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Nutritional Evaluation of Wild Jack Bean (*Canavalia ensiformis* DC) Seeds in Different Locations of South India

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Abstract: The objective of the present study was to evaluate *C. ensiformis* (Jack beans) seeds with the aim of quantifying chemical and biological information that might serve as a guide to exploit its potentials and benefits for human and animal nutrition. The crude protein level is exhibited in the range of 29.8-32.2 % as well as the crude lipid (3.1-6.0 %), crude fiber (7.34-9.98 %r), ash content (3.56-5.93%), Nitrogen Free Extractives (NFE) (50.77-54.28%) Potassium (614-924mg/100g seed flour), Phosphorus (323 g seed flour), Magnesium (209 g seed flour), Albumins (5.9 g/100g seed flour), globulins (16.5 g/100g seed flour) in all the accessions investigated. In the present study, in all minerals, significant diversity ($P < 0.05$) was observed among the accessions collected from different locations based on analysis of variance (ANOVA) analysis. Based on results of this study, the lesser known and under-utilized seed, *C.ensiformis* can be a potential source of edible as well as a source of protein, mineral element and energy supplements in livestock feeds. Further research can also reveal its potential for human consumption.

Key words: Jack Bean seeds · Proximate composition · Seed storage proteins · Minerals

INTRODUCTION

Tropical developing countries are facing an increasing demand for protein-rich food due to teeming population, cereal based diet and scarcity of fertile land. Although cereals have met the apparent hunger of Indians, hidden hunger due to nutritional imbalances still persists, hence the demand for an inexpensive alternative source of protein to overcome protein energy malnutrition [1]. Recently, some Indian wild legumes have been evaluated for their nutritional potential [2,3]. Legumes are target crops in this regard because they offer rich and abundant sources of protein. Many of the legumes have protein contents between 20% and 40% and a few ranges between 40% and 60% [4]. Among the wild legumes were used in South India, *Canavalia* merited further study in view of tapping its nutritional profiles. The genus *Canavalia* encompassing 48 species distributed throughout the tropics [5] and serious work has been conducted by researchers to tap this nutritional asset.

Jack bean (*Canavalia ensiformis*) is one of the under exploited tropical dry beans. It is, however, fairly widely distributed, being cultivated in Africa, Asia, the West Indies, Latin America and India. The jack bean can be grown in marginal soils and arid to semi arid regions not suitable for common legumes such as *Phaseolus* and *Vigna* species. It has, therefore, great potential in most tropical and subtropical parts of the world [6]. The seed of jack bean, the highly produced large seeded tropical legume, contains about 300g/Kg crude proteins and 600g/Kg carbohydrates [7]. *Canavalia ensiformis* ranks among the underutilized legumes that could ameliorate protein deficiency in human nutrition, particularly in developing countries. The mature seeds are consumed by the Indian tribal sects, Kurumba, Malayali, Irula and other Dravidian groups, after cooking [8].

In western countries this legume is used as a cover crop and the roasted seeds are ground to prepare coffee-like drink [9]. It can be grown relatively easily and produce high yields in the region of low altitude; high temperature and relative humidity. The environment of different locations plays an important role in the determination of quality and quantity of seed proteins. Location effect is relatively more important than that of cultivar of effect of protein content [10]. Therefore, the objectives of the present study are: (1) to analysis the physical parameters, (2) to screen the proximate, protein fractions and mineral composition of jack bean.

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Table 1: Collection details of various accessions of *Canavalia ensiformis* L. DC

Location	Seed coat colour	District	State	Date of collection
Bannari	white	Erode	Tamilnadu	22.05.2009
Kuppanatham	Red	Madurai	Tamilnadu	22.05.2009
Ayodhyapattinam	white	Salem	Tamilnadu	29.05.2009
Arachalur	white	Erode	Tamilnadu	29.05.2009
Keelanadukalli	white	The Nilgiris	Tamilnadu	10.06.2009

MATERIALS AND METHODS

Status of the Germplasm Collection: Five accessions of *Canavalia ensiformis* DC were collected from five different places of Tamilnadu, South India (Table 1). The entire collections were of natural populations of Western Ghats.

