

QUANTITATIVE DETERMINATION OF WATER SOLUBLE VITAMINS, MINERALS AND PROXIMATE COMPOSITIONS OF THREE VARIETIES OF BEANS IN BAUCHI STATE NIGERIA

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ABSTRACT

The quantitative determination of water soluble vitamins, minerals and proximate compositions of three varieties of beans in Bauchi State, Nigeria, was carried out in this study. Three varieties of beans which includes one of the most commonly consumed species of cowpea (*Vigna unguiculata*) locally called *Kanannade*, the least consumed (most rare) specie of cowpea (*Vigna unguiculata*) locally called *gayan-gayan* and soybean (*Glycine max*) locally called waken soya found in Bauchi State, Nigeria were analysed. Results for the determination of the proximate composition shows that soybean (*Glycine max*) among three different samples had the highest protein content (34.21 %), ash content (3.11 %), Crude fat (25.30 %). While Cowpea (*kanannade*) has the highest Carbohydrate content (58.04 %) and Cowpea (*gayan-gayan*) has the highest Moisture contents (12.43 %) respectively. Soya bean has the highest contents of vitamin (B₁, B₃ and B₆) for the three water soluble vitamins analysed although the values obtained were less than the recommended dietary allowance recommended by the World Health Organization (WHO). In the Mineral composition of the two species of cowpea beans (*Vigna unguiculata*), and soybean analysed, soybean had the highest content of most of the mineral elements. The concentration of potassium was found to be very much higher than all the other mineral elements that were determined in all the samples. The results from this analysis shows that the three varieties of beans analyzed were found to be rich in minerals and highly nutritious.

KEYWORDS: *Vigna unguiculata*, *Glycine max*, vitamins, minerals and proximate composition

INTRODUCTION

Vitamins and minerals are considered essential nutrients because they perform several roles in the body. They help shore up bones, heal wounds, and boost the immune system. They also convert food into energy, and repair cellular damage. In Nigeria,

cowpea is a major staple food which is consumed in relatively high quantity because of its high nutritional value. Cowpea seeds are also rich sources of vitamins and essential minerals (Jenkins, 2000).

Cowpea is an important legume crop in Nigeria that is consumed in different forms in combination with other

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foods in various forms such as rice, yam, potatoes, plantain and vegetables. The protein content of soybeans was found to be about 38 to 44% which is very much higher than the protein content of other legumes which have about 20-30% protein content. Soybeans contain a complete protein profile with all the essential amino acids with the exception of methionine which must be supplied in the diet (Synder and Kwon, 1987). Soybean offers a high fat content which can serve as a good source of oleic and linoleic acids (essential fatty acids). The carbohydrates of soybean are largely polysaccharides with little starch and hexose and is about 30-35% of the proximate content of the legume (Potter and Hotchkiss, 1995). Consumption of soybean has been associated with decreased risk of breast cancer, inhibit proliferation *in vitro* of human prostatic cancer cell lines (Santibanez, Navarro and Martinez, 1997), improvement of glycemic control and the lipid profile (Azadbakht *et al.*, 2007).

Clinical manifestations of deficiency of some B vitamins such as beriberi (cardiac and dry, peripheral neuropathies, pallegra, and oral and genital lesions (related to riboflavin deficiency) have decreased, there is evidence of widespread subclinical deficiency of these vitamins (Bubko, Gruber and Anuszewska, 2015). These subclinical deficiencies although less dramatic in their manifestations, exert deleterious metabolic effects. Despite the progress in reduction of large-scale deficiency in the world, there are periodic reports of outbreaks of B-complex deficiencies which are linked to deficiency of B vitamins in populations under various distress conditions. The absence of an essential mineral can lead to death particularly with those elements required in very low concentrations. Dietary supplements are routinely taken to fix and manage many ailments. The most common dietary supplements are multi-vitamin and multi-mineral supplements. Multi-vitamins and mineral supplements are commonly consumed to ameliorate certain disease conditions. Although the vitamin requirement of the human body can be easily satisfied by a balanced diet, but there is still a chance of susceptibility to low micronutrient intakes and hence a higher risk of vitamin deficiency (FAO and WHO, 2018). Soybean compositions are characterized with important nutritional contents such as vitamins, lipids, minerals and very high proteins which range from 33 to 43% (Saha *et al.*, 2008). In developing countries like Nigeria such vitamin and mineral supplements are not readily available and even when they are available, most people cannot afford them due to the

