

PJN

ISSN 1680-5194

PAKISTAN JOURNAL OF
NUTRITION

ANSI*net*

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Chemical Composition and Nutritional Evaluation of Velvet Bean Seeds (*Mucuna utilis*) For Domestic Consumption and Industrial Utilization in Nigeria

I.O. Balogun and O.P. Olatidoye
Department of Food Technology, Yaba College of Technology, Nigeria

Abstract: Velvet bean seeds were collected from a farm Ibadan. The mature seed samples were analyzed for proximate and mineral compositions, fatty acid profiles and amino acid composition. The mean values of various parameters for proximate composition (%) were: Moisture (6.02 ± 0.11), crude protein (25.65 ± 0.14), ash (3.60 ± 0.01), ether extract (14.52 ± 0.05), crude fibre (7.23 ± 0.05) and carbohydrate (by difference) (42.98). The calculated fatty acids were (12.49) and gross energy was (1703.95). The investigated seed samples contained higher amounts of crude protein and lipids when compared with most of the commonly consumed pulses. Mineral element (mg/100g) include: Calcium (148.88 ± 0.2), potassium (1472.33 ± 0.2), phosphorus (377.12 ± 0.2), magnesium (23.66 ± 0.3), iron (3.44 ± 0.2) and manganese (5.28 ± 0.1). The fatty acid profiles of the seeds revealed that the seed lipids contained higher concentration of palmitic acid and linoleic acid. Linoleic acid was the dominating fatty acid, followed by palmitic acid and oleic acid. The seed proteins of sample contained higher levels of the essential amino acids such as, threonine, valine, isoleucine, tyrosine, phenylalanine and histidine. Amino acid analysis revealed that velvet bean flour contained nutritionally useful quantities of most of the essential amino acids.

Key words: Velvet bean, amino acid profiles, chemical composition, physico-chemical characteristics

INTRODUCTION

Protein-energy malnutrition is among the most serious problems tropical developing countries are facing today. The average Nigerian does not consume enough protein of animal origin and animal protein is more efficient than plant protein in providing the amino acids necessary for tissue development, repair and function (FAO, 1994). This can be attributed mainly to the ever-increasing population as well as to the enhanced dependence on a cereal-based diet, scarcity of fertile land and degradation of natural resources (Steiner, 1996; FAO, 2000). It has been estimated that 800 million malnourished people exist in some of the least developed countries (Myers, 2002). The prevalence of hunger and protein malnutrition in the tropical and subtropical areas of the world is well recognized and appreciated (FAO, 1994). The dearth in food supply especially of protein is of such magnitude the developing nations have to depend mostly on cereals, grains, starch roots and tubers for energy and protein need (Auret and Behar Syndrome, 1953). The net effect of this protein deficit in the developing countries is manifested in the prevalence of various forms of Protein Calorie Malnutrition (PCM) diseases such as Kwashiorkor, marasmus and mental deficiencies (Bressani, 1975). In view of prevalent food shortage, attention is currently being focused on the exploitation of lesser known and non-traditional plant resources (Becker, 1986). This has necessitated exploration

alternate sources of protein to bridge the gap for protein requirement of the various section of vegetarian population. In this context, alternate sources like untraditional legumes (under exploited/tribal pulses) assume significance. Exploitation of under utilized wild legumes is an important approach to combat the protein-malnutrition in developing countries. Food legumes constitute an important part of diet of a larger section of population in the developing world, as a good source of protein, carbohydrates, minerals and vitamins. Being rich in protein, carbohydrate, calorific value, fibre and vitamins, legumes constitute staple food in many countries (Deshpande, 1992). Among the wild legumes, the genus *Mucuna* is widespread in tropical and sub-tropical regions of world and is considered as an alternative protein source. *Mucuna utilis* (velvet bean) is an under-utilized legume species grown predominantly in Asia, Africa and in parts of the Americas (Vadivel and Janardhanan, 2000). The *Mucuna* bean is also used in indigenous Ayurvedic medicine (Shaw and Bera, 1993) and L-DOPA extracted from it used to provide symptomatic relief in Parkinson's disease (Nagashayana and Sankarankutty, 2000). The beans were also employed as a powerful aphrodisiac in Ayurveda (Amin, 1996) and have been used to treat nervous disorders (Jeyaweera, 1981; Wijeyaratne, 1987) and arthritis (Wijeyaratne, 1987). The bean, if applied as a paste on scorpion stings, is presumed to absorb poison (Jeyaweera, 1981). The non-protein

amino acid, L-DOPA (3, 4 dihydroxy phenylalanine) found in this under-utilized legume seed resists attack from insects and thus controls biological infestation during storage. Further L-DOPA has been extracted from the seed to provide commercial drugs for the treatment of Parkinson's disease (Nagashayana and Sankarankutty, 2000). Despite the potential of this under-utilized species as a source of less consumed food and medicine, to our knowledge, scanty information is available on the chemical composition in Nigeria and whose chemical potential hitherto remains untapped. Therefore, the study is aimed at investigating the proximate, mineral and amino acid composition as well as the physicochemical characteristics of *Mucuna utilis* produced in Nigeria. Such information may expand the scope of knowledge on the utilization and nutritional qualities of cashew nut flour.

