Processing, Composition, Nutritional Evaluation, and Utilization of Mesquite (*Prosopis spp.*) Pods as a Raw Material for the Food Industry[1]

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Mesquite pods (*Prosopis spp.*) were milled in a Bauer disc mill and mechanically separated into four fractions. Fraction A, the exo mesocarp powder, contained most of the pod sugar and flavor components. It was useful as a starting material for sugar syrup and as an ingredient in breads, crackers, and chapatis. Fraction B, the endocarp hulls, was comprised mainly of fiber, with little food value. The seed mucilage/seed coat was separated as fraction C. Gum from this fraction has a galactose to mannose ratio and food applications similar to guar gum. The protein-rich seed cotyledon was separated as fraction D and found to have uses typical of bean protein. This protein is nutritionally limiting in tyrosine and methionine/cysteine. The PER of uncooked pods and seeds was found to be 0.71 and 0.69, respectively. Both pods and seeds had reduced PER's and metabolizable energy values from chick feeding studies after cooking, probably due to the seed gum.

INTRODUCTION

There are 44 *Prosopis spp.* of leguminous plants that occur worldwide in arid and semiarid zones. *Prosopis spp.* grow wild, require little water, fix nitrogen, and depending on species and growing conditions occur as trees or shrubs. The plants produce large amounts of indehiscent pods that many former cultures utilized as an important food staple. Pod yields of 10000 kg/ha have been projected from cultivated trees in an established orchard (Felker, 1979). *Prosopis* biology has been reviewed by Simpson (1977) and its ecology by Felker (1979).

Use of *Prosopis* pods as a modern food source has been suggested by several recent chemical and nutritional studies (Becker and Grosjean, 1980; Del Valle et al., 1983; Zolfaghari and Harden, 1985). The whole pod is 11–17% protein and 13–34% sugar, with the protein being concentrated in the seed (26–37% of the seed) and the sugar, which is mainly sucrose, residing in the pod pericarp. The seed also contains a galactomannan gum similar to guar gum. We therefore became interested in methods to isolate these pod components and to determine their nutritional characteristics and possible uses in food products.

EXPERIMENTAL SECTION

Processing and Fractionation. Mature *Prosopis velutina* pods were collected from beneath trees in the Salton Sea area of California, transported to the laboratory, and stored frozen until processed by the scheme shown in Figure 1. Before milling, the pods were air-dried overnight on trays in a Taylor tunnel dryer at 70 °C with an air velocity of 250 m/min. Pod rehydration was rapid, depending on ambient relative humidity, so milling and separations were performed in a dry room (8% RH). The dried pods were then broken into 1–3-cm-long pieces by one pass through a chopper mill such as a Rietz disintegrator operated at 500 rpm.

The broken pods were milled in a Bauer disc mill, size

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Table I. Proximate Composition of *P. velutina* Pods and Pod Fractions (%)

sample	typ rec,[c] %	total sugars	protein (N × 6.25)	fat	crude fiber	ash
whole pods	100	22	12	2.5	22	3.5
fraction A	53	48.0	9.5	2.0	16.0	4.5
fraction B	15	6.0	6.5	1.3	45.0	3.5
fraction C	13	87.7	0.0	0.0	8.0	na
seed coat	40[a]	na[b]	0.0	na	na	na
endosperm gum	60[a]	na	0.0	0.0	na	na
fraction D	15	na	61.0	8.0	4.0	4.7

[a] Percent recovery from fraction C. [b] na = not available. [c] Typical recovery.

Table II. Amino Acid Composition of Fractions A, B, and D (mg/g of N)[a]

amino acid	fraction A	fraction B	fraction D	FAD provisional score
aspartic acid	866	666	505	
threonine	197	190	146	250
serine	236	284	253	
glutamic acid	762	1029	1236	
proline	481	350	445	
glycine	263	301	276	
alanine	240	249	252	
cysteine	83	91	106	
valine	299	270	242	310
methionine	54	19	61[b]	220
isoleucine	165	207	196	250
leucine	399	416	457	440
tyrosine	161	175	165	
phenylalanine	165	233	235[c]	380
histidine	135	163	187	
lysine	216	285	253	340
arginine	533	533	832	

[a] Tryptophan not determined. [b] Met + Cys. [c] Phe + Tyr.

