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Lipids and other constituents of *Vigna unguiculata* and *Phaseolus vulgaris* grown in northern Nigeria

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Abstract

Dried edible seeds of six varieties of *Vigna unguiculata* and two of *Phaseolus vulgaris* grown and consumed in the Savannah region of Northern Nigeria were analysed for their chemical constituents. Proximate composition values for *V. unguiculata* and *P. vulgaris*, respectively, were as follows: moisture 6.20–8.92%, 4.23–4.42%; protein 20.5–31. 7%; 31.1–33.1%; fat 1.14–3.03%, 1.02–1.22%; fibre 1.70–4.5%, 2.81–3.23%; and carbohydrate 56.0–65.7%, 55.5–57.2%. Seven components were identified by TLC separation of the fat. While the saponification numbers and acid values of the oils from the *Vigna* spp. were lower than those of the *Phaseolus* varieties, the iodine numbers were higher in the *Vigna*. Overall, potassium was the most abundant element in the seeds. Total cyanide, tannin, total oxalate and phytate were found in varying amounts, while 16 amino acids were identified. This paper highlights the safety and high nutritive values of these local varieties.

1. Introduction

In most developing and underdeveloped countries of the world, seeds serve as the major sources of the nutrient needs of humans and animals. While cereals provide energy, and legumes supply vegetable proteins, oil-seeds are important sources of vegetable oil needs. Accordingly, Singh, Rao, Subrahamanuam and Sacena (1993) encouraged poor families to consume local indigenous edible seeds, especially legumes and oil-seeds, as the least costly way of increasing the protein levels in their diets.

In Nigeria, beans (*Vigna* and *Phaseolus* spp.) are one of the most widely consumed seeds, cultivated mainly in northern Nigeria with a few centres of cultivation in lbadan, Owo and Benin in the south-western area of the country, suggesting that the savannah climate of the North and its peculiar soil encourage the cultivation of the crop. Despite the fact that the seeds are mainly cultivated in northern Nigeria, most of the biochemical investigations on *Vigna* and *Phaseolus* spp. in Nigeria have been from laboratories in southern Nigeria, using cultivars grown there, with little or no information from seeds specifically produced in northern Nigeria. (Egbe & Akinyele, 1990; Ologhobo, 1986; Ologhobo & Fetuga, 1988; Osagie, Muzquiz, Borbano, Cuadrado, Ayet & Castono, 1996). Since climate, soil, nutrition, species, strain and other factors affect the chemical make-up and nutrient value of locally-grown food and feeding stuffs (Oyenuga, 1968), it is important that cultivars grown in northern Nigeria be comprehensively studied. Hence, this work was undertaken to determine the proximate composition, total lipid content, mineral constituents, antinutritional factors and amino acid levels in some cultivars of *Vigna unguiculata* and *Phaseolus vulgaris* grown in parts of northern Nigeria.

2. Materials and methods

2.1. Collection and preparation of samples

Six cultivars of *V. unguiculata* and two of *P. vulgaris* were collected directly from farmers from the different areas of large-scale production in parts of northern Nigeria, namely Bauchi, Gombe, Plateau, Sokoto and Yobe States. The seeds were identified at the Department of Botany, University of Jos, Nigeria. The *V. unguiculata* (cowpea) cultivars were “Jan-wake (JW),

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"Farin-wake (FW)", "Dan Sokoto (DS)", "Dan Potiskum (DP)", "Dan Gombe (DG)", and "Achusuru (AC)" while the *P. vulgaris* cultivars were "Baki-wake (BW)" and "Kwakiul (KW)". The dried seeds were cleaned and stored in screw-top jars at room temperature from where portions were ground and used for analyses. The powdered samples were stored in sealed cellophane bags in a freezer at −20°C until required.

2.2. Proximate analysis

The different samples were analyzed for moisture, ash, crude fat and crude protein in portions of 5 g each, by standard methods recommended by AOAC (1980). The crude fibre content was determined by the method described by Joslyn (1970) and AOAC (1980). Carbohydrate was calculated by difference, based on the total seed composition (Ologunde, Ayorinde & Shepard 1990; Onwuliri & Anekwe, 1992; Onwuliri, Anekwe, Ojobe & Onobun, 1995). The caloric values were estimated by multiplying the crude protein, fat and carbohydrate contents with the Atwater factors of 4, 9 and 4, respectively.

