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Full Length Research Paper

The traditional medicinal and food uses of four plants in Oaxaca, Mexico

Angélica Bautista-Cruz[1]*, María R. Arnaud-Viñas[2], Gabino Alberto Martínez-Gutiérrez[1], Patricia Soledad Sánchez-Medina[1] and Rafael Pérez Pacheco[1]

[1]Instituto Politécnico Nacional, CIIDIR-Oaxaca, Hornos 1003, Xoxocotlan. 71230, Oaxaca, Mexico.
[2]Sección de Estudios de Posgrado de la Escuela Superior de Medicina del IPN, Plan de San Luis y Díaz Mirón s/n, 11340 D. F. Mexico.

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Rural and urban populations in Valles Centrales, Oaxaca, Mexico, use certain plant species for therapeutic and dietary purposes. The wild-growing plants most commonly consumed during the rainy season by those with scarce economic resources are *Portulaca oleracea* L., *Galinsoga quadriradiata* Ruiz & Pavon and *Anoda cristata* (L.) Schltdl. (vernacular names: verdolaga, piojito and violeta, respectively). *Cnidoscolus chayamansa* Mc Vaugh, a cultivated plant known as chaya, is also frequently consumed. This work aims to document the ethnobotanical and nutritional importance of these four plants. A semi-structured interview was applied to 175 middle-aged and elderly women selected by snowball technique. Chaya and violeta had both medicinal and dietary uses. Chaya was used in the treatment of diabetes, high cholesterol, renal disorders, high blood pressure, as a weight loss aid, and for inflammation of the arms and legs. Violeta was used as a cough remedy. These plants were consumed in a tea prepared from fresh plant parts. Verdolaga and piojito were only consumed as food. Chaya was the best source of ascorbic acid (350.83 mg/100 g), retinol (5.26 mg/100 g), iron (7.51 mg/100 g) and protein (8.15%). Chaya's potential as a medicinal and edible plant suggests this species ought to be cultivated commercially.

Key words: *Anoda cristata* (L.) Schltdl., *Cnidoscolus chayamansa* Mc Vaugh, *Galinsoga quadriradiata* Ruiz and Pavon, *Portulaca oleracea* L.

INTRODUCTION

Millions of people in developing countries depend on wild resources, including wild medicinal and edible plants, for their healthcare and to meet dietary needs (Balick and Cox, 1996; Balemie and Kebebew, 2006). According to Abbiw (1996), the tendency of populations in developing countries to favour traditional medicinal plants is mainly due to the inaccessibility of modern medical care, as well as to economic and cultural factors. Rural and urban populations in the Valles Centrales region of Oaxaca, Mexico, use certain plant species for therapeutic and dietary purposes. Among the plants traditionally used by people with scarce economic resources, and those most commonly consumed during the rainy season, are certain species of the Portulacaceae family, such as *Portulaca oleracea* L., of the Asteraceae family, such as *Galinsoga quadriradiata* Ruiz and Pavon, and of the Malvaceae family, such as *Anoda cristata* (L.) Schltdl. A cultivated plant belonging to the Euphorbiaceae family, *Cnidoscolus chayamansa* Mc Vaugh, is also frequently consumed. *P. oleracea*, *G. quadriradiata* and *A. cristata* grow in agrestal populations during the rainy season, as well as in various agro-habitats where they may be considered weeds. These agro-habitats include fruit orchards, as well as maize, bean, squash, and tomato fields. *C. chayamansa*, in turn, is cultivated in domestic gardens rather than in agricultural fields, and as such can be used throughout the year. Despite the widespread use of these four plants across the state, scientific literature has yet to fully investigate the traditional uses and nutritional values

*Corresponding author. E-mail: mbautistac@ipn.mx. Tel:/Fax: 52 (951) 517-0400.