Table III. Dietary Fiber Composition of Fractions A and B (%)

fiber	fraction A	fraction B
dietary	35.3	61.6
crude	16.0	45.0
neutral detergent	23.3	69.0
std dev	0.7	3.5
acid detergent	24.7	53.7
std dev	1.0	2.8
lignin	5.7	9.8
std dev	0.8	0.8
cellulose	14.6	41.0
std dev	1.0	2.2

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Table IV. Characteristics of Mesquite Fraction B

material	burning value, BTU/kg as is	burning value, BTU/kg dry-wt basis	% C	% H	% O	% S	% P	% ash
fraction B	15277	16082	44	6.5	44	0	0.13	3.3
fraction B1, >40 mesh	15675	16500	44	6.3	46	0	0.05	3.0
fraction B2, <40 mesh	16101	16949	45	6.6	42	0	0.23	3.5
sawdust	16414	18238	50	6.4	42	0.06		0.86
sugar cane bagasse	8300	16600						
rice straw	10480	13100						
cereal crop residues	13090	15400						

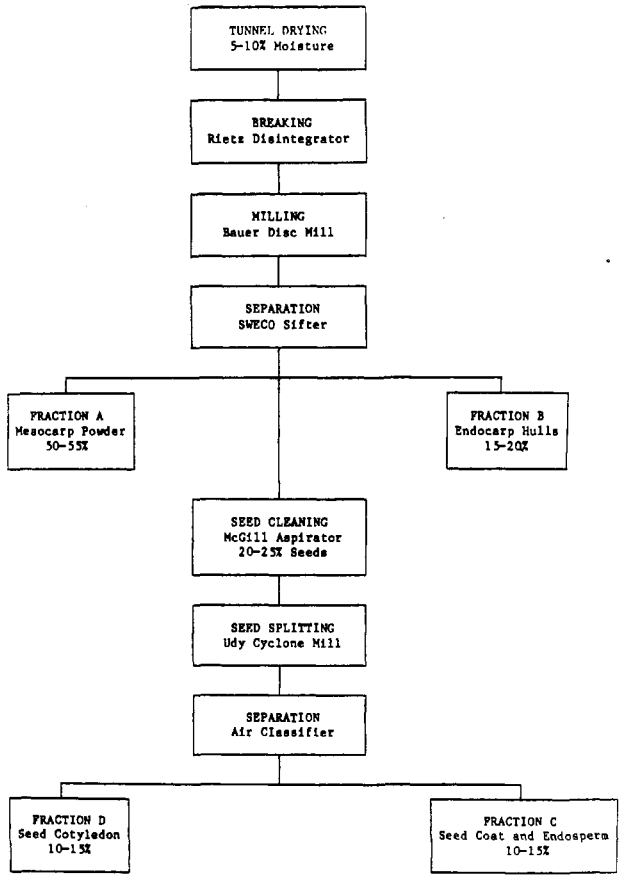

Figure 1. Flowsheet for milling and separation of *Prosopis* pods.

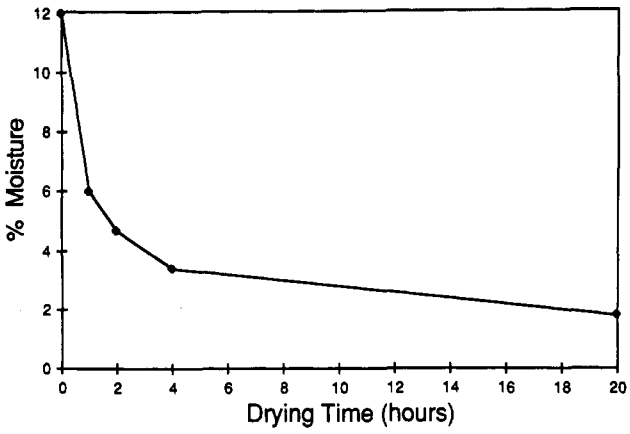

Figure 2. Drying curve of *P. velutina* pods at 70 °C.

