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SEED CHARACTERISTICS AND NUTRIENT AND ANTINUTRIENT COMPOSITION OF 12 *MUCUNA* ACCESSIONS FROM NIGERIA

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SUMMARY

The physico-chemical characteristics of 12 accessions of *Mucuna (*velvetbean*)* seeds were investigated. The results showed 9.01-14.98% hull, 0.71-0.97 and 1.11-2.37 g cm^{-3} bulk and true densities, respectively and 573.18-958.33 g 1000-grain weight and 65.00-173.60 kg hardness in horizontal position. *M. rajada* and *M. veracruz* (mottled) exhibited the minimum and maximum hardness, respectively. Low water absorption capacity (0.66-1.56 g H_2O g^{-1}) was observed. The varieties contained (g 100 g^{-1} DM) 24.50-29.79 protein, 4.72-7.28 fat, 3.19-4.16 ash, 59.20-64.88 carbohydrates, 3.65-4.43 crude fibre, 1.51-3.19 soluble sugars, 39.22-41.17 starch, as well as 16.64-17.17 kJ g^{-1}gross energy; these values are comparable to those in commonly consumed legumes. Minerals included appreciable amounts of calcium (0.08-0.15 g 100 g^{-1}), magnesium (0.16-0.20 g 100 g^{-1}) and phosphorus (0.44-0.56 g 100 g^{-1}). These results indicate that *Mucuna* has potential for exploitation as a food and feed. Antinutrient factors were low, except for (3,4-dihydroxy-L-phenylalanine (L-Dopa), trypsin inhibitors, and tannin. L-Dopa varied between 4.00 g 100 g^{-1} in *M. rajada* and 8.34 g 100 g^{-1} in *M. veracruz* (black), while trypsin inhibitory activity ranged from 30.81 in *M. utilis* to 51.55 TUI mg^{-1} in *M. veracruz (*mottled). Tannin content (1.56-1.70 g 100 g^{-1}) varied little among the accessions. The results from this study suggest that chemical differences between *Mucuna* species are small, and when they exist, may be caused by seed coat. As population growth continues to deplete available food resources in Nigeria, *Mucuna* represents a potential food source, which could relieve critical food shortages if given adequate promotion and research attention.

Key words: *Mucuna* accessions, physical character-ristics, nutrient and antinutrient composition, Nigeria.

INTRODUCTION

The prevalence of hunger and protein malnutrition in the tropical and sub-tropical areas of the world is well recognized and appreciated (Abatena, 1987; FAO, 1994; Univ, 1994). The food situation in Nigeria and West Africa is worsening, owing to increasing population, shortage of fertile land, high prices of available staples and the policy constraints on food importation (Abatena, 1987; Igbedioh, 1993; Weaver, 1994). Several reports indicate protein deficiency as the commonest form of malnutrition in the developing countries, particularly in regions where diets are mainly based on roots and tuber crops (Ashworth, 1985; FAO, 1964; Sankale and Barbotin-Larrieu, 1984). The problem becomes more obvious when *per capita* protein intake is considered (Pellet and Young, 1994). Providing sufficient protein should therefore be given the highest priority in every effort to increase national food supplies.

In view of prevalent food shortages, attention is currently being focused on the exploitation of lesser-known and non-traditional plant resources (Grivetti *et al*., 1987; Becker, 1986; Vietmeyer, 1990; Ezeagu *et al*., 2000). Many of them contain appreciable amounts of protein and nutrients (Savage, 1991; Nordeide *et al*., 1994; Ezeagu and Ologhobo, 1995; El-Adawy and Taha, 2001). Development of inexpensive alternative sources of protein for humans and/or livestock could clearly reduce malnutrition. It may well be that such sources of protein will provide large quantities of animal feed ingredients if given adequate research attention. This increase in feed could both reduce the cost of livestock products and spare for human use protein feeds that otherwise would have been consumed by livestock.

One crop identified in this context is *Mucuna*, an herbaceous legume which has proven to be an excellent green manure/cover crop. While farmers often ask about the edibility of its grain, data on its chemical composition and nutrient quality and the appropriate technology to utilize it are scarce. Carsky *et al*. (1998) identified 12 varieties of *Mucuna.* There is relatively large variability in the plants that are currently considered to belong to the cultivated *Mucuna* species, but there is uncertainty whether such variability is at the species, sub-species, or variety level. Reports to date on its chemical and nutrient composition show that it compares favorably to commonly consumed grain legumes (Janardhanan and Lakshmanan, 1985; Iyayi and

Egharevba, 1998; Ahenkora *et al*., 1999). But, as with most legumes, there are certain limitations associated with its use as food and feed. Most *Mucuna* types have pods that are covered with velvety hairs that irritate the skin. Additionally, toxic constituents in the seeds have been reported, 3,4-dihydroxy-L-phenylalanine (L-Dopa) being the most harmful (Ravindran and Ravindran, 1988; Infante *et al*., 1990). These factors have limited its use and adoption to date.