level of poverty especially in the rural areas. Vitamin and mineral supplements cannot match all the biologically active compounds teeming in locally consumed diets. Common local staples such as cowpeas and soybean can serve as a quality source of essential nutrient, minerals and vitamins. This study was carried out to determine some water soluble vitamins using the high performance liquid chromatography technique, some mineral elements and nutritional content of three varieties of beans; two species (most common and most rare) of cowpea (*Vigna unguiculata*) and soy bean (*Glycine max*) in Bauchi State Nigeria.

MATERIALS AND METHODS

Sample Collection and Preparation

Three different varieties of Beans were used in this research. The samples were selected as follows Beans which is most consumed, *Vigna unguiculata* (*kanannade*), Beans which is least consumed (rare) *Vigna unguiculata* (*gayan-gayan*) and Soy bean, *Glycine max* (*waken soya*).

The samples were purchased from Azare Market, Azare, Bauchi State and taken to the laboratory, Bauchi State University, Gadau, Department of Biological Sciences for authentication by a botanist. Samples were dried at room temperature in the dry season with an overall maximum daytime air temperature of approximately 37 °C. The grains were weighed at various intervals until a constant weight was obtained. The dried grains were grinded into powder using pestle and mortar and stored at room temperature in the laboratory for the analysis.

METHODS

Proximate Analysis (AOAC 1990)

Crude Protein Determination: Dried sample (0.15g) was digested in Kjeldahl flask with catalyst and concentrated H₂SO₄ (2 cm³) to a clear liquid. About 15ml of 40% NaOH was added and ammonia steam was distilled into 10ml 2% boric acid solution with 5 drops of methyl red indicator which was then titrated with 0.01N HCl.

Percentage nitrogen = titre value (ml) x 0.00056 x 6.25/sample weight (g) x 100

Determination of Crude Fat: Sample (3g) was wrapped in a filter paper, weighed (*w*₂) and extraction was done with petroleum ether on a sohxlex apparatus for about three hours. Sample was dried, cooled and weighed. The percentage fat was calculated as

$$\frac{\text{Weight of filter paper + sample before extraction} - \text{weight of filter paper + sample after extraction}}{\text{Weight of dried sample}} \times 100$$

Weight of dried sample

Determination of Crude Fibre: Defatted sample (3g) was boiled with 200cm³ of H₂SO₄ for 30 mins, filtered and washed with boiling water. The residue was boiled with 200cm³ NaOH solution for 30 min, filtered again and washed with hot water and ethanol. The residue was transferred to a crucible (pre-weighed w₁), dried and weighed (w₂). Sample was ashed and weighed again (w₃). % crude fibre = (w₂-w₁)-(w₃-w₁) / weight of sample (2g) x 100

Total Ash Content

An empty crucible was weighed (w₁), 5g of dried (moisture free) sample was placed into the crucible and weighed (w₂). The sample was placed in the muffle furnace for ashing and crucible was weighed (w₃) after ashing. % ash = w₃ - w₁ / w₂ - w₁ x 100

Moisture Determination: Dried sample (3g) was weighed onto the plate of digital moisture analyser, lid was closed and the result displayed was recorded in triplicate.

Calculation of Carbohydrate Content

The percentage of available carbohydrate content was calculated by difference as follows Carbohydrate = 100 - (Moisture + Ash + Crude Fat + Crude Fiber + Crude Protein) %

Energy Calculation: The Atwater method was used for energy calculations = Energy (kcal) = (g protein×4)+(g carbohydrate×4)+(g fat x 9).