MATERIALS AND METHODS

Samples of velvet bean, *Mucuna utilis* (black coloured seed coat) were collected from an evergreen forest in Ibadan, Nigeria. After thoroughly drying in the sun the pods were thrashed to remove seeds. The dry seeds sample were ground into powder form using pestle and mortar. The powder was sieved through a 0.002 mm wire mesh to obtain fine powdered forms. The powdered seed samples were kept in McCartney bottles and each of the extracted oil was used for the determination stored in the dessicator for analysis later.

Proximate composition: The proximate analyses of the samples for moisture, total ash and crude fibre were carried out in triplicate using the methods described by AOAC (1990). The nitrogen was determined by the micro Kjeldahl method described by Pearson (1976) and the nitrogen content was converted to protein by multiplying by a factor of 6.25. Crude lipid content was determined using Soxhlet apparatus (AOAC, 1990) and Carbohydrate content was determined by difference. All the proximate values were reported in%. Total Dietary Fibre (TDF) was estimated by the non-enzymatic-gravimetric method (Li and Cardozo, 1994).

Determination of mineral elements: The minerals were analyzed by dry ashing the samples at 550°C to constant weight and dissolving the ash in volumetric flask using distilled, deionized water with a few drops of concentrated hydrochloric acid. Sodium and potassium were determined by using a flame photometer (Model, 405, Corning, UK) using NaCl and KCl to prepare standards. All other metals were determined by Atomic Absorption Spectrophotometer (Perkin-Elmer Model 403, Norwalk CT, USA). All determinations were done in triplicate. All chemical used were of analytical grade (BDH, London). Earlier, the detection limits of the metals had been determined according to Techtron

(1975). The optimum analytical grade was 0.1 to 0.5 absorbance units with a coefficient of variation of (0.87-2.20)%. The minerals were reported as mg/100 g.

Lipid extraction and fatty acid analysis: The total lipid was extracted from the seeds according to the method of Folch *et al.* (1957) using chloroform and methanol mixture in ratio of 2:1 (v/v). Methyl esters were prepared from the total lipids by the method of Metcalfe *et al.* (1966). Fatty acid analysis was performed by gas chromatography (ASHMACO, Japan; Model No: ABD20A) using an instrument equipped with a flame ionization detector and a glass column (2 m x 3 mm) packed with 1% diethylene glycol succinate on chromosorb W. The temperature conditions for GC were injector 200°C and detector 210°C. The temperature of the oven was programmed from 180°C and the carrier gas was nitrogen at a flow rate of 30 ml/min. Peaks were identified by comparison with authentic standards, quantified by peak area integration and expressed as weight percentage of total methyl esters; the relative weight percentage of each fatty acid was determined from integrated peak areas.

Amino acid analysis: The total seed protein was extracted by a modified method of (Basha *et al.*, 1976). The extracted protein were purified by precipitation with cold 20% Trichloroacetic Acid (TCA). A protein sample of 30 mg was hydrolysed by 6N HCL (5 ml) in an evacuated sealed tube, which was kept in an air oven maintained at 110°C for 24 hr. The sealed tube was broken and the acid removed completely by repeated flash evaporation after the addition of de-ionized water. Dilution was effected by means of citrate buffer pH 2.2 to such an extent that the solution contained 0.5 mg protein ml⁻¹. The solution was passed through a millipore filter (0.45 µm) and derivitized with O-phthalaldehyde by using an automated pre-column (OPA). Amino acids were analyzed by a reverse-phase HPLC (Method L 7400, HITACHI, Japan) fitted with a denali C18 5 micron column (4.6 x 150 mm). The flow rate was 1 ml min⁻¹ with fluorescence detector. The cystine content of protein sample was obtained separately by the method of Liddell and Saville (1959). For the determination of tryptophan content of proteins, aliquots containing known amounts of proteins were dispersed into glass ampoules together with 1 ml 5M NaOH. The ampoules were flame sealed and incubated at 110°C for 18 hr. The tryptophan contents of the alkaline hydrolysates were determined colorimetrically using the method of Spies and Chamber (1949) as modified by Rama Rao *et al.* (1974). The contents of the different amino acids were expressed as g/100 g proteins and were compared with FAO/WHO 1991 reference pattern (FAO/WHO, 1991). The essential amino acid score was calculated as follows:

$$\text{Essential amino acid score} = \frac{\text{g essential amino acid in 100 g of total protein}}{\text{g essential amino acid in 100 g}} \times 100$$

FAO/WHO (1991) reference pattern.

