

USE AND NUTRITIONAL COMPOSITION OF SOME TRADITIONAL MOUNTAIN PIMA PLANT FOODS

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ABSTRACT.—Foods of plant origin traditionally consumed by the Mountain Pima of Chihuahua, Mexico, were analyzed for proximate and mineral content. Fruits and immature cladodes of *Opuntia robusta*, *O. durangensis*, and *O. macrorhiza*; fruits of *Arctostaphylos pungens*, *Arbutus xalapensis*, *Berberis pimana*, *Prunus persica*, *P. serotina* var. *virens*, and *P. gentryi*; roots of *Prionosciadium townsendii*; tubers of *Dahlia coccinea*; bulbs of *Hymenocallis pimana*; inflorescences of *Tillandsia erubescens*; and leaf bases and immature flowering stalks of *Agave shrevei* were analyzed for lipid, protein, fiber, ash, carbohydrate, Fe, Cu, Zn, Ca, and Mg. Mineral content was determined for fruits of *Solanum diphyllum* and for shoots of three native condiments, *Monarda austromontana*, *Hedeoma patens*, and *Teloxys ambrosioides*. We also describe native uses of these foods, as well as of *Physalis* spp., *Echinocereus* spp., *Mammillaria* spp., *Amaranthus* spp., *Chenopodium leptophyllum*, *Portulaca oleracea*, *Passiflora* spp., *Lonicera cerviculata*, *Yucca* spp., *Rhus trilobata*, *Pinus discolor*, *Cyperus esculentus*, *Allium* spp., *Begonia gracilis*, *Oxalis* spp., and *Capsicum annuum* var. *aviculare*.

RESUMEN.—Alimentos de origen vegetal tradicionalmente usados por los pima montañés de Chihuahua, México, se analizaron por sus contenidos próximos y minerales. Frutas y cladodes juveniles de *Opuntia robusta*, *O. durangensis*, y *O. macrorhiza*; frutas de *Arctostaphylos pungens*, *Arbutus xalapensis*, *Berberis pimana*, *Prunus persica*, *P. serotina* var. *virens*, y *P. gentryi*; raíces de *Prionosciadium townsendii*; tubérculos de *Dahlia coccinea*; bulbos de *Hymenocallis pimana*; inflorescencias de *Tillandsia erubescens*; bases de hojas y guíotes jóvenes de *Agave shrevei* se analizaron por grasa, proteína, fibra, ceniza, carbohidrato, Fe, Cu, Zn, Ca, y Mg. Composición mineral se determinó de las frutas de *Solanum diphyllum* y de tres condimentos indígenas, *Monarda austromontana*, *Hedeoma patens*, y *Teloxys ambrosioides*. Describimos también la utilización tradicional de estas comidas y de *Physalis* spp., *Echinocereus* spp., *Mammillaria* spp., *Amaranthus* spp., *Chenopodium leptophyllum*, *Portulaca oleracea*, *Passiflora* spp., *Lonicera cerviculata*, *Yucca* spp., *Rhus trilobata*, *Pinus discolor*, *Cyperus esculentus*, *Allium* spp., *Begonia gracilis*, *Oxalis* spp., y *Capsicum annuum* var. *aviculare*.

RESUME.—Quelques aliments d'origine plantale traditionamment consommées par les pima montagneux de Chihuahua, México, se sont analysés pour sa composition proximale et minerale. Les fruits et les cladodes juveniles d'*Opuntia robusta*, *O. durangensis*, et *O. macrorhiza*; les fruits d'*Arctostaphylos pungens*, *Arbutus xalapensis*, *Berberis pimana*, *Prunus persica*, *P. serotina* var. *virens*, et *P. gentryi*; les racines de *Prionosciadium townsendii*; les tubercules de *Dahlia coccinea*; les bulbes de *Hymenocallis pimana*; les inflorescences de *Tillandsia erubescens*; et les bases de feuilles et les tiges juveniles de l'inflorescence d'*Agave shrevei* se sont analysés pour le gras, la proteine, la fibre, la cendre, les carbohydrates, Fe, Cu, Zn, Ca, et Mg. Le content mineral s'est déterminé pour les fruits de *Solanum diphyllum*, et pour trois condiments traditionnels, *Monarda austromontana*, *Hedeoma patens*, et *Teloxys ambrosioides*. Nous descrivons aussi l'utilisation traditionnelle de ces aliments et celle de *Physalis* spp., *Echinocereus* spp., *Mammillaria* spp., *Amaranthus* spp., *Chenopodium leptophyllum*, *Portulaca oleracea*, *Passiflora* spp., *Lonicera cerviculata*, *Yucca* spp., *Rhus trilobata*, *Pinus discolor*, *Cyperus esculentus*, *Allium* spp., *Begonia gracilis*, *Oxalis* spp., et *Capsicum annuum* var. *aviculare*.

INTRODUCTION

The Mountain Pima utilize several noncultivated plants and animals for food, fiber, building materials, medicine, and several other uses. On a percent weight basis, noncultivated edible plants constitute only a small portion of the total diet, but their importance is far greater than this small percentage would suggest. Many of the wild plant foods represent important sources of vitamins and minerals, especially vitamins A and C. Such resources represent important sources of these nutrients for the neighboring Tarahumara (Connor *et al.* 1978, Cerqueira *et al.* 1979). Wild plants become extremely important during certain seasons of the year. Most of them are available in summer, when stores of the previous year's maize and bean harvests are running low.

Noncultivated resources may also take on an added importance during droughts and other crop failures. Dunnigan (1983) reported that use of noncultivated resources increases among the Mountain Pima during times of adversity, as has been demonstrated for other traditional peoples in other parts of the world (Grivetti 1979). Some of the people acknowledge this increased dependence on wild resources, while others deny that crop failures occurred in past years. Today, the Pima respond to crop failures by working as wage laborers and selling livestock, as well as by increasing their use of noncultivated resources. This, plus the availability of commercially produced food, has lessened the importance of non-cultivated resources under such circumstances but has not eliminated it (Dunnigan 1970). Some of the less-preferred plant resources, e.g. bulbs of *Hymenocallis pimana* Lafer. (Amaryllidaceae), played an important role in the past as famine foods (Laferrrière 1989a).

The Mountain Pima live in the Sierra Madre Occidental in the region straddling the boundary between the States of Chihuahua and Sonora, Mexico. They are linguistically related to the Pima and Tohono O'odham (Papago) of Arizona and lowland Sonora. The people engage in animal husbandry and subsistence agriculture, raising cattle, goats, pigs, chickens, and turkeys, and planting maize,

beans, squash, potatoes, and other crops (Dunnigan 1970, 1983; Laferrière and Van Asdall 1991a). The predominant natural vegetation of the area is pine/oak forest. A few other species of trees are present in the vicinity. Madroño (*Arbutus xalapensis* H.B.K. and *A. arizonicus* (A. Gray) Sarg., Ericaceae) is common in forested areas, while ahuasiqui (*Prunus gentryi* Standl., Rosaceae), capulín (*P. serotina* Ehrh. ssp. *virens* (Woot. & Standl.) McVaugh var. *virens*), and palo prieto (*Ilex tolucana* Hemsl., Aquifoliaceae) are frequent along riverbanks. Sabino (*Cupressus arizonica* E. Greene, Cupressaceae) forms thick shaded stands in moister canyons, and there are a few small groves of haya (*Acer grandidentatum* Nutt., Aceraceae) near larger rivers.

Several of the wild plant foods utilized by the Mountain Pima have never been analyzed for nutritional content, and two have been described botanically only recently (Laferrière 1990a; Laferrière and Marroquín 1990). The present study was undertaken to ascertain the nutritional value of certain cultivated and non-cultivated plant foods. We analyzed several of the more important Mountain Pima plant foods for proximate and mineral composition. Some of the smaller, less important items were not included because of difficulty in obtaining sufficiently large quantities of material. Quelites, or wild edible greens, were not analyzed since several existing publications already describe their nutritional value (Bye 1981; Cerqueira *et al.* 1979; Connor *et al.* 1978; Franke 1985; Maytowitz and Matthews 1984). Sufficient quantities of naranjilla berries (*Solanum diphyllum* L., Solanaceae) were obtained for mineral but not proximate analysis.

METHODS AND MATERIALS

Ethnographic information was obtained by JEL through participant observation and by interviews with residents of Nabogame, Yepachi, and Las Varitas, Chihuahua. Fieldwork lasted a total of 13 months between October 1986 and November 1988. Samples for analysis were collected from the vicinity of Nabogame, Municipio Temósachi, Chihuahua, 28°30'N, 108°30'W, elevation 1800 meters. The site is located approximately 18 km northwest of the commercial center of Yepachi and 10 km east of the Sonoran frontier. This village should not be confused with the larger Tepehuan community of the same name farther south in Chihuahua.

