Preserving Healthy Eating Habits: *Quelites* in the Food System of a Nahua Mountain Community, Mexico

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Abstract

Quelites (edible tender leaves, stems, and flowers) are important components of the Mesoamerican food system, but, according to the literature, their use has been declining. Sociodemographic factors that influence their consumption are not well-known. We studied these factors in relation to species of *quelites* and commercial vegetables used, sources, preparation, and quantities in the highland Nahua community of Tetlatzinga, Veracruz, Mexico. Twenty families, randomly selected, and school students were interviewed. Food diaries contributed some data. The population consumed 35 species of *quelites*; the primary source were maize fields (*milpas*). During the season, May to July, families consumed about 10 kg per week on average. Gender, age, and occupation influenced knowledge and consumption, but not the socioeconomic level, bilingualism (Spanish-Nahuatl), or years of schooling. Contrary to expectations, the consumption of *quelites* was well-regarded with some nuances among students; family cooks innovated, and quantities approached recommended per capita consumption for all vegetables. Talks by the local health clinic apparently had positive effects. We show that quantitative studies help to understand local decisions and can challenge common beliefs.

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A. Casas, J. J. Blancas Vázquez (eds.), *Ethnobotany of the Mountain Regions of Mexico*, Ethnobotany of Mountain Regions, https://doi.org/10.1007/978-3-030-99357-3_12

Introduction

Mountains are refuges and areas of withdrawal, for plants, animals, and, especially, people. This property is due to the variety of habitats they offer, but mostly to their low attractiveness for many elements of modernization. Mountainous areas are more easily defended, both militarily and culturally (e.g., Scott 2009, its critics and derived literature), infrastructure is expensive to build, and one of the strongest drivers of modern life, the economies of scale, is much less powerful. Thus, traditional ways of life tend to have advantages in these areas.

Vegetables are an essential part of balanced human nutrition. Most derive from plant parts other than fruit and seeds. They contribute some calories, proteins, and fat. However, their main value lies in their content of vitamins, minerals, essential oils, antioxidants, fibers, and a large group of other substances that are essential for humans, but only in small quantities (Robertson 2003; Sadler et al. 2005). Also, they add variety to the diet and lower risks of cardiovascular disease (Reddy and Katan 2004). They are much more diverse and subject to chemical changes through processing and spoilage than other food types. Like mountains, they are somewhat less susceptible to economies of scale than other food system components consumed in larger quantities and lower variety, such as carbohydrates, proteins, fats, and oils.

However, even in the mountains, rural livelihoods, food systems, and nutrition are changing (Łucza et al. 2012). Today, people have access to industrialized food, as well as economic and social incentives to consume it. In some cases, this leads to better, less deprived lives. However, very commonly, only the cheapest and most attractive (sweet, salty, and fatty) parts of the dominant urban food culture are adopted, with worrisome public health outcomes. Also, as people integrate into modern ways of life, lack of time leads to an abandonment of previous food habits.

Ethnobotanists can address basic questions on this transition: the degree to which different factors, cultural, agronomical, or economic, influence this change. The answers to these questions, in turn, help to identify policies that are more effective in mitigating negative consequences of cultural change, and to put common generalizations in context. In this chapter, we describe a study that explores the relationship between various sociodemographic factors and the food use of wild-growing leafy vegetables. The study community was a mountain village, which was nevertheless closely linked to the outside world through its trade of woodworking products. It shows that common expectations, such as that poor people consume more wild-growing greens, are not necessarily true; also, relatively simple interventions - such as information on the healthiness of these foods - can counteract cultural prejudices.

Quelites (from the Nahua term *quilitl* in singular and *quilite* in plural) is a term used in Mexico for plants whose leaves, tender stems, flowers, or inflorescences are eaten as vegetables (Bye 2000). The term is sometimes translated as spinach greens, leafy vegetables, weedy or wild-growing vegetables, but none of these translations circumscribe the group adequately. They are mostly, but not always green or leafy, and some are cultivated. For this reason, we use the local term in this chapter.

Historically, these plants have been the main vegetable component in the Mesoamerican diet. Most have not been highly domesticated, though several species have

been subjected to selection (Mapes et al. 1996, 1997; Rendón et al. 2001; Rendón and Núñez–Farfán 2001). Many reproduce spontaneously and do not require much labor input, apart from harvesting them, though some are managed to some extent (Casas et al. 2007; Vibrans 2016).