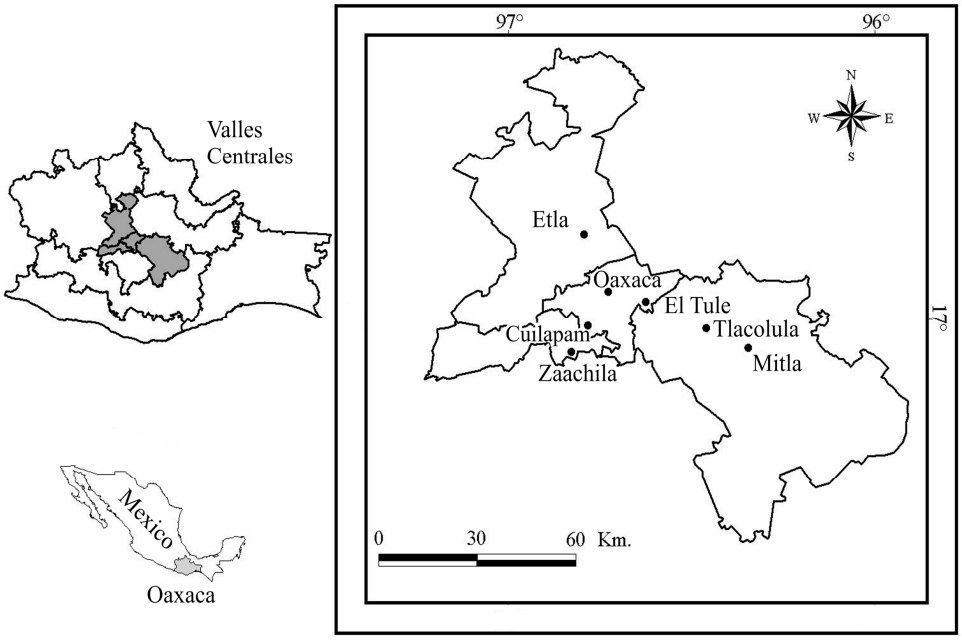

Figure 1. Geographic location of the study area.

of these species. However, there are some reports that describe the nutritive values of *C. chayamansa* (Kuti and Kuti, 1999), *G. quadriradiata* (Kinnup and de Barros, 2008), *A. cristata* and *P. oleracea* in the context of Central Mexico (Muñoz de Chávez et al., 1992; Ranhotra et al., 1998).

Although it is possible to find two species of *Cnidoscolus* sp. in the Valles Centrales region of Oaxaca, namely *Cnidoscolus chayamansa* Mc Vaugh and *Cnidoscolus aconitifolius* (Miller), only *C. chayamansa* is consumed by urban and rural populations. The use of *C. chayamansa* leaves for human consumption in Mesoamerica dates back to the pre-Columbian era (Ross-Ibarra and Molina-Cruz, 2002). *C. chayamansa* was found to be mainly valued as a food source; nonetheless, it was and continues to be an important medicinal plant (Ross-Ibarra and Molina-Cruz, 2002). *P. oleracea* is a widely distributed annual plant, ranging from temperate to tropical zones, and has a long history of use as both a medicinal and edible plant (Nebel and Heinrich, 2009; Dong et al., 2010). It has certain antibacterial and antifungal properties, as well as a contraceptive effect (Dong et al., 2010). It has been observed in use as an antiscorbutic, a diuretic, and a febrifuge, as well as in the treatment of toothaches, earaches, and inflammation (Mitich, 1997; Elkhayat et al., 2008). The fresh leaves, stems, and flowers of *P. oleracea* are eaten in salads and soups. *A. cristata* is a common, wild-growing plant which is used as medicine and food in Central Mexico (Rendón et al., 2001). In medicinal applications, the entire plant, including the flowers, is mixed with other plants to produce a tea for the treatment of stomach inflammation, fever, cough, and lacerations, or to be used as a hair rinse to reduce balding (Rendón et al., 2001). The young, tender leaves and buds of *A. cristata* are boiled and eaten as such, or combined with squash (*Cucurbita* spp.), beans, or corn (Casas et al., 1994).

There is a growing ignorance among young people today about the traditional uses of wild medicinal and edible plants (Odhav et al., 2007). Yirga (2010) argued that the total extent of the knowledge of traditional medicinal plant-based therapies should be documented through botanical surveys before this knowledge is irretrievably lost to future generations (Guarino, 1997). The present study was carried out with the goal of documenting the traditional uses of *C. chayamansa*, *P. oleracea*, *A. cristata* and *G. quadriradiata* in the Valles Centrales region of Oaxaca, Mexico, as well as quantifying some of the nutritional parameters of these plants.