Proximate Composition: For the biochemical evaluation, the seeds collected from different places were subjected to prior dried for 4-6 days in direct sunlight followed with thorough cleaning of any foreign materials, broken seeds and immature seeds. The moisture content of the seeds was estimated by taking 25 transversely cut seeds at a time the weight was taken before and after incubation in a hot air oven at 80°C for 24 hours, followed by cooling in a desicator [11]. Oven dried seeds were weighed and ground in a Willey Mill (Scientific equipment) and passed through a 60-mess size screen; three samples of each accessions were analyzed and the results were expressed on dry weight basis. The micro-kjeldahl method was used for determination of nitrogen [12] and the crude protein was calculated by multiplying by a factor 6.25; ash content was determined by heating 2g of the dried sample in a silica dish at 600°C for 6 h [13] and crude fiber [13] were also determined. Carbohydrates content was calculated by difference [14]. 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 [15].

Seed Storage Proteins: Total proteins of the seeds were extracted according to Basha *et al*. [16]. To save prolamin fraction, the ethanol treatment was omitted. Proteins were precipitated with 10% trichloroacetic acid and estimated by the method of Lowry *et al*. [17]. The albumin and globulin fractions were separated according to Murray [18]. The remaining pellet was treated with 80% ethanol (1:10w/v) overnight, centrifuged at 20,000g, 20min, the supernatant containing prolamin was air-dried and dissolved in 0.1N NaOH (1:10w/v),centrifuged (20,000g, 20min), the supernatant thus obtained designated as glutelins as it is alkali soluble. The protein fractions obtained were precipitated with 10%trichloroaceteic acid and redissolved in 0.2 N NaOH to determine the protein content [17].

Mineral Profiles: 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, using different lamps. Phosphorus content was colorimetrically estimated from the triple acid digested samples [19].

RESULTS

In the present study, the seed materials of five different accessions of an under-utilized legume, Jack bean were collected from different agro-ecological regions of South India. After collection, the physical properties, proximate composition, seed storage proteins and minerals were analyzed and the results were expressed in the tables 2-5. The technological use of legume grains largely depends upon their physicochemical properties, which are the determining properties for their successful incorporation into the food systems. The physical characteristics such as seed weight, seed coat weight, seed length, seed width and seed thickness of five different accessions of jack bean seeds were given in the table 2. The seed weight of jack bean were ranged from 0.420-0.606g/10 seeds, seed coat weight falls between 0.228-0.328g/10 seeds, seed length between 1.66-1.73mm/10seeds, seed width ranged from 0.866-1.0mm/10 seeds and seed thickness falls between 0.782-0.846mm/10 seeds.

The moisture content of seeds of five different Jack bean accessions was found to be ranged from 4.24-8.68% (Table.3). Highest level of moisture content was recorded by Arachalur accession. All the accessions of the present study were found to exhibit higher levels of crude protein (29-32 %). Among the five different

Table 2: Physical parameters of seed samples of five different accessions of jack bean

Accessions	Seed weight (g)	[1]Seed coat weight	[2]Seed length	[2]Seed width	[2]Seed thickness
Bannari (w)	0.567 ± 0.003	0.228 ± 0.016	1.666 ± 0.251	1.06 ± 0.057	0.822 ± 0.008
Kuppanatham (r)	0.606 ± 0.007	0.327 ± 0.012	1.7 ± 0.1	0.866 ± 0.057	0.795 ± 0.002
Ayodhyapattinam(w)	0.539 ± 0.025	0.289 ± 0.006	1.733 ± 0.115	0.966 ± 0.115	0.827 ± 0.005
Arachalur (w)	0.420 ± 0.009	0.328 ± 0.010	1.66 ± 0.208	1.0 ± 0.1	0.846 ± 0.004
Keelanadukalli (w)	0.555 ± 0.130	0.323 ± 0.002	1.666 ± 0.152	1.0 ± 0.1	0.782 ± 0.002