Each sample represented a conglomerate of several individual plants from the same general vicinity. Most samples were sun-dried (Kuhnlein 1986) for shipment to Tucson. Leafy material was air-dried indoors, while tubers of kachana (*Dahlia coccinea* Cav., Asteraceae), leaves and flowering stalks of chugilla (*Agave shrevei* Gentry ssp. *matapensis* Gentry, Agavaceae), bulbs of *Hymenocallis pimana*, and fruits of *Arbutus xalapensis* were transported fresh. Bulbs of *H. pimama* and leaf bases of *A. shrevei* were peeled before analysis. Fruits of *Prunus* spp. were pitted before drying, but those of other fruits were analyzed complete with seeds because this is how they are consumed. *Opuntia* fruits and cladodes (pads) were despined and washed in the Mountain Pima manner. Vouchers are on deposit at ARIZ and MEXU.

Upon arrival at the laboratory all items were weighed and frozen. They were then lyophilized, weighed, and ground into a powder using a blender and/or Wiley mill. The ground samples were placed in plastic bags and stored in a freezer until analyzed.

Samples were analyzed in triplicate. The logistical necessity of drying specimens for transport precluded accurate moisture figures for most of the samples. Protein, fat, and ash were determined by AOAC (1980) methods. Crude fiber was determined by the Acid Detergent Fiber method of Van Soest (1963). Carbohydrate content was calculated by subtracting from 100 the difference of moisture, fat, protein, and ash. The energy values were calculated by multiplying the grams of carbohydrate and protein by 4 kcal per gram and the fat by 9 kcal per gram (National Research Council, 1980). Minerals were determined by wet ashing using the AOAC (1980) method. Acid digested samples were quantitatively transferred and made up to a given volume. Minerals were run by flame atomic absorption spectrophotometry (Hitachi, 180-70). Mineral standards were prepared on a daily basis from certified atomic absorption standard solutions (Fisher Scientific, NJ). Linear regression of the standard curves were determined after running 10 unknown samples and had an accuracy of 5% within runs and 10% between runs. The magnesium and calcium samples were masked with a 1% lanthanum concentration (Deeming and Weber, 1977). Phosphorus was determined by the method of Koenig and Johnson (1942). All glassware was acid-washed in 50% HNO₃ and rinsed three times in distilled deionized water.

RESULTS AND DISCUSSION

Results of proximate analysis are given in Table 1 while results of mineral analyses are presented in Table 2. The results of our nutritional analyses agree in large part with previous studies, for those plants which have previously been analyzed. Values for the two cultivated species, squash and peaches, agree with values published by Gebhardt *et al.* (1984) and Haytowitz and Matthews (1984). Subterranean organs generally showed large amounts of carbohydrates, as did *Agave shrevei*. Fruits analyzed with seeds proved much higher in fiber than the pitted fruits of *Prunus* spp. The four taxa of *Opuntia* varied considerably in chemical content, although all were high in carbohydrate, fiber, calcium, and magnesium.

Cultivated crops.—Major cultivated crops include maize (*Zea mays* L., Poaceae), beans (*Phaseolus vulgaris* L., Fabaceae), squash (*Cucurbita pepo* L., Cucurbitaceae), potatoes (*Solanum tuberosum* L.), and peaches (*Prunus persica* L.) (Laferrière and Van Asdall 1991a). The Mountain Pima cut peeled, seeded squash into strips, wind the strips into coils and sun-dry them for winter use (Laferrière & Van Asdall 1991a). The Navajo and Tarahumara dry squash in a similar manner (Bennett and Zingg 1935; Vestal 1952).

The Mountain Pima use peaches both green and ripe. Green peaches are stewed with sugar or roasted in the fire to soften them. Green peaches are higher in fiber and lower in carbohydrate than ripe fruits (Table 1).

Table 1: Proximate composition of Mountain Pima food plants (percent, moisture-free basis)

SPECIES	PART	KCAL	PROTEIN	CARBOHYDRATE	LIPID	FIBER	ASH
<i>Agave shrevei matapensis</i>	flower stalk	295	4.68	67.44	0.74	21.71	5.43
	leaf base	243	2.73	56.89	0.54	19.61	20.23
<i>Arbutus xalapensis</i>	fruit	276	4.15	58.17	3.00	32.72	1.96
<i>Arctostaphylos pungens</i>	fruit	222	2.67	43.87	4.00	48.31	1.15
<i>Berberis pimana</i>	fruit	329	9.70	58.18	6.35	22.35	3.42
<i>Cucurbita pepo</i>	mesocarp	303	4.86	68.51	1.02	16.38	9.23
<i>Dahlia coccinea</i>	tuber	258	16.39	47.81	0.15	31.28	4.37
<i>Hymenocallis pimana</i>	bulb	389	14.29	77.49	2.40	3.16	2.66
<i>Jaltomata procumbens</i>	fruit	224	12.75	36.67	2.87	43.95	3.76
<i>Opuntia durangensis (duraznillo blanco)</i>	cladode	289	6.11	61.19	2.15	16.33	14.22
	fruit	260	3.34	57.78	1.79	25.46	11.63
<i>Opuntia cf. macrorhiza</i>	cladode	357	2.16	86.17	0.45	7.77	3.45
	fruit	291	5.32	54.56	5.71	30.17	4.24
<i>Opuntia cf. robusta (temporal)</i>	cladode	263	13.84	48.50	1.53	17.43	18.70
	fruit	317	4.59	68.30	2.87	17.76	6.48
<i>Opuntia cf. robusta (noviembrena)</i>	fruit	284	2.61	61.67	3.02	26.51	6.19
<i>Prinosciadium townsendii</i>	root	346	5.83	76.58	1.79	11.86	3.94
<i>Prunus gentryi gentryi</i>	pericarp	324	3.98	76.73	0.13	12.05	7.11
<i>Prunus persica</i>	mature fruit	368	6.18	85.23	0.29	4.77	3.53
	green fruit	311	7.87	64.23	2.56	17.16	8.18
<i>Prunus serotina virens</i>	mesocarp	203	3.11	46.42	0.51	27.86	22.1
<i>Tillandsia erubescens</i>	inflorescence	316	8.75	66.40	1.70	13.80	9.35

Table 2: Mineral composition of Mountain Pima plant foods (ppm, moisture-free basis)

SPECIES	PART	Fe	Cu	Zn	Ca	M
<i>Agave shrevei matapensis</i>	flower stalk	56	3	19	10618	3826
	leaf base	54	10	29	52476	18392
<i>Arbutus xalapensis</i>	fruit	37	6	106	3713	899
<i>Arctostaphylos pungens</i>	fruit	13	8	9	1809	392
<i>Berberis pimana</i>	fruit	51	20	15	2337	1154
<i>Cucurbita pepo</i>	mesocarp	87	7	8	3020	2357
<i>Dahlia coccinea</i>	tuber	41	7	9	3756	1513
<i>Hedeoma patens</i>	shoot	485	8	28	12530	991
<i>Hymenocallis pimana</i>	bulb	34	5	20	3724	912
<i>Jaltomata procumbens</i>	fruit	33	8	21	1171	2412
<i>Monarda austromontana</i>	shoot	821	12	49	13039	4313
<i>Opuntia durangensis (duraznillo blanco)</i>	cladode	96	2	8	24222	19385
	fruit	214	18	24	23543	6392
<i>Opuntia cf. macrorrhiza</i>	cladode	85	13	56	15414	9172
	fruit	161	8	10	6078	4290
<i>Opuntia cf. robusta (temporal)</i>	cladode	156	5	161	12350	8395
	fruit	117	10	15	4543	3613
<i>Opuntia cf. robusta (noviembrena)</i>	fruit	47	76	51	3426	1888
<i>Prionosciadium townsendii</i>	root	174	10	20	6442	2899
<i>Prunus gentryi gentryi</i>	pericarp	44	58	102	2119	946
<i>Prunus persica</i>	mature fruit	45	2	5	395	612
	green fruit	188	10	7	1262	1109
<i>Prunus serotina virens</i>	pericarp	45	6	8	1617	795
<i>Solanum diphyllum</i>	fruit	54	8	8	1080	1383
<i>Teloxys ambrosioides</i>	shoot	127	9	9	18929	14182
<i>Tillandsia erubescens</i>	inflorescence	137	2	32	15528	7697

Cacti.—Fruits and cladodes (pads) of *Opuntia* spp. (Cactaceae) have been widely utilized as food sources in much of the New World (Meyer and McLaughlin 1981; Russell and Felker 1987). Six folk taxa of prickly pear (*Opuntia* spp.) are recognized by the Pima of Nabogame (Fig. 1). These include the cultivated nopal de Castilla (*O. ficus-indica* (L.) Miller) and five wild taxa, i.e. nopal temporal (purple-fruited individuals of *O. cf. robusta* Wendl.), tuna noviembreña (red-fruited *O. cf. robusta*), nopal de zorra (*O. cf. macrorhiza* Engelm.), duraznillo blanco (yellow-fruited *O. durangensis* Britton & Rose), and duraznillo colorado (red-fruited *O. durangensis*).

