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STUDY ON THE NUTRITIONAL, MINERAL AND ANTINUTRIENT COMPOSITION OF SOME UNDERUTILISED SPECIES OF FABACEAE IN ADO-EKITI, EKITI STATE, NIGERIA

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Abstract–Nutritional profile, mineral content as well as mineral ratio, mineral safety index and anti-nutrient content of locally grown fabaceae species (*Cajanus cajan*, *Sphenosytlis sternocarpa*, *Phaseolus lunatus* and *Vigna unguiculata*) were investigated. The bioavailability of the minerals was predicted using antinutrient-mineral molar ratios. The proximate analyses of the beans showed that the moisture content, crude protein, crude fat, ash, crude fiber and carbohydrate ranged as followed: 8.76-9.62%, 14.85-17.55%, 2.48-3.28%, 2.48-2.71%, 2.87-3.59% and 64.76-67.21% respectively. The total energy from carbohydrate, fat and protein was high and close at 1499-1515kJ/100g and low CV% of 0.47-0.48 being mostly contributed by carbohydrate (73.12-75.42%) and followed by protein (16.66-19.82%). Utilization of 60% of energy due to protein was low at 9.99-11.89 at CV% 7.23. The mineral levels (g/100mg) were high in K (33.2-44.4) and P (92.0-128) moderate in Ca (14.5-19.4), Mg (8.14-14.5) and Fe (6.00-13.97) but low in Zn and Cu and very low in Mn, Pb, Cd and Ni. The mineral CV% ranged from low to high (7.44-47181) with no significant difference at P=0.05. The result of the mineral ratio revealed that the calculated mineral ratios for Na/K, K/Na, Ca/P, Ca/Mg, Ca/K, Zn/Cu and [K/(Ca+Mg)] were good when compared with the standard. All calculated mineral safety index were lower than the tabulated values indicated no mineral overload to the consumer. The low anti-nutrient concentrations (mg/100g) of phytate (1.51-2.61) and hydrocyanide (7.49-12.52) could make them ranked among the bean species safe for human consumption while the antinutrient-mineral molar ratios depicted phytate to mineral ratios of all the beans falls below the critical values, no significant difference at P=0.05 among the ratios. This indicated that the bioavailability of Ca, Fe and Zn is not affected by their phytic acid contents. The bean seeds might prove to be a good source of carbohydrate, crude protein, minerals and gross energy values. The anti-nutrient, mineral safety and phytate to mineral ratio were found to be within the acceptable level suggested that the foods are suitable for human and animal consumption.

INTRODUCTION

Food is consumed to supply energy or nourishments in order to sustain life. Food is classified into six classes such as protein, carbohydrate, fats and oil, vitamins, water and minerals (Amanda, 2010). Adequate consumption of the food items result in balance diet. The inadequate supply of these foods in human diet results to malnutrition especially in developing countries due to increase in population growth and high prices of staple food. FAO (2000) noted that protein malnutrition is one of the most serious problems in developing countries. This can be attributed mainly to the increasing population, dependency on cereal based diet, scarcity of fertile land and degradation of natural resources (Balogun and Olatidoye, 2012).

There has been an increase in consumption of foods such as rice, millet, maize, cassava, yam and banana in Nigeria. These foods are grown and consumed locally. In recent years, several factors such as climate change, insecurity, government policy on importation of food and lack of modern farm inputs are threatened food and nutritional security in Nigeria. Notably, poor economy in Nigeria has contributed greatly to the poor consumption of animal products hence, many people particularly the low-income earners rely mainly on mineral from plant based foods (Aremu *et al*., 2009). It is therefore becomes necessary to source for cheaper and nutritious food crops to combat the menace of malnutrition in recent times.

Legumes are important ingredients of a balanced human diet in many parts of the world due to their high protein and carbohydrate contents (Adebowale *et al*., 2009). Grain legumes constitute the main source of protein in the diet of the average Nigerian home. Notably among these legumes are cowpea (*Vigna unguiculata*) and groundnut (*Arachis hypogea*). However, there are other pulses that could help meet nutritional needs but are cultivated only by poor farmers as security crop and are highly under exploited. These crops are at the risk of disappearing due to the major attention on the common legumes such as cowpea and soya bean. These lesser known legumes include Lima bean (*Phaseolus vulgaris*), Pigeon pea (*Cajanus cajan*) and African yam bean (*Sphenostylis sternocarpa*).

