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Proximate and Nutrient Composition of Some Common Bean (*Phaseolus vulgaris* L.) and Cowpea (*Vigna unguiculata* L. Walp.) Accessions of Jos- Plateau, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CN, AO, DN, CO and TV designed the study and managed the experimental process. Authors AO, CN and DN performed the statistical analyses of the experiment. Authors CN and DN wrote the first draft of manuscript. Authors CN, AO, DN and BA reviewed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The compositional analysis of some common bean and cowpea landraces of Jos plateau were carried out to determine their proximate and mineral constituents. The results revealed a wide variability and significant differences (P< 0.05) in proximate compositions with the exception of crude fibre. The percentage moisture content ranged from 9.10% - 10.27%, Protein content

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21.23% -23.83%, ether extract 1.60% -2.03%, Ash 3.10% - 3.87%, Carbohydrate 57.10% - 69.23%, Crude fibre 3.60% – 4.30%. The macro and trace mineral compositions varied and were statistically significant ($P < 0.05$), Ca 208.33-653.33 mg/100 g, K 25.0-54.0 mg/100 g, Mg 30.0-56.0 mg/100 g, P 266.67-850.00 mg/100 g, Fe ranged between 7.07-9.80 µg/100 g , Mn 0.02 -0.03 µg/100 g, Zn 0.20-0.70 µg/100 g and B from 0.00-0.01 µg/100 g. The presences of appreciable quantities of proximate and mineral constituents in the accessions has contributed in physical, mental growth and development of the local population were they provide cheap access to nutrients sources. This high variability in mineral compositions indicates that the accessions could serve as source germplasm for developing improved varieties.

Keywords: Common bean; cowpea; heritability; proximate; variability; nutrient composition.

1. INTRODUCTION

Generally, peas, beans and pulses are legumes and referred to the seeds of Leguminosae. Ikezu et al. [1], reported that legumes are considered as poor man meat, due to their high protein content and low cost compared to meat and meat products. The common bean (*Phaseolus vulgaris* L.) and Cowpea (*Vigna unguiculata* L. Walp.) are traditional food for many people in Africa, Asia and Latin America [2] where intake per capita ranges from 1 to 40 kg/year [3,4]. Legumes and especially, the common bean are the most important grain legume for direct human consumption [5]. The dry bean is a low fat food, good source of protein, essential vitamins and minerals, soluble-fiber starch and phyto-chemicals [2,6]. Leguminous plants are found throughout the world, but the greatest diversity has been known to occur in the tropic and sub tropics ecology. Norman et al. [7] reported that of all edible legumes, *Phaseolus vulgaris* L. have the widest geographical distribution and is the most cultivated amongst members of the species and morphologically diverse with genetic variability for protein concentration and for its specific seed protein components [7,8,9].

Common bean research in terms of crop improvement is still at its lowest level in Nigeria compared to other grain legumes such as cowpea, soybeans, groundnut [10,11]. In spite of the nutritional significance of legumes in various farming communities and the wide range of crop species adaptability to diverse ecology, only a small fraction of its rich natural and promising plant resource existing in their natural habitat as cultivar/ecotypes/landrace have been documented and profitably exploited for improvement to increase food and raw material production in the country [10,12,13].

In Nigeria, beans are grown and widely eaten [1]. Legumes are highly sought after because they tend to have a unique subtle sweetness and flavour. They are also more tender and smooth in texture after cooking and reported to be of high nutritional content [14]. The protein content in dry beans ranges between 20% and 30% [15]. Some health benefits associated with the consumption of common beans include reduction of cholesterol level [16], and coronary heart diseases [17,18,19], favorable effects against cancer [20], decrease of diabetes and obesity [21], high antioxidant capacity [22], anti-mutagenic [23], and anti-proliferative effects [24]. This class of plant are crucial to the balance of nature by producing a great mass of biologically nitrogen fixing organism into the soil, hence, could enable vast land to be brought into arable cultivation.

However, as a protein source, common beans have a disadvantages of requiring long cooking periods and some anti- nutritional properties [25]. The determination of the degree of genetic variability is the first step in identifying promising genotype for improvement for traits of economic importance.

In spite of the fact that the chemical composition of some common bean has been investigated [1], information seems to be lacking on existing compositional variability for proximate and mineral composition among common bean and cowpea landraces. This paper therefore aims at investigating the genetic variability among common bean landraces for proximate and mineral composition of their dry seeds.