MATERIALS AND METHODS

Study area

Oaxaca State, located in Southern Mexico, has the highest levels of biological diversity in the country. Its flora has been collected for over 200 years (García-Mendoza, 2004). The present study was carried out in the traditional markets of the Valles Centrales region of Oaxaca (Figure 1). One market in Oaxaca City, and six markets

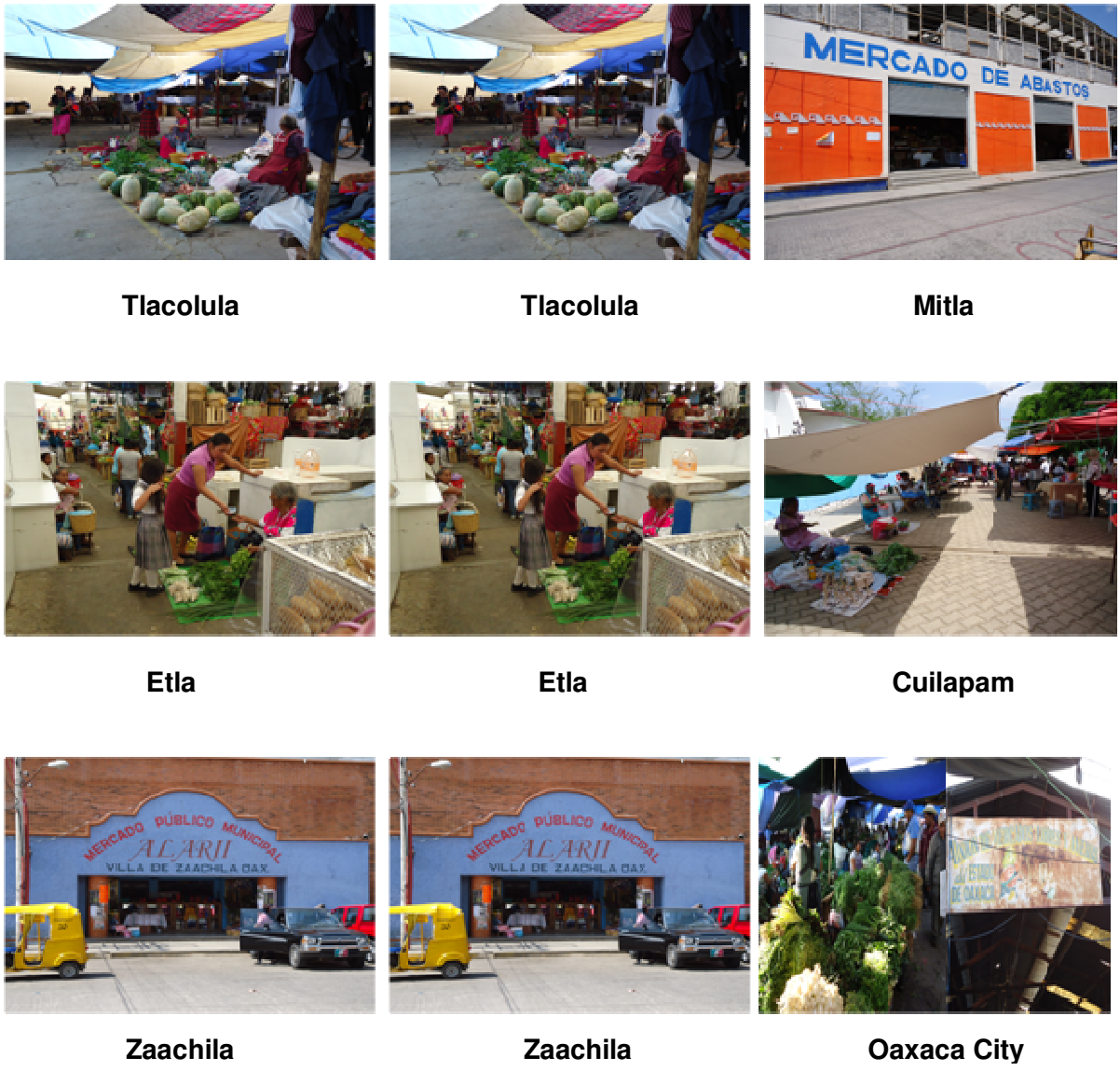

Figure 2. Traditional markets of the Valles Centrales region of Oaxaca (Mexico) included in the study.