Nutritionally, legumes supply significant amount of energy, vitamins and minerals in addition to protein. Udensi *et al*. (2011) noted that legumes are 2-3 times richer in protein than cereal grain and some of these legumes are very rich in oils and mostly called oil seeds. De-oliviera (2006) reported that protein content in legume grains range from 7-11.8 g/100g and approximately equal to the content of meat(18-25g/100g). The legumes and protein rich seeds are added as substitute to high protein foods of animal origin which are too expensive for the majority of low income earners (Wokoma and Aziagba, 2001). In Nigeria, consumption and production of some local beans which can contribute to good nutrition should be encouraged now that the cost of common beans (*Vigna unguiculata*) is expensive for poor man. These locally produced and underutilised beans have contributed significantly to human nutrition among the local populace. African yam beans (*Sphenostylis sternocarpa*), Lima bean (*Phaseolus lunatus*) and pigeon pea (*Cajanus cajan*) are known for their edible seeds which are highly nutritious than the common beans, cowpea, (*Vigna unguiculata*). These neglected pulses have been reported to have high anti-nutritional contents compared to the major legumes (Fasoyiro *et al.,* 2006).

The anti-nutrients in these legumes have been reported to reduce the availability of nutrient for absorption. This effect can be reduced through a number of processing and preparation methods (Ene-Obong and Obizoba, 1996). The underutilised grain legumes are considered to be functional foods in addition to their traditional role of providing dietary protein having higher free radicals scavenging ability and also of their cholesterol lowering ability.

These underutilized species are no longer consumed and grown well in the study area probably because of poor income from the production of the beans hence, lack of interest of growing the crops by farmers. In addition, complains of consumption of much fuel wood while cooking abounds. These reasons might have resulted in low demand for these crops despite their nutritional qualities. The need to unlock the potentials of these legumes which can be sourced locally, readily available and affordable and contribute significantly to food and nutritional security in Nigeria necessitated this study. The locally grown Fabaceae species (*Cajanus cajan. Sphenosytlis sternocarpa, Phaseolus lunatus* were investigated for their proximate, anti- nutrients and mineral compositions while *Vigna unguiculata* serves as a control.

MATERIALS AND METHODS

Collection and preparation of samples

The study was conducted in the Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti, Nigeria, between August and December 2020. The seeds of *Cajanus cajan*, *Sphenostylis, Sternocarpa*, *Phaseolus lunatus* and *Vigna unguiculata* were obtained from Obas's market, Ado- Ekiti. The samples were air-dried and pulverized into a powdery form and stored differently in a tight covered plastic rubber for further analysis.

Proximate Analysis

Proximate analysis of the powdered samples was carried out to determine moisture, ash, crude fiber and crude fat using standard methods (AOAC 1999), protein was determined by the Kjeldahl method (Pearson, 1976). Carbohydrate content was determined by difference as described by AOAC (1999).

Moisture content determination

Moisture continent of the bean samples was determining using AOAC (2005) method. The pulverized bean sample (5g) was weighed into already weighed clean dry cans. The cans with the samples were then placed in the oven at 105^{0}C to dry until constant weight is attained after which the final weight were taken

$$\% \text{ Moisture Content (MC)} = \frac{W_1 - W_2}{W_3 1} \times 100$$

Where

W_1 = Weight of empty can; W_2 = Weight of can + sample before drying; W_3 = Weight of can + sample after drying.

The dry matter was used in the determination of other parameters. The protein content was determined using Micro Kjedhal method by multiplying the total organic nitrogen by 6.25 (AOAC, 2005). Carbohydrate content was determined by the differences obtained after subtracting the total Nitrogen protein, lipid, ash, fiber from the total dry matter and expressed as percentage (AOAC, 2005).

Available Carbohydrate = (100 - %moisture +% ash +% protein + %Fiber).

Ash continent was determined by incineration of 10.0g samples placed in a muffle furnace maintained at 550^{0}C for 5h. Crude fiber was obtained by digesting 2.0g of the samples with H_2SO_4 and NaOH and incinerating the residue in a muffle furnace maintained at 550^{0}C for 5h. Crude fat was obtained exhaustively extracting 5.0g of the sample in Soxhlet apparatus using petroleum boiling range 40-60^{0}C as extract.