8, using #8114 disks and operated at a speed of 3450 rpm. The disk gap was adjusted, depending on the pod size of each lot, so that the endocarp hulls were opened but the seeds were not broken.

The milled pods were immediately fractionated on a continuous Sweco vibrating separator equipped with an upper screen of 4.8-mm-round holes and a lower screen of 1.0-mm-square holes. The endocarp hulls (fraction B) were retained by the upper screen, the seeds along with some pericarp material were retained by the lower screen, and all fine material (fraction A) passed through the screens. Fraction A was used as produced.

Table V. Carbohydrate Composition of *P. velutina* Endosperm Mucilage, Fraction C (Ratio 1.56 Mann/Gal)

monosaccharide	concn, %	monosaccharide	concn, %
rhamnose	0.23	glucose	0.59
arabinose	4.18	galactose	36.24
xylose	1.96	unknown	0.32
mannose	56.47		

The seed pericarp material from the lower screen was further separated with a McGill laboratory aspirator, Model 66, with adjustable air flows, to produce a seed fraction and a pericarp fraction. The pericarp fragments were combined with the endocarp hulls in fraction B.

Either a Udy cyclone mill or a Strong-Scott grain tester was used to separate the seed into two fractions (the seed cotyledon and the seed endosperm). These devices function by throwing the seeds into the unit's frame, causing them to break into endosperm splits (seed coat with endosperm; fraction C) and cotyledon and germ (fraction D). These fractions were separated by multiple passes through the McGill aspirator or by using an air classifier.

Composition. The chemical compositions of the pods and pod fractions were determined by AOAC (1975) procedures. Sucrose and monosaccharides were determined on a Waters HPLC using a Waters carbohydrate column. The sugars were isocratically eluted with 80:20 acetonitrile–water and quantified with a refractive index detector (Conrad, 1976). Amino acids were determined with a Durum amino acid analyzer as in Spackman et al. (1958), with the sulfur amino acids determined after perchloric oxidation as in Moore (1963). Dietary fiber content was determined as in Saunders et al. (1973). The energy of combustion of fraction B was determined by calorimetry (AOAC, 1975). Mucilage carbohydrate composition was determined after hydrolysis with trifluoroacetic acid by gas chromatography of the trimethylsilyl esters as in Becker and Grosjean (1980). Peak identification and quantification were based on comparison of retention times and peak areas with those of known standards. Fatty acids were determined as their methyl esters with a Hewlett-Packard Model 5830A gas chromatograph using a 0.25 mm × 30 mm glass capillary column operated isothermally at 175 °C, with helium as the carrier gas and fid detection (Becker and Grosjean, 1980).

Nutrition. The protein efficiency ratio (PER) was determined by a 28-day rat feeding study using AOAC (1975) methods with diets containing 10% protein. The samples were ground to 20 mesh, autoclaved for the indicated times at 120 °C, and lyophilized. Pericarp and seed samples were mechanically separated and treated as above. The pericarp sample corresponds to combined fractions A and B; the seed sample was comprised of whole seeds before separation into fractions C and D. *Prosopis pubescens* and *Olneya tesota*, other desert legume trees, were

