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Nutrients and Phytochemical Profiles of Some Selected Underutilized Hard-to-Cook Legumes in Nigeria

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Abstract:
Mature seeds of underutilized hard-to-cook legumes Cassia hirsutta, Canavalia ensiformis, Vigna racemosa, Vigna subterranean (cream coloured). Vigna subterranean (mottled coloured) and Sphenostylis sterocarpa.) were analysed for the nutrients and phytochemical properties. Proximate analysis revealed the protein content in the range of 18.25% for cream coloured Vigna subterranean to 21.30% for Vigna racemosa. The seeds are good sources of protein. The legume seeds also contain varying concentrations of mineral elements – Ca, Fe, Zn, Mg, Na, P, and K. Antinutrtional components observed were in the range of 56.26 – 71.78mg/g phytic acid, 5.11 – 7.19mg/g saponin, 27.47 – 62.31mg/g tannin and 10.88 – 25.61 mg/g trypsin inhibitor. The legumes are good sources of nutrients such as protein and hence can be used to apprehend the problems associated with protein energy manultriton (PEM) as well as food and nutrition insecurity in developing countries.

***Keywords** : underutilized, hard-to-cook legumes, nutrients, antinutrtional components, protein energy manultrtion*

1. Introduction

In many areas of the world and especially in the developing countries, legumes which are commonly called beans or peas are important sources of protein. Legumes are good and cheap sources of protein which contribute substantially to the protein intake of a significant proportion of the world population (Gepts *et al*., 2005) . They belong to the family of *Leguminousae* and are worldwide in distribution (Ojo, 2013) Much emphasis has been placed on the need for increased consumption of protein foods. This is because protein as a major nutrients is required for growth, repair and maintenance of body tissues. In spite of this, deficiency of protein as protein energy manultrition (PEM) is still common in many nations of the world. Protein energy malnutrition is a major nutritional syndrome that is affecting more than 200million children and nursing mothers in the world (Lewis, 2005; FAO, 2007). Current trends in population growth indicate that unless well planned measure are put in place to tackle the situation, deficiency of protein may continue to be on the increase.

Many legumes remain underutilized. Because low income earners have poor accessibility to animal protein, there is need for continued search for and utilization of protein rich plants. The problems of hunger and malnutrition are prominent challenges facing the world population today. One out of seven people in the world today go to the bed hungry ref. The regenerative capacity of our planet is greatly being exceeded as the world is producing and consuming more resources than ever (FAO, 2011). The underutilized legumes that could be used to solve the problems of hunger and manultrtion have limitation to their use. These legumes, like many conventional legumes, contain antinutrtional components such as phytic acid, saponin, heamaglutinin, tannin, oxalate etc which interfere with the digestive processes and hence prevent efficient utilization of dietary nutrients (Siddhuraju, 2002 ; Graham and Vance, 2003).; Adeyemo and Onilude, 2013). Moreover, they are hard-to-cook.

Legumes contain varying concentration of nutrients – carbohydrates, protein, lipids and minerals ref. They are not rich sources of vitamins although some groups of vitamins – thiamine, riboflavin and niacin, are present in some (Lewis, 2005). Legumes, in recent times, have been reported reduce the incidence of cardiovascular diseases, obesity, cancer and diabetes which are believe to be associated with food habits (Xu and Chang, 2009).

The legumes used in this study were *Cassia hirsutta*, *Canavalia ensiformis*, *Vigna racemosa*, *Vigna subterranean* (cream coloured). *Vigna subterranean* (mottled coloured) and *Sphenostylis sterocarpa*. They are underutilized legumes cultivated by peasant farmers as alternative crops that are brought out for consumption during the dry season when other food crops are out of stock. Apart from the fact that these legumes contain antinutrtional components, another major limiting factors to their utilization is their hard-to-cook nature The nutritional quality of these lesser known legumes should be of interest to food scientists and nutritionists. Efforts have been made in this study to determine the nutrients and phytochemical profiles of these underutilized hard-to-cook legumes. It is hoped that provision of more information about the nutritional importance will encourage increased consumption pattern and other forms of utilization.