HPLC DETERMINATION OF B VITAMINS (WATER-SOLUBLE)

Vitamin B₁, B₃ and B₆

The vitamin B group was extracted using takadaistase enzyme, extracted samples (20 µl) were injected into the HPLC system and quantification of B vitamins was accomplished through Chromatographic separation by comparison to vitamin B standards.

Analysis of Mineral Elements

Dried sample (5g) was ashed, heated with 5.0cm³ of HNO₃ and HCl (15cm³) was added. It was made up to 100 cm³ with deionised water, after filtration and Mineral elements were determined using micro plasma atomic emission spectrophotometer (MP-AES).

Statistical Analysis: Data were subjected to analysis of variance (ANOVA) using SPSS (Version 20 IBM SPSS Statistics) followed LSD post test which was used to determine the statistical difference in comparisons between samples at p≤0.05. Values are expressed as mean±standard deviation.

RESULTS AND DISCUSSION

Results

Table 1: Proximate Analysis of three varieties of beans (Kanannade, gayan gayan and waken soya)
Carbohydrate content is highest in all the samples analysed except for *Glycine max* in which crude

protein content was the highest amongst all the parameters. *Glycine max* has the highest fat, ash and moisture content.

Samples	Moisture %	Ash %	Crude Fat %	Crude Fibre %	Crude Protein%	Carbohydrate %	Energy (kcal)
<i>Vigna unguiculata</i> (kanannade)	11.56±0.51 ^a	2.84±0.78 ^a	6.01±0.72 ^a	5.59±1.52 ^a	15.94±1.78 ^a	58.04±0.56 ^a	350.01
<i>Vigna unguiculata</i> (gayan gayan)	12.43±0.23 ^b	2.90±0.51 ^a	4.66±0.44 ^a	8.74±3.91 ^a	14.38±0.58 ^a	56.88±3.76 ^a	326.98
<i>Glycine max</i> (waken soya)	10.00±0.30 ^c	3.11±0.35 ^a	25.30±1.67 ^b	4.82±2.38 ^a	34.21±3.03 ^b	22.54±5.21 ^b	454.70

Results are expressed as mean ± Standard Deviation for triplicate determinations. Values on the same column with different superscript are significantly different with respect to each other at P≤0.05.

Table 2: Results for the determination of water soluble vitamins (Vitamins B1 (thiamine), B3 (niacin), B6 (pyridoxine) of the three varieties of beans (kanannade, gayan-gayan and waken soya). HPLC analysis of the vitamin content of the samples showed

that the varieties of sorghum contains all the vitamins analysed and the values were found to be relatively low compared to the WHO recommended dietary allowance.

Samples	Kanannade mg/g	Gayan- gayan mg/g	Waken soya mg/g	WHO RDA (mg/day)		
				Children 0-9yr	Adolescents 10-18yrs	Adults 19yrs- above
Vitamin B1	0.020	0.023	0.030	0.2-0.9,	1.1-1.2	1.1-1.5
Vitamin B3	0.019	0.022	0.031	2-12 (NE),	1-6 (NE),	14-17(NE)
Vitamin B6	0.003	0.004	0.006	0.1-1.0,	1.2-1.3,	1.3-2.0

NE, Niacin equivalent: 1mg NE = 60mg of tryptophan = 1mg = 1mg niacin
 WHO RDA : World Health Organization Recommended Dietary Allowance
 RDA: Recommended Dietary allowance by WHO (2013)

Table 3: Minerals Analysis of beans (Kanannada, gayan gayan and waken soya)

The results showed a relatively high concentration of potassium in all the samples analyzed. The concentration of potassium obtained in Soy bean (741.15 ± 0.99 mg/100g) was higher than those from the other Cowpea. The results also indicate that the highest concentration of magnesium in all the samples of study was observed in sample from Cowpea (gayan-gayan). It is however higher than 8.67 ± 0.38 to 14.00 ± 0.39 mg/100g reported. It is also clear from the analysis that the concentration of sodium in all the samples ranged from 78.12 ± 0.85 mg/100g to