located in the towns of Tlacolula, Mitla, Zaachila, Santa María El Tule, Cuilapam and Etla (Figure 1) were included in this study. In these small markets, it is not uncommon to find women selling wild, edible plants in the streets surrounding the market (Figure 2). Oaxaca State has a total population of 3,801,962 inhabitants, whereas the total number of inhabitants for Oaxaca City is 263,145. The total populations for the towns included in this study are as follows: 34,101 in Zaachila, 19,679 in Ejutla, 19,628 in Tlacolula, 11,825 in Mitla, 9,280 in Etla, and 8,165 in El Tule (National Institute of Statistics and Geography, 2010). The climate in the Valles Centrales is temperate and sub humid (Trejo, 2004). Dry deciduous lowland forest is the primary vegetation in Tlacolula and Mitla (Lorence and García-Mendoza, 1989). Live oak forests and spruce forests are the predominant vegetation in Oaxaca City, Etla and Zaachila, although it is also possible to find some chaparral in Etla (Torres-Colín, 2004).

Field work

The field work was carried out during the rainy season (June to October of 2008). In an attempt to locate the few individuals with knowledge of traditional methods of plant use as efficiently as possible, a semistructured questionnaire (Bernard, 1988) was designed to investigate the knowledge of people living in rural towns, as well as in Oaxaca City, in regards to the traditional applications of these four plants. Each questionnaire consisted of a series of direct questions (Bernard, 1988) related to the knowledge of each plant: vernacular name, practices of transmitting traditional knowledge, use, diseases treated with it, parts of the plants used, route of administration and condition of plant used (Table 1). Based on recommendation from citizens and local authorities of the towns, the majority of informants were middle-aged to elderly women (mean age 58 years). Thus, only the most experienced women

Table 1. Information about the traditional knowledge of each plant studied.

Plant species	Vernacular name	Transmission of practices	Use	Diseases treated	Plant part	Route of administration	Condition of plant used
C. chayamansa	Chaya	Verbally to family members/ observation and identification of the plant in its habitat	Medicinal and food	Diabetes, high blood pressure, renal disorders, as a weight loss aid, high cholesterol, inflammation of the arms and legs	Leaves	Oral	Fresh
P. oleracea	Verdolaga	Verbally to family members	Food		Stems, leaves and flowers		Fresh
A. cristata	Violeta	Observation and identification of the plant in its habitat	Medicinal and food	Cough	Stems, leaves and flowers	Oral	Fresh
G. quadriradiata	Piojito	Verbally to family members	Food		Stems, leaves and flowers		Fresh

were interviewed. Their selection followed the snowball technique, which consists of the sequential indication of recognized informants, based on their degree of experience (Albuquerque and Lucena, 2004). The questionnaire was applied to 175 people in total, 25 in each traditional market. Voucher specimens of the studied plants were collected during regular walks in the fields, identified by specialized personal, and deposited in the Instituto Politécnico Nacional CIIDIR Oaxaca, Mexico Herbarium. The local authorities of each town signed consent forms granting permission to access their traditional knowledge and collect botanical material.

Proximal analyses

Fresh portions of the edible parts of a total of 30 plants of each species were collected from different points in their natural habitat in each location. All samples were healthy and free of infection. The lab analyses were carried out at Food Laboratory of Instituto Politécnico Nacional CIIDIR Oaxaca. The edible sections of each plant were thoroughly washed several times with deionised water to remove attached soil and other impurities. According to the procedure established by Bourges (1985) the samples were oven-dried at 60ºC until they reached a constant weight. All dried materials were ground to a fine powder using a porcelain mortar, and sieved through a 0.25 mm diameter screen, after which they were stored in dark, sealed bottles at room temperature away from light until proximate analyses were performed. To determine retinol, ascorbic acid and iron contents, fresh samples were analyzed the day they were collected. Various recommended methods of plant material nutrient analysis were used as given by AOAC (Association of Official Analytical Chemists 1984) and Bourges (1985). Retinol was extracted with ammonium hydroxide and petroleum ether, and quantified using a UV-visible spectrophotometer model Espectronic 21D (Bourges, 1985). Ascorbic acid was determined using 2,6-dichlorophenolindophenol sodium salt. Ascorbic acid reduces oxidation-reduction indicator dye 2,6-dichlorophenolindophenol to a colorless solution. After the reaction takes place, excess unreduced dye appears rose pink in an acid solution. Ascorbic acid is extracted and titration is performed in the presence of a metaphosphoric acid-acetic acid-sulfuric acid solution to maintain the proper acidity for the reaction and to avoid the auto-oxidation of ascorbic acid at high pH (Association of Official Analytical Chemists, 1984). Iron was reduced with hydroxylamine chlorhydrate in acid medium (hydrochloric acid). The reduced iron reacted with O-phenanthroline to give a colored complex which was quantified using a UV-visible spectrophotometer model Espectronic 21D (Bourges, 1985).