The cladodes are especially important during the spring dry season since they are one of the first noncultivated resources to become available in the year. Cladodes of all six taxa are used in much the same manner. Nopal temporal is the most important, producing the largest cladodes and growing abundantly in virtually any nonplowed site. Tuna noviembreña is very similar, but has red rather than purple fruits which mature in October or November rather than August. Nopal de zorra is a small recumbent species producing narrow obconical fruits. The immature cladodes of both these species have an orange tint, especially toward the distal edge. Duraznillo is strikingly different in general appearance, being a darker shade of green and having smaller cladodes bearing shorter but more numerous spines while lacking the reddish tint. Nopal de Castilla is planted in a few kitchen gardens, and is valued for its large size and absence of spines.



FIG. 1.—Fruits of (l-r) tuna temporal (*Opuntia cf. robusta*), duraznillo blanco (*O. durangensis*), and tuna de zorra (*O. cf. macrorhiza*).

The Mountain Pima harvest the cladodes by holding a bucket underneath and cutting the base, allowing the cladode to fall in. They remove the spines and glochids on a rock at the bank of the brook and scrape away the areoles with a knife, spoon, or other metal object. The small glochids can cause inflammation

of the mouth if ingested (Georgi *et al.* 1982). Scraping is done first toward the distal end of the cladode, removing the majority of the spines, then reversing the scraping direction to remove the remainder. Water is periodically flushed over the cladode to clean away the loosened spines. A few of the cladodes are eaten raw, but the majority are chopped and fried in lard with onions and/or garlic. The cladodes are cut by holding them vertically in the left hand and making parallel slits downward toward the base, followed by further slits perpendicular to the first.

The Mountain Pima consume fruits or "tunas" of all local taxa of *Opuntia*. The fruits ripen in August and September except for those of tuna noviembrena which mature in October or November. Those of nopal de Castilla and nopal temporal are preferred, since they are much larger than the fruits of the other two species. The spines of both species are removed using cuts parallel to and just below the skin. Fruits of nopal de zorra are too juicy for this method, since the interior of the fruit consists primarily of mucilaginous endocarp; hence the juicy area is generally scraped out with a knife. The fruits of duraznillo are the smallest and driest of the four species in the community. These are seldom utilized, but are treated like those of nopal temporal.

All cladodes in our study proved higher in carbohydrate and lower in ash and protein than the values reported for cladodes of the cultivated *O. ficus-indica* (Feitosa-Teles 1977; Feitosa-Teles *et al.* 1984). Cladode composition can vary depending on degree of maturity; protein, fiber contents tend to decrease on a percent weight basis as the cladode matures, while starch, lipid, carotene and free sugar increase (Retamal *et al.* 1987; Rodriguez-Felix and Cantwell 1988).

The cladodes have a very high calcium content, although this may vary somewhat according to soil content (Nobel *et al.* 1987; Gonzalez 1989). The high calcium values of *Opuntia* cladodes are largely due to the plants' accumulation of insoluble calcium oxalate. Up to 85% of the calcium in some cacti may be in the form of calcium oxalate (Trachtenberg and Mayer 1982b). This may constitute as much as 21% of the dry weight of the cladodes (Rodríguez-Mejía *et al.* 1985). *Opuntia plumbea* Rose contains 1.5% oxalate content by fresh weight (Justice 1985). This makes much of the calcium unavailable for human consumption. The calcium present in the cladodes shifts on a diurnal basis from being bound as calcium oxalate to being bound to the mucilage (Trachtenberg and Mayer 1982a,b). This is as a result of the pH cycles characteristic of Crassulacean Acid Metabolism common to most cacti (Trachtenberg and Mayer 1982a,b). Hence the amount of calcium available for digestion may vary according to the time of day.

The quantity of carbohydrate available for utilization may be also somewhat lower than our figures indicate. Some of the mucilage which constitutes a significant proportion of the carbohydrate fraction is digestible, but a sizeable fraction is not. The proportion of digestible matter varies from one species of *Opuntia* to another (McGarvie and Parolis 1979b, 1981). The hypoglycemic effect reported for *Opuntia* cladodes (Ibañez-Camacho *et al.* 1983; Frati-Munari *et al.* 1987) may be due to an inhibition of the absorption of simple carbohydrates rather than any direct effect on insulin production (Frati-Munari *et al.* 1988).

Fruits of cholla (*Mammillaria barbata* Engelm., *M. cf. sonorensis* Craig, *Echinocereus stoloniferus* W.T. Marshall ssp. *tayopensis* (Marsh.) N.P. Taylor, *E. sheeri*

(Salm-Dyck) *Rumpler* var. *sheeri*, and *E. polyacanthus* Engelm. var. *polyacanthus*, all Cactaceae) are also eaten raw when mature in late summer, but are small and comparatively rare. *Echinocereus* fruits possess sharp spines which adversely affect their utilization. Fruits of other species of *Mammillaria* and *Echinocereus* have been reported consumed by the Navajo, Seri, and Tarahumara (Elmore 1943; Vestal 1952; Felger and Moser 1985), and by the Pima of Arizona (Curtin 1949). Stems of several species of *Mammillaria* have also consumed as food (Robbins *et al.* 1916; Vestal 1952). Some of the latex-containing species, however, have been used as hallucinogens (Bye 1979). Fruits of *E. coccineus* Engelm. are reportedly poisonous and used by the Navajo as a heart stimulant (Elmore 1943). Stems of certain species of *Echinocereus* have been used as hallucinogens (Bye 1979; Ferrigni *et al.* 1982), although stems of other species have been used to make candy (Nobel 1988).

Agave. — *Chugilla* (*Agave shrevei*) supplies the Mountain Pima with two food items plus a potent piscicide. Immature flowering stalks or "guiotes" are harvested in May and June. They are roasted in the fire, peeled, and chewed upon to extract the juicy interior. The fibrous material which constitutes a large fraction of the stalk material is then spit out.

Leaves of *Agave shrevei* contain several compounds which inhibit their utilization as food sources. These leaves are used raw as fish stupification plants by the Mountain Pima and the Tarahumara (Bye *et al.* 1975; Dunnigan 1970; Bennett and Zingg 1935; Gentry 1982). The plants contain several different saponins, primarily hecogonin and manogenin, but no flavones or tannins (Hegnauer 1963, 1986; List and Horhammer 1972; Dominguez *et al.* 1960). The saponins present in the leaves and rootstocks make these tissues useful for washing clothes (Sheldon 1980). Extracts from *Agave* sap affect the nervous system and produce diarrhea when injected into laboratory animals (Jones *et al.* 1932). Sap from *Agave* leaves also kills snails and inhibits the growth of fungi (Shoeb *et al.* 1986; de Cassia-Salomao and Purchio 1982) and has been used as an antiseptic (Davidson and Ortiz de Montellano 1983). An unidentified compound in many species, including *A. shrevei*, causes dermatitis (Gentry 1982).

Leaves of various species of *Agave* have, however, commonly been roasted and consumed as food throughout the range of the genus (Gentry 1982; Castetter *et al.* 1938; Ebeling 1986; Mitich 1976). The Mountain Pima use the white leaf bases of *A. shrevei* by roasting them in large pits, peeling them, and eating them (Fig. 7). The roasting is sufficient to destroy most of the saponins, leaving a rather sweet, juicy but fibrous mass. The roasting pits are rather large and can often still be seen years after their utilization. Kovacevic *et al.* (1963) reported somewhat higher protein (3.64% dry weight) and lower ash (5.76%) values from cooked leaf mesoderm of *A. americana* L. Roasting may alter the digestibility of some nutrients as well as lower the saponin content.

Other fruits. — The Mountain Pima also utilize several other wild fruits, although none is common enough to make a significant contribution to the diet. The most important of these is ahuasiqui (*Prunus gentryi*), which grows along the banks of some of the larger creeks. The fruits mature in June and July. Two folk species

are recognized, the purple-fruited ahuasiqui negro (*P. gentryi* f. *gentryi*) and the yellow-to-scarlet-colored ahuasiqui blanco (*P. gentryi* f. *flavipulpa*) (Fig. 2) (Laferrière 1989b). The latter is considered less astringent than the former. Capulín (*Prunus serotina* var. *virens*) (Fig. 3) is also present in similar habitats, but is underutilized because of its astringent taste. Parra (*Vitis arizonica* Engelm.,



FIG. 2.—Fruiting branch of ahuasiqui blanco (*Prunus gentryi* f. *flavipulpa*).



FIG. 3.—Fruiting branches of capulín (*Prunus serotina* var. *virens*).

