Some Physical and Chemical Properties of Honey Mesquite Pod (*Prosopis glandulosa*) and Applications in Food Products

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ABSTRACT

Certain physical and chemical properties of honey mesquite pod, seed, and pericarp were determined relative to food application. Flour made from the mesquite pods had similar density but superior water and oil absorption capacities to those of wheat flour. Of the 1.7% total nitrogen in the pod, 24% was nonprotein nitrogen that was mostly from the pericarp. As a function of pH, the total nitrogen in the pod, seed, and pericarp was more soluble at pH 2.0 and above 7.0. Mesquite pod contained high amounts of detergent fiber, which was mostly contributed by the pericarp. The neutral detergent fiber content of the pod was comparable to that of wheat bran. Sensory attributes of crackers and muffins made from wheat flour substituted with up to 30% mesquite pod flour were evaluated by taste panelists. The mesquite pod flour was a better substitute for wheat flour in crackers than in muffins. When mesquite pod flour was supplemented for wheat flour at 0, 10, 20, and 30% and fed to weanling rats, only the protein efficiency ratio of the 30% substitution level was significantly higher ($P < 0.05$) than that of the 100% wheat flour diet. However, the protein efficiency ratio at this level was still significantly lower ($P < 0.05$) than that of the casein diet.

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Mesquite in North America is known as a common woody leguminous plant of the genus *Prosopis* growing in the arid and semiarid regions of the world. Uses of the different *Prosopis* species as food, feed, fuel, and building material have been reviewed in the literature (Felker and Bandurski 1979, Felker 1979), and at a symposium on mesquite utilization held at Lubbock, TX, in 1982.

All *Prosopis* species produce indehiscent pods (Felker 1979) that consist of two main parts, the pericarp (which includes the exo-, meso-, and endocarp) and the seed. The proportion by weight of seed to pericarp fraction of the pods has been found to be 15:85 for honey mesquite (*P. glandulosa*) and 25:75 for velvet mesquite (*P. velutina*) (Becker and Grosjean 1980, Zolfaghari and Harden 1985). Felker (1979) reported values of seed/pod weight ratio of 20 *Prosopis* species to range from 8.4 to 33%. Chemical analyses of *Prosopis* species have shown that the whole pods contain 9–17% protein, 13–31% sucrose, and 17–31% crude fiber (Walton 1923, Adler 1949, Pak et al 1977, Becker and Grosjean, 1980, Becker 1982, Meyer et al 1982, Del Valle et al 1983, Zolfaghari and Harden 1985). Whereas the pericarp consists mostly of sucrose and crude fiber, the seed contains most of the protein in the pod. Recently, Meyer et al (1982) developed a dry milling process for separating velvet mesquite pod into four fractions including exo-mesocarp (high-sugar fraction), endocarp (high-fiber fraction), endosperm splits (high-gum fraction), and cotyledon (high-protein fraction). Although an elaborate milling process such as this seems to be essential to fractionate mesquite pods, using whole pods may be an alternative, as this would reduce milling costs. In this study certain physical and chemical properties of honey mesquite pods have been investigated. Further, the whole pod flour was used as a supplement to commercial wheat flour in selected food products.

MATERIALS AND METHODS

Sample Preparation

Approximately 40 kg of mature honey mesquite pods was harvested from trees growing in Mitchell County, TX. The pods, free from insect damage, were washed in a solution of sodium dodecyl sulfate (17 cm^3 dry detergent per 38 L of water), rinsed in three changes of fresh water, and spread in a flat basket according to the method of Collins and Post (1981). The pods were then air dried by a fan at room temperature for 4 hr to remove residual water.

Portions of the pods were separated by hand into two fractions, seed and pericarp. The proportion by weight of seed to pericarp fraction of the pods was 15.8:84.2 as received. After drying in a forced-air dehydrator at 48°C for 16 hr, the pods, seeds, and pericarp were ground separately in a Thomas Wiley laboratory mill to pass through a 1-mm screen. The ground samples were stored in a freezer at −18°C until analysis.

Physical Properties

Direct density of mesquite samples was determined according to the method of Parrott and Thrall (1978). The mesquite sample was added to a specified mark on a graduated cylinder with minimal shaking to assure complete filling. The contents of the cylinder were weighed, and the average of triplicate determinations was expressed in grams per milliliter.