Prior to the utilization of any new and unconventional feed resources, data on their nutrient composition should be available (Aylward, 1975). The present project seeks to assess the nutritional and antinutritional factors in 12 *Mucuna* varieties available at the International Institute of Tropical Agriculture (IITA), Nigeria, with a view to ascertaining the food/feed potential of the crop. The accessions evaluated are: *M. utilis* (TMpr1)*, M. pruriens* (*var* IRZ) (TMpr2), *M. cochinchinensis* (TMpr3), *M. deeringiana* (TMpr4), *M. ghana* (TMpr6), *M. jaspeada* (TMpr7), *M. preta* (TMpr8), *M. rajada* (TMpr9), *M. veracruz* (white), *M. veracruz* (black), *M. veracruz* (mottled), and *M. georgia.*

MATERIALS AND METHODS

About 500g samples of the mature seed were procured from the Moist Savanna Programme (MSP), IITA, Ibadan, Nigeria. Impurities were manually separated from the seeds which were ground to flour using a Wiley Mill with the 1 mm mesh sieve and stored in plastic bags at -4^{o} C until analysis.

Hardness was measured in the horizontal position of whole seeds using the Universal Texture Measuring System (INSTROM 4301, England) at Central Food Technological Research Institute, Mysore, India. Kernel length, breadth and depth were measured using a vernier caliper. Bulk and true densities were determined by the method of Bhattacharya *et al*. (1972) while color was observed visually. Thousand seed weight was estimated by weighing 1000 seeds of each sample. Water holding capacity was determined by the centrifugation method as described by Elhardallon and Walker (1993).

Proximate composition was determined by standard methods (AOAC, 1990). Crude protein (CP) and total carbohydrates was calculated by N x 6.25 and by difference, respectively. Minerals were determined by wet digestion and using atomic absorption spectrophotometery (BUCK Scientific, 200A). Potassium was determined colorimetrically using a Flame photometer (Corning 400). Total soluble sugars and starch were determined by the combined methods of Duboise *et al*. (1956) and Kalenga *et al.* (1981). Gross energy was calculated using the Atwater Conversion Factors (FAO, 1982).

Tannin was determined by the Folin-Denis method (AOAC, 1990); phytate was by the method of Wheeler and Farrell (1971); trypsin inhibitor activity was determined by the method of Kakade *et al*. (1974) using benzoyl-DL-arginine-p-nitroanilide (BAPNA) as the substrate and expressing the results as trypsin units inhibited (TUI) per milligram of dry sample. One TUI is arbitrarily defined as an increase of 0.01 in absorbance under the conditions of the assay. Cyanide was extracted with 0.1M ortho-H_3PO_4 acid and estimated using an AutoAnalyzer (Technicon, USA) according to the method of Rao and Hahn (1984). Nitrate (N) was determined colorimetrically using the AutoAnalyzer at the Analytical Service Laboratory, IITA, Ibadan, Nigeria, and oxalate was determined by the method of Baker (1952).

L-Dopa was determined by a modified method of Arnow (1937). First, 0.1 g of milled samples were extracted with 20 mL 0.5N HCl in 50 mL centrifuge tubes for 2 hrs and centrifuged at 3000 g for 20 mins. Then, 0.1 mL aliquots of the extracts, diluted to 1 mL with distilled water, were used for the estimation. Levels of L-Dopa were extrapolated from a standard curve prepared from 1 mL aliquots of L-Dopa standard solutions containing 0.01-0.05 mg mL^{-1}.

RESULTS AND DISCUSSION

The physical description of the 12 species studied is presented in Table 1. Seed coat color of most varieties is different shades of white and black. However, seeds of *M. veracruz*-mottled and *M. pruriens*-IRZ consist of equal ratios of white and mottled seeds, which makes identification difficult. The hull contents vary from 9.01 in *M deeringiana* to 14.98% in *M. utilis*. These varieties would, therefore, upon dehulling yield minimum and maximum amounts of dhal, respectively.

Seed length ranges from 10.10 in *M. rajada* to 15.76 mm in *M. deeringiana*, while the breadth ranges from 8.77 in *M. rajada* to 11.39 mm in *M. deeringiana. M. rajada* and *M. cochinchinensis* exhibit the maximum and minimum depth (thickness) of 7.49 and 6.23 mm, respectively. Mean values for length, breadth and depth are 14.03±1.36, 10.56±0.68 and 6.90±0.42 mm, respectively. These figures indicate that *Mucuna* seeds are much larger and bulkier than most of the common legumes. Kernel size and shape may be important for domestic processing of *Mucuna* seeds. The variability in size and shape affects cooking time and cooking uniformity between and within the accessions. Wanjekeche *et al*. (this volume) observed that not all the seeds cook at the same rate.

The force required to crush the seeds resting in a horizontal position assesses the grain hardness of the varieties. *M. veracruz*-mottled has the hardest seed (173.60 kg) while *M. rajada* has the least hard seed

(65.00 kg). Grain hardness also has a positive correlation with cooking time, so the varieties having least hardness and thickness could be recommended for use as human food.