Determination of mineral compositions

One gram (1g) of the ground seed samples was digested with 10 ml of concentrated Nitric acid, 3ml of 60% Perchloric acid and 1ml of concentrated H_2SO_4. After cooling, the digest was diluted with 50ml de-ionised distil water filtered with Whatman No 42 filler paper and the filtrates were made up to 100ml in a glass volumetric flask with de-ionised distil water. Filtered solutions were used to determined Zn, Fe, Mn, Cu, Pb and Cd by means of Atomic Absorption Spectrophotometer (Bulk Scientific 210 VP Spectrophotometer). The macro-elements Sodium and Potassium were analysed by Flame Photometer-Jenway (FP) 902 unit-122. Phosphorus was analysed by Jenway 6 Compressor. All chemicals used are of British Drug House (BDH, London, UK) analytical grade.

Determination of Energy

This was calculated using Atwater factor method as described by Osborne and Voogt (1978). The estimated energy value in the samples in Kilocalorie (Kcal/100g) was determined by adding the multiply values for crude fat, crude protein and carbohydrate using the factor (9Kcal, 4Kcal and 4Kcal) respectively. The energy value in Kilojoule was determined by adding the multiply values for crude fat, crude protein and carbohydrate using the factor (37Kcal, 17Kcal and 17Kcal) respectively.

Other Calculations

Other calculations made from the mineral elements include mineral ratios and Mineral Safety Index (MSI).

Determination of some Anti-nutrient substances

The Oxalate content was determined using High Pressure Liquid Chromatograph (HPLC) methods described by Wilson *et al*. (1981) while Phytate and Cyanide were determined according to methods described by Wheeler and Ferrel (1971) and AOAC (2010) respectively.

Determination of molar ratio of Phytate/ Mineral

The mole of phytate and minerals was determined by dividing the weight of phytate and minerals with its atomic weight (Phytate: 660g/mol.; Fe: 55.85g/mol.; Zn: 65.38g/mol.; Ca: 40.08g/mol.). The molar ratio between phytate and mineral was obtained after dividing the mole of phytate with the mole of mineral.

Calculation of the mole ratio

The [phytate]:[Zn], [Ca]:[phytate], [phytate]:[Fe] and [Ca][phytate]: [Zn] mole ratios were calculated as previously described by Wyatt *et al*. (1994); IZINCG (2004).

Statistical Analysis

Descriptive statistics (mean, standard deviation and coefficient of variation) (Chase, 1976) were determined and all data were subjected to Chi-square (χ^2) test to determine significant differences among the results obtained (Oloyo, 2001).

RESULTS AND DISCUSSION

The results of the proximate composition of *V. unguiculata* and three underutilized cereals are presented in Table 1. The results showed that the samples contained low moisture content that ranged between 8.76 to 9.26%. The results obtained in the present study agreed with the earlier assertion of Yellavia *et al*. (2015) on lima beans

Phaseolus lunatus. However, the values were lower than 12.39% reported for red kidney bean (Sasanam *et al*., 2011) and 12.44% obtained for *S. stenocarpa* (Sam, 2019). Low moisture content of food could lower their susceptibility to microbial spoilage and promote shelf life (Adeyeye and Adejuyo, 1994). The low moisture content of the bean flour could hinder microbial growth and thus better storability.

The results obtained for the crude fiber showed that the beans have low crude fiber (2.87-3.59%). The values are comparatively lower than 4.3% and 4.5% reported for *Vigna anguiculata* and *Vigna angustifoliata* (Bamigboye and Adepoju, 2015). However, the values are higher than 1.95% reported for *Sphenostylis stenocarpa* (Sam, 2019). The fiber level in this study however would make reasonable contribution to the fiber function. The crude fiber is important in facilitating faecal elimination. Consumption of foods with dietary fiber have been reported to lower blood cholesterol in humans, prevent cancer, reduces risk of diabetics, hypertension and hypercholesterolemia (Obon and Ayanwade, 2008).

The crude protein contents in the beans were high (14.85-17.55%). The protein contents are in the trend of *S. sternocarpa*>*C. cajan*>*P. lunatus*>*V. unguiculata*. High protein content is typically of all legumes but interestingly the three underutilized beans were richer in protein than the common bean. The values obtained in this present study were low when compared to certain lima bean varieties (Oshodi and Adeladun, 2009) and some palatable leguminous (Olaofe *et al*., 1994). The protein values are in accordance with the work of Moses *et al*. (2012) and Yellavila *et al*. (2015). Average crude protein would serve as enzymatic catalyst and mediate cell responses (Whitney and Rolfes, 2005). The high protein content in these beans justifies their use as source of protein in Nigeria, especially among the rural dwellers who could not afford animal protein due to poverty. The crude fat content ranged from 2.48-3.28%. The values obtained in this