Water absorption capacity was determined in triplicate by the procedure of Sosulski (1962) with slight modification for the mesquite seed. Because of the absorption of a large amount of water by the seed flour, 2.5 g of seed flour was used instead of 5 g. A weighed amount of flour samples was transferred into tared 50-ml centrifuge tubes. After addition of 30 ml distilled water, the flour was brought into suspension for 30 sec with a glass stirring rod. The suspension was allowed to rest for 10 min, during which any flour adhering to the side of the centrifuge tube was scrubbed down with the glass rod to prevent drying. Seven additional mixings of 20 sec with 10 min rest periods following each mixing were made. Distilled water (10 ml) was used to wash the flour adhering to the stirring rod into the sample. The suspension was centrifuged at 1,610 × g for 25 min. After centrifugation, the supernatant liquid was decanted, and the centrifuge tube was placed mouth down at an angle of 20° in a forced-draft-air oven. The tube was allowed to drain and dry for 25 min at 50°C. The tube was cooled to room temperature in a desiccator and weighed. Water absorption capacity was expressed as the percentage increase in weight of sample on a dry weight basis.

Oil absorption capacity of mesquite samples was determined in triplicate by the method of Lin et al (1974). Half a gram of sample and 3 ml of corn oil were added to a 15-ml conical graduated centrifuge tube. The contents were stirred for 1 min with a thin brass wire to disperse the sample in the oil. After a holding period of 30 min, the tube was centrifuged at 1,610 × g for 25 min, and the volume of free oil was read. Oil absorption capacity was expressed in percentage as the amount of corn oil bound by a 100-g sample on a dry weight basis.

Chemical Properties

The moisture, total nitrogen, fat, ash, and crude fiber of the mesquite samples were determined in duplicate according to

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AOAC methods 14.003, 2.047, 14.080, 7.010, and 7.050, respectively (AOAC 1975). Nonprotein nitrogen (NPN) was determined in triplicate by the method of Becker et al (1940). The extraction of mesquite nitrogen was studied as a function of pH using the method of Fontaine et al (1944).

The neutral detergent fiber (NDF) was determined in duplicate by the method of Goering and Van Soest (1970) as described by Robertson and Van Soest (1981). The acid detergent fiber (ADF) method of Robertson and Van Soest (1981) was used in duplicate to estimate the lignin and cellulose.

Preparation of Crackers and Muffins

Crackers and muffins were prepared by procedures in a laboratory manual for a course in experimental methods with food (McPherson 1982). The basic formula is shown in Table I. For both crackers and muffins, a commercial whole wheat flour (containing 15.8% protein, calculated as N × 6.25; 2.1% crude fiber; and 1.5% ash, 10% moisture basis) was supplemented with mesquite pod flour at 0, 10, 20, and 30% levels.

For preparing crackers, flour, salt, and shortening were placed in a bowl and mixed with a pastry blender while water was slowly added to make a dough. After rolling, the dough was placed on a baking sheet, scored, and baked at 232° C for 12 min.

For preparation of muffins, milk, egg, and oil were combined in a bowl. The flour, sugar, salt, and baking powder were sifted together and added to the liquid until a lumpy batter was formed. The dough was dropped into greased muffin tins and baked at 218° C for 25 min.

Both crackers and muffins were evaluated 24 hr after baking by a taste panel of seven members including faculty and graduate students of the Department of Food and Nutrition. Color, texture, and flavor of the samples were evaluated using a score card sheet with numerical values. The ratings were based on a 10-point scale: 10, excellent; 9, very good; 7, good; 5, medium; 3, poor; 1, very poor; and 0, unacceptable (Jakobsen 1949).

The panelists were seated in a sensory evaluation room illuminated by white fluorescent light in individual partitioned booths. Each tasted four samples coded with random three-digit numbers. All the samples were served at room temperature and judged in duplicate. Deionized water was provided for the panelists to rinse their mouths after tasting each sample.

Rat Feeding Experiment

Flours containing 0, 10, 20, and 30% mesquite pod flour were formulated with the same commercial whole wheat flour used for the crackers and muffins. Rats were fed whole wheat and mesquite pod flour diets at a 10% protein level. Casein at the 10% protein level was used as the reference protein diet. The composition of diets is shown in Table II.

Weanling male albino rats of the Sprague Dawley strain, 21 days old and weighing 40–45 g, were individually housed in screen-floored cages. All of the rats were given standard purina rat chow for three days before feeding the experimental diets. Ten rats were assigned to each diet for 28 days to estimate the protein efficiency ratio (PER). An extra group of 10 rats was fed a nonprotein diet for the first 10 days of the experimental period, and the average weight loss used for determination of net protein ratio (NPR). Food and water were given ad libitum. The temperature of the experimental room was kept between 21 and 23° C during the assay period. Food intakes and weights of rats were measured weekly.