True density, ranging between 1.11 in *M. deeringiana* and 2.37 g cm^{-3} in *M. jaspeada*, is the weight per unit volume of kernels and is useful in predicting dry milling properties. Bulk density is highest in *M. rajada* (0.97 g cm^{-3}) and lowest in *M. jaspeada* (0.71 g cm^{-3}). Bulk density reflects the way the seeds pack and is useful in determining the size of container needed for a given weight of grain. Thousand grain weights range from 573.18 in *M. rajada* to 958.33 g in *M. pruriens* (var IRZ). Varieties *M. jaspeada, M. preta* and *M. cochinchinensis* also exhibit high grain weights (925.63, 867.16 and 802.12 g, respectively). The values of densities, color, and 1000 grain weight are similar to those reported by Carsky *et al*. (1998). There is a wide variation in the water holding capacity (WHC), as seen in the swelling index ranging from 0.66 to 1.56 g H_2O g^{-1}. *M. pruriens* (var IRZ) and *M. veracruz*-white exhibit minimum and maximum WHC, respectively. The values are quite low compared to 2.17-2.31 g H_2O g^{-1} and 18-19 g H_2O g^{-1} reported for soybean and haliv (*Lepidium sativum)* seeds, respectively (Sharma and Subramanian, 1994; Matthew *et al*., 1993). Low swelling index reflects low fibre content, which in turn indicates low content of the non-starch polysaccharide food reserves that have been reported to have high water-binding capacity (Matthew *et al*., 1993).

Table 2 shows the proximate composition, total sugars and starch, as well as the gross energy value of the *Mucuna* varieties. The parameters show no significant variations and are generally similar to those observed in varieties from other sources. Moisture content ranges from 8.79 to 10.00 g 100 g^{-1}, and is similar to the value of 10.20% reported by Janardhanan and Lakshmanan (1985). Higher and lower moisture contents of 16.70 and 6.0% have been observed for some Indian varieties (Arulmozhi and Janardhana, 1992). The crude protein varies between 24.50 in *M. veracruz*-black and 29.79 g 100 g^{-1} in *M. cochinchinensis,* and is superior to cowpea (23.70), groundnut (24.68) and maize (8.90), but inferior to soybeans (38.69) (Oyenuga, 1968; FAO, 1982). Several workers have reported a range of 20.13-31.44 g 100 g^{-1} for protein content of *Mucuna* varieties from different sources (Ukachukwu *et al*., 2002; Arulmozhi and Janardhanan, 1992; Siddhuraju *et al*., 1996). *Mucuna,* therefore, shows promise as a protein supplement for low-protein foods and feeds such as cereal grains (Ezeagu *et al.,* 2002). The highest level of fat occurred in *M veracruz*-white (7.28 g 100 g^{-1}) while the lowest value of 4.72 g 100 g^{-1} occurred in *M jaspeada*. With a mean fat content of 5.92 ± 1.05 g 100 g^{-1}, *Mucuna* seeds may not be regarded as an oilseed. However, the seed oil could be exploited for industrial use. Crude fibre is also low, with a mean value of 4.05±0.23 g 100 g^{-1}, which is an advantage in terms of monogastric animal feeding. Ash content, representing the inorganic constituent, ranged from 3.19 in *M. pruriens*-IRZ to 4.16 g 100 g^{-1} in *M. cochinchinensis*, suggesting that *Mucuna* accessions may be high in minerals.

The total sugar content ranges between 1.51 in *M. veracruze*-black and 3.19 g 100 g^{-1} in *M. preta*, which is lower than the range of 4.99-7.22 g 100 g^{-1} reported by Naivikul and D'Appolonia (1978) for different legumes. The mean starch content is 40.44± 0.62 g 100 g^{-1} and content of total carbohydrates ranges between 59.20 and 64.88 g 100 g^{-1}. These values are quite high and superior to those of soybean (22.12 g 100 g^{-1}) and most common legumes, suggesting that *Mucuna* could be suitable for feeding monogastric animals. The variation in carbohydrate content among varieties could be attributed to differences in the content of other constituents.

Table 1. Physical characteristics of seeds of 12 *Mucuna* accessions from Nigeria.