Table VI. Compositional Variations of Fractions

sample accession no.	% total sugar		% protein			% fat			% crude fiber		ratio[a] Mann:Gal	ratio[b] % C:% D
	A	B	A	B	D	A	B	D	A	B	C	
FN 1	45.6	9.4	10.4	5.0	56.1	2.2	1.4	9.6	12.6	46.2	1.14	0.71
FN 2	54.2	10.6	9.9	6.9	52.0	1.6	1.0	9.4	11.6	45.6	1.22	1.12
FN 5	43.2	4.4	8.4	4.3	60.4	1.7	1.3	7.6	14.2	54.8	1.99	0.71
FN 12	43.4	4.3	9.1	9.1	56.3	1.8	1.7	8.0	19.3	40.4	1.26	0.56
FN 15	50.2	6.5	7.7	5.7	56.9	2.8	1.4	7.5	14.6	41.6	1.14	0.71
FN 15/30	47.0	8.8	8.9	6.5	56.2	2.3	1.8	9.0	13.2	41.4	1.38	0.60
FN 16	39.9	5.7	7.4	5.9	57.7	1.3	1.2	7.7	14.9	45.7	1.37	0.66
FN 17	41.9	7.6	10.2	6.8	57.1	1.7	1.1	7.2	16.5	48.8	1.52	1.00
FN 23	52.3	5.3	5.7	4.6	59.2	1.6	0.8	7.5	13.0	57.7	1.22	1.10
12 A	48.2	7.3	9.1	5.7	56.3	1.6	1.2	6.2	12.9	41.1	1.40	0.50
12 B	46.2	5.7	8.9	6.3	55.6	2.7	1.1	8.0	10.1	46.6	1.43	0.69
12/8	50.0	5.9	7.1	4.9	55.6	2.1	1.0	9.3	14.3	47.1	1.24	0.69
3/38	49.6	11.0	7.7	7.5	59.1	1.3	1.1	7.0	13.6	39.4	1.31	0.74
18/19 M	56.4	5.8	7.8	6.9	60.7	1.4	0.9	7.3	11.1	46.2	1.36	0.80
X	39.0	7.0	8.7	5.8	57.9	2.9	1.2	7.4	16.3	44.0	1.04	0.74
X2	46.8	4.2	9.0	6.1	56.6	1.7	1.7	6.9	17.0	39.0	–	0.60
mean	47.1	6.8	8.50	6.2	57.1	1.9	1.3	7.8	14.1	45.0	1.34	0.75
std dev	4.9	2.1	1.2	1.2	2.1	0.5	0.4	1.0	2.4	4.5	0.22	0.18
%	10.4	31.3	14.1	19.4	3.7	26.0	34.6	12.7	17.0	10.0	16.4	24.0

[a] Weight mannose in gum divided by weight of galactose. [b] Weight percent of fraction C divided by weight percent of fraction D.

Table VII. Fatty Acid Composition of Fraction D

fatty acid	concn, %
myristic acid (C 14:0)	1.1
palmitic acid (C 16:0)	13.7
stearic acid (C 18:0)	4.6
oleic acid (C 18:1)	24.5
linoleic acid (C 18:2)	46.7
linolenic acid (C 18:3)	4.6

Table VIII. Protein Efficiency Ratio (PER) and Digestibility of Pods and Seeds from Desert Plants

sample	adjusted PER[a]	% digestibility[b] diet	% digestibility[b] nitrogen
P. velutina			
pods, uncooked	0.71	66	56
pods, autoclaved			
5 min	0.63	64	57
10 min	0.61	65	55
20 min	0.55	45	44
seeds, uncooked	0.69	86	64
seeds, autoclaved 10 min	0.63	85	58
pericarp, uncooked	0.32	63	49
P. pubescens			
screwbeans			
pods, uncooked	−0.32	44	19
pods, autoclaved 10 min	−1.35	40	4
O. tesota			
desert ironwood			
seeds, uncooked	0.15	89	81
seeds, autoclaved 10 min	0.46	85	74

[a] PER (protein efficiency ratio) = weight gain/protein intake. [b] Digestibility: diet = (feed intake − fecal weight)/feed intake × 100. Nitrogen = (N intake − fecal N)/N intake × 100. Pooled data, from 7th through 14th test days.

Table IX. Metabolizable Energy Values and Body Weights of Chickens Fed Whole Pods

feedstuff	metabolizable energy, kcal/g
P. velutina pods	
uncooked, 20% of diet	1.65
cooked, 20% of diet	0.70
corn	3.40
oats	2.66
alfalfa meal	1.41
wheat bran	1.19

feedstuff	av body wt, g
control	400
P. velutina pods	
uncooked, 20% of diet	360
uncooked, 40% of diet	260
autoclaved, 20% of diet	335
autoclaved, 40% of diet	348

included for comparison. All diets were compared to an ANRC casein diet containing appropriately adjusted amounts of fiber and corrected to a PER of 2.50.