2. MATERIALS AND METHODS

2.1 Sampling and Sample Preparation

The seed of *Phaseolus vulgaris* and *Vigna unguiculata* landraces were sourced from Mangu, Bokos and Jos–South local government areas of plateau state, Nigeria. Picture Plate 1 shows the seed features of the various genotypes used in this study. The seeds were ground to fine powder and kept in airtight containers for Proximate and mineral compositional investigations.

2.2 Proximate Composition

Seed bean Nitrogen (N) was determined by the thermal conductivity procedure that included the combustion of the sample to 10 40ºC [26]. The N content of the seed was multiplied by 6.25 to obtain the protein content [27].

Moisture content was determination using the air oven method. Crucibles were washed and dried in an oven. They were allowed to cool in the desiccator and weight was noted. A known weight of samples were then transferred into the crucibles and dried at a temperature between 103-105ºC. The dry samples were cooled in a desiccator and the weight noted. They were later returned to the oven and the process continued until constant weights were obtained. Moisture content was calculated using the formula

$$\%\, moisture\ content = \frac{weight\ loss\ x\ 100}{weight\ of\ smaple}$$

Ash content was determined by weighing of finely ground sample into clean, dried previously weighed crucible with lid (W_1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600^{o}C for 6h until it ashed completely. It was then transferred directly to desiccators, cooled and weighed immediately (W_2).

$$\%\, moisture\ content = \frac{weight\ loss\ x\ 100}{weight\ of\ smaple}$$

Crude fat was determined using Soxhlet apparatus. A known weight of sample was weighed into a weighed filter paper and folded neatly. This was put inside pre-weighed thimble (W_1). The thimble with the sample (W_2) was inserted into the Soxhlets apparatus and extraction under reflux was carried out with petroleum ether (40ºC – 60ºC boiling range) for 6h. At the end of extraction, the thimble was dried in the oven for about 30 minutes at 100^{o}C to evaporate off the solvent and thimble was cooled in a desiccator and later weighed (W_3). The fat extracted from a given quantity of sample was then calculated:

$$\%\, Fat\ = \frac{loss\ in\ weight\ of\ sample\ \ X\ 100}{original\ weight\ of\ smaple}$$

Crude fibre was determined by taking the fat-free extract obtained after determining Ether Extract and weight part of it. This is then serially heated with dilute acid and dilute alkali to hydrolyse away the digestible portion. The residue is dried and weighed. This weight, less the weight of ash is the fibre content.

The percentage carbohydrate content of seeds was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100% CHO = 100 - (Sum of the percentages of moisture, ash, fat, protein and crude fibre). The difference in value was taken as the percentage total carbohydrate content of seed [28,29].

2.3 Mineral Composition Analysis

Ten (10) accessions of common bean and two accessions of cowpea were analysed for Ca, Fe, B, Zn, K, Mg, Mn and P by flame atomic absorption spectrometry (Perkin-Elmer spectro-photometer, model 1100B, Phoenix, Arizona, USA), [26]. Bean seed samples were ground to a fine powder to ensure homogeneity before analysis of macro and micronutrients. The samples were concentrated by evaporating 100ml of sample to about 20ml. They were thereafter aspirated through the nebulizer into the air-acetylene flame where atomization took place. Using a source lamp for each element, the amount of energy absorbed in the flame is proportional to the concentration of the element in the sample over a limited concentration range.

2.4 Statistical Analysis

All data were subjected to an ANOVA. The least significant difference (LSD) was used to compare the means of the genotypes using the SPSS (2007) version 16.0 statistical software.

3. RESULTS

Proximate and Nutrient Composition of Some Common Bean (*Phaseolus Vulgaris* L.) [5 and 7] as well as Cowpea (*Vigna Unguiculata* L. Walpers) (1, 2, 3, 4, 6, 8, 9) and 10 accessions is presented in Table 1.

The moisture content of the seed was highest in accession 1 (10.27%), followed by accession 2, 6 and 7 (10.13%, 10.07% and 10.07%), while the lowest percentage moisture content was shown in accession 12 (9.10%). However, there were highly significant differences (P < 0.05) between the percentage moisture content in the twelve accessions of legume dry seeds evaluated.