Vitaceae) is also present in shaded canyons, but rarely yields enough fruit to make a foraging trip worthwhile. This plant is more esteemed for the use of its leaves to treat pimples. The fruits are, however, consumed in the southwestern United States (Castetter 1935; Palmer 1878).

Berberis pimana Lafer. & Marr. (Berberidaceae), variously called palo dulce, palo aigre, or palo amarillo, is common in shaded canyons, and is eaten raw by some persons but disliked by others because of its strong acidity (Laferrière and Marroquín 1990). Norton *et al.* (1984) reported proximate composition of *Berberis nervosa* Pursh. similar to our figures for *B. pimana* except for a somewhat higher protein value (18% dry weight). They also reported values of 1.91 mg calcium, 3 mg iron, 85 mg magnesium, 5 mg zinc, and 145 mg ascorbate per 100 g. Petcu (1965, 1966, 1968) reported ascorbate contents ranging from 329 to 525 mg per 100 g fresh weight of fruits of various Romanian species of *Berberis*. Wierzchowski and Bubicz (1959) reported 92 mg β -carotene per 100 g fresh fruit pulp of *B. vulgaris* L. Thirteen species of *Berberis* from the Soviet Union ranged from 22.0-73.3 mg/100 g, vitamin C and 0.41-1.17% sugar (Kharitonova 1986). Sugars of *B. vulgaris* are predominantly galactose and arabinose but significant amounts of fucose, xylose, and rhamnose are also present (Martynov *et al.* 1984).

Berberis fruits contain compounds limiting their utilization in large quantities. Fruits of *B. siamensis* (Takeda) Lafer.¹, are eaten in Thailand and considered diuretic and a demulcent in dysentery (Ruangrungrasi *et al.* 1984). Many alkaloids are known from the root bark of *Berberis* spp. (List and Horhammer 1972) and a few have been isolated from fruits (Brazdovicova *et al.* 1980).

Manzanilla (*Arctostaphylos pungens* H.B.K., Ericaceae) is very common in certain drier areas, forming open thickets with *Quercus chuhuichupensis* Muller. Its dry, amber-colored fruits are eaten raw in June and July by the Mountain Pima, Tarahumara, Zapotecs and Warihío (Pennington 1963; Gentry 1963; Uphof 1959). Fruits of various species of *Arctostaphylos* have been consumed in large quantities by the natives of California, either fresh or dried (Wickson) 1889; Balls 1962; Ebeling 1986). A cider can also be made from the fruits of several species (Ebeling 1986; Wickson 1889; Palmer 1978). The fruits, though edible, tend to be dry and mealy, and difficult to digest in large quantities (Harrington 1967; Kirk 1975). *Arctostaphylos uva-ursi* (L.) Spreng, is called "mealy-plum" in Massachusetts because of its dry, puckering contents (Sanford 1937). Our high fiber figures support these observations. Kuhnlein (1989) reported similarly high fiber figures for *A. uva-ursi*. Leung and Flores (1961), however, reported a fiber value of only 4.62% dry weight for fruits of *A. tomentosa* Pursh. Seeded, dried fruits of *A. pungens* may contain over 40% sugar and 16% citric acid (Martínez 1939).

Fruits of *A. pungens* contain arbutin, and have diuretic properties (Sociedad Farmacéutica Mexicana 1952). Dried fruits are used in Baja California to treat gall bladder and urinary tract infections (Winkelman 1986). These compounds as well as the high fiber content prevent consumption of large quantities of fruit.

Orange fruits of madroño (*Artutus xalapensis* [Fig. 4] and *A. arizonica*) mature in October. Madroño trees are fairly common in forested regions and along shaded arroyos. Fruits of both species are eaten by both the Tarahumara and Tepehuan (Pennington 1963, 1969). Other species have been utilized in the United States (Balls 1962).



FIG. 4.—Fruits of madroño (*Arbutus xalapensis*).

Tonolochi (*Passiflora bryonioides* H.B.K. and *P. quercetorum* Killip, Passifloraceae) is occasionally found on drier canyon walls and in protected locations in manzanilla thickets. The whitish fruits are occasionally eaten by children. Fruits of several species of *Passiflora* are widely utilized as food sources in many tropical countries (Martin and Nakasone 1970), orange fruits of palo del venado (*Lonicera cerviculata* S.S. White, Caprifoliaceae) are considered edible but are not frequently eaten because of their relative rarity.

Fruits of the weedy tomatillo (*Physalis caudella* Standl., Solanaceae), common in agricultural fields, are consumed green or ripe, primarily by children. Two other related species, collectively called tomatillo chiquito (*P. minima* L. and *P. microcarpa* Urban & Ekman) are present in forested areas and beneath taller vegetation in agricultural fields, and are also eaten occasionally, but are too small and rare to be of much use. Fruits of *Physalis* spp. are widely utilized in several countries (Gibbons 1962; Harrington 1967).

Fruits of tulusin (*Jaltomata procumbens* (Cav.) J.L. Gentry, Solanaceae) are also consumed. *Jaltomata procumbens* is a common weed in much of Mexico and Central America. It is often encouraged by farmers because of its edible berries, and some populations demonstrate some evidence of domestication (Davis and Bye 1982).

Solanum diphyllum is a red-fruited species native to the Sierra Madre and occasionally cultivated there as an ornamental. The Mountain Pima sometimes eat the fruits, but also use them to make wreaths in holiday decorations (Laferrrière and Van Asdall 1991b).

The Mountain Pima recognize fruits of *Rhus trilobata* Nutt. (Anacardiaceae) as edible but do not use them extensively due to their relative scarcity. These

fruits are used in Arizona and California because of their pleasant acidic taste, due to malic acid in the hairs on the fruit (Hodgson 1982; Balls 1962). Piñones (seeds of *Pinus discolor* Bailey & Hawksworth, Pinaceae) are available at lower elevations.

Immature fruits of savaliqui (*Yucca grandiflora* Gentry, Agavaceae) and jamole (*Y. madrensis* Gentry) are also occasionally consumed (Gentry 1972; Laferrière 1990b). Fruits of several other species of *Yucca* were commonly consumed in the southwestern United States (Castetter 1935; Ebeling 1986). Green fruits of *Y. madrensis* are eaten by the Warihio as well as the Mountain Pima (Gentry 1972; Laferrière 1990b). *Yucca grandiflora* is also utilized at lower elevations in the canyons south of Yepachi (Gentry 1972). Fruits of several other species have been consumed in the southwestern United States (Yanovsky 1936). Fruits of both the Mountain Pima species are dry and inedible when mature.

Greens.—Quelites, or wild edible greens, constitute a significant portion of the diet during the early part of the summer rainy season, when the plants are young and tender. The most commonly utilized species include quelite de mayo (red-leaved individuals of *Amaranthus hybridus* L., Amaranthaceae), quelite de agua (white-leaved *A. hybridus*), chuale (*Chenopodium leptophyllum* Nutt., Chenopodiaceae), and verdolaga (*Portulaca oleracea* L., Portulacaceae).

Caña aigre (*Begonia gracilis* H.B.K. ssp. *nervipilosa* A. DC., Begoniaceae) is common in moist, shaded locations, and is occasionally consumed by children. The stalks are juicy, mucilaginous, and pleasantly acidic. Hierba aigre (*Oxalis decaphylla* H.B.K. and *O. albicans* H.B.K. ssp. *albicans*, Oxalidaceae) is treated the same way. Shoots of *Begonia* and *Oxalis* are acidic due to the high concentration of oxalic acid, which is potentially toxic in large quantities (Laferrière 1990c, 1991a). Fortunately, the children do not consume enough of these plants to cause noticeable harm. Shoots of *O. divergens* Benth. are used by the Mountain Pima as tea to relieve fatigue (Pennington 1973). Cravioto (1951) gave a figure of 3.7 mg carotene per 100 g *O. divergens*. Shoots of *B. gracilis* are used in treating toothache or gum disease (Pennington 1973).

Subterranean organs.—Roots of saraviqui (*Prionosciadium townsendii* Rose, Apiaceae [Fig. 5], listed as *P. madrense* S. Wats. by Dunnigan [1970]), are eaten in August or September after the leaves turn brown. The species grows primarily along the steep sides of shaded arroyos, and is not very common in the area. The entire plant, including both above- and below-ground portions, is pleasantly aromatic. The roots of prereproductive specimens of this semelparous species are roasted in the fire, and considered as good as potatoes. The plant was much more common in the past but has declined in abundance due to extensive grazing pressure. The smaller purple-flowered relative, *P. madrense* is considered edible by some people but bitter by others. The Tarahumara consume *P. serratum* Coult. & Rose (Pennington 1963).