[1]Values expressed on gram

[2]Values expressed on mm

Table 3: Proximate composition of seed samples of five different accessions of jack bean*

Accessions	[1]Moisture	[1]Crude Protein[b]	[1]Crude Lipid	[1]Crude fiber	[1]Ash content	[2]NFE[a]	[3]Calorific value
Bannari (w)	8.41 ± 0.01	29.8 ± 0.472	4.1 ± 0.1	7.34 ± 0.015	4.48 ± 0.005	54.28	1558.70
Kuppanatham (r)	8.21 ± 0.20	30.0 ± 0.757	4.2 ± 0.11	9.98 ± 0.005	5.05 ± 0.028	50.77	1507.19
Ayodhyapattinam(w)	4.82 ± 0.01	31.5 ± 0.6	4.1 ± 0.05	9.54 ± 0.030	3.57 ± 0.015	51.29	1537.16
Arachalur (w)	6.18 ± 0.005	31.8 ± 0.378	3.1 ± 0.152	7.34 ± 0.01	5.93 ± 0.020	51.83	1513.49
Keelanadukalli (w)	4.24 ± 0.005	32.2 ± 0.458	6.0 ± 0.1	7.37 ± 0.005	3.56 ± 0.011	50.87	1613.46

NFE-Nitrogen Free Extractives

* Results are the average values of three determinations expressed on dry weight basis (±, standard error)

®-Red colour seed coat, (W) White colour seed coat

[1]Values expressed on g/100g seed flour

[2]Values expressed n percentage

[3]Values expressed on KJ 100g-1 DM

Table 4: Total protein and protein fractions of seed storage protein of five different accessions of jack bean *

Accessions	[1]Total proteins	[1]Albumins	[1]Globulins	[1]Prolamins	[1]Glutelins
Bannari (w)	20.5 ± 1.050	4.0 ± 0.152	15.1 ± 0.1	0.011 ± 0.069	1.9 ± 0.057
Kuppanatham (r)	23.5 ± 1.0	5.9 ± 0.057	16.5 ± 0.173	0.12 ± 0.005	2.2 ± 0.1
Ayodhyapattinam(w)	21.5 ± 1.153	4.8 ± 0.057	15.5 ± 0.115	0.2 ± 0.01	1.8 ± 0.057
Arachalur (w)	22.6 ± 1.00	5.5 ± 0.167	15.8 ± 0.115	0.1 ± 0.011	1.9 ± 0.152
Keelanadukalli (w)	19.8 ± 1.078	4.5 ± 0.040	14.9 ± 0.057	0.09 ± 0.005	1.8 ± 0.057

* Results are the average values of three determinations expressed on dry weight basis (±, standard error)

®-Red colour seed coat, (W) White colour seed coat

[1]Values expressed on g/100g seed flour

Table 5: Mineral profiles of seed samples of five different accessions of jack bean*

Accessions	Phosphorus[b]	Calcium	Magnesium	Potassium[a]	Ca: P ratio
Bannari (w)	260 ± 1.154	480 ±1.0	240 ± 1.154	628 ± 2.516	1: 0.541
Kuppanatham (r)	241 ± 1.527	321 ± 1.527	160 ± 1.527	924 ± 2.516	1:0.750
Ayodhyapattinam(w)	481 ± 1.527	384 ± 1.527	159 ± 3.214	614 ± 2.0	1:1.252
Arachalur (w)	321 ± 2.081	480 ± 1.527	179 ± 1.0	749 ± 1.154	1:0.688
Keelanadukalli (w)	325 ± 2.886	329 ± 0.577	240 ± 1.154	720 ± 2.0	1:0.987

Results are the average values of three determinations expressed on dry weight basis (±, standard error)

®-Red colour seed coat, (W) White colour seed coat

[1]Values expressed on g/100g seed flour

accessions of the present study, the Keelanadukalli germplasm registered high levels of crude protein content (Table.3). The crude lipid content was found to be ranged from 2.0-6.0 % seed flour. The crude fiber content of the present study was 7.34-9.99 %. The Kuppanatham germplasm have registered high levels of crude fiber. The ash content of five different accessions of Jack bean seed flour was found between 3.57-5.93 % and Nitrogen Free Extractives (NFE) or crude carbohydrate (50.77-54.28%) (Table.3).The calorific value recorded by the presently studied Jack bean accessions was to be ranged from 1507.19-1613.46 KJ/100g DM.