Table 1. Proximate composition (mg/100g) of four selected species of Fabaceae family

Proximate	A	B	C	D	Mean	χ^2	Remark
Moisture content	8.76±0.24	9.29±0.71	9.62±0.89	9.28±0.20	9.24	0.041	NS
Crude protein	14.85±0.16	17.55±0.78	16.36±0.56	15.69±0.20	16.1	0.242	NS
Crude Fat	3.24±0.29	2.87±0.02	2.48±0.01	3.28±0.04	2.97	0.141	NS
Ash content	2.71±0.31	2.53±0.15	2.48±0.14	2.71±0.17	2.61	0.017	NS
Crude fiber	3.24±0.19	3.00±0.03	2.87±0.08	3.59±0.05	3.18	0.095	NS
Carbohydrate	67.21±1.20	64.76±1.38	66.44±1.16	65.44±0.24	66.0	0.053	NS

Chi-square (χ^2) at $p_{=0.05,}$ $\upsilon_{= n-1=3}$ critical value =7.81, NS= results not significantly different
A. *Vigna unguiculata*, B. *Sphenostylis sternocarpa*, C. *Cajanus cajan*, D. *Phaseolus lunatus*

Table 2. Proportion of percentage contribution from fat, protein and carbohydrate to total energy

Parameter	A	B	C	D	Mean	SD	CV%
Total energy							
(E in kJ/100g)	1515	1501	1499	1501	1505.1	7.06	0.47
(E in Kcal/100g)	357	355	354	354	355	1.72	0.48
PEF %							
(E in kJ/100g)	7.91	7.10	6.12	8.09	7.31	0.89	12.18
(E in Kcal/100g)	8.16	7.27	6.31	8.33	7.52	0.93	12.37
PEP %							
(E in kJ/100g)	16.66	19.82	18.55	17.78	18.20	1.32	7.25
(E in Kcal/100g)	16.62	19.77	18.51	17.73	18.16	1.33	7.32
PEC %							
(E in kJ/100g)	75.42	73.12	75.33	74.14	74.50	1.09	1.46
(E in Kcal/100g)	75.22	72.96	75.18	73.94	74.33	1.08	1.45
UEDP %							
(E in kJ/100g)	9.99	11.89	11.13	10.67	10.92	0.79	7.23
(E in Kcal/100g)	9.97	11.86	11.11	10.64	10.90	0.80	7.34

PEF = proportion of total energy due to fat; PEP = proportion of total energy due to protein; PEC = proportion of total energy due to carbohydrate; UEDP = utilization of 60% of PEP %.

study fall within the range from 1.2% in legumes to 3.4% in cereals for the average fat composition as stated by the National Academy of Science (1993). Fats are universally stored forms of energy in living organisms. They are also secondary plant productions that yield more energy per gram than carbohydrate (Ilodibia *et al*., 2014). However, fat must be consumed with caution to avoid obesity and other related diseases. The ash content of the beans was low ranging between 2.48 to 2.71% with mean value of 20.61%. The results of our findings closely agreed with low ash value (2.87%) for the leaf of *Synepalum dulcificum* (Awotedu and Ogunbamowo, 2019), but far lower than the range of 8.00-10.00% found in *Moringa oleifera* (Bamishaiye *et al*., 2011). Ash content is a reflection of the mineral content in a plant material.

The results of the carbohydrate content of the bean were high and ranged from 64.76%-67.21% with mean value of 66%. *V. unguiculata* contained the highest amount of carbohydrate while *S. sternocarpa* has the least value. The values are higher compared to the values (22.66%-62.80%) reported for nine leafy vegetables in Nigeria (Idoko *et al*., 2014). This showed that the beans are good source of carbohydrate. Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissue (Whitney and Rolfes, 2005).