81.70 ± 0.22 mg/100g with samples from Soybean having the highest. The concentration of iron in the samples ranged from 9.8 ± 0.10 to 10.11 ± 0.90 mg/100g. Other elements analyzed were calcium, iron, zinc and copper. The elemental composition of calcium in all the samples ranged from 194.01 ± 0.93 to 201.61 ± 0.53 mg/100g with samples from Soya bean having the highest value, while the sample from Cowpea (gayan-gayan) had the highest amount of Zinc (6.80 ± 0.96 mg/100g). Among the various elements analyzed, copper had the least composition in all the samples (0.91 ± 0.16 to 1.00 ± 0.17 mg/100g).

Samples Elements	<i>Vigna unguiculata</i> (kanannade)	<i>Vigna unguiculata</i> (Gayan-gayan)	Glycine max Waken Soya
Mg (ppm)	0.80 ± 0.20^a	0.80 ± 0.20^a	0.73 ± 0.30^a
Na (ppm)	6.02 ± 1.88^a	6.90 ± 3.61^a	8.92 ± 4.92^a
K (ppm)	164.00 ± 138^a	228.33 ± 38.42^a	221.66 ± 22.85^a
Ca (ppm)	0.94 ± 0.25^a	0.50 ± 0.28^a	0.83 ± 0.33^a
Fe (ppm)	0.29 ± 0.06^a	0.44 ± 0.19^a	0.37 ± 0.16^a
Zn (ppm)	6.31 ± 6.78^a	13.37 ± 10.65^a	6.89 ± 6.98^a
Cu (ppm)	0.12 ± 0.21^a	0.23 ± 0.21^a	0.23 ± 0.21^a
Mn (ppm)	0.58 ± 0.90^a	0.83 ± 0.64^a	0.75 ± 0.66^a

Results are expressed as mean \pm SD for triplicate measurements. Values on the same row with same superscript do not differ significant at $P \leq 0.05$

DISCUSSION

Table 1 presents the result of proximate analysis of three varieties of beans analysed. Proximate analysis which includes moisture, ash, lipid, protein and carbohydrate is of interest in food industries for product development, quality control (QC) or regulatory purposes (Thangaraj, 2016) and for health and medical practitioners.

The moisture content of *gayan-gayan* was found to be the highest (12.43%) while soybean (*Glycine max*) had the lowest moisture content (10.00%) with a value which was found to be in range of that reported by Rani, Grewal and Khetarpaul (2008). The differences between all the three samples were significant at $p \leq 0.05$. The moisture content is an essential factor in the preservation of food which affects the stability of most food products. Although moisture content alone is not a reliable indicator of food stability, since foods with the same water content differs in their perishability (Damodaran, Parkin and Fennema, 2007). Since these samples especially soy bean are used to produce many food products, the moisture content as obtained in this study is relatively high and may affect the shelf live and perishability of the processed food products.

The ash content for all three samples were low, although *Glycine max* with ash content of 3.11% was found to have the highest ash content, this is similar to the results previously reported (Rani, Grewal and Khetarpaul, 2008). There was no significant difference ($p \leq 0.05$) in the ash content of all the samples with respect to each other. The ash content which represents the total mineral content in foods was found to be low and since high ash value signifies the presence of an inorganic adulterant, it therefore shows that all the three samples analysed in this study contains little adulteration. Determination of total ash content of food is useful in measuring the quality and nutritional value of many foods. When the ash content exceeds 5%, it is an indication that there may be a momentous quantity of impurities in the sample being analysed (Muller, Huebner and Souza, 2013).