In Mexico, about 250 species of *quelites* (Basurto 2011) are commonly consumed in different regions. Most are seasonal foods, and many are associated with annual crops, particularly the mixed maize cultivation (*milpa*). They are a relevant part of the diet of many peasant families until the main crops are harvested (Bye and Linares 2000). Homegardens, coffee and other perennial crop plantations, as well as pastures and natural vegetation also provide *quelites* (Castro-Lara et al. 2005). Some are planted to extend the growing season or because they do not grow locally (Basurto-Peña et al. 1998).

Quelites are usually for family consumption, but some are sold to neighbors, other communities, or in weekly regional markets (Mota-Cruz et al. 2011). For example, in the markets of the Tehuacán-Cuicatlán Valley near our study area, *quelites* such as *hierbamora* (*Solanum nigrescens* M. Martens & Galeotti), *quintonil* (*Amaranthus hybridus* L.), *pipicha* (*Porophyllum linaria* (Cav.) DC, *papaloquelite* (*Porophyllum macrocephalum* DC. = *Porophyllum ruderale* var. *macrocephalum* (DC) Cronq.), and *chepil* (*Crotalaria pumila* Ortega) are sold (Arellanes and Casas 2011).

Several authors have noticed, and everyday observations show that the consumption of *quelites* is declining in many regions (González 2008; Mera-Ovando et al. 2011). Various reasons have been proposed. *Quelites* are often associated with poverty; this image problem goes back to colonial times, was taken up by agronomists and early ethnobotanists, and still turns up in present-day writing (Vibrans 2016). Several decades of work by contemporary ethnobotanists and the last two decades with its food movements have provided some pushback; for example, one of the best-known and expensive restaurants in Mexico City is called "Quintonil," the Nahuatl word for *Amaranthus* greens; another highly regarded restaurant, Pujol, highlights these greens in its menu.

Other observations on the decline of *quelite* consumption include the abandonment of vegetable consumption in general, the introduction of commercial vegetables, destruction of habitats, change of agricultural practices, economic activities (and the associated lack of time), social class, and urbanization. Additional reasons may be changes in food preferences due to migration to cities and various external influences (Castro-Lara et al. 2005; González 2008). Vázquez-García et al. (2004) consider that the change is due partly to the abandonment of previous fieldwork organization, based on family labor. However, most of these are qualitative observations; there are few quantitative data on the drivers of *quelite* consumption or abandonment.

While numerous aspects of *quelites* have been studied, particularly floristics, we know little about the sociodemographic factors that influence the knowledge and consumption of these plants in a rural environment. For example, *quelite* use and knowledge were differentiated by gender and culture in a comparative study of villages in Oaxaca, Mexico, and in Zimbabwe (Madamombe-Manduna et al. 2009). Women always knew more about food plants than men, as they were usually responsible for their preparation. However, this difference was much more

pronounced in Zimbabwe (where women also collected them and men did not get involved in their procurement) than in Mexico, where men often take home *quelites* from their fieldwork. Also, few studies quantify consumption or cultural aspects (but see Basurto et al. 2011).

For this report, we studied a community in the mountains of Veracruz: Tetlatzinga in the municipality of Soledad Atzompa. It has an indigenous population that retains the native language, Nahuatl. Local agriculture is traditional with little or no external inputs. This region has integrated into the national economy only in the last 30 years. People are inserted partially into the money economy through an important woodworking tradition (mainly for furniture) that has developed in the region. The trade with these products also leads to much travel and exposure to other cultural norms, as well as access to commercial goods.

We analyzed the sociodemographic factors that favor or impede the consumption of *quelites* in this rural area. Also, we investigated the consumption frequency of these plants and commercial vegetables during the *quelite* season (May to July), as well as the quantities and variety of recipes. We expected to find an inverse relationship between socioeconomic status and *quelite* consumption, some amount of cultural disdain for *quelites* as "poor man's food" and an ongoing substitution with commercial vegetables such as broccoli or carrots that are important in the mainstream Mexican diet.