Crude fat was determined by petroleum ether extraction in a Soxhlet apparatus. A representative 3 g of sample was extracted for 6 h (Bourges, 1985). Ash content was determined by the incineration of plant material (4 g) in silica crucibles in a muffle furnace model Thermolyne 1400 at 525°C for 6 h, until the ash turned white (Association of Official Analytical Chemists, 1984). Moisture content was determined by the gravimetric method, by drying a representative 5 g sample in a Thermolyne 9000 oven at 105°C for 3 h (Association of Official Analytical Chemists, 1984). The nitrogen value, which is the precursor for the protein of a substance, was determined by micro Kjeldahl method by digesting a known weight of plant sample and treating it with alkali. Liberated ammonia was collected in boric acid and titrated with H_2SO_4 (Association of Official Analytical Chemists, 1984). The nitrogen value was converted to protein by multiplying to a factor of 6.25. Carbohydrate values were determined by the difference

Table 2. Nutritional values of four edible plants in the Valles Centrales Region of Oaxaca, Mexico. SE represents Standard Error for three replications (n = 3).

Plant species	Retinol equivalents (mg/100 g)	Ascorbic acid (mg/100 g)	Iron (mg/100 g)	Moisture (%)	Ash (%)	Protein (%)	Crude fiber (%)	Crude fat (%)	Carbohydrates (%)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean
C. chayamansa	5.26±3.50	350.83±22.42	7.51±0.48	77.12±0.48	1.88±0.02	8.15±0.16	2.15±0.08	2.46±0.04	8.24
P. oleracea	0.59±0.19	10.70±0.72	3.51±0.01	92.30±0.41	1.21±0.02	1.20±0.05	0.82±0.02	0.33±0.01	4.14
A. cristata	1.9±0.12	12.33±0.85	3.77±0.01	85.43±0.96	2.13±0.03	4.26±0.08	0.50±0.02	1.25±0.04	6.43
G. quadriradiata	1.51±0.22	13.88±0.76	5.72±0.09	85.53±0.61	2.04±0.02	3.24±0.04	1.08±0.01	0.53±0.01	7.58

All results are reported in fresh weight.

method [100 - (protein +fats +moisture +ash)] (Woot-Tsuen, 1985).

All analyses were carried out in triplicate, and values for the proximate components were converted into fresh weight using the following equation (De Leon, 1985):

PCFW = (PCDW) (100-moisture)/100

where PCFW is the proximate component in fresh weight and PCDW is the proximate component in dry weight.

Ascorbic acid, retinol, iron and proximate component contents are therefore expressed in fresh weight and reported as mean values (Table 2).

RESULTS AND DISCUSSION

Table 1 displays information from the interviewees about the traditional applications of each plant. All those surveyed exhibited knowledge of *P. oleracea* commonly known as verdolaga, *G. quadriradiata* known as piojito, *A. cristata* known as violeta and, *C. chayamansa* known as chaya. The knowledge and practices of traditional methods of plant use were reported to be learned exclusively from family members. The majority (88%) of interviewees reported verbally transmitting traditional knowledge to family members, and the remaining 12% through observation and identification of the medicinal plant in its natural habitat. These results agree with the findings of Yirga (2010) in an ethnobotanical study of traditional medicinal plants used by indigenous people in Northern Ethiopia. This author indicated that a majority (69%) of traditional healers verbally transmit their indigenous knowledge to select family members.

The plants are consumed fresh in various ways and prepared using various traditional recipes. Verdolaga, piojito and violeta are consumed cooked; only chaya is consumed both cooked and raw (Table 1). The main plant parts used in the cases of verdolaga, violeta and piojito are the stems (< 5 mm of diameter), leaves, and flowers. For chaya, only the leaves are used (Table 1).