There was no significant difference ($p \leq 0.05$) in the fat content of the two *Vigna species*. The fat content of *V. unguiculata (gayan-gayan)* and *Glycine max (waken soya)* was significantly different ($p \leq 0.05$). *Glycine max* was found to have the highest fat content with a value of 25.30. It has been reported that *Glycine max* has a very high fat content as a legume and about 47% of its energy value comes from its fat content (Mesinna, 1999, Rani, Grewal and Khetarpaul, 2008). The fat content of *Glycine max* was significantly different ($p \leq 0.05$) from the two *Vigna species*. With the high fat content of *Glycine max*, it shows that *Glycine max* can be of high nutritional value especially

for children and young people since fat can serve as a very good source of body energy requirement. *Vigna species* also contain high amount of fat which can serve as a readily available source of fat for both humans and animals. Precise quantification of lipids in foods is very important for accurate nutritional standard to prevent production of foods with undesirable functionality (Min and Ellefson, 2010).

The crude fibre content of *V. unguiculata (gayan-gayan)* was found to be higher than *V. unguiculata (Kanannade)* and *Glycine max*. Although the fibre content for all three samples analysed was found to be in moderately low, there was no significant difference ($p \leq 0.05$) in the fibre content between all the samples with respect to each other. Dietary fibre, being the non digestible part of food is an essential composition of balanced diet which helps to minimize the development of certain health problems (Salovaara, Gates and Tenkanen 2007; Gordon and Goda 2008).

The crude protein content of *Glycine max* is high (34.21), which was found to be within the range of values reported by Zarkardas *et al.* (1999). The value for the protein content of *Glycine max* was found to be very higher when compared to the two *Vigna species*. *Glycine max* was found to be significantly different ($p \leq 0.05$) from the two *Vigna species*. The values for both *Vigna species (kanannade)* (15.94) and *gayan-gayan* (14.38)) were found to be moderately high and the difference in the protein content between the two samples was not significant ($p \leq 0.05$). The protein content values of some varieties of cowpeas in West Africa and United States were found to fall within the Range of 22 to 29% (Hall, 2003). Although the protein content of *Vigna species* are relatively low compared to *Glycine max*, but they can still serve as a good source of protein especially in Nigeria, where the most available and commonly consumed staples are very high in carbohydrate. In northern eastern Nigeria, malnutrition is an issue of concern as most children suffer from protein energy malnutrition largely due to lack of protein rich diets. These legumes can provide the needed protein energy to alleviate malnutrition as one of the major causes of all forms of malnutrition is low-quality diets (FAO and WHO, 2018). *Glycine max* (Soybean) is an anonymous source of protein and can be very useful as a potential tool for combating malnutrition, as functional food to manage different life style nutritional needs and has been found to exhibit a great free radical scavenging activity (Ahsan *et al.*, 2019). For a legume, *Glycine max* is interestingly a very rich source of protein in which the protein content can solely provide for all the amino acid requirement of the body.

The carbohydrate content of one of the most commonly consumed *Vigna specie (kanannade)* was the highest with a value of 58.04% when compared to the *Vigna specie (gayan -gayan)* (56.88%) that is rare and *Glycine max* with carbohydrate value of 22.54%. The value of the carbohydrate content of cowpea species obtained in this result is similar to that obtained by Aggarwal and Sharma (2017). There was no significant difference ($p \leq 0.05$) between the carbohydrate content of the two cowpea species. *Glycine max* was found to have the lowest carbohydrate content which was significantly different ($p \leq 0.05$) from the two cowpea species. The carbohydrate content of *Glycine max* was found to be about the same value as that reported by Ambawat and Khetarpaul (2018). The low carbohydrate content of these legumes is of paramount importance especially to diabetics and pre-diabetics as high carbohydrate diet has been implicated in certain chronic non communicable disease conditions (Jenkins *et al.*, 2002). Foods with high glycemic indices which contains high carbohydrate content has been shown to be one of the primary causes of food related non communicable chronic diseases (NCD) (Ludwig, 2002). This makes *Glycine max* which is low in carbohydrate a healthy diet for diabetics and obese patients as low GI meal will help to manage these diseases and may even prevent the development of these diseases.