2.3. Lipid analysis

The extraction of crude fat from 10 g powdered samples was done using petroleum ether (40–60°C) in a Soxhlet apparatus for 8 h. The neutral lipid (fat) samples and standards were then subjected to analytical thin layer chromatography on silica gel plates using petroleum ether, Diethyl ether, acetic acid (80:20:1 v/v/v) as solvent system (Onwuliri & Anekwe, 1993a). The standard lipid samples were obtained from Applied Science Laboratories, Pennsylvania, USA. Some physicochemical constants of the oil, namely saponification number, acid value and iodine number were estimated using the methods of AOAC (1980).

2.4. Mineral estimation

One gram of powdered samples were used for analysis and quantification of mineral elements. Calcium, iron, manganese, magnesium, potassium, sodium and zinc analyses were performed as before (Onwuliri & Anekwe, 1992) with an atomic Absorption Spectrometer (Hitachi 180-80 polarized Zeeman), using nitric acid and hyperchloric acid (6:1) as the digestion mixture. Phosphorus was determined according to the molybdovanadate method (AOAC, 1980).

2.5. Amino acid determination

Two and a half grams of the defatted powdered seeds were used for this analysis. The protein hydrolyzates were prepared by the method of Spackman, Stein and Moore (1958), and amino acids in the protein hydrolyzates analysed using a Technicon Sequential Multisample Amino Acid Analyser (TSM) (Onwuliri & Anekwe, 1993b), following the methods of Spackman et al. (1958). The amino acid concentrations were expressed as g/16 gN in line with Ologhobo and Fetuga (1983a, 1983b); Mostafa, Rahma and Rady (1987) and Fernandez-Quintela, Macarulla, Del Barrio and Matinez (1997).

2.6. Antinutritional factor (ANF) assay

Total cyanide was determined by the methods of Oke (1969) and Trease and Evans (1989). Tannin was analysed by the method of AOAC (1980). The method of Munro and Bassir (1973) was used in the total oxalate assay while the levels of phytate in the samples were obtained using the procedure of Davies and Reid (1979). Two grams of powdered samples were used for the analysis of the different anti-nutritional factors.

3. Results and discussion

The proximate composition of the cultivars of *V. unguiculata* and *P. vulgaris* studied are presented in Table 1. The moisture content of the six *Vigna* cultivars ranged from 6.14±0.42 to 8.92±2.2% DM while those of the two *Phaseolus* cultivars were 4.23±0.74 and 4.42±0.70% DM. The values, although low, were in good agreement with those of earlier workers who obtained values of 5–10 and 5–15% for cowpeas and *Phaseolus* spp., respectively (Yagodin, 1984) but differ from the results of Fisher and Bender (1985) who reported values of 10–13%. The low moisture content recorded for the mature seeds confers good stability and high yield in line with the observation of Joslyn (1970). As indicated in Table 1, all the samples had high protein contents and this is in good agreement with Ononogbu (1988).

The crude protein concentrations of five out of the six cultivars of *V. unguiculata* were within the range of 20–30% DM reported previously (Mudambi & Rajagopal, 1985; Ologhobo, 1986; Ologhobo & Fetuga, 1988; Yeshajahu, 1991) but slightly higher than the values reported by Holland, Unirin and Burs (1991). Achusuru was found to have a protein content of 31.7±1. 89% (DM) which is higher than all the *Vigna* cultivars (20.5–27.0%). The *Phaseolus* cultivars—Baki-wake and Kwakiul— had 31.1 and 33.1% protein, respectively. These are higher than those reported before by Egbe and Akinyele (1990) for the protein content of *Lima* beans. Ononogbu (1988) noted that legumes represent an important source of vegetable protein in the diet. Generally, the nutritional value of beans lies in their high protein content.