Table 2 revealed the proportion of percentage energy contribution from fat, protein and carbohydrate to total metabolizable energy. The results revealed that total metabolizable energy ranged from 1499.36 to 1514.9 kJ/100g (1.499-1515 MJ) or 353.52-357.4 Kcal/100g with both kJ and Kcal values being very close with CV% range of 0.47-0.48. The energy values were slightly lower than 392.5 Kcal but higher than values of 1142 kJ/100g reported in animal, *Callinectes latimanus* (Adeyeye *et al*., 2014). The energy obtained in this study is an indication that the samples are good sources of energy. Carbohydrates contributed the highest energy values (73.12-75.42 kJ/100g or 72.96-75.22%). The proportion of percentage energy contribution from protein (PEP%) is higher than that of fat (PEF%). The PEF% value of 16.12-8.09% was generally low and below 30% recommended level (NACNE, 1983) and 35% as recommended by COMA (1984) for total fat intake. This low PEF% could be advantageous for obese people who are interested in low fat diet. The utilizable energy due to protein (UEDP%) was at a range of 9.99-11.89 (assuming 60% of protein energy utilization). This range value is slightly higher than the recommended safe level of 8% for adult man who needs about 55 g proteins per day with 60% utilization. However, the value is comparatively lower than values obtained from previous studies. Adeyeye and Adejuyo (2007) reported UEDP% of 56.4 for turkey muscle and 40.0 for skin of turkey. Also, UEDP% range of 46.3-48.5 was reported for *Acanthurus monroviae* and *Lutjanus goreensis* fishes (Adeyeye *et al*., 2016). The UEDP% of 9.99-11.89 is more than enough to prevent energy malnutrition in children and adult fed solely on the bean samples as the main sources of protein. The beans may also be used as supplement protein for cereal products with low protein level.

Mineral Composition

The elemental analysis revealed the presence of K, P, Ca, Mg, Fe, Na in appreciable quantities as depicted in Table 3. However, Cu and Mn were found in low quantities while Pb, Cd, and Ni were < 1.0. This clearly indicated that the samples are rich source of mineral elements. The minerals obtained in this finding (excluding toxic minerals Pb, Cd and Ni) are present in all body tissues and fluids and their presence is necessary for the maintenance of certain physiochemical processes which are essential to life (Aremu and Ibrahim, 2014). Minerals such as Na, P, K, Ca, Zn and Cu are considered quite essential for proper health and growth of human. Na and K are important in the transport of metabolites in the human body. Na regulates plasma volume and acid-base balance which helps in the maintenance of osmotic pressure of the body fluids (Murray *et al*., 2000). K plays an important role in regulation of osmotic pressure, muscle contraction particularly the cardiac muscle, cell membrane function and Na^+/K^+ ATPase (Soetan *et al*., 2010). Ca functions as a constituent of bones and teeth, regulation of nerve and muscle function. It equally helps in blood coagulation as well as activation of large number of enzymes such as Adenosine Triphosphatese (ATPase), Lipase etc. (Soetan *et al*., 2010). Its deficiency leads to syndrome like rickets and calcification of bones. Fe has been reported to facilitate the oxidation of carbohydrates proteins and fats (Whitney and Rolfes, 2005) and its deficiency causes some illness like anaemia. Appreciable amount of Cu was found to be present in the bean samples. Cu is essential in human body and helps catalyses the oxidation of Fe iron (Saupi *et al*., 2009). Zn functions as a cofactor and is a

Table 3. Mineral composition of four selected species of Fabaceae family (mg/100g)

Parameter	Sample A	Sample B	Sample C	Sample D	Total	Mean	SD	CV%	Min(x)	Max(x)	χ^2	Remark
Na	23.8	26.0	24.7	28.2	103	25.7	1.91	7.44	23.8	28.2	0.426	NS
K	41	33.2	38.4	44.4	157	39.2	4.75	12.1	33.2	44.4	1.72	NS
P	103	97.6	92.0	128	420	105	16.0	15.2	92.0	128	7.25	NS
Ca	14.5	17.6	19.4	15.1	66.5	16.6	2.27	13.7	14.5	19.4	0.931	NS
Mg	8.14	12.8	14.5	10.5	46.0	11.5	2.77	24.1	8.14	14.5	2.02	NS
Mn	0.11	0.025	0.019	0.141	0.295	0.735	0.06	8.16	0.019	0.141	0.152	NS
Fe	6.00	10.83	13.97	7.73	38.5	9.63	3.51	36.5	6.00	14.0	3.85	NS
Zn	2.56	1.41	1.71	3.10	8.78	2.19	0.78	35.6	1.41	3.10	0.822	NS
Cu	1.08	0.811	0.69	1.22	3.80	0.95	0.24	25.3	0.69	1.22	0.186	NS
Pb	0.277	0.068	0.094	0.346	0.785	0.196	0.13	66.3	0.068	0.346	0.285	NS
Cd	0.002	0.00	0.00	0.003	0.005	0.001	0.002	200	0.00	0.003	0.005	NS
Ni	0.013	0.006	0.007	0.017	0.043	0.011	5.19	47181	0.006	0.017	0.008	NS