Characteristics	*M. utilis*	*M. cochin-chinensis*	*M. veracruz* (white)	*M. veracruz* (mottled)	*M. veracruz* (black)	*M. georgia*	*M. rajada*	*M. ghana*	*M. preta*	*M. jaspeada*	*M. pruriens* (IRZ)	*M. deeringiana*
Colour	Black	White	Black	Mottled: White (1:1)	White	Black	Mottled	Dark mottled	Black	White	White: Mottled (1:1)	Bright mottled: White (7:3)
Seed shape	Flat/varied	Flat/Short hilium	Elliptic/Short hilium	Elliptic/Short hilium	Varied	Varied	Round	Round/Short hilium	Varied	Elliptic/Short hilium	Elliptic/Short hilium	Elliptic/Short hilium
Kernel Dimensions (mm)												
Length [a]	13.80± 1.64	14.71± 2.04	14.16± 1.71	14.14± 1.99	14.04± 1.15	13.90± 1.13	10.10± 0.59	13.81± 1.96	14.36± 0.74	14.93± 1.722	14.67± 0.86	15.76±2.35
Breadth [a]	10.50± 0.56	10.37± 0.91	10.71± 0.93	11.06± 1.28	10.31± 0.88	10.53± 0.75	8.77± 0.75	10.16± 0.89	10.67± 0.46	10.86± 0.78	11.34± 0.64	11.39±1.09
Depth [a] (thickness)	6.47± 0.59	6.23± 0.66	7.18± 0.48	6.68± 0.80	6.46± 0.65	6.98± 0.36	7.49± 0.34	7.32± 0.37	6.54± 0.59	7.03± 0.41	7.40± 0.48	7.07± 0.49
Hull content [a] (%)[a]	14.98± 0.33	10.88 ± 0.06	12.56± 0.32	10.30± 0.32	14.45± 1.95	14.22 ±1.18	11.71± 0.24	10.34± 0.26	13.89± 0.49	11.13± 0.38	11.52± 0.21	9.01±0.21
1000 Seed weight (g)[b]	609.05± 39.45	802.12± 32.20	693.26± 50	752.87± 69	754.52± 98	784.2± 24.6	573.18± 31.2	783.32± 33.69	867.16± 59.15	925.63± 24	958.33± 23.8	728.75 ±39.9
Bulk density (g/cm3)[c]	0.82	0.73	0.94	0.79	0.96	0.86	0.97	0.93	0.85	0.71	0.80	0.81
True density (g/cm3)[c]	2.26	1.23	1.46	1.56	1.46	1.31	1.92	1.41	1.42	2.37	1.32	1.11
Grain hardness (kg)*[d]	96.46± 16.79	105.18± 32.35	143.90± 24.64	173.60± 15.74	100.69± 35.38	82.94± 10.60	65.00± 8.49	119.98± 16.66	101.60± 27.35	115.88± 6.88	127.63± 33.32	ND
WHC g H_2O g^{-1} **[c]	0.72	0.82	1.56	0.80	0.68	0.69	0.91	0.76	1.19	0.67	0.66	0.69

*100 mm min-1 speed; **WHC, Water-holding capacity, a= Mean±SD of ten independent determinations; b= Mean±SD of five independent determinations; c= Mean of two independent determinations; d= Mean±SD of five independent determinations

Table 2. Proximate composition (g 100 g DM^{-1}) of seeds of 12 *Mucuna* accessions from Nigeria. The values are means of two independent determinations.

Component	*M. utilis*	*M. cochin-chinensis*	*M. veracruz* (white)	*M. veracruz* (mottled)	*M. veracruz* (black)	*M. georgia*	*M. rajada*	*M. ghana*	*M. preta*	*M. jaspeada*	*M. pruriens* (IRZ)	*M. deeringiana*	Range	Mean ± SD	C V %
Moisture	9.97	9.87	9.74	8.79	10.00	9.46	9.24	9.54	9.47	9.59	9.03	9.45	8.79-10.00	9.51 ± 0.37	3.84
Crude protein	29.62	29.79	29.44	26.78	24.50	29.31	29.25	29.16	27.95	27.56	27.17	27.72	24.50-29.79	28.19 ± 1.56	5.54
Fat	6.96	6.51	7.28	5.00	6.96	5.91	6.06	4.82	4.75	4.72	7.21	4.84	4.72-7.28	5.92 ± 1.05	17.70
Ash	4.15	4.16	4.08	3.45	3.66	3.48	3.47	3.24	3.56	3.25	3.19	3.20	3.19-4.16	3.57 ± 0.37	10.25
Carbohydrate	59.27	59.54	59.20	64.77	64.88	61.30	61.22	62.78	63.74	64.47	62.43	64.24	59.20-64.88	62.32 ± 2.18	3.50
Crude fibre	4.10	4.19	4.14	4.03	4.27	3.79	3.86	3.84	4.23	4.43	3.65	4.11	3.65-4.43	4.05 ± 0.23	5.60
Total sugar	1.54	1.54	1.64	1.59	1.51	2.83	2.09	1.57	3.19	3.00	2.37	1.54	1.51-3.19	2.03 ± 0.65	31.77
Starch	39.43	40.24	40.19	40.84	41.00	40.89	40.83	40.13	39.22	41.17	40.50	40.82	39.22-41.17	40.44 ± 0.62	1.53
Gross Energy (KJ g^{-1})	16.90	16.81	16.97	16.73	17.11	16.83	16.86	16.67	16.64	16.70	17.17	16.72	16.64-17.17	16.84 ± 0.17	1.01

Table 3 summarizes the contents of macro- and micro-minerals. As common with most legumes, potassium is the most abundant element, ranging from 3.00 g 100 g^{-1} in *M. georgia* to 8.46 g 100 g^{-1} in *M. jaspeada*. Appreciable levels of calcium (0.11±0.02 g 100 g^{-1}) and phosphorus (0.49±0.04 g 100 g^{-1}) and iron (8.98±2.76 mg 100 g^{-1}) occurred in the accessions. *Mucuna* seeds could be a good source of these minerals, and will easily satisfy animal needs assuming they occur in a readily available form.