Vigna and *Phaseolus* cultivars, in this part of Nigeria, satisfy the protein requirements of traditional villagers

Table 1
Promimate composition of *Vigna unguiculata* and *Phaseolus vulgaris* cultivars (% Dry Matter)[a]

Samples	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate	Caloric values
Vigna							
Jan-wake (JW)	6.20±0.67	26.1±0.50	3.03±0.03	4.21±0.09	3.22±0.60	57.3±0.52	361
Farin wake (FW)	8.92±2.2	21.6±2.1	2.43±0.60	4.50±0.15	2.79±0.02	59.7±1.80	347
Dan Sokoto (DS)	6.14±0.29	20.5±1.64	1.14±0.4	3.20±0.07	3.30±0.37	65.7±0.52	349
Dan Potiskum DP)	7.46±0.42	23.2±0.53	1.53±0.4	3.82±0.17	3.23±0.24	60.8±1.20	350
Dan Gombe (DG)	7.55±0.20	24.1±0.50	1.60±0.3	3.0±0.26	3.11±0.31	61.7±0.15	353
Achusuru (AC)	6.46±0.35	39.7±1.8	2.06±0.6	1.7±0.18	3.03±0.82	55.0±0.85	366
Phaseolus							
Baki wake (BW)	4.23±0.74	31.1±0.80	1.22±0.22	3.27±0.23	2.00±0.12	0.31±0.60	364
Kwakiul (KW)	4.42±0.70	33.1±1.24	1.02±0.50	2.81±0.32	3.11±0.36	61.5±5.52	364

[a] Mean±S.D. ($n=6$)

in the north and this agrees with the findings of Fisher and Bender (1985). Dietary proteins are needed for the synthesis of new cells, enzymes, hormones, antibodies and other substances required for the healthy functioning and development of the body as well as for its protection (Cheeseborough, 1987). Furthermore, dietary proteins help to rehabilitate the protein energy malnutrition status of humans. (Omoruyi, Osagie & Adamson 1994).

The crude lipid values of between 1.02±0.5 and 3.03±0.3% DM are low and fit into the established values already reported by Fisher and Bender (1985), Holland et al. (1991), Ologhobo and Fetuga (1983a). The values also are in good agreement with the range of 1–5% DM obtained by Davidson, Passmore, Brocks and Truswell (1975) and the range of 2.01–2.88% reported by Ologhobo (1986), Ologhobo and Fetuga (1988) and Yeshajahu (1991). The lipid content of beans confers palatability. The crude fibre values recorded (2.82±0.32–4.50±0.15%) agree with the data of Ologhobo and Fetuga (1988), Yeshajahu (1991) and Yagodin (1984).

Fibre is a very important component of food. It has been reported to have a major influence on metabolism in the gastrointestinal tract. According to Guthrie (1989), legumes contain high fibre which slows down the release of glucose into the bloodstream; hence high legume diets are recommended for diabetic patients (Gibney, 1989; Jenkins, Wolever, & Taylor 1982). The high carbohydrate values (55.3–65.8% DM) recorded in this study are in agreement with those of Burkitt (1979), Holland et al. (1991), Ologhobo and Fetuga (1988) and Yeshajahu (1991). Carbohydrates generally function as the storage form of fuel and as structural elements. The calculated caloric values of the different samples are indicated in Table 1 and are in line with those of Ologhobo and Fetuga (1983a). The energy values are moderate when compared with other legumes such as soyabean (408.2 kcal/100 g) and *Arachis hypogoea* (630.48 kcal/100 g) thereby making these varieties of beans suitable in energy- or weight- restriction diets.

The qualitative analysis of the lipids using thin layer chromatography revealed the presence of free sterols, free fatty acids, triacyglycerols and sterol esters with some mono and diacyglycerols in all the samples. The physicochemical constants of the oils from the cultivars are presented in Table 2. The saponification numbers were lower than 200 with low acid values and high iodine numbers, suggesting the preponderance of high molecular weight polyunsaturated fatty acids. (Osagie, Okoye, Oluwayose & Dawodu 1986; Pearson, 1970; Williams, 1950). The oils are therefore suitable for consumption.

