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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 traditionalmente usados por los pima montañés de Chihuahua, Mexico, se analisieron 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 guiotes jóvenes de *Agave shrevei* se analysieron 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 utilisación traditional 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 consumées par les pima montagneux de Chihuahua, Méxique, se sont analyzés 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 analyzés pour le gras, la proteine, la fibre, la cendre, les carbohydrates, Fe, Cu, Zn, Ca, et Mg. Le content mineral s'est determiné pour les fruits de *Solanum diphyllum*, et pour trois condiments traditionels, *Monarda austromontana, Hedeoma patens*, et *Teloxys ambrosioides*. Nous descrivons aussi l'utilisation traditionelle 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 (Laferrière 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 analysls.

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 xalapewsis* 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% HNO_3 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
Agave shrevei matapensis	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
Arbutus xalapensis	fruit	276	4.15	58.17	3.00	32.72	1.96
Arctostaphylos pungens	fruit	222	2.67	43.87	4.00	48.31	1.15
Berberis pimana	fruit	329	9.70	58.18	6.35	22.35	3.42
Cucurbita pepo	mesocarp	303	4.86	68.51	1.02	16.38	9.23
Dahlia coccinea	tuber	258	16.39	47.81	0.15	31.28	4.37
Hymenocallis pimana	bulb	389	14.29	77.49	2.40	3.16	2.66
Jaltomata procumbens	fruit	224	12.75	36.67	2.87	43.95	3.76
Opuntia durangensis (duraznillo blanco)	cladode	289	6.11	61.19	2.15	16.33	14.22
	fruit	260	3.34	57.78	1.79	25.46	11.63
Opuntia cf. macrorhiza	cladode	357	2.16	86.17	0.45	7.77	3.45
	fruit	291	5.32	54.56	5.71	30.17	4.24
Opuntia cf. robusta (temporal)	cladode	263	13.84	48.50	1.53	17.43	18.70
	fruit	317	4.59	68.30	2.87	17.76	6.48
Opuntia cf. robusta (noviembrena)	fruit	284	2.61	61.67	3.02	26.51	6.19
Prionosciadium townsendii	root	346	5.83	76.58	1.79	11.86	3.94
Prunus gentryi gentryi	pericarp	324	3.98	76.73	0.13	12.05	7.11
Prunus persica	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
Prunus serotina virens	mesocarp	203	3.11	46.42	0.51	27.86	22.1
Tillandsia erubescens	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
Agave shrevei matapensis	flower stalk	56	3	19	10618	3826
	leaf base	54	10	29	52476	18392
Arbutus xalapensis	fruit	37	6	106	3713	899
Arctostaphylos pungens	fruit	13	8	9	1809	392
Berberis pimana	fruit	51	20	15	2337	1154
Cucurbita pepo	mesocarp	87	7	8	3020	2357
Dahlia coccinea	tuber	41	7	9	3756	1513
Hedeoma patens	shoot	485	8	28	12530	991
Hymenocallis pimana	bulb	34	5	20	3724	912
Jaltomata procumbens	fruit	33	8	21	1171	2412
Monarda austromontana	shoot	821	12	49	13039	4313
Opuntia durangensis (duraznillo blanco)	cladode	96	2	8	24222	19385
	fruit	214	18	24	23543	6392
Opuntia cf. macrorhiza	cladode	85	13	56	15414	9172
	fruit	161	8	10	6078	4290
Opuntia cf. robusta (temporal)	cladode	156	5	161	12350	8395
	fruit	117	10	15	4543	3613
Opuntia cf. robusta (noviembrena)	fruit	47	76	51	3426	1888
Prionosciadium townsendii	root	174	10	20	6442	2899
Prunus gentryi gentryi	pericarp	44	58	102	2119	946
Prunus persica	mature fruit	45	2	5	395	612
	green fruit	188	10	7	1262	1109
Prunus serotina virens	pericarp	45	6	8	1617	795
Solanum diphyllum	fruit	54	8	8	1080	1383
Teloxys ambrosioides	shoot	127	9	9	18929	14182
Tillandsia erubescens	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.