2. Material and method

2.1. Samples and preparation

The legumes – *Cassia hirsutta*, *Canavalia ensiformis*, *Vigna racemosa*, *Vigna subterranean* (cream coloured). *Vigna subterranean* (mottled coloured) and *Sphenostylis sterocarpa* were obtained from Sanngo market, Saki (8.67^0N , 3.40^0E), Saki West Local Government Area, Oyo State, Nigeria. The samples were cleaned manually by removing stones bad beans and other extraneous materials. The seeds were then milled, sieved through 500μm sieve and packed into cellophane bags prior to analysis.

2.2. Physical examination of the legume seeds

Each of the legume seeds was physically examined for the colour and shape. The mean mass of randomly selected mature one hundred seeds of each of the legumes was determined using an analytical balance (Ohaus Adventurer AR3130).

2.3. Proximate analysis

The procedures of AOAC (2005) were used. The moisture content was determined using air-oven method at 105°C. Total ash determination was carried out by using muffle furnace to incinerate at 550°C. Extraction apparatus of the soxhelet type was used to determine the crude lipid using petroleum ether (40°C). Crude fibre was determined after treating the sample with conc. H_2S0_4, NaOH and petroleum spirit. Macro Kjeldahl method (N × 6.25) was used to determine the protein content of the samples. The total carbohydrate content of the legume samples was estimated by difference.

2.4. Mineral elements determination

Analysis were carried out for some mineral elements; Ca, Zn, Na, Fe, Mg, P and K using atomic absorption spectrophotometer -- Buck 205 (AOAC, 2005). The pulverized ashed sample was dissolved in $100cm^3$ HCl (10% v/v) which was subsequently used in mineral content determination. Atomic absorption spectrophotometer - Buck 205 model was used. Its hollow cathode lamp supplied resonance line radiation of each element. Standard calibrations were employed in the analysis.

2.5. Determination of phytochemical components

The phytic acid content of the legume seed was determined by extraction and precipitation as described by Fagbemi *et al*. (2005). The tannin content of the legumes was determined by the procedure of Makkar (1994). The method described by Smith *et al*.(2000) as reported by Fagbemi *et al*., (2005) was used to determined the trypsin inhibitor. The procedure of Makkar and Becker (1997) was used for the determination of saponin.

3. Results and discussion

3.1. Legume seed samples description

For each legume, the following details are provided in Table 1 : the botanical name, description of its physical characteristics and the local name by which it is designated in the area of collection. *Cassia hirsutta (sese omode)* is relatively smaller with grey colour. The seed coat colour of *Canavalia ensiformis (sese-nla)* is light brown (chocolate) with smooth shining appearance. *Vigna subterranean* (VS1) is a specie of bambara groundnut. It's appearance is creamy and smooth. *Vigna subterranean* (VS2), another specie of bambara groundnut has cream colour mottled with brown. *Vigna racemosa* (*gbomogungi*) has a seed coat that is light grey, smooth and glossy in appearance. Its seed shape is elliptical with broad ends. *Sphenostylis sterocarpa (somona)* is black-brown in appearance and almost elliptical in shape. They are as presented and coded as shown in Table 1.

3.2. Proximate composition of the legume seed samples

Table 2 presents the proximate composition of the selected legume seed samples. The moisture content of all the legume seed samples used in this research work ranged from 9.54% for *Vigna subterranean* (VS2) to 11.30% for *Canavalia ensiformis* (CE). *Cassia hirsutta* (CH), *Vigna racemosa* (VR) and *Sphenostylis sterocarpa* (SS) had moisture contents of 10.66%, 10.21% and 10.81%, respectively. The percentage moisture content values of 9.87 and 9.54% for *Vigna subterranean* (VS1) and *Vigna subterranean* (VS2), respectively were slightly lower than 10.15% reported by Ojimelukwe (1991) for another variety of bambara groundnut. With the exception of *Canavalia ensiformis* that had moisture content of 11.30%, all other legume seed samples had moisture content values comparable to 10% recommended for storage stability (Oyebode *et al*., 2007).