Statistical analysis: Data were analyzed using the statistical analysis system SPSS (SPSS software for windows release 10.0; SPS Inc., Chicago IL USA). Estimates of mean, standard error were calculated.

Table 1: Proximate composition (%) of mucuna utilis seed flour

Composition	%
Moisture	6.02±0.11
Ash	3.60±0.01
Ether extracts	14.52±0.05
Crude protein	25.65±0.14
Crude fibre	7.23±0.05
Carbohydrate (by difference)	42.98
^a Fatty acids	12.49
^b Energy KJ/100 g	1703.95

Values are mean±standard deviation of triplicate determinations.

^aCalculated fatty acids (0.86 x crude fat).

^bCalculated metabolizable energy (KJ/100 g) (Protein x 17 + Fat x 37 + Carbohydrate x 17)

RESULTS AND DISCUSSION

Table 1 presents results of the proximate composition of velvet seed flour. The moisture mean value of velvet bean flour which was 6.02±0.11% dry weight is low when compared with the mean value of moisture of legumes ranging between 7.0% and 11.0% reported by Arkroyed and Doughty (1964) but higher than 5.7% reported for cashew nut flour by Aremu *et al.* (2006). However this value is in close agreement with those reported by Ige *et al.* (1984) and Fagbemi and Oshodi (1991) for fluted pumpkins seed of 5.0% and 5.50% respectively. This indicates that the nut will have good keeping properties. Ash content mean value of velvet bean flour in this present study was 3.6±0.01%. It has been recommended by Pomeranz and Clifton (1981) that ash contents of nuts, seed and tubers should fall in the range 1.5-2.5% in order to be suitable for animal feeds. The ash content of this bean seed fell within this range hence it can therefore be recommended for animal feeds. The ether extract (crude fat) with a mean value of 14.52±0.05% is low compared to the values for varieties of melon oil seeds ranging between 47.9-51.1% reported by Ige *et al.* (1984); for pumpkin seed (49.2% and 47.01%) by Fagbemi and Oshodi (1991) and (Aisegbu, 1987) respectively. It is also low when compared to soybean seed, which has only 23.5% fat (Paul and Southgate, 1980) and cashew nut which has 36.7% fat. Fat is important in diets because it promotes fat soluble vitamin absorption (Bogert *et al.*, 1994). It is a high energy nutrient and does not add to the bulk of the diet. The crude protein of 25.65±0.14% is highly comparable to protein rich foods such as soybeans, cowpeas, pigeon peas, melon, pumpkin and gourd

seeds ranging between 23.1-33.0% (Olaofe *et al.*, 1994); chick beans 19.4% and lima bean, 19.8% (FAO, 1982); Jack bean, 30.8% (Anonymous, 1972) and cashewnut, 25.25±0.2% (Aremu *et al.*, 2006). The recommended daily allowance for protein for children ranges from 23.0-36.0 g and for adult, 44-56 g (NRC, 1989). However, it can be evaluated that velvet bean can supply the recommended daily intake of protein for children. Apart from the nutritional significance of protein as a source of amino acids, they also play apart in the organoleptic properties of foods (FAO/WHO, 1973). The crude protein contents were found to be higher than the pulse crops commonly consumed such pigeon pea, chick pea and cowpea which have been reported earlier (Gupta and Wagle, 1978; Jambunathan and Singh, 1980; Nwokolo and Oji, 1985; Nwokolo, 1987). To meet the protein demands in developing countries where animal protein is grossly inadequate, considerable attention is being paid to less consumed protein sources, especially in legumes (Balogun and Fetuga, 1986) which are considered as protein tablets (Salunkhe *et al.*, 1982). The crude protein levels of the studied samples suggest its usefulness as alternative source of protein. The crude fibre of almond nut (7.23±0.05) was very high compared with legumes, mean values ranging between 5-6% (Aremu *et al.*, 2006) and (Anonymous, 1972). Maintenance of internal distention for a normal peristaltic movement of the intestinal tract is the physiological role which crude fibre plays. Other authors (Anonymous, 1972) reported that a diet low in fibre is undesirable as it could cause constipation and that such diets have been associated with diseases of colon like piles, appendicitis and cancer. The value obtained for carbohydrate (by difference), 42.98% is comparable with an acceptable range mean values of legumes, 20-60% of dry weight (Arkroyed and Doughty, 1964). This result thus gave an indication that the velvet bean is a rich source of energy and capable of supplying the daily energy requirements of the body. Carbohydrates are easily digested, provide the necessary calories in the diets of most people of the world promote the utilization of dietary fats and reduce wastage of proteins. The calculated metabolizable energy value (1703.95 KJ/100 g) showed that velvet bean was concentrated source of energy. The energy from cereals ranged from 1.3-1.6 MJ/100 g reported by (Paul and Southgate, 1980) indicating that velvet bean has energy concentration favourably comparable to cereals. In human diets, protein quality and quantity are major concerns.