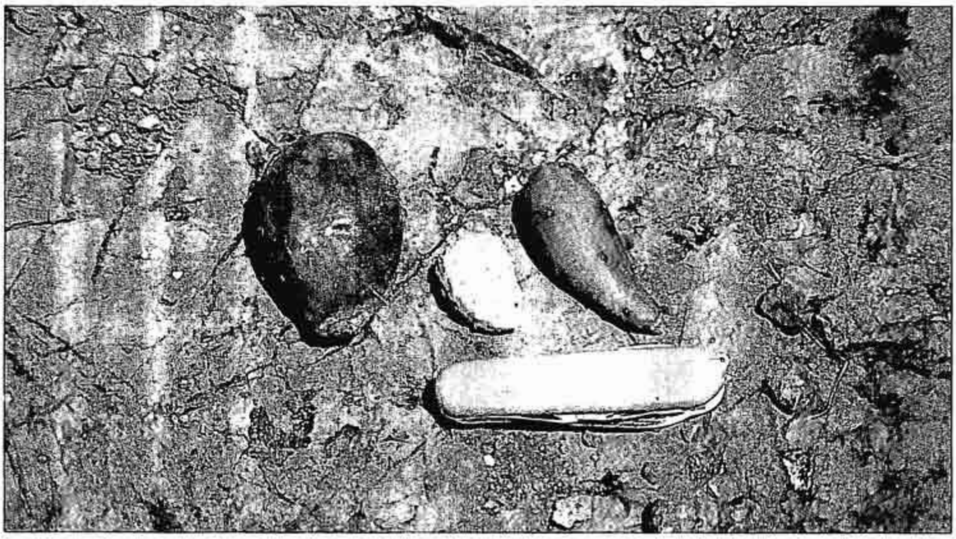

FIG. 1.—Fruits of (l–r) tuna temporal *(Opuntia* cf. *robusta)*, duraznillo blanco *(O. durangensis)*, and tuna de zorra *(O.* cf. *macrorhiza)*.

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 noviembreña 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 accoring 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-caratene 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 (Ruangrungsi *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" is 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 Farmacêutica Mêxicana 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 beon utilized in the United States (Balls 1962).

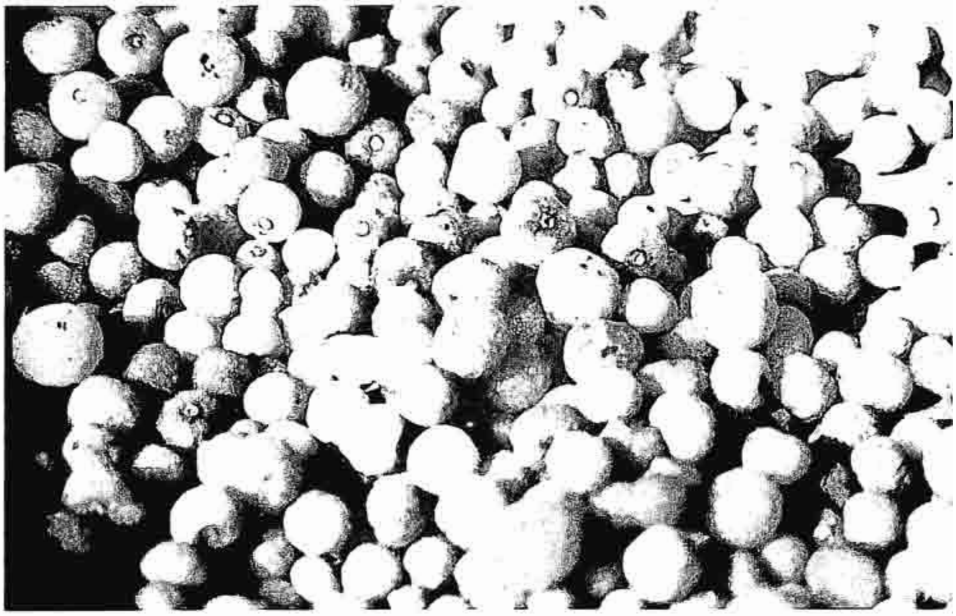

FIG. 4.—Fruits of madroño *(Arbutus xalapensis).*

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 prucumbens* 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 (Laferrière 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 ef 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, flatulance, 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 chiltepines (*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*. Potentially 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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