VITAMIN ANALYSIS

Table 2 represents the result for the HPLC analysis of the three legume samples analysed (*Vigna species* and *Glycine max*) and the World Health Organization (WHO) recommended dietary allowance (RDA). WHO stipulates that a healthy diet should provide sufficient, safe, and diversified foods to maintain active life and reduce risks of diseases. It should contain fruits, vegetables, legumes, nuts and whole grains, and is low in fats (especially saturated fats), free sugars and salt (WHO, 2018). The vitamin content obtained for all the three samples were found to be very low. These values were less than the World Health Organization (WHO) recommended dietary allowance (RDA) (WHO, 2013). Although these vitamins are present in small quantity in the food samples analysed, their presence in these staples are very essential as they are usually not required in large quantities provided there is steady supply from the diet. Vitamin B₁ concentration of *Glycine max* was found to be higher (0.030) than the two *Vigna species kanannade and gayan-gayan* whose Vitamin B₃ and B₆ concentration were 0.020 and 0.023mg/g respectively. *Glycine max* had the highest vitamin B₃ content (0.031mg/g) compared to the two *Vigna species kanannade and gayan-gayan* with vitamin B₃ content of 0.019 and

0.022mg/g respectively. B vitamins have been suggested to elucidate a possible therapeutic potential in the treatment and management of peripheral nerve injury (Nedeljkovic *et al.*, 2018).

Values obtained for vitamin B₆ were found to be the lowest compared to other vitamins that were analysed (Vitamins B₁ and B₃). There is the premise that vitamin B₆ levels, when increased can profer neuroprotective effects (Hwang *et al.*, 2007). *Glycine max* was found to have the highest content of vitamin B₆ (0.006mg/g) while the two *Vigna species kanannade and gayan-gayan* contained 0.003 and 0.004mg/g respectively. In summary for Vitamins, soya bean has the highest contents of Vitamins (B₁, B₃& B₆). Although in the recommended dietary allowance for vitamins, vitamin B₃ is required more than other vitamins. Supplementation of vitamin B₃ with essential dietary anti-oxidants may help to reduce the damage caused by free radical toxicity in diabetes mellitus (Abdullah *et al.*, 2018). Unhealthy diets which lack vitamins are an important cause of malnutrition. They are now responsible for more adult deaths and disability than alcohol and tobacco use (WHO, 2018). Unlike fat soluble vitamins, B complex vitamins are water soluble and are not stored in the body and should therefore be adequately available in the diet. Correct application of vitamins can achieve significant clinical therapeutic efficacy, which is of great significance for the maintenance of human health (Du, Zhang and Du, 2018).

MINERAL ELEMENT ANALYSIS

Dietary minerals are inorganic compounds that are essential for the proper functioning and interactions in biological systems by the role they play in mediating the chemical and biological reactions that are fundamental to life (Quintaes, and Diez-Garcia, 2015). There were no significant differences ($p \leq 0.05$) in all the mineral elements analysed for all the samples with respect to each other. Essential elements are required for the interaction between genetic and physiological factors and dietary deficiency of any of these elements would result to certain physiological and structural abnormalities that are preventable and can be treated by administration of the deficient element (Melo *et al.*, 2008).

The magnesium (Mg) content of all three samples were found to be almost the same value although the two *Vigna species kanannade and gayan-gayan* have the same values (0.80±0.20) while *Glycine max* had a slightly lower value (0.73±0.30). Mg is an essential macro element that is required for a number of biochemical processes in humans. The presence of Mg in foods can provide this essential mineral for the body requirement since it cannot be synthesized by the body system and must be consumed from the diet.

The availability of an adequate quantity of Mg is a crucial factor for proper cellular and body homeostasis (Barbagallo, Belvedere and Dominguez, 2009). Mg deficiency can cause fatigue, depression, insomnia, muscle spasms, heart failure, tachycardia, arrhythmia, anorexia, nausea and vomiting (Harris, 2013).