The Mountain Pima have eaten boiled tubers of kachana (*Dahlia coccinea* [Fig. 6] and *D. sherffii* Sorenson), although their use is declining. Tubers of *Dahlia* spp. were widely used in pre-Spanish Mexico and are very high in inulin and fructose

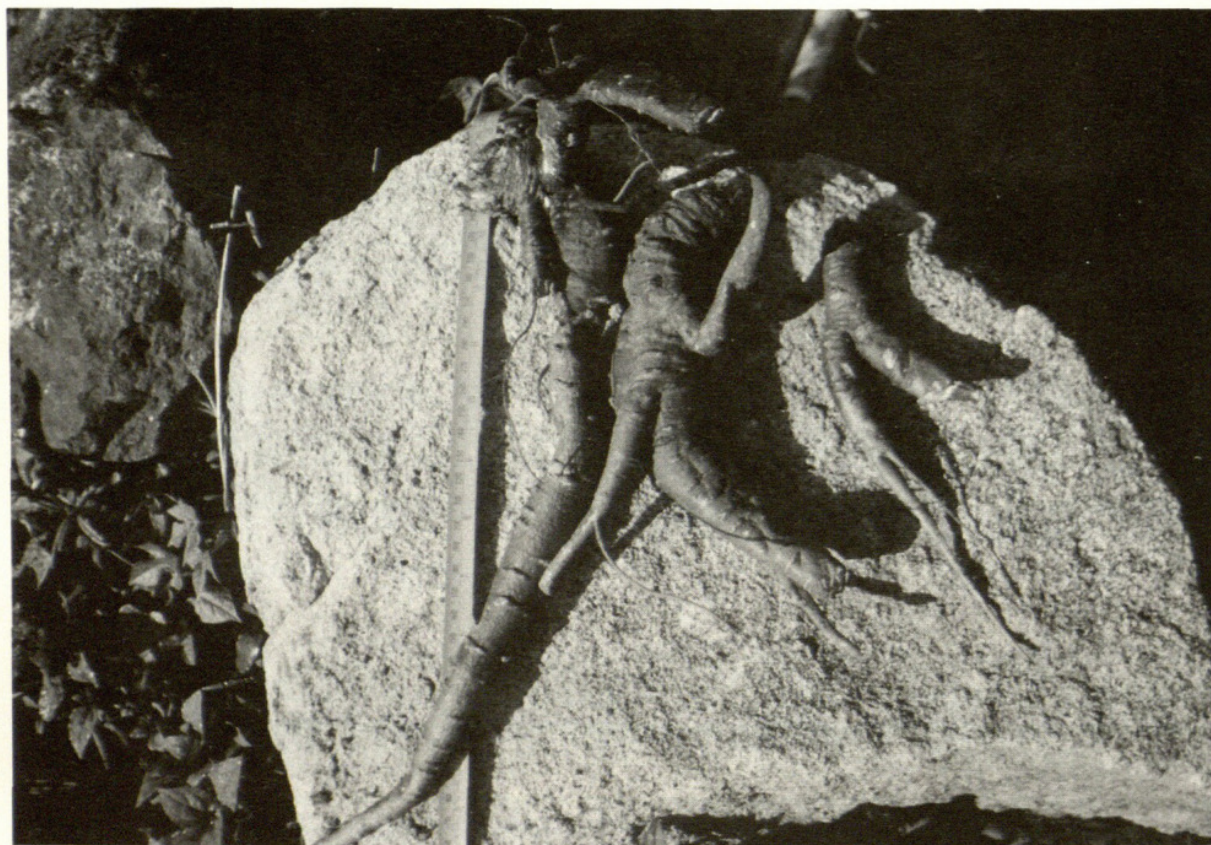


FIG. 5.—Root of saraviqui (*Prionosciadium townsendii*).

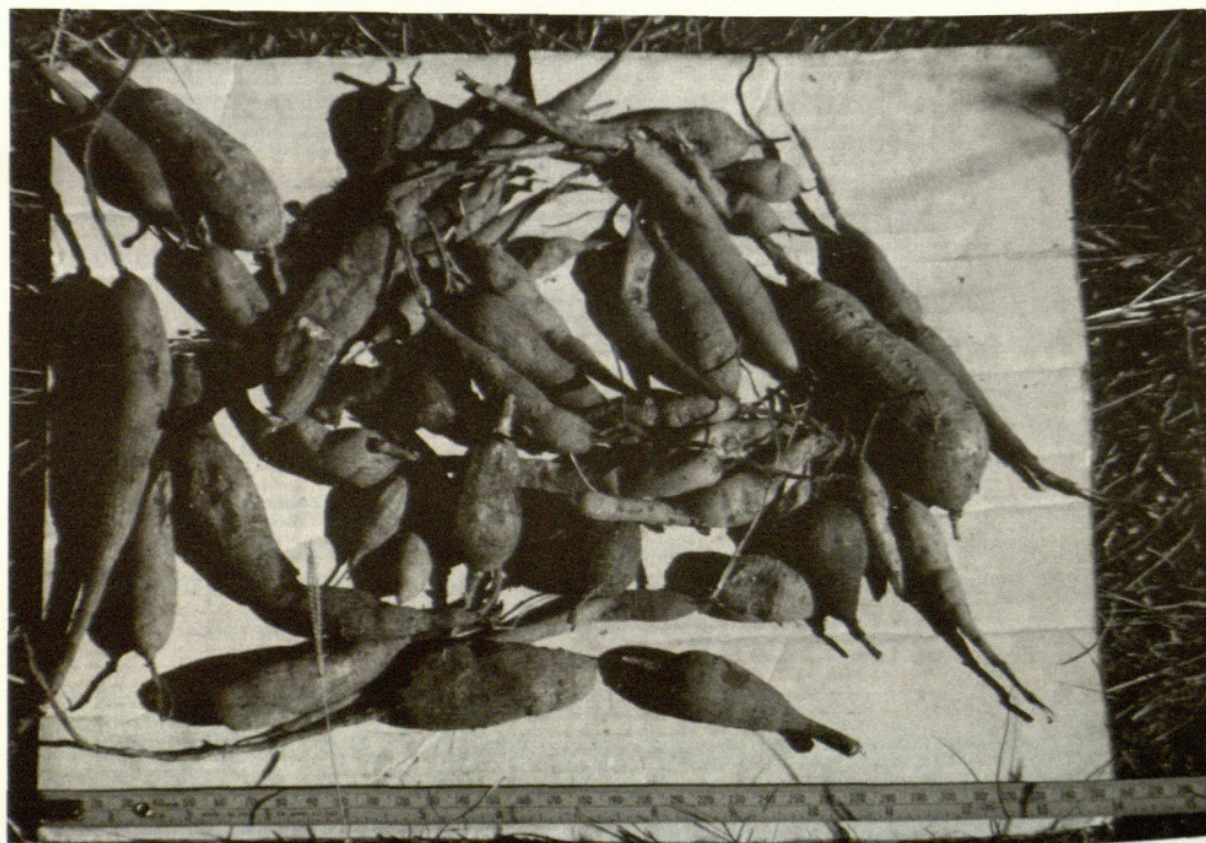


FIG. 6.—Tubers of kachana (*Dahlia coccinea*).

(Whitley 1985). Tubers of *D. coccinea* have antibiotic and antiatherogenic properties and act as central nervous system depressants (Whitley 1985; Jiu 1966).

Tubers of grulla (*Cyperus esculentus* L., Cyperaceae) are occasionally eaten during planting season, mostly by children. This plant grows abundantly in the fields, and since the tubers are produced above the level from which the plows throw up the soil, the plants and the intact tubers are pushed upward and can be gathered very easily. The tubers are gathered and eaten raw in the field with only a minimum of cleaning. They are reported to be very sweet, but do not constitute a major source of food because of their extremely small size, only a few millimeters in diameter. This widely distributed species is utilized in many countries. Raw tubers contain 43.9% carbohydrate, 17.2% lipid, and 4.4% protein by fresh weight (Mokady and Dolev 1970).

The name "cebollín," from the Spanish "cebolla," meaning "onion," is shared by at least two wild species of *Allium* (Liliaceae) as well as the much larger *Hymenocallis pimana*. *Allium* bulbs are often used as a flavoring ingredient in soups and fried dishes. *Hymenocallis* is very common in permanently fallow fields, forming showy displays of white flowers early in the summer rainy season (Laferrière 1990a). The large bulbs, which resemble onions but without the odor, were eaten during famines until the first part of this century (Laferrière 1989b). The bulbs were first boiled in lye to extract the bitter, toxic alkaloids (Laferrière 1989b).

Epiphytes.—Inflorescences of the epiphytic bromeliad "flor de encino" (*Tillandsia erubescens* Schlecht.) (Fig. 8) are occasionally eaten, and are reputed to be very sweet. The species flowers from March through May, and is thus one of the few



FIG. 7.—Roasted leaf bases of chugilla (*Agave shrevei* ssp. *matapensis*).