Medicinal uses

Interviewees reported using only chaya and violeta for medicinal purposes. Of these plants, chaya was found to be the most commonly used medicinally. Few reported using violeta as medicinal plant. The main manner of preparation for both plants was as a tea, prepared with fresh plant parts and usually drunk daily in the morning. The route of administration was oral. Nevertheless, raw chaya leaves were reported as commonly being mixed with orange juice and/or cactus (*Opuntia* sp.) in a kind of blended juice. The results showed that chaya is a multipurpose plant used in the treatment of various human ailments. The most relevant categories of use of this plant according to the number of citations by the interviewees were: diabetes (33); high cholesterol (24); renal disorders (11); high blood pressure (10); as a weight loss aid (8); and inflammation of the arms and legs (7).

The medicinal uses of *C. chayamansa* found in this study agree with the results of previous studies in other regions, such as those carried out by Diaz-Bolio and León de Gutiérrez (1974) in Yucatán, Mexico, and Ross-Ibarra and Molina-Cruz (2002) in the Mexican states of Yucatán, Chiapas, Tabasco and Veracruz, as well as in Guatemala. Andrade-Cetto and Heinrich (2005) also found that in Mexico, chaya leaves are prepared as an infusion to treat diabetes. Most of properties of *C. chayamansa* have never been experimentally tested, and the actual efficacy of this plant in curing various ailments is unknown. Some studies on its anti-diabetic properties have indeed found a significant drop in blood sugar levels in diabetic rabbits and rats fed increasingly higher quantities of *C. chayamansa* (Kuti and Torres, 1996; Loarca-Piña et al., 2010). Similarly,

Figueroa-Valverde et al. (2009) found that *C. chayamansa* induced hypoglycemic effects and changes in lipid levels in a dose-dependent manner in diabetic rats. According to these authors, these effects may depend on the type of flavonoids present in the extracts of *C. chayamansa*, such as dihydromyricetin and amentoflavone.

Despite the multiple medicinal uses of *C. chayamansa*, one disadvantage is that the uncooked leaves of this plant contain high levels of cyanogenic glycosides (Seigler and Bloomfield, 1969; Martin and Ruberté, 1978), which, upon hydrolysis, liberate hydrogen cyanide and cyanide molecules, potent toxic anti-nutritional compounds. Therefore the cyanogenic content of *C. chayamansa* leaves makes it potentially deleterious to health (Kuti and Konoru, 2006). Thus it is imperative that the use of medicinal plants be supported by scientific studies that evaluate their safety and efficacy (Torrico et al., 2003). In this respect, Torrico et al. (2003) indicated that *C. chayamansa* can be used for therapeutic purposes due to the low value of the median toxic dose (TD_{50}) and considering that the toxic effects (lethargy, contortion and piloerection) possibly attributed to cyanogens contained in chaya are lights and reversible. In addition, cooking, as well as other heat treatments hydrolyze the cyanogenic glycosides, minimizing the risk of toxicity (Martin and Ruberté, 1978; Kuti and Konoru, 2006). *C. chayamansa* leaves could be commercialized as a tea in dried form, as the dried leaves conserve high polyphenol contents (Loarca-Piña et al., 2010).

Violeta was reported only as being used as a cough remedy (number of citations by interviewees = 7). These results are concordant with those reported by Rendón et al. (2001) in an ethnobotanical study carried out in Santiago Mamalhuazuca, in Mexico State. Several species of the Malvaceae family, among them *A. cristata* have been used in Mexican traditional medicine (Aguilar et al., 1994). However, their active principles have not been identified (Sotelo et al., 2005).

Dietary uses

Of the plants studied, those most commonly consumed as food were verdolaga and piojito. All interviewees reported eating verdolaga. The most common preparation of verdolaga was fried with green tomato sauce and pork. Other significant forms of preparation of this plant, in decreasing order of significance, were: boiled with onions, garlic and salt, then drained and eaten with tomato sauce and chiles; fried with onions and tomato; and fried with eggs, similar to an omelette.

Only 75% of interviewees reported eating piojito. The main form of preparation for piojito was in a traditional soup made of the leaves, stems, fruit, and flowers of squash, with chepiles (*Crotalaria longirostrata*), corn, and violeta. Piojito was also found to be consumed boiled with onions, garlic and salt.

