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Diversity in nutritional composition of wild jack bean (*Canavalia ensiformis* L. DC) seeds collected from south India

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Abstract

Nine accessions of the wild jack bean (*Canavalia ensiformis* L. DC) seeds collected from nine different locations of south India were analysed for proximate composition and mineral profiles. The major findings of the study were as follows: crude protein ranged from 28.9 to 35.0%, crude lipid 3.4–4.7%, crude fibre 7.0–10.7%, ash 3.0–5.8%, carbohydrates 46.1–54.5% and energy levels 1469–1574 kJ 100 g^{-1} DM. Significant ($P<0.05$) diversity was observed in crude protein and carbohydrate contents among the accessions collected from different locations based on analysis of variance (ANOVA) analysis. Potassium was the most abundant mineral, which ranged from 634 mg 100 g^{-1} in Dasukuppam accession to 1017 mg 100g^{-1} in Valacode accession. Sodium and magnesium levels are generally low with mean values of 63 and 250 mg 100 g^{-1}, respectively. In the present study, in all minerals, significant diversity was observed among the accessions collected from different locations. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: *Canavalia ensiformis*; Proximate composition; Mineral profiles

1. Introduction

Legumes are low-priced sources of protein-rich foods that have been important in alleviating protein–energy–malnutrition (Aykroyd, Doughty, & Walker, 1982). The Indian subcontinent may be the area of greatest dependence on pulses (Singh & Singh, 1992). However, pulse production in India could not keep pace with population growth and consequently the per capita availability has declined from 70 g in 1956 to 34 g in 1996 (Ali, 1997). Alternatives to such a situation are not easily found. However, the use of less-known grain legumes provides one possibility, which are not used to an important extent by human population. Among these, one that offers an excellent possibility is the seeds of jack beans (*Canavalia ensiformis* L. DC).

The mature seeds are consumed by the Indian tribal sects, Kurumba, Malayali, Erula and other Dravidian groups, after cooking (Mittre, 1991). In Western countries, this legume is used as a cover crop and the roasted seeds are ground to prepare a coffee-like drink (Bressani, Brenes, Garcia, & Elias, 1987). Jack bean is considered one of the few pulses that grow well on the highly leached, nutrient-depleted lowland tropical soils (Emebiri, 1996). It can be grown relatively easily and produce high yields in the regions of low altitude, high temperature and relative humidity (Molina, Arguta, & Bressani, 1974). The proximate composition of the jack bean has been investigated earlier and the seeds contain 24.25–32.23% crude protein, 1.8–9.60% crude lipid, 4.65–10.00% crude fibre, 2.00–4.64% ash and 43.1–60.30% carbohydrates (Ajah & Madubuike, 1997; Apata & Ologhobo, 1994; Bressani et al., 1987; Mohan & Janardhanan, 1994; Molina et al., 1974; Rajaram & Janardhanan, 1992; Revilleza, Mendoza, & Raymundo, 1990; Rodrigues & Torne, 1991; Tepal, Castellanos, & Larios, 1994). The contents of minerals also are reported (Bressani et al., 1987; Mohan & Janardhanan, 1994; Rajaram & Janardhanan, 1992; Rodrigues & Torne, 1991).

The environment of different locations plays an important role in the determination of quality and

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quantity of seed protein. The interaction of genotype and location on protein content in the cultivated legumes is reported (Dodd & Pushpamma, 1980; Erskine, Williams, & Nakkoul, 1985; Rao & Belavady, 1979; Singh, Kumar, & Gowda, 1983). Location effect is relatively more important than that of cultivator effect on protein content (Dodd & Pushpamma, 1980). Little is known about cultivable difference on crude protein, amino acids and relative nutritive value in jack bean and Laurena, Rodriguez, Sabino, Zamora, and Mendoza (1991) reported significant difference in the contents. To our knowledge, no studies have been conducted concerning the location effect on proximate composition and mineral profile in wild jack bean seeds collected from south India. Therefore, the objectives of this paper are: (1) to screen the proximate and mineral composition of jack bean collections and compare their levels with earlier reports in jack bean and with Indian food legumes; (2) to examine the variability of proximate composition and mineral profiles within the collection and find out the location effect; and (3) to study the relationship between their composition.