The chick feeding experiments were performed with *P. velutina* pods ground to 20 mesh, autoclaved 10 min at 120 °C, and substituted into chick diets (Vohra et al., 1982). Literature values for other common feedstuffs are shown for comparison (Schaible, 1970). The metabolizable energy (ME) of a feed was calculated as the gross energy of the feed less the amount lost in the excreta.

Products. Mesquite syrup was prepared by suspending 20 g of fraction A in 200 mL of water, heating to 80 °C for 20 min, and filtering through cheesecloth and then through S and S #602 filter paper. The filtrate was heated to 80 °C, calcium oxide added to 2% level, the resultant mixture held at 80 °C for 25 min, cooled to 25 °C, and centrifuged for 20 min at 12 000 rpm, and the supernatant decanted.

Table X. Composition of Bread and Crackers Using Mesquite Fractions

Bread

100 parts whole wheat Peavey flour with 0–25% mesquite fraction A	4 parts sugar (or mesquite syrup)
3 parts shortening	3 parts yeast
2 parts NaCl	59 parts water

procedure: add ingredients to water, mix 5 min, ferment 105 min at 20 °C (90% RH); 1st punch, fold dough, ferment 20 min; 2nd punch, roll dough and make two loaves, ferment 55 min; bake 25 min at 220 °C

Chapitas and Crackers

100 g of wheat flour	9 g of shortening
100 g of mesquite fraction A	2 g of gum
112 mL of water	

procedure: dissolve gum in water, mix flours and shortening, and add to water; pin-mix 5 min and fork-mix 10 min; roll dough until 3 mm thick, cut shapes as desired; bake 15 min at 180 °C or bake 30 s/side on griddle or deep fry in vegetable oil 20 s each side at 200 °C

Gaseous carbon dioxide was bubbled through the supernatant for 5 min, the solution was centrifuged for 20 min at 12 000 rpm, and the supernatant was made 2% in activated charcoal with stirring for 5 min. After centrifuging, the decanted supernatant was concentrated in a rotary evaporator to 12.5% sucrose (refractive index 1.3515).

Tortilla chips were made from 100 parts of processed corn flour (Masa), 2 parts of salt, and 100 parts of water. Corn flour was replaced with various percentages of mesquite fraction A, while water was reduced by 5 parts for each 10 parts of fraction A. Warm water (50 °C) was added to the dry mix and the dough mixed for 5 min and rolled into 1.5-mm-thick sheets. The sheets of dough were cut into 2 cm × 5 cm pieces and pierced with a fork and the pieces deep fried 25 s on each side in partially hydrogenated soy oil (Crisco) at 210 °C.

Chapatis were prepared with equal amounts of whole wheat flour and fraction A. Water, shortening, and gum were added for smoother texture, and the mixture was baked on a griddle for 1 min on each side.

Drum-dried flakes were prepared with mesquite fraction A, which had been milled to pass a 1-mm screen. The mesquite fraction A was combined with equal amounts of whole wheat flour, mixed 5 min with enough water or dilute mesquite syrup to form a thick slurry, and drum dried. The drum dryer was operated at a drum temperature of 145 °C at 20 psig of stream pressure, gap of 0.016 in., and drum speed of 0.52 rpm. Rancidity of the drum-dried samples was measured as the hexanal value by headspace determination on samples stored in the dark at 38 °C for 16 weeks (Fritsch, 1977).

RESULTS AND DISCUSSION

Drying, Milling, and Separation. The milling and separation process shown in Figure 1 was designed to yield fractions with optimum economic value (mesocarp flour, gum, seed cotyledon) while removing less valuable components (fiber). A critical step in this process is drying the pods. If the pods contain more than about 4% moisture, they become flexible and the pod sugar becomes sticky (hygroscopic), which makes milling impossible with most mills.

The drying curve of typical *P. velutina* pods is shown in Figure 2. Drying temperatures above 75 °C resulted in severe browning of the pods with little improvement in drying time; temperatures below 65 °C required much longer drying times. The dried pods were broken in the Rietz disintegrator to facilitate feeding into the Bauer mill.