The mineral content (mg/100 g) of almond nut flour is shown in Table 2. They serve as cofactors for many physiologic and metabolic functions. The least abundant minerals were Cu (0.71), Zn (3.46) and Mn (5.28) while K was found to be the most abundant mineral (1472.33±0.2 mg/100 g). This is in close agreement with the observation of (Olaofe and Sanni, 1988) and (Aremu

Table 2: Concentration of macro and microelement in of mucuna utilis flour (mg/100 g)

Mineral	mg/100 g
Ca	148.88±0.2
Na	54.46±0.2
K	1472.33±0.2
Mg	23.66±0.3
P	377.12±0.2
Fe	3.44±0.2
Zn	3.46±0.1
Cu	0.71±0.1
Mn	5.28±0.1

Values are mean±standard deviation of triplicate determinations

et al., 2005) that K was the most predominate mineral in Nigerian Agricultural Products. Mg was found to be next highest mineral component. It has been reported that magnesium is an activator of many enzymes systems and maintains the electrical potential in nerves (Ferrao *et al.*, 1987). The body contains 20-28 g of magnesium, more than half of which is stored in the bones. Tropical almond nut contains large amounts of magnesium and an adequate serving would satisfy Recommended Daily Allowance (RDA). Calcium mean value (148.88±0.3 mg/100 g) of the present study is higher than melon, pumpkin and gourd seeds of 130.7, 72.3 and 54.9 mg/100 g respectively reported by Olaofe *et al.* (1994) and higher than cashew nut (21.9 mg/100 g) reported by Aremu *et al.* (2006). Calcium in conjunction with phosphorus, magnesium, manganese, vitamins A, C and D, chlorine and protein are all involved in bone formation (Fleck, 1976). Calcium is also important in blood clotting muscle contraction and in certain enzymes in metabolic processes. Calcium, an important mineral required for bone formation and neurological function, was found to be present at significant levels. The mean value of Mg (23.66±0.3 mg/100 g) is very close to that of calcium. Phosphorus is always found with calcium in the body both contributing to the blood. Sodium is a macronutrient and constitutes 2 percent of the total mineral content of the body. The mineral is vital in maintaining the body fluid volume, osmotic equilibrium and acid-base balance. Deficiency of sodium occurs during hot weather or as a result of heavy work in hot climate. The seed samples of *Mucuna utilis* contained higher levels of sodium, potassium, calcium, phosphorous, magnesium, iron and manganese, when compared with other legumes, *Phaseolus vulgaris*, *P. limeneis*, *V. unguiculata*, *Cicer arietinum*, *Pisum sativum* and *lens culinaris* (Meiners *et al.*, 1976). In the present investigation, all the seed samples registered a higher level of potassium when compared with Recommended Dietary Allowance Value (RDA) of infants and children (<1550mg) NRC/NAS (NRC/NAS, 1980). The high content of potassium can be utilized beneficially in the diets of people who take diuretics to control hypertension and suffer from excessive excretion of potassium through the body fluid (Siddhuraju *et al.*, 2001).

Table 3: Relative fatty acid content (%) of Anarcadium occidentale oil

Fatty acid	Concentration (%)
Palmitic (C16:0)	28.80
Stearic (C18:0)	18.21
Oleic (C18:1)	20.12
Linoleic (C18:2)	26.40
Linolenic (C18:3)	8.71
Behenic (C22:0)	2.42
O/L level	2.31

