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Studies on the Underexploited Tree Pulses, *Acacia catechu* Willd., *Parkinsonia aculeata* L. and *Prosopis chilensis* (Molina) Stunz: Chemical Composition and Antinutritional Factors

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ABSTRACT

Three different underexploited tree pulses, Acacia catechu, Parkinsonia aculeata *and* Prosopis chilensis, *are analysed for proximate composition, seed protein fractions, amino acid profiles, minerals and antinutritional factors. The seeds of* Prosopis chilensis *contain higher contents of crude protein and crude lipid compared with most common pulses. The seeds of all the three pulses analysed are rich in the minerals K, Ca, Mg and Fe. The albumins and glutelins constitute the major bulk of seed proteins in* Parkinsonia aculeata *and* Prosopis chilensis. *All the three species are distinctly deficient in sulpho-amino acids, cystine and methionine. Apart from this, the seed proteins of* P. aculeata *are deficient in isoleucine + leucine and the seed proteins of* P. chilensis *are deficient in threonine and tyrosine + phenylalanine. Antinutritional factors such as total free phenols, tannins,* L-*DOPA, haemagglutinating activity and trypsin inhibitor activity are also analysed.*

INTRODUCTION

The food legumes contribute about 2/5 or more of protein in the diet of the inhabitants of the tropics (Luse & Rachie, 1978) and they are potentially able to fill the protein-gap (Pinstrup-Anderson *et al.*, 1984). One of the important approaches in improving modern cultivars is to utilize the secondary and tertiary gene pools of wild progenitors in the inter-breeding programmes.

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The exploration of such wild germplasms led to the discovery of certain novel variants with superior nutritional qualities (Gopinathan *et al.*, 1987). Very scanty information is available on the chemical composition of wild relatives of crop plants. In this context, in the present investigation, an attempt has been made to understand the chemical composition and antinutritional factors of the tree pulses, *Acacia catechu*, *Parkinsonia aculeata* and *Prosopis chilensis* with a view to assessing their nutritional quality. In India the cooked seeds of these three tree species are known to be consumed by tribal people living in Madhya Pradesh (Personal communication from Dr J. K. Maheswari, Deputy Director, National Botanical Research Institute (NBRI) Lucknow, Uttar Pradesh, India).

MATERIALS AND METHODS

The seeds of *Acacia catechu*, *Parkinsonia aculeata* and *Prosopis chilensis* were procured from Dr J. K. Maheswari, NBRI, Lucknow, UP, India. The moisture content was measured by drying 50 transversely cut mature and dry seeds in an oven at 80°C for 24 h and it is expressed on a percentage basis. The seeds were powdered separately in a Wiley Mill to 60 mesh size. The fine seed powder so obtained was used for further analyses. The crude protein content was calculated by multiplying the percent Kjeldahl nitrogen (Humphries, 1956) by the factor 6·25. The remaining proximate constituents were estimated by AOAC (1970) methods. The nitrogen-free extractives were calculated by difference (Muller & Tobin, 1980). The energy content was determined by multiplying percentages of crude protein, crude fat and nitrogen free extractives (total crude carbohydrates) with the factors 4, 9 and 4, respectively (Osborne & Voogt, 1978). The total true proteins were extracted by the method of Basha *et al.* (1976) with slight modification (ethanol treatment was omitted so as to save the prolamin fraction). The extracted proteins were purified by precipitation with cold 20% TCA. The seed protein fractions, albumins and globulins, were extracted following the method of Basha and Beevers (1975). From the residual pellet the prolamin fraction was extracted by treating it with 70% ethanol 1:5 (w/v) overnight; after centrifugation the supernatant, containing prolamins, was air-dried and dissolved in 0·1 N NaOH. To the remaining pellet 0·4N NaOH (1:10 w/v) was added, left overnight and centrifuged at 20 000*g* for 20 min. The supernatant thus obtained was designated as glutelins. The fractions so obtained were estimated (Lowry *et al.*, 1951) after 20% cold TCA precipitation. The purified total seed proteins were acid-hydrolysed with 6N HCl at 110°C for 24 h *in vacuo*. After flash evaporation the dried residue was dissolved in citrate buffer (pH 2·2). Known aliquots were analysed in a LKB-

Biochrome Automated Amino Acid Analyser Model, 4151-Alpha Plus. The different amino acids recovered are presented as g/100 g protein. All the minerals except phosphorus were analysed by Atomic Absorption Spectrophotometer (Issac & Johnson, 1975). Phosphorus content in the triple acid-digested extract was determined colorimetrically (Dickman & Bray, 1940). The antinutritional factors such as tannins (Burns, 1971), total free phenols (Bray & Throne, 1954), the non-protein amino acid, L-DOPA (3,4-dihydroxyphenylalanine) (Brain, 1976) were quantified. The haemagglutinating activity of albumin and globulin fractions of seed proteins (Liener, 1976) and the trypsin inhibitor activity of the seed meal (Chrispeels and Baumgartner, 1978) were also assayed.

