng, O. M. (2022). Proximate and Mineral Nutrition of Common Bean Genotypes as Influenced by Harvesting Time. *Journal of Agricultural Science*, 14(1): 85-93.

Onwuka, G.I. (2005). *Food analysis, instrumentation and proximate composition of food minerals*. 1st ed. Naplithali Print, A Division of H. G. Support Nigeria Ltd., Nigeria 64 81, 114p.

Owolabi, O.A., Dankat, C.B., Okolo, I. and Anigo, K. M. (2020). Proximate, Anti-nutrient and Mineral Composition of commonly consumed Food from Lima Beans (*Phaseolus lunatus*) in Kaduna State, North Western Nigeria. *International Journal of Advances in Scientific Research and Engineering*, 6: 40 – 45. https://doi.org/10.31695/IJASRE.2020.33823.

Palupi, H.T., Estiasih, T., Yunianta, Y. and Sutrisno, A. (2022). Physicochemical and protein characterisation of Lima bean (*Phaseolus lunatus* L) seed. *Food Research*, 6 (1): 168 – 177.

Pedrosa, M.M., Cuadrado, C., Burbano, C., Muzquiz, M., Cabellos, B., Olmedilla-Alonso, B. and Asensio-Vegas, C. (2015). Effects of industrial canning on the proximate composition, bioactive compound contents and nutritional profile of two Spanish common dry beans (*Phaseolus vulgaris* L.). *Food Chemistry*, 166: 68-75. https://doi.org/10.1016/j.foodchem.2014.05.158.

Pineda, M.I., Galdón, B.R., Álvarez, I.N.P., Morales, D.A., Mesa, D.R., Romero1, C.D. and Rodríguez-Rodríguez, E. M. (2023). Physico-chemical and Nutritional Characterisation of *Phaseolus vulgaris* L. Germplasm. *Legume Research, An International Journal*, 48(3): 273-280.

Prolla, I.R.D., García, R., Lima, A.P., Rossini, P., Picolli, L., Dalfollo, N. and Emanuelli, T. (2010). Cultivar, harvest year and storage conditions affecting nutritional quality of common beans (*Phaseolus vulgaris* L.). *Food Science and Technology*, 30: 96-102. https://doi.org/10.1590/S0101-2061201000 0500016

Rasool, S., Nazir, M., Sofi, P. A., Murtaza, I., Shikari, A. B., Shah, M. D., Nazir, N., Nehvi, F.A. and Zargar, S.M. (2019). Mineral profiling of common bean (*Phaseolus vulgaris* L.) germplasm. *Indian Journal of Agricultural Research*, 53(3): 270-276. https://doi.org/10.18805/IJARe.A-5160.

Rezende, A.A., Pacheco, M.T., Silva, V.S. N. and Ferreira de Castro, T.A.P. (2018). Nutritional and protein quality of dry Brazilian bean (*Phaseolus vulgaris* L.). *Food Science and Technology*, 38: 421-427. https://doi.org/10.1590/ 1678-457X.05917.

Richardson, K.V.A. (2012). Evaluation of six fresh green bean varieties for pod quality and yield. Gladstone Road *Agricultural Centre. Crop Research Report*, 9: 1-8.

Saulawa, L.A., Yaradu, A.I. and Shuaibu, L. (2014). Effects of different processing methods on proximate, mineral and anti-nutritional factors content of baobab (*Adansonia digitata*) seeds. *Pakistan Journal of Nutrition*, 13(6): 314-318.

Siulapwa, N. and Mwambungu, A. (2014). Nutritional value of differently processed soybean seeds. *International Journal of Research in Agriculture and Food Science*, 2(6):8-16.

Sujeetha, J.A., Abirami, C. V. and Alagusundaram, K. (2014). Bio-intensive safe storage methods for pulses: Review. *Journal of Pest Science*, 7(1): 98-103.

World Health Organisation (2013). Global Nutrition policy review. What does it take to scale up nutrition action? Available from http://apps.who.int/iris/bitstream/10665/84408/1/9789241505529[Accessed 2 April 2024

Xu, B. and Chang, S. K. C. (2012). Comparative study on anti-proliferation properties and cellular anti-oxidant activities of commonly consumed food legumes against nine human cancer cell lines. *Food Chemistry, 134*:1287–1296.

Yellavila, S.B., Agbenorhevi, J. K., Asibuo, J.Y. and Sampson, G.O. (2015). Proximate Composition, Mineral Content and Functional Properties of Five Lima Bean Accessions. *Journal of Food Security*, 3 (3): 69-74. doi: 10.12691/jfs-3-3-1.