O/L = Oleic:Linolenic ratio

Table 3 presents the fatty acid composition of the oils from velvet bean. In our result, the saturated fatty acids were palmitic (C16:0) and stearic (C18:0); the monosaturated acid was oleic (C18:1) while the polyunsaturated component were linoleic (C18:2). Linoleic acid was the dominating fatty acid, followed by palmitic acid and oleic acid. This value compares favourably with African oil bean (30.3) reported by Achinewhu (1990) however higher than most legume seed oils reported by Adeyeye *et al.* (1994), Oshodi *et al.* (1993), Paul and Southgate (1980) and Ihekoronye and Ngoddy (1985). The nutritional value of linoleic acid is due to its metabolism at tissue levels which produce the hormone like prostaglandins. The activity of these prostaglandins includes lowering of blood pressure and constriction of smooth muscle (Aurand *et al.*, 1987). Linoleic acid and linolenic acids are the most important essential fatty acids required for the growth, physiological functions and maintenance (Pugalethi *et al.*, 2004). In the present study, most of the fatty acids were unsaturated fatty acids. The fatty acid composition and high amounts of unsaturated fatty acids make velvet bean a special legume, suitable for nutritional applications. The fatty acid composition of the presently investigated pulses is comparable with some edible legumes such as *Vigna radiata*, *V. mungo* (Salunkhe *et al.*, 1982); *V. unguiculata* and *Phaseolus vulgaris* (Omogbai, 1990). Oleic acid in both samples of *M. pruriens* var. *utilis* is higher than the previous study in the same pulse (Mohan and Janardhanan, 1995). The antinutritional fatty acid, behenic acid is detected in all the three samples. Earlier reports indicate the detection of behenic acid in ground nut (Kritchevsky *et al.*, 1973), winged bean (Bean *et al.*, 1984; Fernando and Bean, 1985; Fernando and Bean, 1986), *Parkia roxburgii*, *Entada phaseoloides* (Mohan and Janardhanan, 1993) and *M. monosperma* (Mohan and Janardhanan, 1995). The Oleic Acid/Linoleic Acid (O/L) ratio has been used as an indicator of peanut oil stability. High O/L associated with high stability and potentiality of the oil for deep frying fat (Branch *et al.*, 1990). The O/L level of velvet bean oil (2.31) in the present study is higher than peanut oil (1.48) (Branch *et al.*, 1990) hence velvet bean oil may be more stable than peanut oil and may also be useful as frying oil.

The amino acid profiles of purified seed protein and the essential amino acids score are presented in Table 4.

Table 4: Amino acid composition of mucuna utilis flour (g/100 g protein)

Mineral	Concentration		
	g/100 g	EAAS	FAO/WHO
Lysine*	5.72	98.62	5.8
Histidine*	3.13	164.74	1.9
Arginine*	7.41		
Aspartic acid	14.28		
Glutamic acid	13.28		
Glycine	5.49		
Valine*	4.47	127.72	3.5
Methionine*	0.69		
Isoleucine*	7.24	258.57	2.8
Leucine*	6.14	90.29	6.8
Tyrosine	3.94	62.54	6.3
Cystein	4.52	180.8	2.5
Phenylalanine*	4.58		
Serine	4.53		
Proline	3.64		
Tryptophan	0.81	73.64	1.1
Alanine	4.28		
Threonine*	3.86	113.53	3.4

*Essential amino acids

The protein quality, also known as the nutritional value of a food depends on its amino acid content and on the physiological utilization of specific amino acid after ingestion, absorption and minimal obligatory rates of oxidation (Friedman, 1996). The essential amino acids such as threonine, valine, isoleucine, tyrosine, phenylalanine and histidine are found to be higher in all the investigated pulse than those of FAO/WHO 1991 requirement pattern (FAO/WHO, 1991). The major abundant amino acids were Glutamic acid, Arginine and Aspartic acid with the values of 13.28, 7.41 and 14.28 g/100 g proteins respectively. This observation is in close agreement with the report of Olaofe *et al.* (1993), Oshodi *et al.* (1998) and Adeyeye (2004) and Aremu *et al.* (2006). The sum of the Asp and Glu amino acids was 24.7 g/100 g protein (32.6%) this value is higher than the values obtained from selected oil seeds (melon, pumpkin and gourd seeds) ranging between 24.2-29.5 (Olaofe *et al.*, 1994) and Ige *et al.* (1984). The Total Amino Acid (TAA) of 75.8 g/100 g protein indicated that velvet bean will contribute significantly to the supply of amino acid in diet. This value is higher than that of melon, pumpkins and gourd seed of 53.4, 38.3 and 53.6 g/100 g protein respectively reported by Olaofe *et al.* (1994); soybean, 44.4 g/100 g protein (Kuri *et al.*, 1991), pigeon peas, 45.2 g/100 g protein (Nwokolo, 1987). This is an indication that velvet bean seed is very rich in proteins. The% total amino acid (% TEAA) of 43.7 (with His) was an indication that cashew nut flour is a good source of essential amino acids. The leucine (Leu) (6.9 g/100 g protein) and phenylalanine (Phe) (4.1 g/100 g) protein values are higher than that of the reference values of 4.2 and 2.8g/16g of N protein respectively. However lysine (Lys), methionine (Met) and valine (Val) values of 3.2, 2.0 and 3.7g/100 protein are lower than the

reference values of 4.2, 2.2 and 4.2 g/100 g protein respectively. Threonine (Thre) (2.5 g/100 g) protein is comparable to the reference value of 2.8g/16g of N protein (FAO, 1970).