Statistical Analysis

Data were analyzed by the analysis of variance (Steel and Torrie 1960). The least significant differences at the 5% level were computed when *F* values indicated significant differences between means.

RESULTS AND DISCUSSION

Physical Properties

Direct density, and water and oil absorption capacities of honey mesquite pod, seed, and pericarp flour are compared to the values obtained for whole wheat flour in Table III. On a dry weight basis, the direct density of pod flour was 0.60 g/ml, which was similar to that of whole wheat flour. Density of pericarp flour was less than 75% of that of the seed flour. This could partly be explained by the high amount of fiber in the pericarp fraction of the mesquite pod. Mesquite pod flour absorbed water about 1.5 times its weight, whereas whole wheat flour absorbed only about 75% of its weight. On a dry weight basis, water absorption capacity of honey mesquite seed was 283%. This value was higher than the water absorption capacities of eight legume seed flours (63–173% on a dry weight basis) reported by Sosulski and Youngs (1979) and of eight out of nine cultivars of dry bean flour (1.66–2.03 g water/g flour, dry weight basis) reported by Deshpande et al (1982). However, a value of 3.76 g water/g flour (dry weight basis) has been reported for the water absorption capacity of small white bean flour (Deshpande et al 1982). The high water-absorption capacity of the honey mesquite seed could be caused by the presence of gum. Becker and Grosjean

TABLE I
Basic Formula for Crackers and Muffins

Ingredients	Formula: Crackers	Muffins
Whole wheat flour[a] (g)	164	110
Shortening (g)	54	...
Salt (g)	4	3
Water (ml)	84	...
Sugar (g)	...	26
Baking powder (g)	...	5.4
Egg (g)	...	24
Oil (g)	...	26
Milk (ml)	...	118

[a]Substituted at levels of 0, 10, 20, and 30% with mesquite pod flour.

TABLE II
Composition of Rat Diets (%)

Dietary Components	Percentages of Wheat Flour Substituted with Mesquite Pod Flour[a]: Control 0	10	20	30	Nonprotein Diet	Casein Reference
Whole wheat flour	63.1	58.9	54.3	49.4	...	...
Mesquite pod flour	0	6.5	13.6	21.2	...	...
Casein	...	...	...	...	...	11.5
Nonnutritive fiber	5.0	3.5	1.8	...	6.3	6.3
Corn oil[b]	5.0	5.0	5.0	5.0	5.0	5.0
Mineral mix (AIN/76)[b]	3.5	3.5	3.5	3.5	3.5	3.5
Vitamin mix (AIN/76)[b]	1.0	1.0	1.0	1.0	1.0	1.0
Choline bitartrate[b]	0.2	0.2	0.2	0.2	0.2	0.2
Cerelose (dextrose)	22.2	21.4	20.6	19.7	84.0	72.5

[a]Calculated as $\frac{\text{mesquite pod flour}}{\text{whole wheat flour + mesquite pod flour}} \times 100\%$.

[b]Recommended for laboratory animals by The National Research Council, National Academy of Sciences (Anonymous 1978).

TABLE III
Physical Properties of Honey Mesquite Flour Compared with Wheat Flour[a]

Sample Flour	Flour Density (g/ml)	Water Absorption Capacity (%)	Oil Absorption Capacity (%)
Mesquite			
Pod	0.602 ± 0.008	150.7 ± 3.2	123.7 ± 0.1
Seed	0.747 ± 0.009	283.0 ± 2.0	103.4 ± 0.3
Pericarp	0.578 ± 0.002	117.7 ± 2.6	131.1 ± 0.1
Whole wheat	0.618 ± 0.009	75.1 ± 0.8	98.4 ± 0.1

[a]Mean ± standard deviation on dry weight basis.

(1980) and Meyer et al (1982) have shown that mesquite seeds contain large amounts of gum.

On a dry weight basis, the oil absorption capacities of mesquite samples ranged from 103% for seed flour to 131% for pericarp flour, compared to the 98% for whole wheat flour (Table III). The oil absorption capacity of mesquite seed flour was within the range of those reported for eight legume seed flours (63–134%, dry weight basis) by Sosulski and Youngs (1979) and was close to the lower limit range value reported by Deshpande et al (1982) for nine cultivars of dry bean flour (1.05 to 1.32 g oil/g sample, dry weight basis).