The crude protein fraction of the seed was highest in accessions 6, 4 and 8 (23.83%, 23.63% and 23.57%). While, the lowest crude protein component of the seed was recorded in accession 5 (21.23%). There were significant differences (P < 0.05) between the crude protein fractions of the twelve accessions of bean seeds.

The ether extract component of the seed ranged between (2.03% - 1.60%). Accession with highest values were 12, 7 and 10 (2.03%, 1.90% and 1.83%). While accession 4 recorded the lowest ether extract fraction (1.60%). The various fractions of ether extract values were statistically significant (P > 0.05).

The ash fraction of the seed was more in accession 3, 12 and 2 (3.87%, 3.83% and 3.70). While accession 4 showed the lowest ash fraction (3.10%). The percentage ash fractions showed highly significant differences (P < 0.05) amongst the bean seeds accessions evaluated.

The crude fibre fraction of the legumes seeds was highest in accession 1 (4.30%), followed by accession 7 (4.27%). Least crude fibre fraction was recorded in accession 10 (3.60%). There was no significant difference (P < 0.05) in the crude fibre contents of the twelve accessions evaluated.

The results in Table 1 indicate that the seeds of accession 10, 9 and 5 had the highest carbohydrate content (69.23%, 60.37% and 59.70%). While accession 2 recorded the lowest (57.10%) carbohydrate content. There were highly significant differences (P < 0.05) between the carbohydrate contents in the legumes accessions of common bean (*Phaseolus vulgaris* L.) and cowpea (*Vigna unguiculata* L.)

Mineral composition analysis revealed variation in the concentration of macronutrient in the dry bean seeds. Calcium (Ca) ranged between 653.33-208.33 (mg/100 g) accession 3 and 7 have highest values (65.33 and 620.00 mg/100g). While accession 4 had the least value of 208.33 mg/100 g. The values were statistically different (P < 0.05) among the accessions evaluated.

Magnesium (Mg), values ranged between 56.00-30.00 mg/100 g. Accession 1, 10 and 3 have high magnesium values (56.00, 47.00 and 48.00 mg/100 g respectively. Accession 3 has lowest value of 30.00 mg/100 g. The values were statistically different (P < 0.05), among the accessions evaluated.

The Phosphorus (P) content among the accession ranged between 850.00-266.67 mg/100 g. Accession 3, 1, 9 and 6 have high values (850.00, 753.33, 650.00 and 626.67). Lowest value were recorded by accession 5 (266.67). The values were statistically different (P < 0.05), among the accessions evaluated.

The content of Potassium (K) in the accessions ranged between 54.00-25.00 mg/100 g. Accessions 2, 8 and 10 have high potassium content (54.00, 45.00 and 45.00 mg/100g). Lowest value was recorded in accession 4 (25.00 mg/100g). However, the values were statistically different (P< 0.05), among the accessions evaluated.

Among the micronutrients, iron (Fe) composition in the accessions ranged between 9.80-7.07 µg/100 g. High values were recorded for accessions 3, 12 and 5 (9.80, 9.43 and 9.23 µg/100 g). The lowest iron value were found in accession 4 (7.07 µg/100 g).The values were statistically different (P< 0.05), among all the accessions evaluated.

Boron (B), compositional value for the accession investigated ranged between 0.01-0.00µm/100g. Accessions with very low Boron traces were 2, 3, 6, 10 and 12 (0.00 µg/100 g for all), while the other accessions have 0.01 µg/100 g respectively. The results were statistically different (P < 0.05).

The Zinc (Zn) content of the accessions ranged between 0.70-0.20 µg/100 g. The highest values were found in accession 11 (0.70 µg/100 g), while the least was recorded for accession 3 (0.20 µg/100 g). The results were statistically different (P< 0.05).

Manganese (Mn) content of the accessions ranged between 0.04-0.02 µg/100 g. Accession 5, 8 and 9 have high values of 0.04 µg/100 g respectively, while the accession with the lowest content was accession 2 (0.02 µg/ 100 g). The results were statistically different (P< 0.05).