The antinutritional factors estimated in the accessions are shown in Table 4. *Mucuna* species is known to contain L-Dopa, which is the most potent antinutrient present in the seeds, in appreciable amounts. L-Dopa content ranges from 4.00 in *M. rajada* to 8.34 g 100 g^{-1} in *M. veracruz*-black. Accessions *M. deeringiana, M. preta* and *M. georgia* are equally high in L-Dopa (8.18, 7.50 and 7.24 g 100 g^{-1}, respectively). These values are similar to the range of 6-8% reported in Japan (Fujii *et al*., 1991). Similar levels and variability were also observed by St-Laurent *et al*. (2002), suggesting that genotype may have an effect on L-Dopa content. As common with legumes, *Mucuna* seeds also contain tannin, phytate, trypsin inhibitors and oxalate. Wide variation in trypsin inhibitor contents occurs among these accessions. Maximum level of 51.55 TUI mg^{-1} occurred in *M. veracruz*-mottled, while *M. utilis* contained the minimum level of 30.81 TUI mg^{-1}. Machuka (2000) observed a similar wide variability in his study. Little variation occurs in tannin contents, which ranges between 1.56 g 100 g^{-1} in *M. deeringiana* to 1.70 g 100 g^{-1} in *M. ghana*. The same level of cyanide (0.12 mg 100 g^{-1}) occurs in all the accessions. Very low cyanide contents have generally been reported in *Mucuna* (Ukachukwu *et al.,* 2002). Nitrate-N is also low and is detected only in six of the accessions, ranging from 1.60 in *M. veracruz*-mottled to 5.20 mg 100 g^{-1} in *M. pruriens* (var IRZ); these levels are high compared to the 0.20 mg 100 g^{-1} nitrate-N reported by del Carmen *et al*. (2002). Phytate contents range from 0.26 g 100 g^{-1} in *M. veracruz*-black and *M. preta* to 0.90 g 100 g^{-1} in *M. veracruz*-mottled, which is within the range of 0.50-0.63g 100 g^{-1} reported for some Indian varieties (Vijayakumari *et al*., 1996). Phytate-P, calculated as a percentage of total P, is low, ranging between 14.18 and 49.38%. Rackis and Anderson (1977) reported that about 80% of all phosphorus in bean seed is present as phytate phosphorus. The mean total oxalate is 1.98±0.60 mg g^{-1} and an average of 79.37% of the total oxalates occurs in the soluble form. Soluble oxalates are considered to have more deleterious effect on Ca^{2+} and Mg^{2+} absorption from foods undergoing digestion simultaneously, whereas insoluble oxalate binds Ca^{2+} within the food and renders it unavailable to the body. Soluble oxalates are easily leached out during the soaking or boiling process

Most food plants, especially legumes, contain these antinutritional factors, though the concentrations are often too low to present any actual hazard. However, plant-derived foods are usually processed and most toxicants are virtually eliminated before consumption (Laurena *et al*., 1991; Josephine and Janardhana, 1992; Vijayakumari *et al*., 1996; Siddhuraju, *et al*., 1996). An effective processing method in removing L-Dopa may be germination (sprouting). On sprouting (3 days), the level of L-Dopa was reduced by 50.91-69.32% (Higasa *et al*., 1996, Ukachukwu *et al*., 2002). These antinutritional factors can therefore be eliminated if the seeds are properly processed.

CONCLUSIONS

In conclusion, results from this study suggest that chemical differences between *Mucuna* varieties are small and may have been due to the seed coat. The overall nutrient quality is similar to that of most edible food legumes. Therefore, *Mucuna* represents a potential food source if given adequate promotion and research attention. This would relieve critical food shortages, broaden the food base, generate income, and afford farmers the opportunity to spread risk in times of crop failure. Furthermore, development of multiple uses of *Mucuna* will be an incentive for its adoption as a green manure/cover crop.

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Table 3. Mineral content of seeds of 12 *Mucuna* accessions from Nigeria. The values are means of two independent determinations.