The sodium (Na) content of all the three samples were found to be low. *Glycine max* was found to have higher Na content (8.92 ± 4.92) than the two *Vigna species kanannade* and *gayan-gayan* whose Na content were found to be 6.02 ± 1.88 and 6.90 ± 3.61 respectively. Na consumption has been implicated as a leading risk factor in high blood pressure and cardiovascular disease (Micha *et al.*, 2017). The main source of Na in the diet is added salt which is in the form of sodium chloride, although naturally occurring sources of Na from food account for only about 10% of consumed Na. The low level of sodium in these samples analysed may serve as an advantage for them to be recommended for the management and prevention of hypertension and cardiovascular diseases. The excess risk associated with Na intake appears to be solely mediated through the damaging consequence of excess Na consumption on blood pressure (Mozaffarian *et al.*, 2014).

The Potassium (K) values for all the samples analysed were relatively high. One of the two *Vigna specie gayan-gayan* had higher K content (228.33 ± 38.42) compared to *Glycine max* which had a value of 221.66 ± 22.85 and the most commonly consumed *Vigna speciekanannade* had a value of 164.00 ± 138 . High intake of K helps to lower blood pressure and invariably confer protective effect against heart ailments (He and Mac Gregor, 2001). There is a strong recommendation for the consumption of more K and less Na (WHO, 2012) as excess intake of Na and inadequate K has been one of the major risk factors for hypertension and other associated diseases. *Glycine max* and *gayan gayan* were found to have higher K concentration, which makes them a preferable food source for the management and prevention of hypertension. High dietary K has been associated with defensive effects against various pathological conditions that affect the cardiovascular system, kidneys, and bones, and also reducing urinary calcium (Ca) excretion leading to positive bone health and preventing the risk of osteoporosis (Lanham-New and Lambert, 2012). Thus, food and food products with high potassium and low Na content is required for good health condition and conversely these legumes were found to contain higher K and lower Na content.

Adequate dietary ingestion of Ca has been shown to decrease the risk of certain chronic diseases which includes osteoporosis, hypertension, colon cancer,

breast cancer, kidney stones, polycystic ovary syndrome, ovarian cancer, and several other disorders (Nicklas, 2003). The Ca content for all the samples were found to be low and *kanannade* had the highest Ca value (0.94 ± 0.25) amongst all the samples analysed. *Glycine max* was found to have Ca value of 0.83 ± 0.33 and *gayan-gayan* had the least Ca value of 0.50 ± 0.28 amongst the three samples. The major dietary source of Ca are dairy products, diets such as beans can serve to provide reasonable quantity of Ca and this can help to prevent deficiency that can result in serious pathological condition. Ca deficiency in children can cause diseases such as rickets and in adults may cause osteoporosis (Gueguen and Pointtilart, 2000). Higher dietary intake of Ca has been associated with a decreased risk for the development of type 2 diabetes (Kim, Oh and Hong, 2018). These legumes will serve as a preferred diet for diabetics and pre-diabetics as they may aid in lowering the risk developing type 2 diabetes and managing the complications that follows.

Iron (Fe) content of all samples were very low, although *kanannade* had the lowest value of 0.29 ± 0.06 ppm and *gayan-gayan* had the highest iron concentration (0.44 ± 0.19 ppm). The metabolic role of Iron in synthesis of haemoglobin or myoglobin and the enzymatic role of Fe²⁺ containing enzymes are very crucial to the physiological function of the human body (Amaro and Camara, 2004). Fe deficiency is a major global health problem which is particularly common in developing countries, and is associated with lowered immunity, and impaired cognitive development (de Benoist, *et al.*, 2008). The level of Fe obtained in both samples of *V. Species* and *Glycine max* are relatively low, but they can complement the amount of Fe consumed from other foods especially in developing countries, where most of the foods available contain little or no Fe.