RESULTS AND DISCUSSION

The contents of crude protein and crude lipid reported in the present study for the seeds of *P. chilensis* (Table 1) are higher when compared with the four most commonly consumed pulses, green gram, black gram, pigeonpea and chickpea, in India (*IARI Res. Bull.* No. 6, 1971; Gupta & Wagle, 1978; Jambunathan & Singh, 1980, 1981). Similarly, the crude protein content of *P. aculeata* is more or less equal to that of the four most commonly consumed pulses in India. Of the three tree pulses investigated, *Prosopis chilensis* has a higher calorific value than *A. catechu* and *P. aculeata.* Seed protein fractionation data (Table 2) reveal that only in *A. catechu* the albumins and globulins constitute the major bulk of seed proteins as in most of the legumes (Boulter & Derbyshire, 1976; Duranti & Cereletti, 1979; Janardhanan & Lakshmanan, 1985). Nonetheless, the glutelin fraction of seed proteins predominates in *P. aculeata* and *P. chilensis* as in *Phaseolus aureus*, *P. mungo* and *P. mungoreus* (Gupta & Wagle, 1979) and *Bauhinia racemosa* (Rajaram & Janardhanan, 1990). The data on amino acid profiles indicate that *A. catechu* seed proteins are distinctly deficient only in cystine and methionine compared with the WHO requirement pattern (FAO/WHO, 1973). The levels of all the other essential amino acids are more or less comparable or higher than that of the WHO requirement pattern (Table 3). The seed proteins of *P. aculeata* are distinctly deficient not only in sulpho-amino acids but also in isoleucine + leucine. On the other hand, the seed proteins of *P. chilensis* are markedly deficient in sulpho-amino acids, threonine and tyrosine + phenylalanine when compared with the WHO requirement pattern. Thus it is evident that the seed proteins of *A. catechu* are nutritionally superior to the other two tribal pulses, whereas the seed proteins of *P. chilensis* are nutritionally inferior to the other two pulses investigated.

TABLE 1
Proximate and Mineral Composition[a]

	Proximate composition (%)				*Mineral composition (mg 100 g^{-1} seed flour)*		
	Acacia catechu	Parkinsonia aculeata	Prosopis chilensis		Acacia catechu	Parkinsonia aculeata	Prosopis chilensis
Moisture	6·21 ± 0·03	13·33 ± 0·02	9·80 ± 0·03	Na	26·49 ± 0·33	34·60 ± 0·05	23·93 ± 0·19
Crude protein (Kjeldahl N × 6·25)	16·25 ± 0·06	21·25 ± 0·48	26·69 ± 0·24	K	2 267·28 ± 1·91	2 968·86 ± 2·07	2 749·22 ± 1·94
Crude lipid	2·20 ± 0·04	2·50 ± 0·03	12·33 ± 0·05	Ca	472·35 ± 0·83	553·63 ± 0·57	582·73 ± 0·51
Crude fibre	11·06 ± 0·11	4·71 ± 0·05	9·80 ± 0·06	Mg	990·78 ± 0·74	403·70 ± 0·26	509·89 ± 0·26
Ash	4·65 ± 0·06	5·55 ± 0·02	4·72 ± 0·07	P	293·78 ± 0·33	311·40 ± 0·19	338·19 ± 0·31
Nitrogen-free extractives (NFE)	65·84	65·99	46·46	Fe	26·38 ± 0·12	32·30 ± 0·11	20·81 ± 0·08
				Cu	0·58 ± 0·06	0·35 ± 0·02	5·21 ± 0·05
Calorific value (kcal 100 g^{-1} DM)	348·16	371·46	403·57	Zn	1·38 ± 0·02	1·27 ± 0·02	1·23 ± 0·02
				Mn	1·73 ± 0·04	4·61 ± 0·05	5·21 ± 0·07

[a] All values are means of triplicate determinations expressed on dry weight basis.

TABLE 2
Data on Seed Total (true) Proteins and Protein Fractionation ($g\ 100\,g^{-1}$ seed flour)[a]

Name of the fraction	Acacia catechu	Parkinsonia aculeata	Prosopis chilensis
Total protein (True protein)	14·30 ± 0·04	17·44 ± 0·08	23·28 ± 0·05
Albumins	4·60 ± 0·04	4·72 ± 0·07	7·70 ± 0·07
Globulins	6·10 ± 0·15	2·51 ± 0·04	6·40 ± 0·04
Prolamins	1·20 ± 0·05	0·89 ± 0·02	0·56 ± 0·03
Glutelins	2·40 ± 0·06	9·32 ± 0·11	8·62 ± 0·08

[a] All values are means of triplicate determinations expressed on dry weight basis.