The level of different solubility classes of seed storage proteins of Jack bean seeds was presented in table 4. The protein fractionation data revealed that, the globulin forms the major fraction (14.9-16.5g/100g seed flour), which is followed by albumins (4.0-5.9g/100g seed flour). The Jack bean seeds of the present study exhibited high level of minerals such as phosphorous (241-481 mg/100g seed flour), calcium (321-480 mg/100g seed flour), magnesium (159-240 mg/100g seed flour) and potassium 9614-924 mg/100g seed flour).

DISCUSSION

In south India, the tropical forests of Eastern and Western Ghats have a large group of under-utilized food plants from Leguminosae, whose potential hitherto remains untapped [20]. Unless the collected accessions of plant genetic resources from different regions have been properly evaluated and their attribute became known to breeders they will have only a little practical use. Hence, in the present study, the physical characters, proximate composition and minerals were studied and the results were given in the tables 2-5. The range of variation with respect to all the parameters displays the existence of diversity among the five different accessions.

Five different accessions of jack bean seeds have exhibited the moisture content ranged from 4.24-8.68% (Table 3). These values were found to be similar to that of earlier reports on the same legume (3.8-9.2%) [1]. The moisture content of the presently investigated accessions of jack bean seeds were found to be comparable with that of certain wild legume seeds such as *Mucuna monosperma* (6.9%) [21]; *Abrus precatorius* (6.10%) [22]; *Erythrina indica* (6.86%) [23]) and *Entada scandens* (8.26%) [24]. The moisture content of the legume grains plays an important role in giving resistant to insect damage and favors the long storage.

Among the five different accessions of the present study, the Keelanadukali (white) germplasm registered the highest level of crude protein content (32.2g/100g seed flour) (Table 3). The crude protein content (29-32g/100g seed flour) of the presently investigated accessions of jack bean seeds were found to be comparable with that of certain wild legume seeds such as *Mucuna pruriens* var.*pruriens* (24.9-39.5%) [25]; *Canavalia gladiata* (29.3%) [26] and *Entada scandens* (26.82%) [24]. According to Bressani [27], higher level of protein content of seed materials of *Canavalia ensiformis* has nutritional significance, since moderate intake of these seeds will greatly increase the total dietary protein intake of the consumers. Its utilization as a protein ingredient in the animal feed will reduces the over-dependence on the conventional protein supplements notably soybean and other common legumes.

The crude lipid content of all the presently analyzed accessions of jack bean seeds were found to be ranged between 4.1-6g/100g of seed flour (Table 3). The crude lipid values of the present study was higher than *Cassia floribunda* (2.1-3.1%) [20]; *Canavalia gladiata* (2.46%) [26] and *Canavalia gladiata* (2.8-3.8%) [28], but lower than the value reported earlier on *Mucuna pruriens* var. *pruriens* (9.6%) [25] and *Entada scandens* (9.53%) [25].