Chi-square (χ^2) at $p_{=0.05,}$ $\upsilon_{=n-1=3}$critical value = 7.81, S=results significantly different, NS=results not significantly different.

constituent of many enzymes. It is a membrane stabilizer and a stimulator of the immune response. Lack of Zn might leads to poor growth and poor development of gonadal function (Ihedioha and Okoye, 2011). Mg is a constituent of bones, teeth and enzyme cofactor (Murray *et al*., 2000). Absence of Mg leads greatly to reduction of oxidative phosphorylation. The levels of Pb, Cd, and Ni in the bean samples are relatively low thus suggests that they are good for human health. Cd was not detected in *S. sternocarpa* and *C. cajan*. The presence of these heavy metals could be as a result of onset pollution where these beans were sourced. The overall mineral results showed no significant different at P= 0.05.

Mineral Ratio

The summary of results of the calculated mineral ratios of the bean samples was illustrated in Table 4. The Na/K ratio values ranged from 0.58-0.78. The Na/K ratio must be less than 1 to control blood pressure (FAO/WHO, 2016). The Na/K ratio of the bean samples under study is less than 1. This support the earlier assertion of Nieman *et al*. (1992) who reported that the sodium to potassium ratio of less than 1 is recommended for the prevention of high blood pressure. The Na/K ratio result favours the consumption of the beans by the people with high blood pressure disease. The Ca/P values ranged from 0.118-0.18 which was lower than 0.5 required minimum ratio for favourable Ca absorption in the intestine for bone formation

Table 4. Calculated mineral ratios of four selected species of Fabaceae family

Mineral ratio	Standard	Sample A	Sample B	Sample C	Sample D	Mean	SD	CV%	χ2	Remark
Na/K	0.6	0.58	0.784	0.644	0.635	0.661	0.86	130	0.0343	NS
K/Na	0.5	1.72	1.28	1.55	1.57	1.53	0.81	11.76	0.0658	NS
Ca/P	≥0.5	0.141	0.18	0.21	0.118	0.162	0.04	24.69	0.0308	NS
Ca/Mg	1.0	1.78	1.37	1.33	1.44	1.48	0.21	14.19	0.0853	NS
Na/Mg	4.17	2.92	2.03	1.70	2.69	2.34	0.57	24.35	0.413	NS
Ca/K	4.0	0.353	0.531	0.505	0.34	0.432	0.1	23.15	0.0690	NS
[K/(Ca+Mg)]	2.2	1.81	1.09	1.13	1.74	1.44	0.39	27.08	0.3088	NS
Zn/Cu	8.0	2.37	1.74	2.48	2.54	2.28	0.37	16.23	0.1784	NS
Fe/Cu	0.9	5.56	13.35	20.24	6.34	11.37	6.87	60.42	12.5	S
Ca/Pb	84	52.2	258.9	204.9	43.58	139.89	108.5	77.56	253	S
Fe/Pb	4.4	21.66	159.3	148.6	22.3	87.97	76.31	86.75	199	S
Zn/Cd	500	128	235	244	1033	410	418	102	1283	S

Chi-square (χ^2) at $p_{=0.05,}$ $\upsilon_{=n-1=3}$critical value = 7.81, S=results significantly different, NS=results not significantly different

(Nieman *et al*., 1992). Although low Ca in this present study indicates that more Ca would have to be consumed from other food source to supplement Ca requirement. K/Na level (1.28-1.72) was lower than the standard value of 5.0 hence more K needed for optimal health could be sourced from other food such as vegetables. Low Na and high K promote good health. Ca/Mg ratio ranged from 1.33-1.78 and is slightly greater than the standard value of 1 hence the result support optimal health growth. The expected value of the milliequivalent ratio of [K/(Ca+Mg)] is 2.2 while the values obtained in the studied bean samples ranged from 1.09-1.81. This low milliequivalent could be cheering considering the submission of NRC (1989) which stated that high value might promote hypomagnesaemia. This implies that the values in this present study might encourage consumption of these beans without fear of hypomagnesaemia disease. The following ratios obtained in this finding were also lower than the recommended Na/Mg (1.70-2.92), standard = 4.17, Zn/Cu (1.74-2.54), standard = 8.0, while Fe/Cu (5.56-20.24) is far higher than the required 0.9. High Fe/Cu ratio was due to relative abundant of Fe in the bean samples. Emphasis had been laid by several researchers on the importance of mineral ratios. Analytical Research Laboratories (2012) reported that mineral ratio are sometimes important than mineral levels. The ratios represent homeostatic balances. It also provides useful information regarding possible factors that may be represented by a disruption of their relationship. This disruption could affect disease states, the effect of diet as well as physiological and developmental factors (Watts, 2010).

