Protein Quality and Antinutritional Factors of Wild Legume Seeds from the Sonoran Desert

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Seeds from seven species of legume trees of the Sonoran Desert were studied to determine their potential value as a nonconventional food and/or as a feed source. Seed proximal composition and protein quality were evaluated by conventional methodology. Defatted flours from *Acacia farnesiana*, *Cercidium microphyllium*, *Cercidium sonorae*, *Mimosa grahamii*, *Olneya tesota*, *Parkinsonia aculeata*, and *Prosopis juliflora* have protein contents that ranged from 20 to 30%. These proteins were deficient in sulfur amino acids but high in lysine and phenylalanine content. Except for *M. grahamii* seeds, trypsin inhibitors were relatively high in all species and varied from 50 to 70 TIU/g. Other antinutritional factors as lectins, alkaloids, saponins, and phenols were detected in all but *Mimosa* seeds. Protein *in vitro* digestibility was found to be 77−84%, and these values increased (5−10%) after a thermic treatment. The calculated C-PER values were found to be 1.8−2.1%. From the seeds of the seven species evaluated, *M. grahamii* showed the highest potential as a protein source.

Keywords: *Desert legume seeds; protein quality; antinutritional factors*

INTRODUCTION

Intense efforts to find alternative sources of proteins from plants adapted to adverse conditions are been conducted around the world (Siddhuraju et al., 1995; Bravo et al., 1994; Bhattacharya et al., 1994). Seeds from *Cassia laevigata* and *Tamaridus indica*, both legumes from India, were reported as a low-cost protein source to alleviate the protein malnutrition among people living in developing countries (Siddhuraju et al., 1995). Seeds and pods from the genera of *Acacia*, *Olneya* (palo fierro, iron wood), and *Prosopis* (mesquite) have been used in several countries for human consumption, livestock food, and fodder production (Figueiredo, 1990; Degen et al., 1995; Felker, 1981). Studies of mesquites from South America and the Mediterranean confirmed that these plants produce pods and seeds that are palatable to human and animals. In a recent comparison of mesquite pods with carob pods (the latter is widely used in the food industry), it was demonstrated that mesquite pods had better nutritional properties than carob pods, including lower polyphenolic content and higher protein digestibility (Bravo et al., 1994).

In Mexico, the Sonoran Desert has a large group of perennial trees from the Leguminosae family that produce large amounts of indehiscent pods; however, the chemical composition and protein quality of their seeds remain unknown. These plants have important agronomic characteristics applicable under unfavorable conditions such as reduced availability of water and fertilizers (Felker, 1981; Meyer et al., 1986; Bresanni and Elias, 1974). In the United States, some of these species have been used for arid land reforestation and erosion control (Estrada and Marroquin, 1992). Furthermore, *Prosopis* pod yield has been estimated up to 10 000 kg/ha (Felker, 1981; Felger and Nabham, 1978). In this work, seeds of seven legume species of the Sonora Desert were selected based on their abundance in the natural habitat and productivity, and their seed composition and protein quality were determined by conventional methods.

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MATERIALS AND METHODS

Seeds from selected species were collected from various regions of the Sonoran Desert (Rodney et al., 1972; Ortega-Nieblas, 1993). The species were *Acacia farnesiana* (huizache), *Cercidium microphyllium* (palo verde 1), *Cercidium sonorae* (brea), *Mimosa grahamii* (gatuña), *Olneya tesota* (palo fierro, iron wood) *Parkinsonia aculeata* (palo verde 2), and *Prosopis juliflora* (mesquite). Seeds were manually separated from husks and ground on a Wiley grinder using a 150 μm mesh. All reagents used were of analytical grade.

Chemical Analysis. Fat was extracted from 100 g of meal in a Soxhlet apparatus using hexane (AOAC, 1990). Defatted flours were stored at 4 °C until used. The nitrogen content of flours was determined using the micro-Kjeldahl method (AOAC, 1990). A conversion factor of 6.25 was used to calculate protein content. Moisture, crude fiber, and ash were determined using the official methods (AOAC, 1990). Carbohydrate content was calculated by difference.

Antinutritional Factors. Trypsin inhibitors were determined by using the procedure described by Hamerstrand and Black (1981). Phenols, alkaloids, and saponins were determined using the methods described by Goldstein and Swain (1975), Waldi and Schnackerz (1973), and Harbone (1984).

Hemagglutinin Activity. Crude extracts were obtained by extraction of flours in saline solution, 1:10 (w/v), for 2 h at room temperature and overnight at 4 °C. Crude extracts were recovered after centrifugation, 20 min at 5000*g* (Lis and Sharon, 1986). Hemagglutinin activity was determined by the serial double-dilution method using human B^+ erythrocytes treated with trypsin (Turner and Liener, 1975).