Table 1. Proximate and mineral compositions of common bean (*Phaseolus vulgaris* L.) and Cowpea (*Vigna unguiculata* L)

Accessions	Proximate composition (%)						Minerals composition							
	Moisture content	Protein	Ether extract	Ash	Crude fibre	Carbohydrate	Ca (mg/100 g)	Fe (mg/100g)	B (µg/100 g)	Zn (µg/100 g)	K (mg/100 g)	Mg (mg/100 g)	Mn(µg/100 g)	P (mg/100 g)
1	10.27	22.57	1.70	3.53	4.30	57.63	451.67	8.53	0.01	0.30	36.0	56.00	0.03	753.33
2	10.13	22.73	1.63	3.70	4.13	57.10	420.00	7.43	0.00	0.40	54.00	37.00	0.02	541.67
3	9.77	22.30	1.80	3.20	3.80	59.13	653.33	9.80	0.00	0.20	42.00	48.00	0.02	850.00
4	9.40	23.63	1.60	3.10	3.73	58.53	208.33	7.07	0.01	0.50	25.00	30.00	0.03	266.67
5	9.90	21.23	1.87	3.87	4.10	59.70	275.00	9.23	0.01	0.40	32.00	35.00	0.04	356.67
6	10.07	23.83	1.70	3.27	4.07	57.03	403.33	7.93	0.00	0.40	40.00	42.00	0.03	626.67
7	9.13	22.23	1.90	3.27	4.27	59.10	620.00	9.00	0.01	0.60	35.00	38.00	0.03	550.00
8	9.57	23.57	1.73	3.53	3.90	57.70	510.00	8.57	0.01	0.50	45.00	35.00	0.04	421.67
9	9.13	21.77	1.73	3.67	3.67	60.37	495.00	7.83	0.01	0.60	42.00	45.00	0.04	650.00
10	10.07	21.77	1.83	3.50	3.60	69.23	475.00	8.47	0.00	0.40	45.00	47.0	0.03	523.33
11	9.70	22.20	1.70	3.43	3.70	59.27	351.67	7.37	0.01	0.70	37.33	52.00	0.02	393.33
12	9.10	23.03	2.03	3.83	3.73	58.27	421.67	9.43	0.00	0.50	40.00	42.00	0.03	455.00
Sig.	***	***	***	***	ns	***	***	***	***	***	***	***	***	***
$F\text{-}LSD_{(0.05)}$	0.21	0.27	0.13	0.14	ns	0.62	4.53	0.11	0.00	0.11	0.30	1.38	0.00	8.94

****: Statistically Significant at ($P \leq 0.001$)*

ns: not Statistically Significant at ($P > 0.05$)