The analytical values for the amount of crude protein in the legume seed samples studied ranged from 18.75% for *Vigna subterranean* (VS1) to 21.30% for *Vigna racemosa* (VR). The percentage crude protein content was calculated on dry basis. The protein content of the two varieties of *Vigna subterranean* – VS1 and VS2 used in this study were lower than 20.28% reported by Ojimelukwe (1991) but higher than 17.80% reported for bambara groundnut by Adewusi and Osuntogun (1991). Factors such as modification or changes in analytical procedures and agronomical factors may be responsible for such differences. Analysis revealed that *Cassia hirsutta* (CH), *Vigna racemosa* (VR), *Sphenostylis sterocarpa* (SS) and *Canavalia ensiformis* (CE) had protein contents of 21.15, 21.30, 20.25 and 19.95%, respectively.

Legumes have been reported to be good sources of protein, and with the exception of soybean seeds that have exceptionally high protein content of about 44% (Ojimelukwe, 1991), the percentage protein content obtained for all the legume seed samples analysed compare favourably well with values reported by previous studies on other legume seeds (Siddhuraju *et al.*, 2002 ; Fasoyiro *et al*., 2006; Onigbogi and Adesina, 2006).

Of all the legume seed samples analyzed, the two varieties of bambara groundnut (VS1 and VS2) had the highest quantity of fat. *Vigna subterranean* (VS1) had 5.73% fat while *Vigna subterranean* (VS2) had 6.85% fat. Fat content was lowest in *Cassia hirsutta* (CH) – 0.91%. Generally, legumes have been reported to be poor sources of fat. The fat content of most legume seeds is low (Lewis *et al.*, 2005). With the exception of soybean, groundnut and *Adenopus breviflorus* that have significant quantities of fat, legumes, in general, are not rich in fat. Because of the low quantity of fat present in each of the legumes studied, none of them qualifies as an oil seed.

The crude fibre content was highest for *Cassia hirsutta* (CH) – 7.19%. Other legume seeds contained lower percentages of crude fibre. Crude fibre was lowest for *Canavalia ensiformis* (CE) – 3.56% followed by *Sphenostylis sterocarpa* -3.23%. The values for crude fibre obtained for seed samples VS1 – 4.44% and VS2 – 4.25% were lower than 12.60% reported for a variety of bambara groundnut (Ojimelukwe, 1991).

Although legumes are not regarded as rich sources of mineral elements, the total ash content determined shows that the ash contents of samples CH, CE and VS1 were 4.08, 3.23 and 3.03, respectively. The highest ash content of 4.08% was recorded for *Cassia hirsuta* while the lowest value of 2.88% was recorded for sample VR. These results agree with a previous study carried out by Siddhuraju *et al*. (2002) in which seeds from different species of an unconventional legume, *Sesbania* and a common legume, *Vigna radiata* were reported to have varying concentrations of ash. Similar work by Fasoyiro *et al.* (2006) showed that soybean, groundnut, lima bean and cowpea contained 4.86, 5.80, 4.31 and 3.80% ash, respectively.

3.3. Mineral elements composition of the legume seeds

The mineral elements profile of the legume seeds studied are as presented in Table 3. Calcium content of *Cassia hirsutta* was 90.54 mg/100g. Higher concentrations of 131.56 and 138.00 mg/100g were recorded for *Canavalia ensiformis* and *Vigna racemosa,* respectively. The two varieties of bambara groundnut – VS1 and VS1 were relatively high in calcium having 400.36 and 405.23 mg/100g, respectively. Fasoyiro *et al*. (2006) reported calcium contents of 0.31% for lima beans and 0.26% for a variety of pigeon pea. In an earlier report, Ihekoronye and Ngoddy (1985) reported calcium contents of 90 mg/100g for lima bean and 86 mg/100 g for kidney bean. Many matured dry legume seeds have been reported to contain reasonable quantities of calcium (FAO, 2007). Calcium, being a mineral element responsible for the formation and development of bones and teeth, is therefore an element of interest in the nutritional composition of these underutilized legume seeds.