Conclusion: The observation made in present study show that seed samples of *M. utilis* are rich in crude protein, most of the essential amino acids, fatty acid such as linoleic, palmitic and oleic acids and some minerals when compared to some other oil seeds and nuts. This study reveals that the nutritional profile of samples of *M. utilis* can also be explored as an alternate protein source to alleviate protein-energy-malnutrition among economically weaker sections of peoples in developing countries.

REFERENCES

- Achinewhu, S.C., 1990. Composition and food potential of melon seed (*C. vulgaris*). Nig. Food J., 8: 130-133.
- Adeyeye, E.I., 2004. The chemical composition of liquid and solid endosperm of ripe coconut. Oriental J. Chem., 20: 471-475.
- Adeyeye, E.I., A.A. Oshodi and K.O. Ipinmoroti, 1994. Functional properties of some varieties of African yam sear (*Sphenostylis stenocarpa*) flour. Int. J. Food Sci. Nutr., 45: 115-126.
- Aisegbu, J.E., 1987. Some biochemical evaluation of fluted pumpkin seeds. J. Sci. Food Agric., 40: 151-155.
- Amin, K.M.Y., 1996. Sexual function improving effects of mucuna pruriens in sexually normal rats. Fitoterapia, 67: 53-58.
- Anonymous, 1972. Tropical Legumes: Resources future. National Academic of Science Washington, DC., pp: 24.
- AOAC, 1990. Official Methods of Analysis, 15th Edn., Washington, DC.
- Aremu, M.O., A. Olonisakin, J.W. Otene and B.O. Atolaye, 2005. Mineral content of some agricultural products grown in the Middle Belt of Nigeria. Oriental J. Chem., 21: 419-426.
- Aremu, M.O., O. Olaofe and T.E. Akintayo, 2006. A Comparative study on the chemical and amino acid composition of some Nigerian under utilized legume flours. Pak. J. Nutr., 5: 34-38.
- Arkroyed, W.R. and J. Doughty, 1964. Legumes in human nutrition, Food and Agricultural Organization nutrition studies publication, 19.
- Aurand, L.W., A.E. Woods and M.R. Wells, 1987. Food Composition and analysis. New York, USA: VAN Nostrand Reinhold company.
- Auret, M. and M. Behar Syndrome, 1953. Polycorencies de'l Entrant (Kwashiokor) etsa prevention en Amerique FAO No.13.