Methods

Study Area

Tetlatzinga belongs to the municipality of Soledad Atzompa, located in the central-western part of the state of Veracruz, Mexico, within the mountainous region of the Sierra de Zongolica (Fig. 1; 18 ° 41′ 18″ N and 97 ° 09′ 08″; altitude 2400–2800 m). The climate belongs to the temperate subhumid subtropics with rainfall in summer (García 1987). The average annual temperature ranges from 15 °C to 18 °C because of altitude differences (SEFIPLAN 2015). The natural vegetation consists of pine-oak forests (Juárez 2007).

Nahuatl is the main language spoken, though most people are bilingual with Spanish as their second language. The food system is based on maize tortillas, beans, rice, lentils, pasta soup, potatoes, peas, beans, nopales (prickly pear cactus pads), squash and pumpkins, various *quelites* and mushrooms, and seasonal fruit (apples, pears, plums, peaches, prickly pears). Meat is not eaten daily, but occasionally (chicken, beef, pork, fish, and lamb). Most people practice traditional intercropped maize agriculture on hillsides. The main crops are maize (*Zea mays* L.), squash (*Cucurbita ficifolia* Bouché and *Cucurbita pepo* L.), runner beans (*Phaseolus coccineus* L.), peas (*Pisum sativum* L.), broad beans (*Vicia faba* L.), potatos (*Solanum tuberosum* L.), oka (called foreign or red potato in the region, *Oxalis tuberosa* Molina) (Sánchez 2014), and barley (*Hordeum vulgare* L.). However, agriculture is not the principal source of income: a traditional activity, carpentry of pine wood furniture, has expanded in the last decades, and most households are involved in both production and commerce of these products.

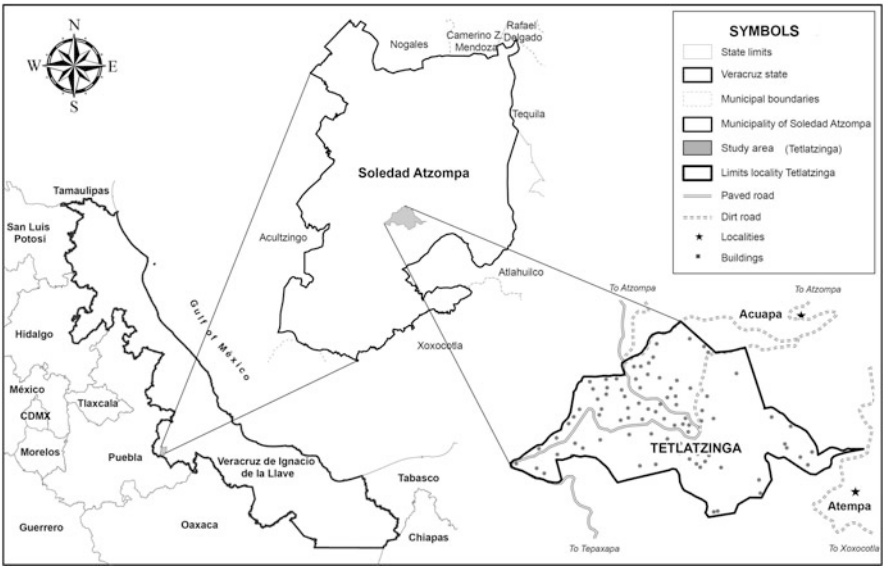

Fig. 1 The study area (Tetlatzinga, municipality of Soledad Atzompa, Veracruz, Mexico)

Fieldwork

Permission was sought from the local authorities, and approval was given in writing. A random sample of 20 families was chosen by drawing lots from a list of families kept by the local clinic, which had the most complete population data. In May 2015, these families were visited. The first author, who speaks Nahuatl, explained the reason for the study and sought their consent orally.

Preliminary *quelite* collections between November 2014 and April 2015 were used to make a field herbarium and for initial, informal interviews. During the main fieldwork phase (May to June 2015), the first author walked different types of vegetation with members of the selected families. The species mentioned in the initial interviews were collected and identified with literature at CHAPA and MEXU, and the help of some specialists. The voucher specimens were deposited at CHAPA.

In this main work phase, 53 individuals of the 20 families over the age of 10 were interviewed individually. First, a list of *quelites* they knew and used was requested orally and documented by the first author. Then, the field herbarium was shown to the interviewees, to complete the list of *quelites* known to and consumed by each family. Interviews were about the source of each species mentioned and consumed by the family. These conversations were audio-recorded with consent. Two additional species were reported during informal interviews with other villagers (*Piper auritum* and *Rumex acetosella*; full names of the *quelites* mentioned in this text with author citations can be found in Table 1); we included these in the species list, but do not know the use frequency or sources.