The concentration of zinc in the samples of raw legume seeds studied ranged from 6.12 mg/100g for *Cassia hirsutta* and 21.79 mg/100g for *Canavalia ensiformis*. Other legume seeds such as *Vigna racemosa* and *Sphenostylis sterocarpa* had zinc content of 6.49 and 19.72 mg/100g, respectively. There was no significant difference ($p < 0.05$) in zinc content between the two varieties of *Vigna subterranean*. Zinc is a constituent of enzymes involved in body metabolism. It is involved in the proper functioning of insulin, normal skin hair and taste acuity (Norman and Joseph, 2006). Legumes have never been reported to be good sources of zinc.

Sodium, a common mineral element in many food plants was present in each of the legume seeds. The concentration was, however, low and varied from sample to sample. Of all the samples analyzed, sodium content of *Vigna subterranean* (VS1) was 47.22 mg/100g, *Vigna subterranean* (VS2) was 50.04 mg/100g and *Vigna racemosa* was 22.09 mg/100g. The quantity of sodium in these legumes is within the tolerable level for human health (FAO, 2007; Sunetra, 2009). Sodium as well as chloride ions are the chief extracellular ions of the body that are involved primarily with maintaining osmotic equilibrium and body-fluid volume (Norman and Joseph, 2006). Significant losses of these ions occur in the loss of body fluids such as perspiration or sweating during exercise and these must be replaced to prevent weakness, nausea and muscle cramps. Since many food plants, including legumes are generally low in sodium, human consumers need sodium supplementation in their diets. However, high intake of sodium has been reported to elevate blood pressure i.e. hypertension (Apata and Ologbobo, 1994; Norman and Joseph, 2006).

The iron (Fe) content of the legume seeds ranged from 3.23 mg/100g for *Vigna subterranean* (VS2) to 10.42 mg/100g for *Canavalia ensiformis* (*CE*). This indicates that the two varieties of bambara groundnut had the lowest contents of iron of all the selected legumes. *Canavalia ensiformis* had the highest iron content of 10.42 mg/100g. The value of iron content of 4.26 mg/100g obtained for *Vigna subterranean* (VS1), the cream coloured variety of bambara groundnut was similar to the earlier report of 4.20 mg/100g reported by Ihekoronye and Ngoddy (1985) for bambara groundnut. However, Fasoyiro *et al.* (2006) obtained a lower value of 0.003% Fe for bambara groundnut. Although iron is an essential mineral element in human nutrition as a component of blood haemoglobin, the literature revealed that much of the iron in plant foods is bound in poorly soluble iron phytate and iron phosphate and is not bioavailable unlike the iron ion from animal sources which is more readily absorbed during digestion (Apata and Ologbobo, 1994; Norman and Joseph, 2006).

Magnesium (Mg) was detected in all of the underutilized hard-to-cook legumes at varying concentrations. The content of Mg ranged from 115.18 mg/100g for *Cassia hirsutta* (CH) to 180.21 mg/100g for *Vigna racemosa* (VR). Magnesium is essential to the function of several enzyme systems, in maintaining electrical potential in nerves and membranes and in liberation of energy for muscle contraction. Its deficiency symptoms are more common in experimental animals which may have a restricted diet than in humans whose diets generally are adequate in magnesium (Norman and Joseph, 2006).

Phosphorus (P), a mineral element which is an essential part of every living cell, is not only involved in bone and teeth formation and enzyme-controlled energy-yielding reactions of metabolism but also helps in the control of acid-alkaline reaction of the blood. As recorded in Table 3, the highest content of phosphorus of 520.13 mg/100g was recorded for *Sphenostylis sterocarpa* (SS) while the lowest value of 240.32 mg/100g was recorded for *Mallotus subulatus* (MS2). There was no significant difference

(p<0.05) in phosphorus content of both species of *Mallotus subulatus*. However, there was significant difference (p<0.05) in the content of phosphorus in the two species of *Vigna subterranean*. While the cream coloured variety (VS2) had 452.44 mg/100g of phosphorus, the mottled coloured variety (VS1) of bambara groundnut had 395.57 mg/100g. The phosphorus content of VS2 was comparable to that reported for bambara groundnut (0.46%) by Fasoyiro *et al.* (2006). As shown in Table 4.6, other legume seeds such as *Canavalia ensiformis* (CE) and *Sphenostylis sterocarpa* (SS) had phosphorus content of 116.94 and 122.88 mg/100g, respectively. In a previous analysis for some other legumes, cowpea, soybean and groundnut had phosphorus content of 450 mg/100g, 500 mg/100g and 410 mg/100g, respectively (Rockland and Nishi, 1979; Obatolu *et al.,* 2001; Fasoyiro *et al.*, 2006).