Chemical Composition

The proximate composition of the honey mesquite pod, seed, and pericarp is shown in Table IV. On a dry weight basis, honey mesquite pod contained 1.7% total nitrogen, of which 24% was NPN. Whereas most of the NPN of the pod was from the pericarp, most of the protein nitrogen was contributed from the seed. On the basis of total nitrogen, Becker and Grosjean (1980) found that the inorganic nitrogen of honey mesquite pod (nitrogen in the form of NO_3^- and NH_3) was 14%, which was mostly contributed from the pericarp fraction. In this study, honey mesquite seed was found to contain 8% NPN. This value was within the range of those reported for defatted soybean varieties (Becker et al 1940).

The curve of nitrogen extractability as a function of pH for the honey mesquite pod (Fig. 1) was similar to that of the *P. juliflora* pod (Del Valle et al 1983), with relatively higher solubilities observed around pH 2.0 and above pH 7.0. The same behavior of nitrogen solubility was observed for both the seed and pericarp fraction of the honey mesquite pod. In the pH range of 2–12, the least solubility of nitrogen (representing the isoelectric point of the major proteins) was found to be around pH 4.0 for pericarp and around pH 5.0 for the seed. However, at the isoelectric pH, only 10% of the total nitrogen in the seed was soluble, whereas more than 50% of the total nitrogen in the pericarp was extractable. This was probably attributable to the large amounts of NPN in the pericarp fraction (Table IV). The shape of the nitrogen solubility curve obtained for the honey mesquite seed was similar to those of soybean (Smith and Circle 1938) and of other legume seeds (Pant and Tulsiani 1969, Hang et al 1970, Sosulski 1983). Although, at approximately pH 5.0 (isoelectric pH), the percent nitrogen solubility of the honey mesquite seed was similar to that of soybean (Smith and Circle 1938), at the acidic (pH 2.0) and alkaline regions (pH above 8.0) it was relatively lower than that of soybean. For example, at pH 9.0 about 60% of the total nitrogen of the honey mesquite seed was extractable (Fig. 1), whereas 90% of total nitrogen of soybean was soluble (Smith and Circle 1938).

Like other *Prosopis* pods, the honey mesquite pod is high in fiber. On a dry weight basis, the pod contained 25% crude fiber (Table IV), more than twice as much as in the reference AACC soft wheat bran (11.27% on a dry weight basis). Although the crude fiber method has been used as a measure of fiber content of foods, it has a limited value because of the loss of the major portion of hemicellulose and lignin in sequential treatment with acid and alkali during analysis (Van Soest and Robertson 1977). The fiber components of mesquite samples shown in Table V are compared with the values reported for AACC soft wheat bran. The ADF value estimates lignin and cellulose. On a dry weight basis, the lignin and cellulose contents of the honey mesquite pod were found to be 6.54 and 21.63%, respectively. These values were more than twice as much as reported for wheat bran. Del Valle et al (1983) reported a value of 35% ADF for *P. juliflora* pod as compared to the value of 28% obtained for honey mesquite pod in this experiment. The pericarp portion of the honey mesquite pod contained about 32% ADF, which was four times greater than that in the seed. Both lignin and cellulose of the honey mesquite seed were lower than values reported by Del Valle et al (1983) for *P. juliflora* seed.

The NDF value estimates lignin, cellulose, and hemicellulose. The NDF minus ADF value is assumed to be the estimate of hemicellulose. On a dry weight basis, the honey mesquite pod contained 39.5% NDF, which was comparable to that of AACC soft wheat bran (Table V). The calculated hemicellulose of mesquite pod was about one-third of that estimated for AACC wheat bran. The pericarp fraction of honey mesquite pod contained

TABLE IV
Proximate Composition of Honey Mesquite (%)

Component	Mesquite Pod	Mesquite Seed	Mesquite Pericarp
Moisture	8.40	6.44	7.98
Total nitrogen	1.70 ± 0.10[a]	6.48 ± 0.14	0.84 ± 0.01
Nonprotein nitrogen	0.41 ± 0.00	0.52 ± 0.00	0.31 ± 0.00
Fat	3.50 ± 0.12	4.93 ± 0.17	2.76 ± 0.10
Ash	3.52 ± 0.08	3.50 ± 0.05	3.39 ± 0.04
Crude fiber	25.95 ± 0.19	6.73 ± 0.20	30.43 ± 0.09

[a] Mean ± standard deviation on dry weight basis.