Table 1. Proximate Composition and Antinutritional Factors of Wild Legume Seeds from the Sonoran Desert[a]

	composition (%)					antinutritional factors				
species	protein	ash	fiber	CHO	fat	TIU/g	phenols (%)	alkaloids	saponins	HT
A. farnesiana	$23.5^{b} \pm 0.3$	$5.0^{a} \pm 0.2$	$6.3^{a} \pm 0.1$	$53.2^{c} \pm 0.5$	$12.0^{d} \pm 0.1$	$67^{b} \pm 0.4$	$13^{a} \pm 1.0$	+	−	4
C. microphyllium	$22.5^{b,c} \pm 0.3$	$3.7^{b} \pm 0.4$	$6.0^{a} \pm 0.1$	$49.6^{e} \pm 0.5$	$18.2^{b} \pm 0.2$	$67^{b} \pm 0.4$	$8^{d,c} \pm 0.6$	+	−	4
C. sonorae	$22.0^{b,c} \pm 0.5$	$3.6^{b} \pm 0.3$	$6.0^{a} \pm 0.1$	$51.9^{d} \pm 1.0$	$16.5^{b} \pm 0.1$	$63^{c} \pm 1.0$	$8^{b,c} \pm 0.1$	+	−	2
M. grahamii	$30.1^{a} \pm 0.2$	$1.3^{c} \pm 0.1$	$2.3^{b} \pm 0.5$	$42.8^{g} \pm 0.2$	$23.5^{a} \pm 0.3$	$50^{e} \pm 1.0$	$3^{e} \pm 1.0$	−	−	0
O. tesota	$19.5^{c} \pm 0.2$	$2.5^{b,c} \pm 0.2$	$6.5^{a} \pm 0.2$	$61.2^{b} \pm 0.5$	$10.3^{d,e} \pm 0.2$	$70^{a} \pm 1.0$	$10^{b} \pm 0.5$	+	−	8
P. aculeata	$21.0^{b,c} \pm 0.1$	$3.3^{b} \pm 0.2$	$5.2^{a} \pm 0.2$	$62.0^{a} \pm 0.6$	$8.5^{e} \pm 0.1$	$65^{b,c} \pm 1.0$	$7^{d} \pm 0.4$	+	−	8
P. juliflora	$28.7^{a} \pm 0.2$	$3.5^{b} \pm 0.1$	$5.2^{a} \pm 0.1$	$48.1^{f} \pm 0.5$	$14.5^{c} \pm 0.3$	$60^{d} \pm 1.0$	$5^{d,e} \pm 0.3$	+	−	2

[a] Mean values within each column followed by the same letters are not significantly different at $p < 0.05$. TIU, trypsin inhibitors, international units; HT, hemagglutinin titer; +, detected; −, not detected.

Amino Acid Composition. All amino acid analyses were performed using the hydrolysis procedure (Schmidt et al., 1979) followed by separation and quantitation of derivatized amino acids using a LKB 4150 amino acid analyzer with an C_{18} column according to Yensen and Weber (1987).

***In Vitro* Digestibility.** The multienzymatic method was used according to Satterlee et al. (1982). The flours received a thermal treatment at 75 °C for 5 min.

Index of Computerized Protein Efficiency (C-PER). Calculated by the procedure described by Satterlee et al. (1984), this index represents an estimated PER value.

Statistical Analysis. Statistical significance of means was evaluated by analysis of variance (SAS, 1988). Means were separated by Tukey's studentized range test.

RESULTS AND DISCUSSION

Proximate Composition. Seed protein content ranged from 20% in *O. tesota* to 30% in *M. grahamii* (Table 1). This range was generally similar to the values reported by Bressani and Elías (1974) for edible legume seeds (18−32%). Protein content of *P. juliflora* was higher than values given for *P. chilensis* and *P. argentina* and lower than those for *P. nigra*, *P. caldenia*, and *P. alba* by Lamarque et al. (1994). On the other hand, *A. farnesiana*, *C. microphylium*, and *P. aculeata* agree with the percentages reported for these species (Sotelo, 1981). Fat contents varied from 9 to 24%; these percentages were higher than for most cultivated legumes. Interestingly, *M. grahamii* had an oil content higher than that reported for soybean (*Glycine max*), a common oil source (Bressani and Elias, 1974). This content remains unchanged independently of the year or area of collection (unpublished data; Ortega-Nieblas and Vázquez-Moreno, 1995). Fat content of *P. juliflora* was lower than that of *P. flexuosa* and similar to that of *P. argentina* and *P. nigra*. The ash content was within 1−5%, the lowest was for *M. grahamii*, and *A. farnesiana* had the highest. This range is similar to that found in the literature for legumes that serve as good source of minerals such as iron, potassium, manganese, and phosphorus. Except for gatuña (2%), the rest of the species had similar fiber content (Table 1) as those reported for widely consumed legumes (Sotelo, 1981). Also the desert seeds contained more carbohydrates. In particular, gatuña showed protein and fat in significantly higher amounts than the other studied species.