	M. utilis	*M. cochin-chinensis*	*M. veracruz* (white)	*M. veracruz* (mottled)	*M. veracruz* (black)	*M. georgia*	*M. rajada*	*M. ghana*	*M. preta*	*M. jaspeada*	*M. pruriens* (IRZ)	*M. deeringiana*	Range	Mean ± SD	CV %
Potassium (g 100 g^{-1})	3.89	3.99	4.52	3.23	4.51	3.00	4.24	5.37	5.76	8.46	5.12	3.85	3.00-8.46	4.66 ± 1.45	31.07
Calcium (g 100 g^{-1})	0.15	0.09	0.11	0.08	0.12	0.10	0.13	0.12	0.08	0.08	0.13	0.09	0.07-0.14	0.11 ± 0.02	22.06
Magnesium (g 100 g^{-1})	0.19	0.18	0.19	0.16	0.18	0.19	0.16	0.20	0.17	0.17	0.18	0.15	0.16-0.20	0.18 ± 0.02	9.01
Phosphorus (g 100 g^{-1})	0.50	0.46	0.48	0.56	0.52	0.54	0.45	0.44	0.51	0.47	0.45	0.54	0.44-0.56	0.49 ± 0.04	8.28
Iron (mg 100 g^{-1})	10.34	9.09	9.45	4.08	7.80	9.19	14.85	10.91	9.56	6.80	10.27	5.55	4.08-14.85	8.98 ± 2.76	49.85
Copper (mg 100 g^{-1})	4.10	2.48	3.40	1.65	2.33	2.85	2.34	3.24	2.62	1.82	1.92	2.22	1.65-4.10	2.58 ± 0.72	27.72
Zinc (mg 100 g^{-1})	5.10	3.76	4.72	3.84	3.65	3.60	4.75	3.91	4.28	4.60	3.85	3.77	3.60-5.10	4.15 ± 0.51	12.37
Manganese (mg 100 g^{-1})	6.82	6.18	10.21	7.72	4.79	7.44	11.29	6.75	6.18	5.17	6.42	9.61	4.79-11.29	7.38 ± 2.01	27.25

Table 4. Antinutritional components of seeds of 12 *Mucuna* accessions from Nigeria. The values are means of two independent determinations

Antinutritional component	*M.utilis*	*M. cochin-chinensis.*	*M. veracruz (white)*	*M. veracruz (mottled)*	*M. veracruz (black)*	*M. georgia*	*M. rajada*	*M. ghana*	*M. preta*	*M. jaspeada*	*M. pruriens (IRZ)*	*M. deeringiana*	Range	Mean ± SD	CV %
L-Dopa (g 100 g^{-1})	6.82	6.35	5.75	6.43	8.34	7.24	4.00	5.35	7.50	6.57	6.30	8.18	4.00-8.34	6.57 ± 1.21	18.36
Trypsin Inhibitors (TUI/mg)	30.81	42.12	36.97	51.55	36.64	45.97	43.02	38.32	43.27	46.55	45.04	47.63	30.81-51.55	42.32 ± 5.74	13.57
Phytate (g 100 g^{-1})	0.85	0.79	0.85	0.90	0.26	0.32	0.29	0.53	0.26	0.45	0.37	0.66	0.26-0.90	0.54 ± 0.25	46.47
Phytate-P (g 100 g^{-1})	0.24	0.10	0.24	0.25	0.07	0.09	0.08	0.15	0.07	0.13	0.11	0.19	0.07-0.25	0.14 ± 0.07	48.46
Phytate-P (as % Total P)	47.89	22.41	49.38	45.26	14.18	16.57	18.43	33.79	14.57	27.10	24.44	34.38	14.18-49.38	29.03 ± 12.97	44.67
Total Oxalate (mg 100 g^{-1})	1.35	2.48	2.08	1.98	1.13	1.53	1.98	2.95	2.31	1.81	1.26	2.85	1.13-2.95	1.98 ± 0.60	30.27
Soluble Oxalate (mg 100 g^{-1})	1.12	1.19	1.71	1.08	1.08	1.08	1.76	1.89	1.85	1.08	1.17	2.01	1.08-2.01	1.42 ± 0.38	27.07
Soluble oxalate (% total)	82.96	78.63	82.21	54.55	95.58	70.59	88.89	64.07	80.09	91.53	92.86	70.53	54.55-95.58	79.37 ± 12.47	15.71
Cyanide (mg 100 g-1)	0.12	0.12	0.12	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.10-0.12	0.12 ± 0.01	4.88
Nitrate-N (mg 100 g^{-1})	1.80	ND	ND	1.60	ND	ND	ND	ND	ND	ND	5.20	2.40	nd-5.20	2.75 ± 1.67	60.67
Tannin (g 100 g^{-1})	1.62	1.63	1.62	1.60	1.59	1.63	1.66	1.70	1.65	1.57	1.62	1.56	1.56-1.70	1.62 ± 0.04	2.39

ND=not detected

REFERENCES

Abatena, H. 1987. Hunger and starvation in Africa: an appraisal. Rural Sociologist 7(3): 175-186.

Ahenkora, K, Dadzie, M, Osei-Bonsu, P. 1999. Composition and functional properties of raw and heat processes velvet bean (*Mucuna pruriens* (L) DC. Var utilis) flours. International Journal of Food Science and Technology 34(2): 131-135.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis, 15th edn., K. Helich, AOAC, Arlington, VA, USA.

Arnow, LE. 1937. Colorimetric determination of the components of 3,4-dihydroxphenylalanine-tyrosine mixture. Journal of Biological Chemistry. 118: 531-537

Arulmozhi, M, Janardhanan, K. 1992. The biochemical composition and nutritional potential of the tribal pulse, *Mucuna monosperma*. Plant Foods for Human Nutrition. 42:-53.

Ashwort, A. 1985. Protein and `malnutrition' (Editorial). Journal of Tropical Pediatrics. 31(6): 288-289.