Several other types of mills were tested before selection of the Bauer disc mill. A corregated roller mill opened less than half of the endocarp hulls and tended to break the seeds. Hammer mills and pin mills invariably broke most of the seeds into small pieces. These mills may be useful to mill pods into a homogeneous mixture but could probably not be used in applications where whole seeds are desired. The Bauer disc mill has the advantage of producing up to 85% of the seeds intact, allowing easy separation. It also scarifies the seeds, which promotes rehydration and germination, a significant advantage in reforestation applications. Additionally, the intact seeds can be easily milled to produce seed cotyledon and seed mucilage, both economically important fractions.

The milled pods from the disk mill were readily separated by the SWECO vibrating sifter. The screens chosen worked well for *P. velutina* and *Prosopis chilensis* pods, but *Prosopis tamarugo* and *P. pubescens* pods require somewhat smaller screens. During milling the fractions were inspected for unopened endocarp hulls or excessive broken seed material, indicating the need for mill adjustment (disk gap, speed). Fractions A and B were useful as obtained from the separator, but these fractions can be easily milled to smaller particle size in almost any mill for special applications.

The seed fraction from the SWECO vibrating sifter contains from 5 to 20% pericarp fragments, depending on the mill adjustment, which can be separated with almost any air classifier.

After the pericarp material was removed, the seeds were next milled with either the Udy cyclone mill or Strong-Scott grain tester. The Udy mill is more efficient but requires more operator attention and fine tuning than the Strong-Scott mill. Both mills produced some fine material that is primarily cotyledon fragments. Seeds typically consisted of 45% by weight fraction C (seed coat and endosperm) and 55% fraction D (seed cotyledon).

Composition. The proximate composition of the fractions is shown in Table I. The recovery and composition of the mill fractions varied, depending on the quality of the starting material and mill adjustments, but these figures are considered representative. The exo mesocarp powder (fraction A) was the preponderant fraction from the pod and contained most of the pod sugar with lesser amounts of fiber and protein. Analysis by HPLC shows the sugar is 92% sucrose, 3% glucose, and 5% fructose (data not shown). Fraction A is the sweetest fraction (Table I) and also contains most of the flavor components. The protein in fraction A is limiting in the sulfur amino acids methionine and cysteine (Table II). Considerable amounts of dietary fiber are present in fraction A (Table III).

Fraction B is primarily fibrous material (Tables I–IV) with a caloric content near that of sugar cane bagasse. Its protein composition is similar to that in fraction A in that the sulfur amino acids are nutritionally limiting, followed by threonine (Table II).

Fraction C is made up of seed coat and endosperm gum. Before milling, the whole seeds comprise 20–25% of the pod (Figure 1). About 85% of the seeds is recovered in the milling process. When the recovered seeds are milled, 42% is fraction C and 56% fraction D. Fraction C is comprised of about 40% seed coat and 60% gum. The seed gum is a galactomannan gum with an average mannose to galactose ratio of 1.34 ± 0.22 (Tables V and VI; Meyer et al. (1985)).

Fraction D is seed cotyledon and seed germ. It contains large amounts of protein, most of the seed fat, small

Table XI. Characteristics of *Prosopis* Flours in Cereal Products

product	opt amt of added mesquite flour, %	remarks	effects of inc amts
bread, wheat flour + fraction A	10	sweet, favorable color	over 25% fraction A hay taste, astringent compct loaf, coarse
bread, wheat flour + mesquite syrup	10	satisfactory taste	too dark
bread, wheat flour + fraction B	15	neutral	too coarse, gritty
crackers + fraction A	5	neutral	off-flavor
chapitas + fraction A	50	good taste, good appearance	poor texture
tortillas + fraction A	20	better than pure corn chips	poor texture
drum-dried wheat flour + fraction A	50	better taste and oxidn stability than wheat flour alone	poor sheeting, browning

amounts of fiber, and ash similar to the other fractions. This protein is nutritionally limiting in threonine followed by cysteine and methionine (Table II). Fraction D contains about 4.5% free sugars (data not shown). The fat (8%) is made of linoleic, oleic, and palmitic acids and small amounts of other fatty acids (Table VII).