FIG. 8.—Flor de encino (*Tillandsia erubescens*).

wild plant species available in the early spring. The smaller *T. recurvata* L. is also present in the valley, but is less common. The two are ethnotaxonomically conspecific and are utilized in the same manner. *Tillandsia* has been widely used medicinally and as a source of packing material (Robinson 1947; Bennett and Zingg 1935; Laferrière 1991b), but we have been unable to locate any references to food uses for members of this genus. French and Abbott (1948) reported 1500 mg carotene and 46 mg ascorbate per 100 g fresh weight of shoot material of *T. usneoides* L.

Condiments.—Three local plant species are used in Nabogame as condiments to flavor beans. Oregano grande (*Monarda austromontana* Epling, Lamiaceae) is very common in permanently fallow fields, while the smaller, rarer oregano chiquito (*Hedeoma patens* Jones, Lamiaceae) is found in small clumps on the walls of

shaded canyons. These, as well as *H. floribunda* Standl., are used in a similar manner by the Warihío (Gentry 1963). Pazote or epazote (*Teloxys ambrosioides* (L.) W. Weber, Chenopodiaceae; = *Chenopodium ambrosioides* L.) is used in a similar manner.

Our figures for mineral composition for the two species of wild oregano correspond closely to values given for the cultivated *Origanum vulgare* L. (Lamiaceae) (Marsh *et al.* 1977). Some of the organic constituents of both species, however, may be potentially toxic in large amounts. Foliage of *Hedeoma pulegioides* (L.) Pers. contains pulgenone, a terpene capable of causing dermatitis and, in large doses, death (Duke 1985; Sleckman *et al.* 1983). The plant has been widely used to treat headache, flatulence, colds, bowel disorders, and rheumatism (Duke 1985). *Monarda didyma* L. (Oswego tea) and *M. fistulosa* L. (wild bergamot) have been used in the eastern United States as tea and as condiments in cooking (Medsger 1939). The most common essential oil of *M. fistulosa* is thymol in the shoots, borneol in the roots (Heinrich *et al.* 1983; Pfab *et al.* 1980). Shoots of *T. ambrosioides* have been widely employed as anthelmintics but have been replaced by less toxic drugs (Claus *et al.* 1970; Osol and Rarrar 1960). The herbage contains 0.35% volatile oil, of which 45-70% is ascaridol (Ayensu 1981). The Mountain Pima use the plant in treating colic (Pennington 1973).

Wild chiltepinas (*Capsicum annuum* L. var. *aviculare* (Dierb.) D'Arcy & Eshbaugh, Solanaceae) are used to make chili and salsa, and are used to flavor beans, potatoes, and other foods. These are highly prized by the Mountain Pima but are relatively rare. Some people travel as much as three days to collect the fruits.

CONCLUSIONS

A few of the noncultivated species used by the Mountain Pima probably served as important energy sources in the past, especially the subterranean organs. *Prionosciadium townsendii* is still an important starchy food, while quelites and *Opuntia* spp. are still consumed in large enough quantities to supply a significant number of calories. Foods such as *Hymenocallis pimana* and *Dahlia* spp. probably supplied large amounts of starch in the past.

Most of the species, however, were probably more important as sources of micronutrients. Studies among the Tarahumara (Cerqueira *et al.* 1979; Connor *et al.* 1978) and other peoples have emphasized the importance of quelites as sources of vitamins A and C. While these and other noncultivated foods are certainly important in vitamin nutrition during the summer months among the Mountain Pima as well, they are lacking at other seasons of the year. Some vitamin A can be stored several months in the liver (National Research Council 1980) but the water-soluble vitamin C must be consumed regularly. There are no known good sources of vitamin C in the traditional Mountain Pima winter diet other than potatoes.

Mineral contributions from noncultivated resources may be as important as vitamins. Several of the plants analyzed showed high amounts of calcium and magnesium, although oxalate concentrations interfere with calcium utilization in *Opuntia*, *Agave*, *Begonia*, *Oxalis*, *Amaranthus*, *Chenopodium*, and *Portulaca*. Poten-

tially toxic compounds in some species, especially *Arctostaphylos pungens* and the three condiments, prohibit their use as important sources of micronutrients.

In times past, ashes were used in place of salt, pine ashes being preferred over those of oak since the former were not as strong. These ashes when added to food undoubtedly contributed significant amounts of minerals to the diet. Iodized salt is now purchased commercially and used frequently on beans, potatoes, and eggs. This may lessen the traditional dependence on noncultivated foods for these nutrients.

NOTE

¹*Berberis siamensis* (Takeda) Laferrière, comb. nov.—*Mahonia siamensis* Takeda, Kew Bull 1915:422, 1915. See Moran (1982) and Laferrière and Marroquín (1990) for a discussion of the status of *Mahonia*.

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LITERATURE CITED

- AOAC. 1980. Official methods of analysis, 13th ed. Washington: Association of Official Analytical Chemists.
- AYENSU, EDWARD S. 1981. Medicinal plants of the West Indies. Algonac MI: Reference.
- BALLS, EDWARD K. 1962. Early uses of California plants. Berkeley: University of California Press.
- BENNETT, WENDELL CLARK, and ROBERT M. ZINGG. 1935. The Tarahumara: an Indian tribe of northern Mexico. Chicago: University of Chicago Press.
- BRAZDOVICOVA, B., D. KOSTALOVA, J. TOMKO, and HWANG YANG JIN. 1980. Isolation and identification of alkaloids from fruits of *Berberis thunbergii* DC. *Chemické Zvesti* 34:259-262.
- BYE, ROBERT A. JR. 1979. Hallucinogenic plants of the Tarahumara. *Journal of Ethnopharmacology* 1:23-48.
- . 1981. Quelites—ethnoecology of edible greens—past, present, and future. *Journal of Ethnobiology* 1(1):109-123.
- BYE, ROBERT A. JR., DON BURGESS, and ALBINO MARES TRIAS. 1975. Ethnobotany of the western Tarahumara of Chihuahua, I: notes on the genus *Agave*. *Botanical Museum Leaflets of Harvard University* 24:85-112.
- CASTETTER, EDWARD F. 1935. Uncultivated native plants used as sources of food. *University of New Mexico Bulletin Biological Series* 4(1):1-62.
- CASTETTER, EDWARD F., WILLIAM H. BELL, and ALVIN R. GROVE. 1938. The early utilization and the distribution of *Agave* in the American Southwest. *University of New Mexico Bulletin Biological Series* 5(4):1-92.
- CERQUEIRA, MARIA T., MARTHA McMURRY FRY, and WILLIAM E. CONNOR. 1979. The food and nutrient intake of the Tarahumara Indians of Mexico. *American Journal of Clinical Nutrition* 32:905-915.
- CLAUS, EDWARD P., VARRO E. TYLER, and LYNN R. BRADY. 1970. *Pharmacognosy*. Philadelphia: Lea and Febiger.
- CONNOR, WILLIAM E., MARIA T. CERQUEIRA, RODNEY W. CONNOR, ROBERT B. WALLACE, M. RENE MALINOW and

LITERATURE CITED (continued)