TABLE 3
Amino Acid Profiles of Acid-Hydrolysed, Purified Total Seed Proteins

	Acacia catechu (*g 100 g*$^{-1}$) *protein*)	Parkinsonia aculeata (*g 100 g*$^{-1}$ *protein*)	Prosopis chilensis (*g 100 g*$^{-1}$ *protein*)	*FAO/WHO (1973) requirement pattern (g 100 g*$^{-1}$ *protein)*
Glutamic acid	9·03	13·16	20·53	—
Aspartic acid	11·00	12·93	13·64	—
Serine	3·57	4·85	2·96	—
Threonine	3·90	3·86	2·34	4·0
Proline	7·32	5·49	3·42	—
Alanine	6·46	4·09	4·38	—
Glycine	3·47	4·32	4·81	—
Valine	4·90	8·64	5·96	5·0
Cystine } Methionine	Trace Trace	Trace Trace	Trace Trace }	3·5
Isoleucine } Leucine	14·27	9·84	12·41	4·0 7·0
Tyrosine	3·37	4·20	2·52	
Phenylalanine	4·86	4·91	2·12	6·0
Lysine	5·53	5·43	8·53	5·5
Histidine	3·23	3·55	1·67	—
Tryptophan	ND	ND	ND	1·0
Arginine	10·8	7·12	9·0	—

ND Not detected.

The data on mineral analysis reveal that the seeds of all the three tree species appear to be rich sources of K, Ca, Mg and Fe. Besides these four elements, the seeds of *Prosopis chilensis* contain adequate concentrations of Cu and Mn when compared with RDA values (NRC/NAS. 1980).

The usefulness of legumes is decreased by toxic or antinutritional compounds associated with the large protein content in their seeds (Nowacki, 1980). Some of the antinutritional factors like protease inhibitors, lectins, tannins, goitrogens, cyanogens, amylase inhibitors and antivitamin factors constitute the heat-labile antinutritional factors (Liener, 1980), whereas toxic amino acids, alkaloids and cyanogenic glucosides form the heat-stable antinutritional factors (Nowacki, 1980). The amount of free phenols and tannins estimated in the seeds of the three species (Table 4) seems to be not exceeding the levels present in commonly consumed legume

TABLE 4
Data on Antinutritional Factors

Component		Acacia catechu	Parkinsonia aculeata	Prosopis chilensis
Total free phenols		$1{\cdot}03^a \pm 0{\cdot}02$	$0{\cdot}77^a \pm 0{\cdot}03$	$0{\cdot}96^a \pm 0{\cdot}02$
Tannins		$0{\cdot}83^a \pm 0{\cdot}01$	$0{\cdot}05^a \pm 0{\cdot}01$	$0{\cdot}07^a \pm 0{\cdot}01$
L-DOPA		NP	$0{\cdot}64^a \pm 0{\cdot}02$	$1{\cdot}25^a \pm 0{\cdot}06$
Phytohaemagglutinating activity[b]				
Name of the protein fraction	*Erythrocytes from the human blood group*		*Haemagglutinating activity*	
Albumins	A	+	—	+
Albumins	B	+ +	—	+
Albumins	O	+	—	+
Globulins	A	+	+	+
Globulins	B	+ +	+	+
Globulins	O	+	+	+
Half inhibition of trypsin/mg protein[b]		46·20 units	36·10 units	37·10 units
Protein content of the extract used for trypsin inhibitor assay (mg/ml)		15·40	12·03	12·40

[a] Denotes mean of triplicate determinations expressed on dry weight basis (%).
[b] Values of two independent experiments.
+ = Some clumping, pellet disperses partially.
+ + = No dispersion of pellet.
— = No clumping, pellet disperses easily.
NP = Not present.

seeds such as chickpea, black gram, green gram and cowpea (Khan *et al.*, 1979; Rao & Deosthale, 1982). The content of L-DOPA present in *Parkinsonia aculeata* and *Prosopis chilensis* appears to be relatively low when compared with the earlier values reported in different species of *Mucuna* (Pieris *et al.*, 1980; Janardhanan & Lakshmanan, 1985).

With the exception of *Parkinsonia aculeata*, the albumin and globulin fractions of the other two species exhibit haemagglutinating activity without any specificity against the human ABO system as in the case of *Dolichos lablab* (Kaushik, 1984); *Psophocarpus tetragonolobus* (Kotaru *et al.*, 1987) and *Psophocarpus scandens* (Kortt, 1988). Hence the haemagglutinating activity is very weak in *P. aculeata*, whereas it is very strong in *A. catechu*. In soyabean seeds, haemagglutinins (lectins) played a minor role in the nutritional value (Liener, 1980). Nonetheless, Jaffe (1960) (see Liener, 1980) postulates that the action of haemagglutinins is to combine with cells that line the intestinal mucosa, and cause a nonspecific interference with the absorption of nutrients. The trypsin inhibitor activity in all the investigated tribal pulses falls within the physiological limits not exceeding the levels present in soybean (Roy & Bhat, 1974) and winged bean (Misra *et al.*, 1987).

From these chemical investigations it is concluded that the three tree legume seeds viz., *Acacia catechu*, *Parkinsonia aculeata* and *Prosopis chilensis*, can be used as alternative protein crops. The adverse effect of the antinutritional factors (total free phenols, tannins, lectins and trypsin inhibitor) detected in the present study can be eliminated by moist heat treatment or the cooking process since they are heat-labile.

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