Mineral safety index

The mineral safety index (MSI) as calculated for the beans samples was shownin Table 5. The MSI showed that Na, Mg, P, Fe, Zn and Cu were all lower than standards. The calculated MSI <standard MSI meant that such minerals would not constitute mineral overload or pose health challenges when consumed by man. The results of anti-nutrient content were presented in Table 6. The oxalate (42.4-58.8mg/100g) and hydrocyanide (7.47-12.52mg/100g) were lower compared to the values obtained for oxalate and hydrocyanide reported for *S. sternocarpara* seeds (Sam, 2019). The phytate range of 1.51-2.61 mg/100g in this present study were lower than the value range of 2.76-9.90 mg/100g reported for some staple cereal foods commonly consumed

Table 5. Mineral safety index (MSI) of Na, Mg, P, Ca, Fe, Zn, Cu

Sample	Na			Mg			P			Ca			Fe			Zn			Cu		
	TV of MSI	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
A	4.8	0.23	4.57	15	0.31	14.6	10	0.85	9.15	10	0.12	9.88	6.7	2.68	4.02	33	5.63	27.4	33	11.9	21.1
B	4.8	0.25	4.55	15	0.48	14.5	10	0.81	9.19	10	0.15	9.85	6.7	4.83	1.87	33	3.10	29.9	33	8.92	24.0
C	4.8	0.24	4.56	15	0.55	14.5	10	0.76	9.24	10	0.16	9.84	6.7	6.23	0.47	33	3.76	29.2	33	7.59	24.4
D	4.8	0.27	4.53	15	0.39	14.6	10	1.06	8.94	10	0.13	9.87	6.7	3.45	3.25	33	6.82	26.2	33	13.4	19.6
Mean	-	0.25	4.55	15	0.43	14.6	-	0.87	9.13	-	0.14	9.86	-	4.30	2.40	-	4.83	28.2	-	10.5	22.6
SD	-	0.02	0.02	-	0.10	0.09	-	0.13	0.13	-	0.02	0.02	-	1.59	1.57	-	1.71	1.71	-	2.67	2.67
CV%	-	8.00	0.44	-	23.3	0.62	-	14.9	1.42	-	14.3	0.20	-	36.5	65.4	-	35.6	6.06	-	25.6	11.8

TV = Table Value; CV = Calculate value; D = difference (TV-CV) in Zaria, Nigeria (Amos, 2020). All the beans investigated had low levels of anti-nutrients apart from oxalate which is moderate. However, all the values obtained in this work were below the toxic level and hence, does not pose any health hazard when consumed by man and animal.

Estimation of calcium-, zinc-, iron- and phytate relationships in the four samples were given in Table 6. The range of values were as follows: [Phy]:[Zn] (0.083 – 0.131), [Ca]:[Phy] (4.23 – 6.85), [Ca][Phy]:[Zn] (0.031 – 0.057) and [Phy]:[Fe] (0.009 – 0.037) with CV% values from 18.2 – 49.4 which indicated that the results were closely varied. According to literatures reports, food with a molar ratio [Phy]:[Zn] less than 10 showed adequate availability of Zn and problems were reported when the ratio is greater than 15(Oberleas and Horlard, 1981). A reduced zinc bioavailability had been reported at [Phy]:[Zn] molar ratios of 15:1 (Adeyeye *et al.*, 2000). According to WHO (1996), the level of [Phy]:[Zn] in the present report (0.083 – 0.131) indicated a very low Zn bioavailability for all the samples analysed. Nevertheless, the levels of [Phy]:[Zn] observed in the present report (0.083 – 0.131) were comparatively lower than values reported for dehulled and whole seed flour of Bambara groundnut (Olaleye *et al*., 2013), some Nigeria food samples (Adeyeye *et al.*, 2000), four lesser known African seeds (*Citrullus colocynthis*), *Cucumeropsis edulis*, *Ricinus communis* and *Prosopis africana* (3.35-11.81) (Igwe *et al.*, 2013).