A crucial role of Zinc (Zn) is in relation to its antioxidant function and its involvement in the antioxidant defence system (Salguero *et al.*, 2000). The value obtained for Zn content of all the three were moderately high with *gayan-gayan* having the highest value of 13.37 ± 10.65 ppm and *kanannade* and *Glycine max* were found to have almost the same concentration of Zn 6.31 ± 6.78 and 6.89 ± 6.98 respectively. This result corresponds with the values reported by Olabanji *et al.* (2018). The concentration of Zn present in these legumes as obtained in this study is very significant since they are processed and consumed almost on daily basis as different food products. Deficiency of Zn is a critical global health issue, especially in developing countries as about 50% the food consumed all over the world is low in absorbable Zn, as a result of shortage or lack of

available of animal products (Akhta, Anjum, and Anjum, 2011).

The Copper (Cu) and manganese content of all the samples were found to be very low. *V. unguiculata* (*gayan-gayan*) and *Glycine max* were found to have the same concentration of Cu (0.23 ± 0.21) while *V. unguiculata* had a slightly lower value (0.12 ± 0.21). Cu, an essential micronutrient that is required for proper function of metabolic pathways and several metallo enzymes. Deficiency of Cu has been associated with different clinical manifestations which includes skeletal abnormalities, cardiovascular defects, impaired melanin production, impaired growth and defective hematopoiesis, especially anemia (Williams, 2019). All the three samples analysed in this study contains copper, although the concentration is not high but it provides the consumers with good intake of dietary Cu since they are easily obtained and can be consumed regularly as different food products. Elevated levels of Cu may increase the production of reactive oxygen species (ROS) and consequently oxidative stress (Tsuboi *et al.*, 2014). The result from this study reveals that the concentration of Cu contained in these legumes is not high enough to result in such elevated levels as to lead to high production of ROS. Therefore, Cu concentrations should be maintained below levels that cannot be toxic and above levels that can result in deficiency (Aliabadi, 2008).

Manganese (Mn) content for all the samples were found to range from 0.58 ± 0.90 – 0.83 ± 0.64 . Manganese (Mn) is an essential mineral element that is required in minute quantity by humans. However, high levels of manganese can be very detrimental to human health as it has been associated with lower performance in verbal memory, hyper activity behaviors (de Carvalho *et al.*, 2018), hormonal imbalance in children (dos Santos *et al.*, 2019), abnormality of hormones secretion and decrease of sperm motility in adult males (Yang *et al.*, 2018).

CONCLUSION

Soy bean (*Glycine max*) had the highest ash, crude fat and crude protein content while the least consumed beans *Vigna unguiculata* (*gayan-gayan*) had the highest moisture and crude fibre content. The most consumed beans *Vigna unguiculata* (*kannanade*) had the highest carbohydrate content. From the results obtained, the various samples were also found to contain several mineral elements with potassium having the highest mineral composition in all the samples analyzed. Although all three samples contain vitamins and essential minerals, it is clear that Soya bean most nutritious amongst as it has the highest percentage of protein, content of water soluble vitamins, essential mineral elements as determined in this study. The rarely consumed *Vigna unguiculata*

sample was found to be more nutritious than the commonly consumed *Vigna unguiculata* sample. These legumes would help to provide healthy diets needed for good health and proper wellbeing which will improve the current nutrition situation in Nigeria especially in Bauchi State. Since these legumes are readily available and affordable they can also help to combat hunger and under nutrition more especially in countries like Nigeria where malnutrition is a big challenge. In conclusion, *V. Unguiculata* and *Glycine max* may be recommended as nutritiously advantageous for the prevention and management hypertension, diabetes and cardiovascular diseases as they contain essential macro and micro nutrients at concentrations that is neither toxic nor deficient.

Contribution of Authors

Authors Zinat, Suleiman Mohammed and Aliyu Abdullahi carried out the research and laboratory work and wrote the first draft of the manuscript. Authors Adamu Idris Matinja and Habibu Tijjani Co-supervised the research work and made corrections to the manuscript. Authors Jamila Salihu and Maryam Abdulkadir Dangambo made extensive corrections to the manuscript.

Competing Interests

The authors declare that there is no conflict of interest for this manuscript

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