The milling process (Figure 1) was tested on pod samples from 16 different trees (Table VI). Fraction A was invariably richest in sugars, fraction B richest in fiber, fraction C in gum, and fraction D in protein and oil. The uniform quality of the gum was demonstrated by the generally constant mannose to galactose ratio. Variations in the yield of gum are shown by the ratio of % C:% D. These data demonstrate that the milling and separation process will produce fractions of predictable composition and that gum compositional variations between trees are not extreme.

Nutrition. The whole pods were fed to rats to determine the PER (Table VIII). Uncooked pods had a PER of 0.71, and autoclaving the ground pods for 20 min reduced the PER to 0.55. This reduction in PER is possibly due to increased solubilization and accompanying increased water absorption and bulking effects of the heated seed mucilage and its subsequent interference in digestion. These heated extracts were found to be free of trypsin inhibitor, hemagglutinins, and cyanogenic compounds (data not shown). Similar galactomannan gums are thought to interfere with nitrogen retention in poultry by reducing the food to feces transit time (Vohra et al., 1979).

Related effects were observed in the chick studies, where cooking decreased the ME from 1.65 to 0.70 (Table IX). The uncooked *P. velutina* pod flour ME is less than that of the traditional cereal grains such as corn and oats but more than the ME of high-fiber commodities such as wheat bran. The weight gain of the chicks fed cooked *Prosopis* flour was also reduced, which when considered with the ME and PER data indicates that whole pods should not be cooked before use as a feed. This does not hold for pod fractions free of seed mucilage, which should be cooked.

Uses and Applications of Pod Fractions. The mesocarp flour (Fraction A) is the preponderant fraction from the pods. Chemical analysis revealed that sucrose is the major component, followed by fiber and protein, so use of fraction A as a raw material for sucrose recovery is an obvious application.

Unfortunately, the high soluble protein and mineral contents of mesquite fraction A would interfere with the crystallization and purification of sucrose, so it was decided not to compete directly with refined sugar but to prepare a "special" mesquite sugar or syrup such as a maple syrup.

The syrup preparation procedure described in the Experimental Section was used on 500-g lots of fraction A, with an initial sucrose concentration of 42%, to produce a syrup containing 13% sucrose and 1.2% protein with a 71% yield of extracted sucrose. The syrup contained 17 ppm Zn, 4 ppm Mg, 20 ppm Fe, 2 ppm Cu, 0.4% Ca, and 0.1% Na. Pilot plant lots were concentrated to over 50% sucrose.

The mesquite syrup had an attractive taste, comparable to maple syrup, but a more pronounced aroma. It could likely be used as an ingredient for soft drinks, as a pancake syrup, or as a general-purpose liquid sweetener.

The precipitates and filtrates from syrup production are fibrous byproducts that may be useful for animal feed.

Fraction A, mesquite syrup, and fraction B were also tested as bakery ingredients using the recipes shown in Table X with substitution of various percentages of mesquite fractions for wheat flour or sugar. Characteristics of mesquite breads are shown in Table XI. A taste panel of untrained judges found that substitution of 10% mesquite flour A could be detected but was still acceptable. At concentrations of 25% fraction A and above, the bread tasted astringent and the texture was too coarse. Intermediate levels of fraction A received mixed scores (data not shown).

Incorporation of 10% mesquite syrup reduced bread loaf volume and increased crumb firmness while maintaining a satisfactory taste.

Use of fraction A in crackers was not very successful. Oven baking and griddle baking resulted in products with a similar appearance, but both had an undesirable off-taste. Deep frying gave a crunchier product with no off-flavor, but the crackers were not very stable due to the high oil content. The chapatis had a very acceptable taste, texture, and appearance and were undoubtedly the best products made from the fractions. Amino acid analysis demonstrated that the 50% wheat–50% mesquite fraction A blend had a better balance than either individual product (data not shown).

A variety of cooking conditions for tortillas using fraction A were examined. Samples deep fried below 200 °C for less than 20 s were chewy (worse with higher fraction A concentrations); those deep fried above 210 °C for longer than 30 s were overcooked (worse with higher fraction A concentration). In both cases higher temperature/shorter time gave a better product than lower temperature/longer time.