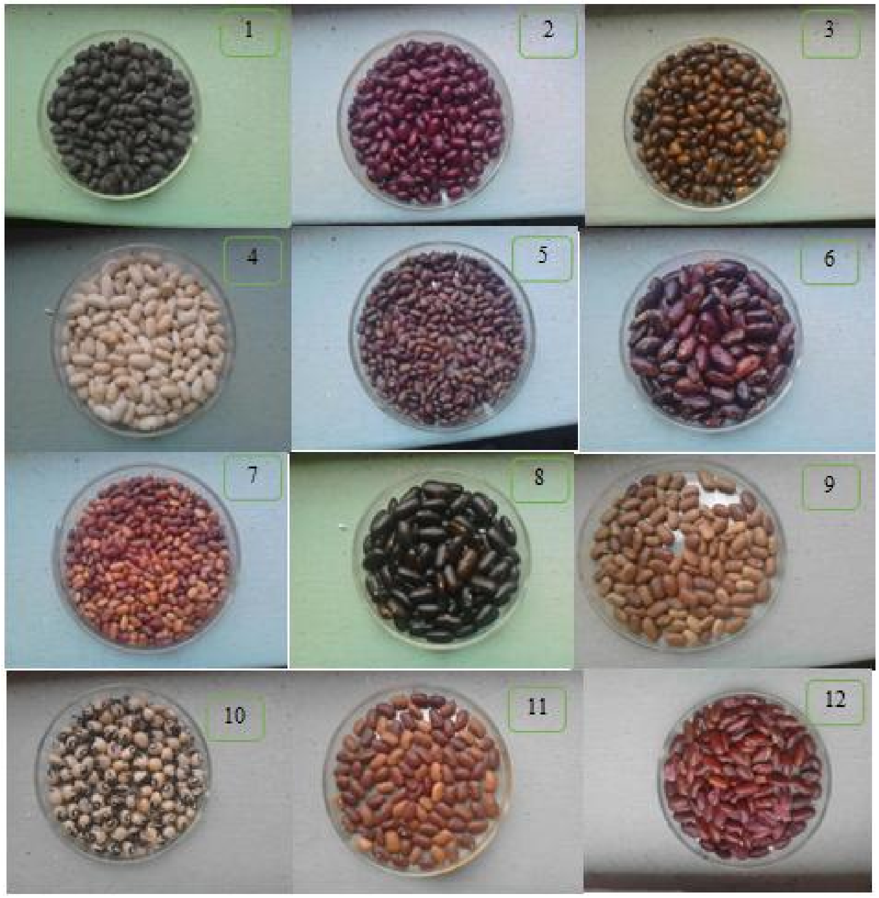

Plate 1. Picture showing seed variability of common bean and cowpea landraces on the Plateau

4. DISCUSSION

The results of the Proximate and Nutrient Composition of some common bean (*Phaseolus vulgaris* L.) and Cowpea (*Vigna Unguiculata* L. Walpers) accessions presented in Table 1. Revealed that the proximate composition is comparable to those of other legumes such as soybean, groundnut, Winged bean and Jack beans and other less emphasized legumes such as Chickpea (*Cicer arietinum* L.), pigeon pea *(Cajanus cajan)*, Sword bean (*Canavalia ensiformis)* Bambara bean (*Kerstingiella* spp) [11]. The intake of dry beans have been linked to reduced disease risks such as oxidative stress, inflammation, cancer, heart disease, and metabolic syndrome [30].

The Carbohydrate and protein in the plant indicated the high nutritional value of the seed. Presence of Carbohydrate revealed that the plant is a good source of energy while Protein indicated that it can help in physical and mental growth and development as earlier reported [2,14]. The carbohydrate component of common bean is reported [31] to comprise resistant starch (RS) and the fructooligosaccharides, stachyose and raffinose. These compounds serve as substrates for bacterial fermentation in the human intestine, thus influencing the microbial ecology of the gastrointestinal (GI) tract and gut metabolism [32].

The ash content showed that they contained some quality of mineral element which is essential in our diet [24]. The percentage of the crude fiber suggested that diet prepared with these accessions could help to ensure good gut movement of food through the gut to provide energy and ensure break down of the food. Moreover crude fibre is known to influence production of high butyrate levels and butyrate has been linked to lower risks for cancer [33]. The high moisture content suggested that they should be dried properly before storage so as to avoid the invasion of micro-organisms which can lead to their spoilage [34].

The ether extract fractions (crude fat or lipid) provides a very good source of energy and aids in transport of fat soluble vitamins, insulates and protects internal tissues and contributes to important cells processes [34,35]. The protein content of the sample showed that the seed is highly proteinous and could be incorporated into the diet of both old and young including pregnant and nursing mothers and the high carbohydrate value indicated that the seed contained reasonable amount of energy and will give high amount of energy when consumed.

Mineral composition analysis revealed variation in the concentration of both macro and trace mineral elements in the accessions of dry bean seeds. Most of these macro (N, P, K and Mg) and trace elements (Fe, Mn, Zn, and B) found in appreciable quantities in the studied accessions are currently of growing concern to human nutrition [36]. Common beans contain iron and calcium at levels that respectively fulfil ~11 and 2%–6% (100 g serving) of the daily reference intake (DRI) for a 2000 Calorie (kcal) diet [36]. The relevance of iron as an important vehicular haemoglobin carrying oxygen around the body cannot be overemphasised. This study has revealed that common bean consumption will help in tackling Iron deficiency, a common nutrition disorder worldwide that affects a large proportion of women and children in developing countries [37]. Pregnancy complications, low birth weight, maternal and infant mortality and reduction of growth in infancy and childhood resulting from Zn deficiency [38] Frossard et al. 2000) could become a thing of the past. On the other hand, Ca intake is essentially in prevention of several chronic diseases, including osteoporosis, hypertension, and colon cancer [33].

5. CONCLUSION

The presence of variable levels of proximate and mineral nutrients in common bean and cowpea landraces provides nutrient availability to the local community and an affordable means to a good health. The variability of the nutrients in different accessions of cowpea and *Phaseolus* reported by the authors provides for improvement of the crop for better nutritional qualities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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