A [Ca]:[Phy] molar ratio lower than 6:1 makes phytate precipitation incomplete so that some of the dietary Zn remain in solution. The proportion remaining in solution increases with decreasing [Ca]:[Phy] molar ratio (Wise, 1983). Based on this explanation, Ca has a sparing effect on Zn and at critical [Ca]:[Phy] molar rations of >6:1, phytate is completely precipitated from the solution. Interestingly,both *Sphenostylis sternocarpa* and *Cajanus cajan* analyzed had their [Ca]:[Phy] ratios greater than 6:1. Thus, Zn is available in solution and for absorption (Ojiako *et al*., 2010), whereas for *Vigna unguiculata* and *Phaseolus lunatus* with their low[Ca]:[Phy] (5.05:1 and 4.23:1) may require supplementation from other food sources. It has been observed that both the solubility of phytate and Zn availability in the intestine is dependent on dietary calcium levels (Ellis *et al*., 1987). It was this observation that led to the idea that [Ca][Phy]:[Zn] is a better indicator of Zn bioavailability than either of [Ca]:[Phy] or [Phy]/[Zn] and noted that if the value is greater than 0.5molkg^{-1}, then there would be inference with Zn availability. In the present report, the values (*Vigna unguiculata* (0.036), *Sphenostylis sternocarpa* (0.057), *Cajanus cajan* (0.042) and *Phaseolus lunatus* (0.031)) agreed with the critical value of 0.5molkg^{-1}. Also calculated was the [Phy]:[Fe] ratio for the beansamples. Interestingly, the values obtained were low at 0.009 – 0.037 showing that Fe in the samples would also be moderately available. However, these values were comparably lower than those reported for grains obtained from full and reduced irrigation processes (12.1-20.4) (Magallenes-Lopez *et al.*, 2017), durum wheat grains (15.5-31.3) (Salunke *et al.*, 2014) and two bread wheat whole-meal flour samples (12.0) (Eagling *et al*., 2014).

CONCLUSION

The beans under study are rich source of carbohydrate and protein. These could contribute to the daily requirement of proteins and carbohydrate

Table 6. Anti-nutrient composition (mg/100g), calculated [Phy]/[Zn], [Ca]/[Phy], [Phy]/[Fe] and [Ca][Phy]/[Zn] Mole ratios of four selected species of Fabaceae family

Parameter	A	B	C	D	Mean	SD	CV%	÷^{2}	Remark
Phytate	2.61	1.86	1.51	2.6	2.15	0.55	25.6	0.423	NS
Oxalate	47.1	42.4	51.4	58.8	49.9	6.96	14.0	2.91	NS
Cyanide	9.06	7.98	7.47	12.52	9.26	2.27	24.5	1.68	NS
Ca	14.5	17.6	19.4	15.1	16.6	1.97	11.8	0.931	NS
Fe	6.00	10.8	14.0	7.73	9.63	3.04	31.6	3.85	NS
Zn	2.56	1.41	1.71	3.1	2.19	0.672	30.7	0.822	NS
[Phy]/[Zn]	0.101	0.131	0.088	0.083	0.101	0.019	0.124	0.014	NS
[Ca]/[Phy]	5.05	6.85	6.20	4.23	5.58	1.01	5.93	0.735	NS
[Ca][Phy]/[Zn]	0.036	0.057	0.042	0.031	0.042	0.010	0.084	0.009	NS
[Phy]/[Fe]	0.037	0.015	0.009	0.028	0.089	0.011	0.091	0.022	NS

Chi-square (χ^2) at $p_{=0.05,}$ $\upsilon_{= n-1=3}$critical value = 7.81, NS=results not significantly different for healthy growth and source of energy. The beans are also rich in essential nutrients such as K, Ca, P, Fe which play a very indispensible role in normal human metabolism. The results also suggest that the beans contain low phytate and hydrocyanide, hence the beans are not toxic for consumption. The moderate concentration of oxalate could be reduced through processing of cooking, boiling, heating and soaking in water over time to leach out the oxalate concentration before consumption. The Phy/Zn, Phy/Fe and Ca x Phy/Zn molar ratios suggested that Zn and Fe could sufficiently be absorbed in the beans by the consumers.These underutilized peas could be used to fortify the conventional cowpea which is lower in protein. Therefore, increased efforts should be made to encourage the cultivation of these species as well as its consumption and utilization in order to maintain food security and sustainability.

Conflict of interest

The authors declared that they have no competing interests.

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