The results of the mineral estimation of the bean varieties are presented in Table 3. Potassium was the most abundant element in beans while manganese was the least. The results are in good agreement with the recommended daily dietary allowances (RDA) of the minerals. Accordingly, these varieties of beans are strongly recommended as rich sources of potassium, essential for the maintenance of normal muscle functioning, acid base balance and proper nerve stimulation (Don-Mannerberg & Roth, 1981). To cater for the low levels of manganese recorded in the samples, it is

Table 2
Physicochemical characteristics of oil from *Vigna* and *Phaseolus* seeds[a]

Cultivars	Saponification number (mg KOH/g fat)	Acid value (mg KOH/g fat)	Iodine (g/100 g fat)
Vigna			
Jan wake	110	1.3	146
Farin wake	106	1.4	147
Dan Sokoto	107	1.2	149
Dan Potiskum	109	1.2	150
Dan Gombe	108	1.5	143
Achusuru	109	2.0	149
Phaseolus			
Baki wake	186	8.3	118
Kwakiul	184	8.8	120

[a] Determinations were performed in duplicate

Table 3
Mineral consituents of the bean varieties (mg/100 g samples)[a]

Samples	Na	K	Ca	Mg	Mn	Fe	Cu	Zn	P
Vigna									
Jan wake	7.00±0.05	2899±156	161± 15.4	350±20	1.40±0.04	18.9±1.5	4.276±0.55	5.01±0.62	412±15.2
Farin wake	10.6±1.3	1146±11.2	132±11	158±14.2	1.36±0.05	21.6±2.2	2.820±0.08	4.20±0.02	345±12.4
Dan Sokoto	6.56±0.5	1384±85.5	84.5±9.2	250±15	0.546±0.04	12.7±3.1	3.45±0.04	4.85±0.5	276±21.50
Dan Potiskum	9.17±0.45	1075±122.5	123±11.2	225±12.5	1.20±0.072	15.0±1.6	2.41±0.05	3.01± 0.70	300±15.85
Dan Gombe	8.83±0.81	1144±35.2	130±12.1	206±22	0.934±0.02	14.9±0.85	2.75±0.06	2.97±0.05	322±20.8
Achusuru	40.4±2.5	633±11.5	946±10	26.0±8.4	0.723±0.02	1.74±0.04	0.612±0.02	8.95±1.1	442±24.2
Phaseolus									
Baki wake	4.20±2.50	2324±35.2	180±7.2	295±12.40	1.5±0.05	35.1±3.4	6.20±0.21	2.75±0.45	362±21.75
Kwakiul	7.5±2.81	1960±42.5	91.4±5.4	180±22.00	0.0852±0.02	8.46±0.05	32.5±0 09	2.46±0.52	245±18.22
RDA(mg)[b]	1100–3300	1525–4574	800–1200	300–400	2.5–5.0	10–18	2–3	15	800–1200

[a] Mean±S.D. ($n=4$).
[b] Recommended daily dietary allowance (RDA) (Kermasha et al., 1987)

suggested that green leafy vegetables, nuts and whole cereals, which are rich sources of manganese, be incorporated in the diet to prevent the deficiency problem of reproduction function, and abnormalities in skeletal structure (Riedman, 1976).

The levels of phosphorus encountered were appreciable and represent between 30.6 and 36.8% of the RDA (Kermasha, Barthakui, Mohab & Arnold 1987), while reasonable amounts of zinc, varying from 2.46 to 8.95 mg/100 g of the samples, were recorded with the RDA for zinc being 15 mg. The magnesium contents of the seeds were high and in agreement with Holland et al. (1991) and Ologhobo (1986). Also copper contents were high, most of them showing concentrations higher than the RDA of 2–3 mg/100 g sample. Sodium contents were strikingly low in all the seeds studied (4.20±2.50–40.4±2.5 mg/100 g), especially when compared with the RDA of 1100–3300 mg (Kermasha, et al. 1987). However, the levels obtained in this study agree with those of Holland et al. (1991). The finding positively recommends beans for use by people on salt restricted diets. On the other hand, the values recorded for iron were fairly high ranging from 1.74±0.04 to 35.1±3.4 mg/100 g sample for most varieties (Table 3). Although few of the varieties had values higher than the 10–18 mg RDA, most of the values were in line with earlier reports (Davidson et al., 1975; Fisher & Bender, 1985; Holland et al., 1991; Mudambi & Rajagopal, 1985; Ologhobo, 1986). The concentrations of calcium in all the cultivars are appreciable and in agreement with the reports of Mudambi and Rajagopal (1985), Davidson et al. (1975) and Holland et al. (1991). They are therefore good sources of calcium in human nutrition, especially in developing countries where milk and dairy products are in very short supply (Kermasha et al., 1987; Zizza, 1997).