The highest reported requirements for phosphorus are for the young, pregnant and nursing mothers (Norman and Johnson, 2006). The legumes studied contain appreciable quantities of phosphorus and are therefore ideal for human consumption especially where high premium is placed on consumption of valuable source of phosphorus.

Potassium is the principal intracellular cation which helps regulate osmotic pressure and pH equilibria. The concentrations of potassium in each of the legume seeds are as recorded in Table 3. This ranged from 125.80 mg/100g for *Sphenostylis sterocarpa* to 675.24 mg/100g for *Vigna racemosa*. The potassium content of the two varieties of bambara groundnut were different. VS1 had 350.75 mg/100g while VS2 had 452.44 mg/100g of potassium. The concentrations of potassium in *Cassia hirsutta,* 220.11 mg/100g was higher than that of *Canavalia ensiformis,* 175.29 mg/100g. It was reported for some other legumes such as cowpea, yam bean, soybean and groundnut that the potassium contents were 141, 200, 160 and 200 mg/100g, respectively (Edem *et al.*, 1990; Apata and Ologbobo, 1994). The concentration of potassium in lima bean –143.04 mg/100g as reported by Oyebode (2005) was lower than those of the creamy coloured *Vigna subterranean* (VS1), mottled coloured *Vigna subterranean* (VS2) and *Canavalia hirsutta* (CH) which were 350.78, 340.89 and 220.11 mg/100g, respectively. Another legume, *Adenopus benth* seed was also reported to contain 125.74 mg/100g of potassium (Oyebode *et al.*, 2007). This is similar to that of *Sphenostylis sterocarpa* --- 125.80 mg/100g as presented in Table 3.

3.4. Anti-nutritional components of the legume seeds

The anti-nutritional components of each of the legumes are presented in Table 4. The tannin content of these underutilized legumes ranged from 27.47 mg/g for *Canavalia ensiformis* to 62.31 mg/g for *Cassia hirsutta*.

The two varieties of *Vigna subterranean*, VS1 and VS2 had 31.58 and 42.59 mg/g of tannin, respectively. *Vigna racemosa* had a tannin content of 28.97 mg/g while *Sphenostylis stereocarpa* had the tannin content of 39.88 mg/g. The tannin content of these minor legumes were observed to be higher than those reported for the major grain legumes. Soybean, for instance was reported to have 1.80 g/100g while groundnut was reported to have 1.10 g/100g of tannin (Fasoyiro *et al*., 2006). Also, a variety of bambara groundnut was reported to have 6.47 g/100g tannin while cowpea (*Vigna unguiculata*) was reported to have 2.85 g/100g tannin. The raw seed of *Senna occidentalis*, a minor legume that is used as natural medicine for the treatment of asthma, bronchitis, liver diseases and anaemia was reported to contain 63.33 mg/100g of tannin (Abdullahi, 2007b). Tannin is reported to be located in the seed hull. Therefore, seed dehulling process may be expected to reduce its level. Dehulling treatments that legume seeds undergo prior to processing into traditional dishes such as *akara* and *moinmoin* are means through which tannin content of legumes is reduced before consumption.