2. Materials and methods

2.1. Status of the germplasm collection

Nine accessions of *Canavalia ensiformis* L. DC were collected from nine agroclimatic regions of south India (Table 1). The entire collections were of natural populations of Western Ghats (eight accessions) and Eastern Ghats (Dasukuppam accession). One of the 18 biodiversity hot-spots of the world (Gadgil, 1996), the Western Ghats together with the Western coast forms an important ecological zone and the landscapes here are very heterogeneous (Subash Chandran, 1997).

2.2. Biochemical evaluation

The seeds after collections were dried in open sunlight for 2–3 days. The dried seeds were cleaned thoroughly and any foreign materials, broken seeds and immature seeds were removed. The seeds were stored in airtight plastic containers at room temperature until further use.

The moisture content of the seeds was estimated by taking 50 transversely cut seeds at a time and the weight was taken before and after incubation in a hot-air oven at 80°C for 24 h, followed by cooling in a desiccator (Rajaram & Janardhanan, 1990). Oven-dried seeds (20 g), were weighed and ground in a Wiley Mill (Scientific Equipment, Delhi, India) and passed through a 60-mesh size screen; three samples for each accession were analysed and the results expressed on dry weight basis. The micro-kjeldahl method was used for determination of nitrogen (Humphries, 1956) and the crude protein was calculated by multiplying by a factor of 6.25; ash content was determined by heating 2–4 g of the dried sample in a silica dish at 600°C for 6 h (AOAC, 1975; 14.006); crude lipid using Soxhlet apparatus (AOAC, 1975; 14.018) and crude fibre (AOAC, 1975; 7.054) were also determined. Carbohydrate content was calculated by difference (Muller & Tobin, 1980). The energy content of the seeds was determined by multiplying the percentages of crude protein, crude lipid and carbohydrates with the factors 16.7, 37.7 and 16.7, respectively (Siddhuraju, Vijayakumari, & Janardhanan, 1992).

The mineral constituents were determined first by wet ashing 2 g each of the samples with a mixture of nitric acid, perchloric acid (60%) and sulfuric acid (10:4:1), followed by flaming in an atomic absorption spectrophotometer (Perkin–Elmer, Model 5000), using different lamps (Issac & Johnson, 1975). Phosphorus content was determined colorimetrically (Dickman & Bray, 1940) from the triple acid digested samples.

2.3. Statistical analysis

Analysis of variance (ANOVA) technique was used to find out the location effect on proximate composition and mineral profile. Correlation co-efficient was worked out to find out the degree of relationship between the proximate components and between the mineral profiles and their significance was tested using *t*-test.

Table 1
Collection details of various accessions of *Canavalia ensiformis*

Location	Seed coat colour	District	State	Date of collection
Pathanamthetta	Maroon	Pathanamthetta	Kerala	17 February 1994
Valacode	Red	Kollam	Kerala	18 February 1994
Neyar dam	Red	Thiruvananthapuram	Kerala	19 February 1994
Kodacherry	Red	Malapuram	Kerala	12 March 1994
Vazhikkadavu	Maroon	Malapuram	Kerala	12 March 1994
Maananthavaadi	Maroon	Wyanad	Kerala	13 March 1994
Naduvil	Red	Cannur	Kerala	15 March 1994
Dasukuppam	Red	Chittoor	Andhra Pradesh	12 July 1994
Gundalpet	Red	Mysore	Karnataka	12 February 1995

Table 2
Proximate composition of nine accessions of *Canavalia ensiformis*[a] (g 100 g^{-1} seed flour)

Location[b]	Moisture[c]	Crude protein[c]	Crude lipid	Crude fibre	Ash	CHO[c]	KJ $100g^{-1}$ DM
Pathanamthetta[M]	8.7±0.2	30.3±0.8	4.0±0.4	8.2±0.3	3.0±0.2	54.5±0.5	1567
Valacode[R]	8.5±0.3	35.0±0.3	4.3±0.5	7.7±0.3	3.9±0.1	49.2±0.5	1568
Neyar dam[R]	3.8±0.6	29.6±0.5	3.4±0.1	10.6±1.3	5.7±1.1	50.7±2.8	1469
Kodacherry[R]	7.0±1.9	34.8±0.5	4.2±0.1	9.9±1.2	5.1±0.8	46.1±0.7	1508
Vazhikkadavu[M]	4.7±0.5	30.6±0.5	4.7±0.2	8.5±2.5	5.8±1.3	50.4±1.4	1532
Maananthavaadi[M]	5.1±1.5	28.9±0.5	3.9±0.1	9.8±1.7	4.6±0.6	52.8±1.0	1511
Naduvil[R]	8.3±0.2	32.4±0.6	3.7±0.5	7.0±0.2	3.4±0.1	53.6±0.2	1574
Dasukuppam[R]	9.2±0.2	32.8±1.1	3.8±0.1	8.5±0.7	4.5±0.1	50.4±1.5	1532
Gundalpet[R]	8.0±0.1	32.3±1.1	3.7±0.1	10.7±0.2	4.6±0.1	48.7±1.0	1493
Range	3.8–9.2	28.9–35.0	3.4–4.7	7.0–10.7	3.0–5.8	46.1–54.5	1469–1574
Mean	7.0	31.9	4.0	9.0	4.5	50.6	1528
S.D.	2.3	2.3	0.5	2.2	1.3	3.1	46.03