Only 63% of interviewees reported eating violeta. The majority of those surveyed reported consuming this plant in a traditional soup made of the leaves, stems, fruit, and flowers of squash, with chepiles, piojito and corn. Violeta was also found to be consumed boiled with onions, garlic and salt. This plant is also prepared with eggs.

Boiling the edible parts of the plant with onions, garlic, and salt was a form of preparation found to be common to verdolaga, piojito and violeta. Passalacqua et al. (2006) reported that *P. oleracea* is consumed in some areas of Calabria (in Southern Italy) boiled in water. Recent studies also showed that the stems and fleshy leaves of *P. oleracea* are eaten fresh in salads (Nebel and Heinrich, 2009) in a Graecanic area in Calabria, Southern Italy.

Only 40% of interviewees consumed chaya. The leaves of this plant were reported as being prepared in the following ways: cooked in vegetable soup with chicken or rice; fried with eggs, onions, chiles, and tomatoes; and raw chaya leaves blended with pineapple into a juice. *C. chayamansa* is also consumed in other states of Southern Mexico, such as Chiapas. In this state, the leaves and flowers of *C. chayamansa* are used in the preparation of tamales. Raw *C. chayamansa* leaves are also used to prepare traditional flavored beverages, and the flowers of this plant are battered and fried (Chávez-Quiñones, 2009).

Nutrient content

The ascorbic acid content of the plant samples varied considerably, ranging from 350.83 mg/100 g in *C. chayamansa* leaves to 10.70 mg/100 g in *P. oleracea* (Table 2). Retinol equivalents ranged from 5.26 mg/100 g in *C. chayamansa* leaves to 0.59 mg/100 g in *P. oleracea*. Raw *C. chayamansa* leaves were found to have the highest retinol, ascorbic acid, iron, crude fiber, protein, carbohydrates and crude fat content (Table 2). In contrast, *P. oleracea* was found to have the lowest retinol, ascorbic acid, iron, ash, protein, crude fat and carbohydrate content. *G. quadriradiata* and *A. cristata* were also found to contain significant amounts of ascorbic acid, retinol, iron, proteins and carbohydrates (Table 2). All samples contained between 92.30 and 77.12% moisture. Ash contents ranged from 2.13 to 1.21% (Table 2). The ascorbic acid content of raw *C. chayamansa* leaves was found to be higher than the values reported by Muñoz de Chavez et al. (1992); however, protein and iron contents were found to be lower than the results reported by Kuti and Torres (1996) and Kuti and Kuti (1999). Similarly, the results for ascorbic acid and iron content in *P. oleracea* found in this study were higher than values reported by Muñoz de

Chavez et al. (1992). However, the protein, ash, crude fiber, and carbohydrate contents of this plant were lower than those found by Odhav et al. (2007). In the interest of comparison, the protein content of *G. quadriradiata* (Table 2) was converted to dry weight, using the equation previously described. The protein content for this plant in dry weight corresponds to 22.39%. This value is higher than the 19.55% in dry weight found by Kinnup and de Barros (2008) for aerial parts in the same species.

According to Odhav et al. (2007) variations in the chemical composition of leafy vegetables, including the quantities of compounds that are beneficial or detrimental to humans, are influenced by farming practices and prevailing environmental conditions. Often, differences may be attributable to the age of plants at harvest, stage of ripeness, plant moisture content, or soil and climate type (Muñoz de Chávez et al., 1992). Previous studies have reported that *C. chayamansa* has great potential for the alleviation of nutritional deficiencies in the populations of developing countries, as it is rich in essential amino acids, vitamins, and minerals (Booth et al., 1992; Ranhotra et al., 1998). In fact, green vegetables with high ascorbic acid content, such as *C. chayamansa*, may enhance the absorption of non-heme iron (Brise and Hallberg, 1962). The antioxidant activity of *C. chayamansa* may be due to its chemical constituents, such as tannins, phenolics, flavonoids, saponins, and vitamins A and C (Jimoh et al., 2009). Additionally, ascorbic acid may potentially act as an anticancer agent (Shibata et al., 1992). The potential of *C. chayamansa* as a medicinal and edible plant suggests that this species ought to be grown for commercial cultivation and adopted as a horticultural crop. Furthermore, this plant has great adaptability to diverse climates and soil types (Martin and Ruberté, 1978).

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