Despite the abundance of these mineral elements in the beans varieties studied, many of them may be generally unavailable due to the presence of antinutritional factors and improper processing procedures. Accordingly, the results of some antinutritional constituents estimated in this study are summarized in Table 4. The total cyanide (HCN) content of the seeds ranged from 0.045±0.02 to 0.08±0.03 g/100 g for the *Vigna* cultivars, and from 0.075±0.03 to 0.077±0.045 g/100 g for the *Phaseolus* group. These values though higher than those reported by Egbe and Akinyele (1990) for *P. lunatus* were, however, in agreement with the observations of Okolie and Ugochukwu (1989) for *Vigna* species.

HCN levels obtained by some earlier workers have shown wide variability between different legume species and also among varieties of the same species (Montgomery, 1969; Okolie & Ugochukwu, 1989). The widespread use of nitrogen fertilizers by farmers in this area could be one of the factors contributing to the fairly high levels of HCN in the raw seeds. Seeds that have been processed for eating would contain reduced levels of HCN, as prolonged processing, e.g. by soaking, cooking, discarding water used and removal of testa, reduces the HCN levels in seeds. Low concentrations of tannin were recorded and these were in agreement with Liener (1989) and Ogun, Markakis and Chenoweth

Table 4
Some antinutritional components of the bean cultivars (g/100 g)[a]

	Total cyanide (HCN)	Tannin	Total oxalate	Phytate
Vigna				
Jan wake	0.08±0.02	0.18±0.03	1.47±0.51	1.39±0.06
Farin wake	0.062±0.02	0.14±0.02	0.813±0.15	0.28±0.02
Dan Sokoto	0.08±0.013	0.0145±0.012	0.77±0.12	0.45±0.020
Dan Potiskum	0.050±0.03	0.0130±0.011	0.91±0.14	0.33±0.03
Dan Gombe	0.045±0.02	0.125±0.02	1.02±0.11	0.24±0.025
Achusuru	0.055±0.023	0.20±0.015	1.71±0.23	1.41±0.016
Phaseolus				
Baki wake	0.075±0.03	0.30±0.022	1.44±0.95	1.40±0.33
Kwakiul	0.077±0.045	0.22±0.015	0.811±0.21	1.63±0.43

[a] Mean±S.D. ($n=4$)

Table 5
Amino acid contents of the bean varieties (g/16 g N)[a]