The highest content of saponin was recorded for VS1 containing 7.19 mg/g while the lowest was *Cassia hirsutta* containing 5.11 mg/g saponin. Contrary to the concentration of tannin in the coloured variety, saponin content of the mottled and coloured variety of *Vigna subterranean* (VS 2) was lower – 5.33 mg/100g than the creamy variety (VS1). *Vigna racemosa*, *Sphenostylis stereocarpa and Canavalia ensiformis* had saponin contents of 5.14, 5.98 and 5.29 mg/g, respectively. The saponin content of *Albizzia lebbeck*, another minor legume, commonly grown in some northern parts of Nigeria was reported to contain 18.00 g/100g (Abdulahi *et al*., 2007a). The presence of saponin in foods induces bitterness. Studies have shown that samples of saponin isolated from pea and soy flour possess a characteristic flavour which is perceived to be bitter or astrigent by human subjects and there is a linear relationship between the strength of the sensory response and the concentration of the saponins in water over the range of 0 - 0.1% (Chandel and Rastogi, 2008). One consequence of this is the likelihood that saponin is a factor contributing to the undesirable organoleptic properties, especially the taste of some legume products. Processing methods that would significantly reduce saponin concentration are therefore suggested for the legumes studied to encourage their wider acceptability.

Trypsin inhibitor is another important anti-nutritional factor that is in all the legumes studied. the lowest value of TIA was recorded for *Vigna racemosa* – 9.72 mg/g. *Sphenostylis stereocarpa* and *Canavalia ensiformis* contained 23.09 and 25.57 mg/g of trypsin inhibitor, respectively. The inhibitor impairs protein hydrolysis thereby decreasing the nutritive value of any product containing them.

As presented in Table 4, the concentration of phytic acid in the legumes ranged from 56.26 mg/g for *Cassia hirsutta* to 71.78 mg/g for *Sphenostylis sterocarpa*. *Canavalia ensiformis*, creamy *Vigna subterranean*, (VS1) and *Vigna racemosa* had phytic acid contents of 59.28, 70.80 and 63.15 mg/g, respectively. The phytic acid contents of these legumes are high when compared with values reported for some other legumes such as bambara groundnut, 4.17 g/100g, lima bean, 3.17 g/100g, pigeon pea, 4.80 g/100g and cowpea 1.65 g/100g (Fasoyiro *et al*., 2006). However, Abdullahi (2004) reported a value of 106.0 mg/g phytic acid for *Delonix regia*. Similarly, Oyebode *et al.* (2007) reported that the raw dried seed of another minor legume A*denopus benth* seed contained 677.89 mg/100g of phytic acid. There is a correlation between the presence of phytic acid and protein content and mineral availability (Muzquiz, *et al*., 1999; Siddhuraju *et al.* , 2002).

A large body of literature exists that indicates that minerals are less available from foods of plant origin even after accounting for the high overall digestibility of plant foods. This could be partly due to the presence of phytates (Fagbemi *et al*., 2005 ; Xu and Chang, 2009). Phytic acid reduces the absorption of minerals like calcium, magnesium, zinc and iron by forming complexes with them. Therefore, any processing method that these legumes must undergo before consumption should ensure reduction of phytic acid to a level that will not constitute any form of impairment to mineral element absorption. In recent times, components of food legumes such as phytic acid and saponin that have hitherto been regarded as antinutrients have been reported to offer nutritional and health benefits to food consumers (Xu and Chang, 2009). Therefore, the designation of such food components as "antinutrients" need to be reconsidered.

4. Conclusion

The underutilized hard-to-cooked legumes have been observed to be good sources of critically important nutrients such as protein. Provision of information on the constituents, it is hoped, will encourage and widen the scope of consumption. This is apt for apprehending the problem of protein energy malnutrition as well as food and nutrition insecurity in developing countries. It is expedient to state that efforts are being made to proffer solution to the problem of the hard-to-cook nature of these legumes during processing.

Sample Code	Botanical name	Local name	Seed coat colour	Mean mass (in g) of 100 seeds	Seed shape
CH	Cassia hirsutta	Sese omode	Grey, relatively smaller	11.27	Near spherical
CE	Canavalia ensiformis	Sese nla	Chocolate, light brown smooth shining.	27.56	Near elliptical
VS1	Vigna subterranean	Bambara	Cream mottled with brown.	75.83	Near spherical
VR	Vigna racemosa	Gbomogungi	Light grey, smooth shining	30.47	Near elliptical
VS2	Vigna subterranean	Bambara	Cream, smooth	80.11	Near spherical
SS	Sphenostylis stereocarpa	Somona sese	Black brown	30.76	Near elliptical

Table 1 : Legume seed samples, sources of collection and descriptive characteristics.