- RICHARD CASDORPH. 1978. The plasma lipid, lipoprotein, and diet of the Tarahumara Indians of Mexico. *American Journal of Clinical Nutrition* 31:1131-1142.
- CRAVIOTO, RENE. 1951. Valor nutritivo de los alimentos mexicanos. *América Indígena* 11:297-309.
- CURTIN, LEONORA SCOTT MUSE. 1949. *By the prophet of the earth: ethnobotany of the Pima*. Santa Fe: San Vicente Foundation. Reprint: 1984, Tucson: University of Arizona Press.
- DAVIDSON, JUDITH R., and BERNARD R. ORTIZ DE MONTELLANO. 1983. The antibacterial properties of an Aztec wound remedy. *Journal of Ethnopharmacology* 8:149-161.
- DAVIS, TILTON IV, & ROBERT A. BYE JR. 1982. Ethnobotany and progressive domestication of *Jaltomata* (Solanaceae) in Mexico and Central America. *Economic Botany* 36:225-241.
- DE CASSIA-SALOMAO, RITA and ADHEMAR PURCHIO. 1982. Atividade de substâncias de origem vegetal na inibição do crescimento e na produção de aflatoxinas por *Aspergillus flavus* e *A. parasiticus*. *Revista de Microbiologia* 13:394-401.
- DEEMING, SUSAN B., and CHARLES W. WEBER. 1977. Evaluation of hair analysis for determination of zinc status using rats. *American Journal of Clinical Nutrition* 30:2047-2052.
- DOMINQUEZ, XORGE ALEJANDRO, PAULINO ROJAS, VIRGINIA COLLINA, and MA. DEL REFUGIO MORALES. 1960. A phytochemical study of eight Mexican plants. *Economic Botany* 14:157-159.
- DUKE, JAMES A. 1985. *CRC handbook of medicinal herbs*. Boca Raton FL: CRC Press.
- DUNNIGAN, TIMOTHY. 1970. Subsistence and reciprocity patterns among the Mountain Pimas of Sonora, Mexico. PhD. dissertation, University of Arizona.
- _____. 1983. Lower Pima. In: A. Ortiz and W.C. Sturtevant (eds.), *Handbook of Northern American Indians*, v. 10, pp. 217-229. Washington: Smithsonian Institution.
- EBELING, WALTER. 1986. *Handbook of Indian foods and fibers of Arid America*. Berkeley: University of California Press.
- ELMORE, FRANCIS H. 1943. *Ethnobotany of the Navajo*. Albuquerque: University of New Mexico Press.
- FEITOSA-TELES, FRANCISCO FRANCO. 1977. Nutrient analysis of prickly pear (*O. ficus-indica*, Linn.). *Journal of the Science of Food and Agriculture* 35:421-425.
- FEITOSA-TELES, F.F., J.W. STULL, W.H. BROWN, and F.M. WHITING. 1984. Amino and organic acids of the prickly pear cactus (*Opuntia ficus-indica* L.). *Journal of the Science of Food and Agriculture* 35:421-425.
- FELGER, RICHARD S., and MARY BETH MOSER. 1985. *People of the desert and sea: ethnobotany of the Seri Indians*. Tucson: University of Arizona Press.
- FERRIGNI, N.R., D.E. NICHOLS, J.L. McLAUGHLIN, and R.A. BYE. 1982. Cactus alkaloids, XLVIII: N-methyl-N-(dimethylhistamine), a hypotensive component of *Echinocereus triglochidiatus*. *Journal of Ethnopharmacology* 5:359-364.
- FRANKE, WOLFGANG. 1985. Wildgemüse als Anbau-Alternative? *Deutscher Gartenbau* 19:966-968.
- FRATI-MUNARI, ALBERTO C., JOSE LUIS QUIROZ-LAZARO, PERLA ALTAMIRANO-BUSTAMANTE, MANUEL BANALES-HAM, SERGIO ISLASANDRADE, and C. RAUL ARIZA-ANDRACA. 1988. Efecto de diferentes dosis de nopal (*Opuntia streptacantha* Lemaire) en la prueba de tolerancia a la glucosa en individuos sanos. *Archivos de Investigación Médica (México)* 19:143-148.
- FRATI-MUNARI, ALBERTO C., ANGELES YEYER-GARCES, SERGIO ISLASANDRADE, C. RAUL ARIZA-ANDRACA, and ADOLFO CHAVEZ-NEGRET. 1987. Estudios sobre al mecanismo de la acción "hipoglucemiante" del nopal (*Opuntia* sp.). *Archivos de Investigación Médica (México)* 18:7-12.
- FRENCH, R.B., and O.D. ABBOTT. 1948. Levels of carotene and ascorbic acid in Florida-grown foods. *University of Florida Agricultural Experiment Station Technical Bulletin* 444:1-21.
- GEBHARDT, SUSAN E., RENA CUTRUFELLI, and RUTH H. MATTHEWS. 1982. Composition of foods: fruits and fruit juices, raw, processed, prepared. *USDA Agriculture Handbook* 8-9.

LITERATURE CITED (continued)

- GENTRY, HOWARD SCOTT. 1963. The Wariho Indians of Sonora-Chihuahua: an ethnographic survey. Smithsonian Institution Bureau of American Ethnology Bulletin. 16:61-144.
- . 1972. The Agave family in Sonora. USDA Agriculture Handbook 399.
- . 1972. Agaves of continental North America. Tucson, University of Arizona Press.
- GEORGI, M.E., P. HARPER, P.A. HYPPIO, D.K. PRITCHARD & E.D. SCHERLINE. 1982. Pappus bristles: the cause of burdock stomatitis in dogs. Cornell Veterinarian 72:43-48.
- GIBBONS, EUELL. 1962. Stalking the wild asparagus. New York: David McKay.
- GONZALEZ, C.L. 1989. Potential of fertilization to improve nutritive value of pricklypear cactus (*Opuntia lindheimeri* Engelm.) Journal of Arid Environments 16:87-94.
- GRIVETTI, LOUIS EVAN. 1979. Kalahari agropastoral-hunter-gathers: Tswana example. Ecology of Food and Nutrition 7:235-256.
- HARRINGTON, HAROLD DAVID. 1967. Edible native plants of the Rocky Mountains. Albuquerque: University of New Mexico Press.
- HAYTOWITZ, DAVID B., and RUTH H. MATTHEWS. 1984. Composition of foods: vegetables and vegetable products. USDA Agriculture Handbook 8-11.
- HEGNAUER, ROBERT. 1963. Chemotaxonomie der Pflanzen, Band 2: Monocotyledoneae. Basel: Birkhäuser Verlag.
- . 1986. Chemotaxonomie der Pflanzen, Band 7: Nachträge zu Band 1 und Band 2. Basel: Birkhäuser Verlag.
- HEINRICH, GEORG, WULF SCHULTZE, INGO PFAB and MICHAEL BOTTGER. 1983. The site of essential oil biosynthesis in *Poncirus trifoliata* and *Monarda fistulosa*. Physiologie Vegetale 21:257-268.
- HODGSON, WENDY CAYE. 1982. Edible native and naturalized plants of the Sonoran Desert north of Mexico. M.S. thesis, Arizona State University, Tempe.
- IBANEZ-CAMACHO, R., M. MECKESLOZOYA and V. MELLADO-CAMPOS. 1983. The hypoglycemic effect of *Opuntia streptacantha* studied in different animal experiment models. Journal of Ethnopharmacology 7:175-181.
- JIU, J. 1966. A survey of some medicinal plants of Mexico for selected biological activities. Lloydia 29:250-259.
- JONES, HERMAN D., G. NELSON FURBECK, and ROUL COLORADO. 1932. Isolation and study of the saponin content of the juice and leaf of the agave plant, maguey, manso fino. Journal of the American Pharmaceutical Association 21:787-793.
- JUSTICE, KEITH E. 1985. Oxalate digestibility in *Neotoma albigula* and *Neotoma mexicana*. Oecologia 67:231-234.
- KHARITONOVA, L.A. 1986. Biochemical characterization of fruits from some *Berberis* spp. Rastastitel'nye Resursy 22:510-513.
- KIRK, DONALD R. 1975. Wild edible plants of the western United States. Happy Camp CA: Naturegraph.
- KOENIG, RUTH A., and C.R. JOHNSON. 1942. Colorimetric determination of phosphorus in biological materials. Industrial and Engineering Chemistry Analytical Edition 14: 155-156.
- KOVACEVIC, J., J. CIZEK, and V. KIRJAKOVIC. 1963. Kraska kupina (*Rubus ulmifolius* Schott), portulaka (*Portulaca oleracea* L.), i agava (*Agave americana* L.) kao krmne biljke za ishranu svinja. Veterinaria, Sarajevo 12:369-372. [Nutrition Abstracts 34, #3844.]
- KUHNLEIN, HARRIET V. 1986. Food sample collection for nutrient analyses in ethnobiological studies. Journal of Ethnobiology 6:19-25.
- . 1989. Nutrient values in indigenous wild berries used by the Nuxalk people of Bella Coola, British Columbia. Journal of Food Composition and Analysis 2:28-36.
- LAFERRIERE, JOSEPH E. 1989a. Mountain Pima ethnobiology: a preliminary report. Paper presented at the Twelfth Annual Conference of the Society of Ethnobiology, Riverside, California, 30 March 1989. Abstract: Journal of Ethnobiology 9:244.
- . 1989b. A yellow-fruited form of *Prunus gentryi* (Rosaceae). Phytologia 65:482.
- . 1990a. *Hymenocallis pimana* (Amaryllidaceae): an new species from north-western Mexico. Phytologia 68:255-259.
- . 1990b. Taxonomy and ethnobotany of *Yucca madrensis*. Cactus and Succulent Journal [U.S.] 62:95-96.