Amino acids	Jan wake (JN)	Farin wake (FW)	Dan Sokoto (DS)	Dan Potiskum (DP)	Dan Gombe (DG)	Achusuru (AC)	Baki wake (BW)	Kwakiul (KW)	FAO%[b]	Whole egg[c]
Essential										
Lysine	6.74±0.46	6.41±0.14	6.51±0.29	6.21±0.06	5.53±0.13	6.50±0.27	5.4±0.5	6.3±1.2	4.2	4.36
Leucine	7.61±0.31	7.35±0.11	6.84±0.17	5.3±0.47	4.6±0.23	10.3±0.31	6.5±0.06	9.5±0.02	4.8	5.51
Isoleucine	3.75±0.19	4.10±0.10	4.75±0.27	4.70±0.18	4.05±0.43	5.1±0.23	5.7±0.05	5.6±0.41	4.2	3.93
Threonine	3.54±0.05	3.92±0.48	3.76±0.17	3.23±0.22	4.30±1.11	5.0±0.05	5.4±0.03	4.8±1.0	2.8	1.60
Methionine	2.85±0.06	2.00±0.02	1.75±0.03	1.71±0.51	2.91±0.03	2.5±0.06	1.21±0.02	1.5±0.05	2.2	
Valine	6.01±0.23	5.75±0.16	5.90±0.44	5.56±0.50	5.30±0.06	4.5±0.05	6.3±0.08	5.91±1.10	4.2	2.60
Phenylalanine	6.11±0.24	6.02±0.02	5.54±0.32	5.84±0.50	5.59±0.09	5.8±0.62	8.4±0.74	7.5±0.75	2.8	
Arginine	5.2±0.14	5.5±0.22	4.8±0.32	6.7±1.01	5.5±0.821	6.6±0.16	7.51±0.22	7.0±0.08	2.0	3.20
Histidine	3.2±0.10	3.4±0.23	3.52±0.51	3.60±0.32	3.4±0.03	3.0±0.42	2.75±0.35	2.4±0.06	2.4	
Non-essential										
Proline	9.42±0.46	7.17±0.41	8.5±0.22	6.32±0.20	7.54±1.20	7.4±0.62	5.2±0.34	6.8±0.56		
Tyrosine	3.31±0.03	3.24±0.01	3.66±0.27	3.45±0.14	3.33±0.21	3.74±0.21	3.42±0.7	4.2±0.42		
Glycine	7.45±0.27	6.52±0.24	6.0±0.32	5.8±0.03	7.15±0.90	5.4±0.15	6.1±0.04	6.5±0.29		
Serine	8.56±0.31	8.0±103	7.24±1.01	8.35±0.49	6.45±0.293	7.1±0.08	6.4±0.05	5.4±0.31		
Alanine	8.20±017	7.95±0.50	5.55±1.20	8.11±0.60	7.68±0.37	4.8±0.06	7.1±0.81	7.5±0.06		
Aspartic acid	12.8±0.16	14.5±2.42	11.4±2.56	12.1±1.51	11.9±0.65	13.5±0.08	10.3±1.0	12.67±1.7		
Glutamic acid	23.7±0.10	26.3±1.32	19.7±2.33	21.1±1.62	23.1±1.34	25.1±1.08	24.5±1.85	27.4±1.12		

[a] Mean±S.D. (n=4)
[b] FAO pattern of Amino acid requirement (FAO 1957)
[c] Ifon and Umoh (1987).

(1989). These levels of tannin might not affect the nutritional potential of the cultivars since the values were less than 10% of the total dry weight of the samples (Chang & Fuller 1964; Osagie et al., 1996).

Similarly, the oxalate levels recorded might not pose a high risk to the consumer, since cooking and removal of the testa result in a significant reduction in total oxalate content of seeds (Eka, 1977). The phytate levels obtained were in agreement with the findings of Ologhobo and Fetuga (1988), Osagie et al. (1996), and Yagodin (1984). Usually, phytate chelates di-and trivalent metal ions such as zinc, iron, magnesium and calcium to form complex compounds that are not readily absorbed by the intestine thereby making them unavailable for metabolism. Fortunately simple ways of reducing the phytate levels include soaking, dehydrating and cooking (Ihekoronye & Ngoddy, 1985), and fermentation, germination and autolysis of aqueous suspensions of the ground beans under appropriate conditions of time, temperature and pH (Liener, 1989).

Table 5 shows the amino acid contents of the bean varieties. Overall, 16 amino acids were determined in each sample, nine essential and seven non-essential. The results are in line with some of the earlier reports of Ologhobo and Fetuga (1983a) but higher than the values reported by Plahar, Annan and Nti (1997). Glutamic acid (19.7–27.4 g/16 g N) and aspartic acid (10.5–14.5 g/16 g N) were the most abundant amino acids in the samples. The high contents of these two amino acids could possibly be due to the fact that they are storage forms of nitrogen. Additionally, they are starting compounds from which the backbones of amino acids are formed (Onwuliri & Anekwe, 1993b). Methionine was the limiting amino acid in all the samples. This agrees with the findings of Nti and Plahar (1995). The low methionine content can be overcome when beans are eaten with other foods with high or moderate amounts of sulphur-containing amino acids, such as cereals and vegetables. The practice should therefore be encouraged. The results also reveal that the *Vigna* and *Phaseolus* cultivars contained more lysine, phenylalanine, arginine and histidine than the FAO reference protein (FAO, 1957) and whole egg protein (Ifon & Umoh, 1987).

From the results, the beans grown in northern Nigeria are rich and of high nutritional value when compared with those grown in the south, even though they are cheaper. We therefore recommend large scale cultivation and consumption of both the traditional and common cultivars as alternatives to animal protein which is currently beyond the reach of many.

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