The crude fiber content of the presently investigated five different accessions of jack bean seeds were found to fall between 7.34 and 9.99 g/100g of seed flour (Table 3) where the Kuppanatham (red) accession registered highest level of crude fiber contents, which is followed by Ayodhyapattinam (white) (9.54) germplasm. The crude fiber content of jack bean seeds was found to be comparable with that of earlier reports on the same jack bean (4.71-11.4%) [1]; *Canavalia gladiata* (9.32%) and *C.virosa* (10.47%) [26]; *Mucuna monosperma* (8.9-9.2%) [21]. The ash content is within the 3.57-5.93% the lowest is found in the Keelanadukali (white) accession and Arachalur (white) has the highest. The Nitrogen Free Extractive (NFE) or crude carbohydrates level of five different accessions of jack bean seeds were found to range from 50.77-54.28% (Table 3). The NFE values of jack bean seeds of the present study was found to be lower when compared to previous reports on certain under-utilized food legumes such as *Cassia floribunda* (58-60.5%) [20]; *Mucuna monosperma* (59.60%) [21] and *Tamarindus indica* (58.8%) [23]. The calorific value of jack bean seeds of the present investigation was found to fall between 1507.19 and 1613.46 KJ/100g Dry Matter (DM) (Table 3). These values appears to be comparable with the earlier reports on the same bean (1568 KJ/100g DM) [29]; *Canavalia gladiata* (1510-1575 KJ/100g DM) [28]; *Abrus precatorius* (1661 KJ/100g DM) [22] and *Entada scandens* (1516 KJ/100g DM) [24]. Energy intake above the actual requirements is harmful, leading to hazards of obesity and its health consequences. On the other hand, energy intake is far below the requirement level leads to under-nutrition and loss of body weight. Proteins are an extremely and increasingly important component of nutrition for both human and animals.

The data of protein fractions of five different accessions of jack bean seeds were presented in table 4, which revealed that, the globulins forms the major fraction (14.9-16.5g/100g of seed flour), which is followed by

albumins (4-5.9g/100g of seed flour), prolamins (0.01-0.2%) and glutelins (1.8-2.2%). The globulin fractions were reported as free from antinutritional factors such as protease inhibitors and lectins and also exhibited good nutritional value [30]. The recent research trend has been directed to evaluate the under-utilized legume seeds as an alternative protein source to meet the protein requirements of increasing human population and expanding livestock industries. In conclusion, among the five different jack bean accession analyzed in the present studies, the Keelanadukali (white) accession was found to possess many desirable nutritive potential with good biological value. Hence, such versatile elite germplasm could be recommended for large-scale cultivation to obtain higher grain yield with cost-effective agricultural practices.

The mineral profiles of five accessions are shown in table.5. Of all the minerals determined, Potassium is the most abundant, ranging from 614 mg/100g seed flour in Keelanadukali to 924 mg/100g seed flour in Kuppanatham, followed by Calcium with values ranging from 321 mg/100gseed flour^{-1} in Keelanadukali to 480 mg/100seed flourg^{-1} in Kuppanatham accessions. Nonetheless, the range of potassium, magnesium and phosphorus evaluated in the present study, is found to be less when compared with earlier reports in *Canavalia ensiformis* [31] and *Cicer arietinum* [32] and their calcium levels seems to be high when compared to *Canavalia ensiformis* [33] and food legumes like *Cajanus cajan* [34] and *Vigna radiata* [35]. Magnesium levels are generally low with the mean values of 209.5 mg100g^{-1} respectively. A wide variability (S.D = 84.682) obtained in respect of phosphorus content of the jack bean accessions may be the reflection of the differences in the phosphorus status of the soils of the different locations where the seeds are collected in accordance with the view of Vadivel and Janarthanan [2]. Considering the most important major mineral elements (Calcium and Phosphorus), high calcium with correspondingly low phosphorus in the seeds of Kuppanatham (1:0.541), Arachalur (1:0.0987), Keelanadukali (1:0.750) and Ayodhyapattinam (1:0.688) accessions reflect the disproportionate distribution of calcium and phosphorus. This may affect their utilization for ideal growth and bone formation (Vadivel and K Janardhanan, 2001a).

CONCLUSIONS

The study indicates that the seeds have potential for human feeding, judging from their proximate composition, total proteins and gross energy in several aspects, compared favorably with the reported conventional edible legumes. Exploitation of such potential under-utilized legume grains as a protein ingredient in the food/feed will clearly reduce the over-dependence on common legumes for increasing protein requirements, especially in the developing countries. In conclusion, the seed of jack bean constitute an important substitute for humans since there is compositional variability of proximate contents.

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