[a] Results are the average values of three determinations expressed on dry weight basis. ±, standard error.
[b] M, Maroon-colour seed coat; R, Red-colour seed coat.
[c] Significant at $P<0.05$ based on ANOVA.

3. Results and discussion

The mean (±standard error) of three determinations of the proximate composition is shown in Table 2. The results demonstrate considerable variation for proximate components within jack beans collections. The mean percentage moisture is 7.0 and ranged from 3.8% for Neyar dam accession to 9.2% for Dasukuppam accession. The mean crude protein content of the nine accessions is 31.9% with the standard deviation of 2.3. The range in protein content extended from 28.9 to 35.0%. This large genotypic variability for seed protein content is encouraging when looking for genetic improvement. There is a significant ($P<0.05$) variation in the crude protein content between the locations. The presently reported protein range is highly appreciable compared with previously reported values of jack bean samples from Nigeria (Ajah & Madubuike, 1997; Apata & Ologhobo, 1994); Guatemala (Bressani et al., 1987); Mexico (Tepal et al., 1994) and Ghana (Akpapunam & Sefa-Dedeh, 1997). Nonetheless, their level is comparable with the reports of India (Mohan & Janardhanan, 1994; Rajaram & Janardhanan, 1992; Rodrigues & Torne, 1991) and Philippines (Revilleza et al., 1990).

The mean percentage crude lipid is 4.0, and the contents varying from 3.4% for Neyar dam to 4.7% for Vazhikkadavu; this range is found to be higher than the reports in the same legume from Nigeria (Apata & Ologhobo, 1994); Mexico (Tepal et al., 1994); Philippines (Revilleza et al., 1990) and Guatemala (Bressani et al., 1987). However, this range is found to be low compared with earlier reports from India (Mohan & Janardhanan, 1994; Rajaram & Janardhanan, 1992). In the present study, there is no significant variability in the oil content between the locations.

The ash content is within 3.0–5.8%, the lowest is for Pathanamthetta accession and Vazhikkadavu has the highest. This range is similar to that found in literature for Indian food legumes that serve as good sources of certain minerals.

The crude fibre level is shown in Table 2. High crude fibre could effectively trap and protect a greater proportion of nutrients (protein and carbohydrates) from hydrolytic breakdown, resulting in low digestibility (Balogun & Fetuga, 1986). The South Indian accessions of jack bean, presently investigated, contain high carbohydrates level 46.1–54.5%. The seeds of jack bean, although rich in protein, exhibit energy levels in the range of 1469–1574 kJ 100 g^{-1} DM.

In the present study, the range of protein and lipid is found to be higher than reported for Indian food legumes such as cowpea, field bean, green gram, horse gram, moth bean and peas (Narasinga Rao, Deosthale, & Pant, 1989). Similarly, the range of protein and lipid are found to be lower than some other food legumes such as soybean (Narasinga Rao et al., 1989) and winged bean (Misra, Misra, Prakash, Tripathi, Chandhary, & Misra, 1987; Sathe & Salunkhe, 1981).