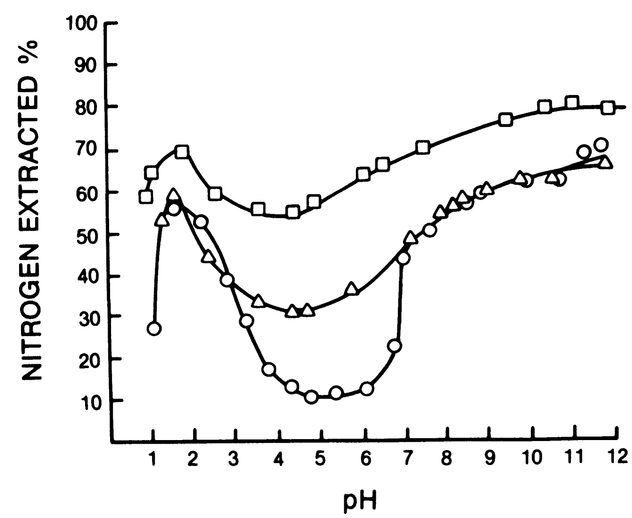

Fig. 1. Extraction of total nitrogen from honey mesquite flours as a function of pH: △, pod; O, seed; □, pericarp.

TABLE V
Fiber Composition of Honey Mesquite as Compared to Wheat Bran (%)

Component	Mesquite Pod	Mesquite Seed	Mesquite Pericarp	Wheat Bran[a]
Neutral detergent fiber	39.53 ± 0.02[b]	24.92 ± 0.46	48.80 ± 0.33	42.65
Acid detergent fiber	28.18 ± 0.05	8.37 ± 0.17	31.72 ± 0.37	12.36
Lignin	6.54 ± 0.04	1.42 ± 0.05	6.98 ± 0.17	3.12
Cellulose	21.63 ± 0.01	6.95 ± 0.23	24.74 ± 0.20	9.24
Hemicellulose[c]	11.52	16.67	11.12	30.29

[a] The AACC certified soft white wheat bran. Values on dry weight basis.
[b] Mean ± standard deviation on dry weight basis.
[c] As neutral detergent fiber minus acid detergent fiber.

TABLE VI
Sensory Evaluation Scores for Honey Mesquite Crackers and Muffins[a]

Sensory Attributes	Percentages of Wheat Flour Substituted with Mesquite Pod Flour: Control 0	10	20	30
Crackers				
Color	7.0 ± 0.8	8.2 ± 0.6	8.9 ± 0.3[b]	8.4 ± 1.3[b]
Texture	7.4 ± 1.2	7.1 ± 0.9	7.6 ± 1.1	7.5 ± 0.6
Flavor	7.0 ± 1.3	7.4 ± 1.1	7.9 ± 1.1	7.3 ± 0.9
Muffins				
Color	7.8 ± 1.8	8.3 ± 1.1	7.4 ± 1.1	6.3 ± 1.4
Texture	9.0 ± 0.5	7.5 ± 1.7	5.8 ± 0.7[b]	4.8 ± 1.2[b]
Flavor	7.3 ± 0.9	7.9 ± 1.6	7.2 ± 0.9	6.2 ± 1.1

[a] Mean ± standard deviation. Score range 0 = unacceptable, 10 = excellent.
[b] Means in the same row are significantly ($P < 0.05$) different from the control (100% whole wheat flour).

TABLE VII
Protein Efficiency Ratio (PER) and Net Protein Ratio (NPR) of Whole Wheat Flour Substituted with Mesquite Pod Flour as Compared with Casein Reference[a]

	Percentage of Wheat Flour Substituted with Mesquite Pod Flour				
	Control 0	10	20	30	Casein Reference
PER	1.27 ± 0.10 a	1.26 ± 0.13 a	1.40 ± 0.14 a	1.50 ± 0.16 b	2.82 ± 0.25 c
PER (adjusted)	1.13 ± 0.09	1.12 ± 0.12	1.24 ± 0.13	1.33 ± 0.15	2.50
NPR	1.71 ± 0.12 ab	1.69 ± 0.16 a	1.79 ± 0.12 ab	1.87 ± 0.18 b	3.18 ± 0.24 c

[a]Mean ± standard deviation. Means within same row followed by different letters are significantly different ($P < 0.05$).