Aylward, F. 1975. Development of regulations pertaining to novel foods. Food and Nutrition. 1(3): 24-29.

Baker, CJC. 1952. The determination of oxalates in fresh plant material. Analyst (London.) 77: 340-344.

Bhattacharya, KR, Soubhagya, CM, Swamy, YMI. 1972. Some physical properties of paddy and rice and their inter-relationships. Journal of Science of Food and Agriculture. 23: 171-186.

Becker, B. 1986. Wild plants for human nutrition in the Sahelian zone. Journal of Arid Environment. 11:61-64

Carsky RJ, Tarawali, SA, Becker, M, Chikoye, D, Tian, G, Sanginga N. 1998 *Mucuna* – herbaceous cover legume with potential for multiple uses. Resources and Crop Management Research Monograph No.25. IITA, Ibadan, Nigeria.

Del Carmen, J, Gernat, AG, Myhrman, R, Carew, LB. 1992. Evaluation of raw and heated velvet bean (*Mucuna pruriens*) as feed ingredients for broilers. In: Flores M, M. Eilitta, R. Carsky, Myhrman, L.Carew, and J. Rojas (Eds.). Food and feed from *Mucuna*. Current uses and the way forward. Proceedings of a workshop held in Tegucigalpa, Honduras, April 26-29,2000. CIDICCO, Honduras. pp 258-271.

Duboise, MC, Gruillies, KA, Hamilton, JK, Rogers, PA, Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry. 28: 350-356.

El-Adaway, TA, Taha, KM. 2001. Characteristics and composition of different seed and flours. Food Chemistry 74: 47-54.

Elhardallou, SB, Walker, AF. 1993. The water-holding capacity of three starchy legumes in the raw, cooked and fibre-rich fraction forms. Plant Foods for Human Nutrition 44: 171-179.

Ezeagu, IE, Sri Devi, Haridas Rao, P, Harandra Nath, Appu Rao, AG, Gowda LR, Tarawali, G. 2002. Prospects for incorporation of defatted *Mucuna* flour in biscuits formulation. Journal of Food Science and Technology. (in press).

Ezeagu, IE, Petzke, KJ, Ologhobo, AD, Metges, CC, Akinsoyinu, AO. 2000 Compositional evaluation and feed potential of the African kudzu (*Pueraria phaseoloides*) seed meal. Journal of Food Science and Technology. 37: 191-195.

Ezeagu, IE, Ologhobo, AD. 1995. Proximate composition of unfamiliar plant seeds in Nigeria - A short report. Polish Journal of Food and Nutrition Sciences. 4/5: 79-83.

FAO (Food And Agricultural Organization). 1964. Protein at the heart of the world food problem. FAO/UN, Rome.

FAO (Food and Agricultural Organization. 1994. The state of food and agriculture. FAO Agric. Series No 27. FAO/UN, Rome.

FAO (Food and Agricultural Organization). 1982. Food Composition Tables for the Near East. Food and Nutrition Paper 26, FAO/UN, Rome.

Fujii, Y, Shibuya, T, Yasuda, T. 1991. L-3,4-Dihydroxphenylalanine as an allelochemical candidate from *Mucuna pruriens*(L) DC. Var *utilis*. Agricultural Biology and Chemistry. 55(2): 617-618.

Grivetti, LE, Frentzel, CJ, Ginsberg, KE, Howell, KL, Ogle BM. 1987. Bush foods and edible weeds of Agriculture: Perspective on Dietary use of wild plants in Africa, their role in maintaining Human Nutritional Status and Implications for Agricultural development. In: Health and Disease in Tropical Africa. Geographical and Medical View Points, (R. Akhtar, ed.) pp. 51-81. Harwood, New York.

Higasa, S, Negishi, Y, Aoyagi, Y, Sugahara, T. 1996. Changes in free amino acids of tempe during preparation with velvet beans (*Mucuna pruriens*).

Journal of Japanese Society of Food Science and Technology. 43(2): 188-193.

Igbedioh, SO. 1993. Undernutrition in Nigeria: dimensions, causes and remedies for alleviation in a changing socio-economic environment. Nutrition and Health. 9: 1-4.

Infante, ME, Perez, AM, Simao, MR, Manda, F, Baquete, EF, Fernandes, AM, Cliff JL. 1990 Outbreak of acute toxic psychosis attributed to *Mucuna pruriens*. The Lancet. 336: 1129.

Iyayi, EA, Egharevba, JI. 1998. Biochemical evaluation of seeds of an under utilized legume (*Mucuna utilis*). Nigerian Journal of Animal Production. 25(1-2): 40-45.

Janardhanan, K, Lakshmanan, KK. 1985. Studies on the pulse, *Mucuna utilis*: chemical composition and antinutritional factors. Journal of Food Science and Technology. 22: 369-371

Josephine, RM, Janardhanan, K. 1992. Studies on chemical composition and antinutritional factors in the three germplasm seed materials of the tribal pulse, *Mucuna pruriens*. Food Chemistry. 43: 13-18.