A taste panel of 29 adults tested two tortilla recipes of 10:90 and 20:80 mesquite fraction A to corn flour (data not shown). Chips containing 20% mesquite fraction A were judged as better than pure corn chips in all organoleptic categories (color, texture, aroma, taste). Judges who regularly consumed corn chips preferred the higher level of mesquite incorporation. Mesquite corn chips scored even higher in all categories when the judges were aware mesquite was in the chips.

Drum-dried flakes based on cereal or composite flours are widely used in the U.S. as food ingredients. Drum-dried flakes can be produced at any level of mesquite fraction A incorporation up to about 50% fraction A:50% wheat flour. A dilute mesquite syrup may replace the water. Samples containing mesquite fractions had 4–62% lower hexanal values than a 100% wheat control. The oxidation stability and overall good taste and appearance of the mesquite containing flakes make them another attractive mesquite based product.

Breads containing 25% mesquite fraction B (milled endocarp hulls) had reduced loaf volume and increased crumb firmness. The bread was much darker than the control and had a sandy texture due to the high fiber content. Fraction B may have some use as a dietary fiber, but its high BTU value (Table IV) probably gives it more value as a fuel. In the mesquite processing plant designed by Meyer (1984), it is incinerated to supply the hot air required to dry the pods before processing.

The seed gum is the most valuable component in fraction C. Its galactose to mannose ratio and viscosity (data not shown) are close to those of guar gum so it has applications and a commercial value similar to guar, i.e. as a food thickening agent or for use in oil-drilling operations. The seed coat in fraction C could be burned as a heat source.

Fraction D has the typical beaney, nutlike taste of other legumes and would be expected to have similar food and feed uses. The protein has a lower solubility than soy protein, good foam expansion, foam stability, and emulsifying properties (Meyer, 1984).

Registry No. C (14:0), 544-63-8; C (16:0), 57-10-3; C (18:0), 57-11-4; C (18:1), 112-80-1; C (18:2), 60-33-3; C (18:3), 463-40-1; lignin, 9005-53-2; cellulose, 9004-34-6; L-rhamnose, 3615-41-6; arabinose, 147-81-9; D-xylose, 58-86-6; D-mannose, 3458-28-4; D-glucose, 50-99-7; D-galactose, 59-23-4.

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Formation of Sodium Bisulfite Addition Products with Trichothecenones and Alkaline Hydrolysis of Deoxynivalenol and Its Sulfonate[1]

J. Christopher Young

The mycotoxin deoxynivalenol (DON) and its 3-acetyl derivative reacted quickly with aqueous sodium bisulfite at room temperature to form sulfonate salts. Addition of sodium bisulfite was shown to occur across the 9,10 double bond. The related compound nivalenol reacted about 4 times more quickly, while reactions with Ac_2DON and the DON isomer, isoDON, proceeded more slowly by about 7- and 60-fold, respectively; the triacetyl derivatives of DON and isoDON did not react at all. Although DON-S was stable under acid conditions, it was converted back to DON under alkaline conditions, especially at elevated temperature and pH. Subsequent rapid isomerization of DON to isoDON was observed at 75 °C in a variety of bases and solvents and resulted in the subsequent formation of another isomer of DON in addition to three lower molecular weight isomers.

INTRODUCTION

The presence of the mycotoxin 4-deoxynivalenol (DON, vomitoxin, 3α,7α,15-trihydroxy-12,13-epoxytrichothec-9-en-8-one) in grains (e.g., corn and wheat) contaminated by the fungus *Fusarium graminearum* Schwabe is of concern due to undesirable toxicological consequences when such material is used in human food or animal feeds. Recent studies have shown that levels of DON in contaminated grains can be reduced by at least 95% upon treatment with aqueous sodium bisulfite (Young, 1986; Young et al., 1986b). When bisulfite-treated contaminated soft white winter wheat was milled and baked, levels of DON increased to 50–75% of that in the corresponding wheat (Young et al., 1986b). Although those treatments examined were too drastic (on the rheological properties) for direct application to human foods (Young et al., 1986b), they were successful in detoxifying contaminated corn used

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