42.8% NDF (dry weight basis) composed of 7% lignin, 24.7% cellulose, and 11.1% hemicellulose. In comparison, the seed had 25% NDF, of which lignin, cellulose, and hemicellulose contributed 1.4, 6.9, and 16.7%, respectively.

Little information has been published on the detergent fiber estimate of common legume seeds; however, Lin (1983) recently determined the ADF and NDF contents of some cultivars of southern peas. The ADF value of the honey mesquite seed determined in this experiment was close to the upper limit range of values reported for southern peas (ADF 5.48–8.13%, dry weight basis). The NDF value of mesquite seed was higher than those reported by Lin (1983) for southern pea cultivars (NDF 6.93–13.34%, dry weight basis).

Sensory Evaluation

The mean sensory evaluation scores of crackers and muffins from control (100% whole wheat) and mesquite pod flours are shown in Table VI. Substitution of mesquite pod flour for whole wheat flour significantly affected color but not the texture or flavor of crackers. At both 20 and 30% substitution levels, the color scores were significantly ($P < 0.05$) higher than for those of the control. Higher scores attained for the color of mesquite crackers may be caused by the formation of a dark golden color as a result of a slight browning reaction between the sugar of mesquite and protein of the flour. Scores of the sensory evaluation for all of the crackers ranged between good and very good with the 20% mesquite crackers scoring highest in all three attributes.

Use of mesquite pod flour in the muffins significantly affected the texture but not the color and flavor (Table VI). Generally, the 10% pod flour muffins received the highest scores for both color and flavor. However, substitution of mesquite pod flour for whole wheat flour beyond 10% seemed to lower the scores for those two characteristics. Both 20 and 30% mesquite pod flour muffins had significantly ($P < 0.05$) lower scores for texture than the control, probably because of the gritty texture detected by the panelists. The grittiness was probably a result of the coarse milling procedure conducted in our laboratory.

Honey mesquite pod flour could be substituted for up to 30% for whole wheat flour in crackers but only up to 10% in muffins. Meyer et al (1982) demonstrated that substitution of 8% of whole cereal grain with milled exo-mesocarp fraction of *P. velutina* gave a sweet taste and favorable color to bread judged by taste panels. In cookies, substitution of 5% of the whole cereal grain with this fraction was shown to be the maximum acceptable level, with no significant change compared to the control. Meyer et al (1982) reported that substitution of 15% of whole cereal grain with the milled endocarp fraction of *P. velutina* was the maximum acceptable level for breads, whereas 20% of the whole cereal grain substituted with this fraction gave a pleasant taste and improved structure in cookies.

Animal Diet Studies

Results from a previous study (Zolfaghari and Harden 1985) showed that honey mesquite pod protein contained a low level of the sulfur-containing amino acids but a high amount of lysine. As lysine is the first limiting amino-acid in most cereal grains (Lockhart 1978), a higher protein quality was expected when wheat flour was supplemented with mesquite pod. As shown in Table VII, however, PER values of the diets containing up to 20% pod flour were not significantly ($P > 0.05$) different from that of the control, which was 100% wheat flour. The diet containing 30% mesquite pod flour showed a PER value of 1.5 ± 0.16, which was significantly ($P < 0.05$) higher than that of the control diet. This value, however, was still only about 53% of that of the casein diet.

The adjusted PER values for raw *Prosopis* pods have been reported to be −0.32 for *P. pubescens*, 0.71 for *P. velutina* (Becker 1982), and 1.4 for *P. juliflora* (Del Valle et al 1983). The low PER values of *Prosopis* pods have been attributed to the low digestibility of the protein (Becker 1982, Del Valle et al 1983) and to the limitation of some of the amino acids, e.g., sulfur-containing amino acids (Becker 1982) or isoleucine and threonine (Del Valle et al 1983). In feeding experiments, Becker (1982) used corn-soybean fortified chick feed ration with 20 and 40% of *P. velutina* pods substituted for the corn. Chicks fed the diet with 20% raw pods grew faster than those fed the diet substituted by 40%. However, average weight gains of animals on diets at both substitution levels were lower than those in the control group.

In conclusion, honey mesquite pod does seem to have potential as a supplementary food product, although more evaluation is needed. The pod flour was superior to wheat flour in water and oil absorption capacities and comparable to wheat bran in NDF content. Sensory data indicated that honey mesquite pod flour could be substituted for wheat flour up to 30% in crackers and 10% in muffins. At high-level substitution (30%), the pod protein significantly improved the nutritional quality of wheat protein.

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