Protein quality is affected by factors that interact with the intestinal tract, digestive proteases, or other proteins, reducing protein digestibility and amino acid absorption (i.e., trypsin inhibitors, phenols, and agglutinins) (Pusztai et al., 1993). In studied seeds, trypsin inhibitors were within the range of 50−70 TIU/g (Table 1) and phenols ranged from 3 to 13%. These values are lower than those reported for commonly consumed legume seeds (Hamerstrand and Black, 1981; McFarlane, 1975). Both factors were significantly lower in gatuña seeds. All species, except *M. grahamii*, contained alkaloids and hemagglutinating activities. However, none of the species presented factors in high enough concentration to constitute a major nutritional problem. These antinutritional factors are polar compounds, soluble in saline solutions, which, if required, can be removed by soaking or during cooking.

Table 2. Essential Amino Acid Contents in Wild Legume Seeds (Grams per 100 g of Protein)[a]

species	Met + Cys	Lys	Ile	Leu	Phe	Val	Thr	Trp
A. farnesiana	1.6	7.0	2.3	6.0	3.7	5.0	3.1	0.8
C. microphyllium	1.9	6.9	2.5	6.0	3.4	5.0	3.7	0.6
C. sonorae	2.2	6.0	2.1	6.1	3.6	4.3	3.3	0.5
M. grahamii	3.8	5.1	1.9	6.3	2.6	2.7	4.7	0.6
O. tesota	0.8	7.7	1.9	5.0	3.1	3.0	1.2	0.2
P. aculeata	1.4	6.7	2.4	6.2	3.4	5.1	3.9	0.7
P. juliflora	1.8	2.9	2.0	6.3	2.3	2.8	3.0	0.4
FAO/WHO 1973	3.5	5.5	4.0	7.0	2.8	5.0	4.0	1.0

[a] Analysis performed in triplicate.

Table 3. *In Vitro* Digestibility and C-PER of Proteins from Desert Legume Seeds[a]

	digestibility (%)		
flour	raw flour	thermally treated flour	C-PER
casein (control)	92^{a}	94^{a}	2.5
A. farnesiana	73^{d}	82^{d}	1.9
C. microphyllium	76^{d}	$85^{c,d}$	1.8
C. sonorae	80^{c}	$86^{c,b}$	1.9
M. grahamii	84^{b}	90^{b}	2.1
O. tesota	74^{d}	79^{e}	1.8
P. aculeata	76^{d}	$85^{c,d}$	1.8
P. juliflora	67^{e}	76^{e}	1.9

[a] Mean values within each column followed by the same letters are not significantly different at $p < 0.05$. C-PER, computerized index of protein efficiency; standard deviations were <1%.

Amino Acid Composition. As in all legumes, the seeds studied were deficient in sulfur-containing amino acids; also Ile, Trp, Leu, and Thr were low, but they have higher levels of lysine and phenylalanine than the FAO/WHO (1973) reference pattern (Table 2). However, *A. farnesiana*, *C. microphyllium*, *C. sonorae*, and *M. grahamii* contained higher levels of all the essential amino acids than those suggested for human adult amino acid requirements (FAO/WHO, 1991). As traditionally done with legumes, their amino acids could be supplemented with that from cereals (Bressani, 1975; Sotelo, 1981).

Flours had an *in vitro* digestibility of 67−84% (Table 3). These values were higher than those reported for conventional legumes such as common beans (*Phaseolus vulgaris*), chickpea (*Cicer arietinum*), pea (*Pisum sativum*), and soybean (*G. max*) proteins (64−67%) (Elias and Bressani, 1976). The highest *in vitro* digestibility value was for *M. grahamii* followed by *C. sonorae*.

However, these values were significantly lower than casein (Table 3). Furthermore, these digestibility percentages increased 5−10%, when the flours were heat treated (75 °C for 5 min), and *M. grahamii* digestibility was closer to that of casein but continued significantly lower (Table 3). Based on amino acid composition and digestibility data, C-PER indexes were calculated, and most species presented values of 1.8−1.9 (Table 3). These are similar to those reported for chick pea and peas. The *M. grahamii* C-PER value was identical with that of soybean and common bean (Wolzack et al., 1981).

Among the studied seeds, *M. grahamii* presented significantly higher values of protein content, *in vitro* digestibility, C-PER, and fat content. From these qualities, it was considered to have the highest potential for use as a nutritional source.

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