Kakade, ML, Rackis, JJ, McGhee JE, Puski, G. 1974 Determination of trypsin inhibitor activity of soy products: A collaborative analysis of an improved procedure. Cereal Chemistry. 51: 376-382.

Kalenga, K, Hood, LF, Van Soest, PJ. 1981. Characterisation of starch and fibre of banana fruit. Journal of Food Science. 46: 1885-1890.

Laurena, A, Rodrigueze, FM, Sabino, NG, Zamora, AF, Mendoza, EMT. 1991. Amino acid composition, relative nutritive value and in vitro protein digestibility of several Phillippine indigenous legumes. Plant Foods for Human Nutrition. 41: 59-68.

Machuka, J. 2000. Characterization of seed proteins of velvet bean (*Mucuna pruriens*) from Nigeria. Food Chemistry, 68: 421-427.

Matthew, S, Singhal RS, Kulkarni PR. 1993. Some physicochemical characteristics of *Lepidium sativum* (haliv) seeds. Die Nahrung 37: 69-71.

Naivikull, O, D'Appolonia, BI. 1978. Comparison of legumes and wheat fluour carbohydrates 1. Sugar analysis. Cereal Chemistry, 55: 913-918.

Nordeide, MB, Holm, H, Oshaug, A. 1994. Nutrient composition and protein quality of wild gathered foods from Mali. International Journal of Food Science and Nutrition. 45: 275-286.

Oyenuga, VA. 1968. Nigeria's Food and Feeding Stuff. Ibadan University Press, Nigeria, 3rd Edition.

Pellet, PL, Young, RV. 1994. Plant proteins in relation to human protein and amino acid nutrition. American Journal of Clinical Nutrition. 59: 1203S-1212S.

Rackis, JJ, Anderson, RL. 1977. Mineral availability in soy protein products. Food Product Development. 11: 44-47.

Rao, PV, Hahn, SK. 1984 An automated enzymatic assay for determining the cyanide content of cassava products. Journal for Science of Food and Agriculture. 35: 426-436.

Ravindran V, Ravindran G. 1988 Nutritional and antinutritional characteristics of *Mucuna* (*Mucuna utilis*) beans seeds. Journal for Science of Food and Agriculture. 46:71-79

Sankale, M, Barbotin-Larrieu, M. 1984. Nutritional disorders of adult man in the Sahel. Medecine Tropical 44(2): 107-111.

Savage, GP. 1991. Lentils: a forgotten crop. Outlook on Agriculture. 20(2): 109-112.

Sharma, YK, Subramanian N. 1994. Comparative studies on functional properties of soymeals from Kalitur and Bragg varieties. Journal of Food Science and Technology. 31(1): 27-31.

Siddhuraju, P, Vijayakumari K, Janardhanan, K. 1996. Chemical composition and protein quality of the little-known legume, Velvetbean (*Mucuna pruriens* L. DC.) Journal of Agricultural and Food Chemistry. 44: 222636-266641

St-Laurent, L, Livesey, J, Arnason, JT, Bruneau A. 2002.Variation in L-DOPA concentration in accessions of *Mucuna pruriens* (L) DC varutilis(Wall.ex Wigt) Baker ex Burk. and in *M. brachycarpa* Rech. In Food and Feed from *Mucuna*: Current Uses and the Way Forward, Proceedings of an International Workshop, Tegucigalpa, Honduras, April 26-29 2000, eds. Flores, M.B., Eilitta, M., Myhrman, R., Carew, L.B. and Carsky, R.J. CIDICCO, CIEPCA, Judson College.

Ukachukwu, SA, Ezeagu IE, Tarawali G, Ikeorgu JEG. 2002. Utilization of *Mucuna* as food and feed in West Africa. Pp. 189-217 in Food and Feed from *Mucuna*: Current Uses and the Way Forward, Proceedings of an International Workshop, Tegucigalpa, Honduras, April 26-29 2000, eds. Flores, M.B., Eilitta, M., Myhrman, R., Carew, L.B. and Carsky, R.J. CIDICCO, CIEPCA, Judson College.

Univ, P. 1994. The state of World hunger. Nutrition Reviews 52(5): 151-161.

Vietmeyer, N.1990. The new crop era.(Foreword). In: Advances in new crops (Janick, J. & Simon, J.E. eds.). Timber Press, Portland, Oregon

Vijayakumari, K, Sddhuraju, P, Janardhanana, K. 1996. Effect of soaking, cooking and autoclaving on phytic acid and oligossacharide contents of tribal pulse, *Mucuna monosperma* DC. Ex Wright. Food Chemistry. 55: 173-177.

Wanjekeche, E, Wakasa V, Mureithi, JG. 2002. (This volume) Effect of alkali, acid and germination on nutritional composition and antinutritional factors of *Mucuna* (*Mucuna pruriens*).

Weaver, LT. 1994. Feeding the weanling in the developing world: problems and solutions. International Journal of Food Science and Nutrition. 45: 127-134.

Wheeler, EL, Ferrel, RE. 1971. A method for phytic acid determination in wheat and wheat fractions. Cereal Chemistry. 48: 312-320.

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