The mineral profiles of nine accessions are shown in Table 3. Of all the minerals determined, potassium is the most abundant, ranging from 634 mg 100 g^{-1} in Dasukuppam to 1017 mg 100 g^{-1} in Valacode, followed by calcium with values ranging from 323 mg 100 g^{-1} in Dasukuppam to 498 mg 100 g^{-1} in Valacode accessions. Nonetheless, the range of potassium, evaluated in the present study, is found to be less compared with earlier reports in *Canavalia ensiformis* (Mohan & Janardhanan, 1994; Rajaram & Janardhanan, 1992) and *Cicer arietinum* (Attia, El Tabay, Shehata, Aman, & Hamza, 1994) and their calcium levels seem to be high compared to *Canavalia ensiformis* (Bressani et al., 1987; Rodrigues & Torne, 1991) and food legumes like *Cajanus cajan* (Kumar et al., 1991); *Cicer arietinum* (Attia et al., 1994; Meiners et al., 1976) and *Vigna radiata* (Sharma,

Table 3
Mineral profiles of nine accessions of *Canavalia ensiformis*[a] (mg 100 g^{-1} seed flour)

Location[b]	Sodium[c]	Potassium[c]	Calcium[c]	Magnesium[c]	Phosphorus[c]	Ca:P ratio
Pathanamthetta[M]	48±3.4	876±2.5	350±2.0	191±7.5	467±4.6	1:1.33
Valacode[R]	57±3.8	1017±2.8	498±9.1	192±7.5	240±5.2	1:0.48
Neyar dam[R]	59±4.4	696±5.3	497±9.1	232±3.5	262±5.7	1:0.53
Kodacherry[R]	60±4.5	777±4.8	427±4.3	290±3.9	448±3.2	1:1.05
Vazhikkadavu[M]	42±3.8	848±3.5	420±9.6	319±6.3	469±5.7	1:1.12
Maananthavaadi[M]	39±4.4	784±4.7	450±3.9	187±3.8	281±5.7	1:0.63
Naduvil[R]	43±3.1	752±3.3	392±5.1	192±7.7	51±7.3	1:0.12
Dasukuppam[R]	115±4.7	634±3.8	323±8.3	282±6.2	382±4.7	1:1.18
Gundalpet[R]	103±4.9	712±4.7	405±9.0	366±2.5	355±7.2	1: 0.88
Range	39–115	634–1017	323–497	187–366	51–469	
Mean	62.8	789.3	418.0	250.1	328.3	
S.D.	26.9	109.0	57.9	64.3	131.0	

[a] Results are the average values of three determinations expressed on dry weight basis. ±, standard error.
[b] M, Maroon-colour seed coat; R, Red-colour seed coat.
[c] Significant at $P<0.05$ based on ANOVA.

Bakhshi, & Verma, 1991). Sodium and magnesium levels are generally low with mean values of 63 and 250 mg 100 g^{-1}, respectively. However, all the presently investigated accessions of jack bean seeds are found to contain higher levels of sodium and magnesium than other accessions of *Canavalia ensiformis* reported earlier (Rajaram & Janardhanan, 1992); *Cicer arietinum* (Meiners et al., 1976) and *Phaseolus vulgaris* (Barampama & Simard, 1995). A wide variability (S.D. = 131.0) obtained in respect of phosphorus content of the jack bean accessions may be the reflection of the difference in the phosphorus status of the soils of the different locations where the seeds are collected in accordance with the view of Balogun and Fetuga (1986).

The results showed that there is a vast variability in the mineral contents (as indicated by standard deviation) between the accessions and earlier reports in the same pulse (Mohan & Janardhanan, 1994; Rajaram & Janardhanan, 1992). Such variability in the content of minerals for the same species may be related to genetic origin, geographical source and the levels of soil fertility. Considering the most important major mineral elements (calcium and phosphorus), high calcium with correspondingly low phosphorus in the seeds of Valacode (1:0.48), Neyar dam (1:0.53), Maananthavaadi (1:0.63), Naduvil (1:0.12) and Gundalpet (1:0.88) accessions reflect the disproportionate distribution of calcium and phosphorus. This may affect their utilization for ideal growth and bone formation (Balogun & Fetuga, 1986). However, since the preparation of legume meals by the people in India involves the addition and mixing of a variety of nutritious condiments, the existing imbalance ratio in the legumes could be offset. Finally, in all minerals there is a significant ($P<0.05$) divergence between accessions collected from different locations.

The correlation studies revealed that in the proximate composition, there is a positive correlation between carbohydrates and energy levels ($r=0.52$, $P<0.01$) and significant negative association ($r=0.78$, $P<0.001$) between crude fibre and energy levels. In mineral profiles, a positive correlation occurs between sodium and magnesium ($r=0.57$, $P<0.001$) and between magnesium and phosphorus contents ($r=0.45$, $P<0.01$).

In conclusion, the seeds of jack bean constitute an important substitute for humans since there is compositional variability of proximate and mineral contents.

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