Legume sample	% Constituents						
	Moisture (db)	Ash	Crude Protein	Ether Extract	Crude Fibre	Carbohydrate	Dry mater
Cassia hirsutta	10.66d±0.53	4.08c±0.51	21.15d±1.01	0.91a±0.01	7.19e±0.20	56.01a±0.98	89.34b±1.34
Canavalia ensiformis	11.30e±0.65	3.23b±0.28	19.95c±0.64	1.91c±0.03	3.56b±0.15	60.05d±1.65	88.70a±0.96
Vigna subterranean 1	9.87b±0.47	3.03b±0.57	18.25a±0.61	5.73d±0.22	4.44d±0.55	58.68c±1.22	90.13cd±2.01
Vigna racemosa	10.21c±0.51	2.88a±0.08	21.30d±1.00	1.65b±0.04	3.90c±0.07	60.06d±0.97	89.79c±1.77
Vigna subterranean 2	9.54a±0.32	3.35b±0.07	18.75b±0.97	6.85e±0.03	4.25d±0.60	57.26b±1.02	90.46d±2.34
Sphenostylis sterocarpa	10.81d±0.79	3.15b±0.15	20.25c±1.01	1.87bc±0.12	3.23a±0.12	60.69e±1.93	89.19b±1.37

Table 2 : Proximate composition of the selected underutilized legumes.
Values are means ± standard deviation (n=3) ; means with different letters in the same column are significantly different ($p<0.05$). db = dry basis

Legume sample	Ca	Zn	Na	Fe	Mg	P	K
Cassia hirsutta	90.54a±0.98	6.12a±0.03	39.96c±0.74	5.60c±0.01	115.18a±0.84	410.03c±2.24	220.11c±1.00
Canavalia ensiformis	131.56c±1.20	21.79f±0.42	10.04a±0.23	10.42f±0.21	116.94b±0.81	325.67a±2.31	175.24b±1.02
Vigna subterranean	400.36f±1.34	14.73d±0.50	47.22e±1.01	4.26b±0.03	120.97c±0.46	395.67b±2.07	350.78e±1.76
Vigna racemosa	138.80d±0.69	6.49b±0.40	22.09b±0.02	6.30d±0.03	180.21f±0.67	460.20e±1.51	675.24f±2.02
Vigna subterranean	405.23h±1.91	14.50c±0.20	50.04f±0.11	3.23a±0.02	121.42d±0.91	452.44d±0.97	340.89d±1.20
Sphenostylis sterocarpa	152.63e±0.68	19.72e±0.41	44.91d±0.21	9.93e±0.41	122.88e±0.87	520.13f±0.87	125.80a±0.93

Table 3: Mineral elements composition of the legume seeds (mg/100g)
Values are means ± standard deviation (n = 3) on a dry weight basis ; means with different letters in the same column are significantly different ($p < 0.05$).

Legume sample	Phytic acid (mg/g)	Saponin content (mg/g)	Tannin (mg/g)	Trypsin inhibitor (mg/g)
Cassia hirsutta	56.26a ±0.18	5.11a ±0.28	62.31f ±0.37	10.88b ±0.14
Canavalia ensiformis	59.28c±0.26	5.29c ±0.33	27.47a ±0.44	25.61f ±0.21
Vigna subterranean	70.80e ±0.49	7.19f ±0.43	31.58c ±0.31	21.46d ±0.30
Vigna racemosa	63.15d ±0.28	5.14b ±0.48	28.97b±0.32	9.72a ±0.04
Vigna subterranean	58.45b±0.34	5.33d ±0.39	42.59e ±0.53	18.60c ±0.20
Sphenostylis sterocarpa	71.78f ±0.80	5.98e ±0.52	39.88d ±0.24	23.09e ±0.17

Table 4: Antinutritional components of the selected legume seeds.
Values are means ± standard deviation (n = 3) on a dry weight basis ; means with different letters in the same column are significantly different ($p <0.05$).

5. References

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