LITERATURE CITED (Continued)

- _____. 1990c. On the edibility of begonias. *Begonian* 57:175.
- _____. 1991a. Begonias as food and medicine. Submitted to *Economic Botany*.
- _____. 1991b. Use and composition of *Tillandsia* spp. (Bromeliaceae). Submitted to *Economic Botany*.
- LAFERRIERE, JOSEPH E., & JORGE S. MARROQUIN. 1990. *Berberis pimana* (Berberidaceae): a new species from Northwest Mexico. *Madroño* 37:283-288.
- LAFERRIERE, JOSEPH E., & WILLARD VAN ASDALL. 1991a. Mountain Pima subsistence technology. Submitted to *Journal of the Southwest*.
- _____. 1991b. Plant use in Mountain Pima holiday decorations. *Kiva*, in press.
- LEUNG, WOOT-TSUEN WU and MARINA FLORES. 1961. Food composition table for use in Latin America. Rome: Food and Agriculture Organization.
- LIST, P.H. and L. HORHAMMER. 1972. *Hagers Handbuch der pharmazeutischen Praxis*, 3. Band. Berlin: Springer-Verlag.
- MARTYNOV, E.G., E.A. STROEV, and D.D. PESKOV. 1984. Polysaccharides of *Berberis vulgaris*. *Chemistry of Natural Compounds* 20:99-100.
- MARSH, ANNE C., MARY K. MOSS, and ELIZABETH W. MURPHY. 1977. Composition of foods: spices and herbs, raw, processed, prepared. *USDA Agriculture Handbook* 8-2.
- MARTIN, FRANKLIN W. and HENRY Y. NAKASONE. 1970. The edible species of *Passiflora*. *Economic Botany* 24:333-343.
- MARTINEZ, MAXIMINO. 1939. *Las plantas medicinales de México*, 2nd edition. México: Ed. Botas.
- MCGARVIE, DONALD, and HARALAMBOS PAROLIS. 1979a. The mucilage of *Opuntia ficus-indica*. *Carbohydrate Research* 69:171-179.
- _____. 1979b. The mucilage of *Opuntia ficus-indica*, part 2: the degraded polysaccharide. *Journal of Chemical Society Perkin Transactions I* 1979:1464-1466.
- _____. 1981. The mucilage of *Opuntia aurantiaca*. *Carbohydrate Research* 94:67-71.
- MEDSGER, OLIVER PERRY. 1939. *Edible wild plants*. New York: Macmillan.
- MEYER, BRIAN N., & JERRY L. McLAUGHLIN. 1981. Economic uses of *Opuntia*. *Cactus and Succulent Journal [U.S.A.]* 53:107-112.
- MITICH, LARRY W. 1976. Uses of the genus *Agave*. *Excelsa* 6:67-76.
- MOKADY, S., and A. DOLEV. 1970. Nutritional evaluation of tubers of *Cyperus esculentus* L. *Journal of the Science of Food and Agriculture* 21:211-214.
- MORAN, REID. 1982. *Berberis claireae*, a new species from Baja, California; and why not *Mahonia*. *Phytologia* 52:221-226.
- NATIONAL RESEARCH COUNCIL. 1980. *Recommended dietary allowances*, 9th ed. Washington: National Academy of Sciences.
- NOBEL, PARK S. 1988. *Environmental biology of agaves and cacti*. Cambridge: Cambridge University Press.
- NOBEL, PARK S., CHARLES E. RUSSELL, PETER FALKER, JORGE GALO MEDINA, and ENRIQUE ACUNA. 1987. Nutrient relations and productivity of prickly pear cacti. *Agronomy Journal* 79:550-555.
- NORTON, H.H., E.S. HUNN, C.S. MARTINSEN, and P.B. KEELY. 1984. Vegetable food products of the foraging economies of the Pacific Northwest. *Ecology of Food and Nutrition* 14:219-228.
- OSOL, ARTHUR, and GEORGE E. FARRAR. 1960. *The dispensatory of the United States of America*, 25th edition. Philadelphia: J.B. Lippincott.
- PALMER, EDWARD. 1878. Plants used by Indians of the United States. *American Naturalist* 12:593-606, 646-655.
- PENNINGTON, CAMPBELL W. 1963. *The Tarahumar of Mexico: their environment and material culture*. Salt Lake City: University of Utah Press.
- _____. 1969. *The Tepehuan of Chihuahua: their material culture*. Salt Lake City: University of Utah Press.
- _____. 1973. Plantas medicinales utilizadas por el pima montañés de Chihuahua. *América Indígena* 33:213-232.
- PETCU, P. 1965. Phytochemische Untersuchungen an *Berberis hauniensis* Zab. *Archiv der Pharmazie* 298:73-77.
- _____. 1966. Phytochemische Untersuchungen an *Berberis virens* Hook. *Pharmazie* 21:54-56.
- _____. 1968. Zur Kenntnis der in Rumänien akklimatisierten Pflanze *Berberis crataegina* DC. *Archiv der Pharmazie* 301:680-682.

LITERATURE CITED (continued)

- PFAB, INGO, GEORG HEINRICH, and WULF SCHULTZE. 1980. Ueber das äterische Oel in den Oeldrüsen und in aussendrischen Bereich von *Monarda fistulosa*. *Biochemie und Physiologie der Pflanzen* 175:29-44.
- RETAMAL, NORMA, JOSE M. DURAN, and JESUS REFNADEZ. 1987. Seasonal variations of chemical composition in prickly pear (*Opuntia ficus-indica* (L.) Miller). *Journal of the Science of Food and Agriculture* 38:303-311.
- ROBBINS, WILFRED WILLIAM, JOHN PEABODY HARRINGTON, and BARBARA FREIRE-MARRECO. 1916. Ethnobotany of the Tewa Indians. *Smithsonian Institution Bureau of American Ethnology Bulletin* 55:1-74.
- ROBINSON, BRITAIN B. 1947. Minor fiber industries. *Economic Botany* 1:47-56.
- RODRIGUEZ-FELIX, ARMIDA, and MARITA CANTWELL. 1988. Developmental changes in composition and quality of prickly pear cactus cladodes (nopalitos). *Plant Foods for Human Nutrition* 38:83-93.
- RODRIGUEZ-MEJIA, MARTHA, VIRGINIA RIVAS-MONTALVO, and RENE ROSILES-MARTINEZ. 1985. Niveles de oxalatos en forrajes silvestres procendentes de los estados de Hidalgo, Guanajuato, México, Tlaxcala, y Distrito Federal. *Veterinaria México* 16:21-25.
- RUANGRUNGSI, NIJSIRI, WANCHAI DEEK-NAMKUL, and GORDON L. LANGE. 1984. Constituents of *Mahonia siamensis*. *Planta Medica* 432-433.
- RUSSELL, CHARLES E., and PETER FELKER. 1987. The prickly-pears (*Opuntia* spp., Cactaceae): a source of human and animal food in semiarid regions. *Economic Botany* 41:433-445.
- SANFORD, SAMUEL NEWTON FOLIUS. 1937. *New England herbs: their preparation and use*. Boston: New England Museum of Natural History.
- SHELDON, SAM. 1980. Ethnobotany of *Agave lechuguilla* and *Yucca carnerosana* in Mexico's Zona Ixtlera. *Economic Botany* 34:376-390.
- SHOEB, H., A.A. HASAAN, and A.M. SAAD. 1986. The molluscicidal properties of the crude steroidal saponins in *Agave heteracantha* and *Agave utahensis*. *Egyptian Journal of Veterinary Science* 23:51-60.
- SLECKMAN, BARRY P., JOSEPH SHERMA, and LORRAINE C. MINEO. 1983. Determination of pulegone in *H. pulegioides* and peppermint oil by thin layer chromatography with densitometry. *Journal of Liquid Chromatography* 6:1175-1182.
- SOCIEDAD FARMACEUTICA MEXICANA. 1952. *Nueva farmacopea mexicana*, 6th edition. México: Ed. Botas.
- TRACHTENBERG, S., and A.M. MAYER. 1982a. Biophysical properties of *Opuntia ficus-indica* mucilage. *Phytochemistry* 12: 2835-2843.
- _____. 1982b. Mucilage cells, calcium oxalate crystals and soluble calcium in *Opuntia ficus-indica*. *Annals of Botany new series* 50:549-557.
- UPHOF, J.C.Th. 1959. *Dictionary of economic plants*. Weinheim: H.R. Engelman.
- VAN SOEST, P.J. 1963. Use of detergents in the analysis of fibrous foods, II: a rapid method for the determination of fiber and lignin. *Journal of the Association of Official Applied Chemists* 46:829-835.
- VESTAL, PAUL A. 1952. Ethnobotany of the Ramah Navaho. *Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University* 40(4):1-94.
- WHITLEY, GLENN ROSS. 1985. The medicinal and nutritional properties of *Dahlia* spp. *Journal of Ethnopharmacology* 14:75-82.
- WICKSON, EDWARD J. 1889. *The California fruits and how to grow them*. San Francisco: Dewey.
- WIERZCHOWSKI, ZENON, and MARIA BUBICZ. 1959. Carotenoids of the berries of *Berberis vulgaris*. *Annales Universitatis Mariae Curie-Sklodowska, Lublin-Polonia, Sectio C* 14:383-405. [Chemical Abstracts 55, #22498f].
- WINKELMAN, MICHAEL. 1985. Frequently used medicinal plants in Baja California Norte. *Journal of Ethnopharmacology* 18: 109-131.
- YANOVSKY, ELIAS. 1936. *Food plants of the North American Indians*. USDA Miscellaneous Publication 237.



Laferrière, J E, Weber, Charles W., and Kohlhepp, Edwin A. 1991. "USE AND NUTRITIONAL COMPOSITION OF SOME TRADITIONAL MOUNTAIN PIMA PLANT FOODS." *Journal of ethnobiology* 11, 93–114.

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