- Balogun, A.M. and B.L. Fetuga, 1986. Chemical composition of some underexploited leguminous crop seeds in Nigeria. *J. Agric. Food Chem.*, 34: 189-192.
- Basha, S.M.M., J.P. Cherry and C.T. Young, 1976. Changes in free amino acids, carbohydrates and proteins of maturing seeds from various peas (*Arachis hypogaea*) cultivars. *Cereal Chem.*, 53: 583-597
- Bean, G., T. Fernando, H. Holden and G. Patterson, 1984. Total plant analysis of sterols and fatty acids of the winged bean, *Psophocarpus tetragonolobus*. *J. Food Sci.*, 49: 964-965.
- Becker, B.K., 1986. Wild plants for human nutrition in the Sahelian zone. *J. Arid Environ.*, 11: 61-64.
- Bogert, J.L., G.M. Briggs and D.H. Galloway, 1994. Nutrition and Physical fitness. *Int. J. Food Sci. Nutr.*, 45: 223-230.
- Branch, W.D., T. Nakayama and M.S. Chinnan, 1990. Fatty acid variation among US runner type peanut cultivars. *J. Am. Oil Chem. Soc.*, 67: 591-596.
- Bressani, R., 1975. Legumes in human diet and how they might be improved. In polyphenols in cereals and legumes: Ed, Milner: IDRE, Ottawa, Canada. Conference. Washington, D.C: IFPRI, pp: 100.
- Deshpande, S.S., 1992. Food legumes in human nutrition. A personal perspective. *Crit. Rev. Food Sci. Nutr.*, 32: 333-363.
- Fagbemi, T.N. and A.A. Oshodi, 1991. Chemical composition and functional properties of Full fat fluted pumpkin seed flour. *Nig. Food J.*, 9: 26-32.
- FAO/WHO, 1991. Protein quality evaluation. Report of Joint FAO/WHO Export Consultant, FAO food Nutrition paper; 51, FAO/WHO, Rome, pp: 19-21.
- FAO, 1994. Food and Agricultural Organization. The state of food and agriculture. FAO Agric. Series No 27. FAO/UN, Rome.
- FAO, 1970. Amino acid contents of food and Biological Data on protein; FAO.
- FAO/WHO, 1973. Energy and protein requirements. In P.L. Pellet and V.R. Young (Eds). Nutritional Evaluation of proteins in Foods. United Nation University, Tokyo, Japan, pp: 1-6.
- FAO, 1982. Food composition table for use in Africa development of health education and Welfare. Rome. Health Science and FAO Nutrition Division. pp: 32.
- FAO, 2000. Food Insecurity: When people live with hunger and fear starvation. Rome, Italy: FAO.
- Fernando, T. and G. Bean, 1985. Variation of the antinutritional behenic acid content among the cultivars of winged bean (*Psophocarpus tetragonolobus* (L.) (DC.) seeds. *Food Chem.*, 185: 265-269.
- Fernando, T. and G. Bean, 1986. The reduction of antinutritional behenic acid in winged bean (*Psophocarpus tetragonolobus* (L.) (DC) seeds. *Plant Food Hum Nutr.*, 36: 93-96.
- Ferrao, J.E.M., A.M.B.C. Ferro and A.M.G. Antunes, 1987. Bambara groundnut (*Vigna subterranean*) aspect of its nutritive value. *Gracia deorta serie de Estudos Agronomicos*, 14: 35-39.
- Fleck, H., 1976. Introduction to Nutrition, 3rd Edn., Macmillan, New York, USA, pp: 207-219.
- Folch, J., M. Lees and G.M. Solane-Stanly, 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.*, 226: 497-506.
- Friedman, M., 1996. Nutritional value of proteins from different food sources-A review. *J. Agric. Food Chem.*, 44: 6-29.
- Gupta, K. and D.S. Wagle, 1978. Proximate composition and nutritive value of *Phaseolus mungoreous*, a cross between *Phaseolus mungo* and *Phaseolus aureus*. *J. Food Sci. Technol.*, 15: 34-35.
- Ige, M.N., A.O. Ogunsua and O.L. Okon, 1984. Functional properties of the protein of some Nigeria oil seeds. Casophor seeds and three varieties of some Nigeria oil seeds. *Food Chem.*, 32: 822-825.
- Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated Food Science and Technology for the Tropics. London: Macmillan.
- Jambunathan, R. and U. Singh, 1980. Studies on Desi and Kabuli Chickpea. (*Cicer arietinum*) Cultivars. 1. Chemical composition. In Proceedings of the International Workshop on Chickpea Improvement, ICRIAT, Hyderabad, India, 28 February-2 March 1979.
- Jeyaweera, D.M.A., 1981. Medicinal plants used in Ceylon. Colombo, Sri Lanka. National Science Council of Sri Lanka.
- Kritchevsky, D., S.A. Tepper, D. Vesselinovitch and R.W. Wissler, 1973. Cholesterol vehicle in experimental atherosclerosis, 13. Randomised peanut oils. *Atherosclerosis*, 17: 225-237.
- Kuri, Y.E., I. Sundar, K. Rao, L. Kahuwi, G.P. Jones and D.E. Rivelt, 1991. Chemical composition of monerdica characteristics, L. fruits. *J. Agric. Food Chem.*, 39: 1702-1703.
- Li, B.W. and M.S. Cardozo, 1994. Determination of total dietary fiber in foods and products with little or no starch, nonenzymatic-gravimetric method: collaborative study. *J. Asso. Offi. Anal. Chem. Inter.*, 77: 687-689.
- Liddell, H.F. and B. Saville, 1959. Colorimetric determination of cysteine. *Analyst.*, 84: 133-137.
- Meiners, C.R., N.L. Derise, H.C. Lau, M.G. Crews, S.J. Ritchey and E.W. Murphy, 1976. The content of nine mineral elements in raw and cooked mature dry legumes. *J. Agric. Food Chem.*, 24: 1126-1130.

- Metcalf, L.D., A.A. Schemitz and J.R. Pelka, 1966. Rapid preparation of fatty acid esters from lipids for gas chromatographic analysis. *Anal. Chem.*, 38: 514-515.
- Mohan, V.R. and K. Janardhanan, 1995. Chemical analysis and nutritional assessment of lesser known pulses of the genus, *Mucuna*. *Food Chem.*, 52: 275-280.
- Mohan, V.R. and K. Janardhanan, 1993. Chemical and nutritional evaluation of raw seeds of the tribal pulses *Parkia roxburghii*. G. Don and *Entada phaseoloides* (L.) Merr. *Int. J. Food Sci. Nutr.*, 44: 47-53.
- Myers, W., 2002. In: Sustainable food security for all by 2020. Proceedings of an International Conference. Washington, D.C: IFPRI, p 100.
- Nagashayana, N. and P. Sankarankutty, 2000. Association of L-Dopa with recovery following Ayurveda medication in Parkinson's disease. *J. Neurol. Sci.*, 176: 124-127.
- National Research Council (NRC), 1989. Recommended Dietary Allowances 10th Edn.
- NRC/NAS, 1980. National Research Council Committee on Dietary Allowances. 9th Edn., National Academy of Science Press. Washington, DC, USA.
- Nwokolo, E. and D.I. Oji, 1985. Variation in metabolizable energy content of raw or autoclaved white and brown varieties of three tropical grain legumes. *Anim. Food Sci. Technol.*, 13: 141-6.
- Nwokolo, E., 1987. Nutritional evaluation of pigeonpea meal. *Plant Food Hum. Nutr.*, 37: 283-90.
- Olaofe, O. and C.O. Sanni, 1988. Mineral contents of Agriculture products. *Food Chem.*, 30: 73-79.
- Olaofe, O., F.O. Adeyemi and G.O. Adediran, 1994. Amino acid and Mineral Composition and functional properties of some oil seeds. *J. Agric. Food Chem.*, 42: 878-884.
- Olaofe, O., J. Mustapha and S.A. Ibiyemi, 1993. Amino acid and mineral composition of Some Nigerian chillies. *Trop. Sci.*, 33: 226-231.
- Omogbai, F.E., 1990. Lipid composition of tropical seeds used in the Nigerian diet. *J. Sci. Food Agric.*, 50: 253-255.
- Oshodi, A.A., K.O. Esuoso and E.T. Akintayo, 1998. Proximate and amino acid composition of some underutilized Nigerian legume flour and protein concentrates, *La Rivista Italiana*.
- Oshodi, A.A., O. Olaofe and G.M. Hall, 1993. Amino acid, fatty acid and mineral composition of pigeon pea (*Cajanus cajan*). *Int. J. Food Nutr.*, 43: 178-191.
- Paul, A.A. and B.A.T. Southgate, 1980. Mucance and Widdowson's Composition of Food, 4th Edn., Her majesty's stationary office, London, UK., pp: 227-228.
- Pearson, D., 1976. The Chemical Analysis of Foods. 7th ed. Churchill Livingstone, London.
- Pomeranz and D. Clifton, 1981. In food analysis theory and practices. Westport, L.T, AVI Publishing Comp.P.17, Properties of defatted soybean, peanut, field pea and pecan flours. *J. Food Sci.*, 42: 1440-1450.
- Pugalenthi, M., V. Vadivel, P. Gurumoorthi and K. Janardhanan, 2004. Comparative nutritional evaluation of little known legumes, *Tamarindus indica*, *Erythrina indica* and *Sesbania bispinosa*. *Trop. Subtrop. Agroecosys*, 4: 107-123.
- Rama Rao, M.V., M.R. Tara and C.K. Krishnan, 1974. Colorimetric estimation of tryptophan content of pulses. *J. Food Sci. Technol. (Mysore)*, 11: 213-216.
- Salunkhe, D.K., S.K. Sathe and N.R. Reddy, 1982. Legume lipids. In *Chemistry and Biochemistry of Legumes*, Ed, Arora S.K. Oxford, IBH Publishing Co, New Delhi, India, pp: 51-107.
- Shaw, B.P. and C.H. Bera, 1993. A preliminary clinical study to evaluate the effect of Vogorex-SF in sexual debility patients. *In. J. Inter. Med.*, 3: 165-169.
- Siddhuraju, P., K. Becker and H.P.S. Makkar, 2001. Chemical composition and protein fractionation, essential amino acid potential and anti-metabolic constituents of an unconventional legume, Gila bean (*Entada phaseoloides* Merr.) seed kernel. *J. Sci. Food Agric.*, 82: 192-202.
- Spies, J.R. and D.C. Chamber, 1949. Chemical determination of tryptophan in proteins. *Anal. Chem.*, 21: 1249-1266.
- Steiner, K.G., 1996. Causes of soil degradation and approaches to sustainable soil management. Weikersheim, Germany: Margaf Verlag, p50.
- Techtron, V., 1975. Basic Atomic Absorption Spectroscopy, A Modern Introduction, Dominican Press Victoria, Australia, pp: 104-106.
- Vadivel, V. and K. Janardhanan, 2000. Nutritional and antinutritional composition of velvet bean: An under-utilized food legume in South India. *Int. J. Food Sci. Nutr.*, 51: 279-287.
- Wijeyaratne, S., 1987. Poisonous plants another's medicine. *Mirror Magazine (Sri Lanka)*, 18: 8-9.