Table 1 Quelite species consumed by the families of Tetlatzinga, Soledad Atzompa. The species with an asterisk were purchased at regional markets

Family	Species	Common name in Spanish	Common name in Nahuatl	Life form
Amaranthaceae	*Amaranthus hybridus* L.	Quintonil	Wahkilitl	Herb
Amaranthaceae	*Beta vulgaris* L.	Acelga	–	Herb
Amaranthaceae	*Chenopodium berlandieri* Moq.	Quelite blanco o cenizo	Kohkokilitl	Herb
Amaranthaceae	*Dysphania ambrosioides* L.	Epazote	Epazotl	Herb
Amaranthaceae	*Spinacia oleracea* L. *	Espinaca	–	Herb
Apiaceae	*Coriandrum sativum* L.	Cilantro	Kolanto	Herb
Asparagaceae	*Agave atrovirens* Karw. ex Salm-Dyck	Cacaya o flor de maguey	Kahkaya	Succulent rosette without stem
Asparagaceae	*Beschorneria yuccoides* K. Koch	–	Patahmolkahkaya	Succulent rosette without stem
Asparagaceae	*Yucca guatemalensis* Baker	Flor de izote	Ikzoxochitl	Succulent rosette with stem (shrub)
Asteraceae	*Bidens triplinervia* Kunth	–	Kuilakochi	Herb
Asteraceae	*Porophyllum linaria* (Cav.) DC. *	Pipitza	–	Herb
Asteraceae	*Porophyllum ruderale* (Jacq.) Cass. *	Pápalo	Pápaloquilitl	Herb
Asteraceae	*Sonchus oleraceus* L.	Lechuguilla	Memeya	Herb
Brassicaceae	*Brassica oleracea* L.	Col de hoja	Kolex	Herb
Brassicaceae	*Brassica rapa* L.	Nabo	Kilapox	Herb
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	–	Kilkolex o Koahkolex	Herb
Brassicaceae	*Nasturtium officinale* W.T. Aiton *	Berro	Ateskilitl	Herb
Brassicaceae	*Raphanus raphanistrum* L.	Quelite de rábano	Rabanoskilitl, Horrohkilitl o Kiramonoskilitl	Herb
Caryophyllaceae	*Stellaria media* (L.) Vill.	–	Momatilana, Mozozowa, Mapisil o Torohkilitl	Herb
Cleomaceae	*Cleome magnifica* Briq. (= *Andinocleome magnifica* (Briq.) Iltis & Chochrane)	Quelite de cinco hojas	Makuilkilitl	Shrub

(continued)

Table 1 (continued)

Family	Species	Common name in Spanish	Common name in Nahuatl	Life form
Cucurbitaceae	*Cucurbita ficifolia* Bouché	Guías y flores de chilacayote	Ayohkilitl iwan ayohkilxochitl	Herbaceous liana
Cucurbitaceae	*Sechium edule* (Jacq.) Sw.	Guías de chayote	Witzayohkilitl, Witzkilitl o Pinozoskilitl	Herbaceous liana
Fabaceae	*Erythrina americana* Mill. *	Gasparito	–	Tree
Fabaceae	*Phaseolus coccineus* L.	Guías y flores del ayocote	Esokilitl iwan esokilxochitl	Herbaceous liana
Lamiaceae	*Mentha spicata* L.	Hierba buena	Alwaweno	Herb
Montiaceae	*Calandrinia ciliata* (Ruiz & Pav.) DC.	Quelite de borrego	Ichkakilitl	Herb
Oxalidaceae	*Oxalis tuberosa* Molina	Hojas de papa extranjera	Xokokamohkilitl	Herb
Phytolaccaceae	*Phytolacca rugosa* A. Braun & C.D. Bouché	Ñamole	Ñamoli	Herb
Piperaceae	*Piper auritum* Kunth	Hierba santa	Tlanekpakilitl	Shrub
Polygonaceae	*Rumex acetosella* L.	Quelite agrio o lengua de vaca chiquito	Xokokilitl inon pixintzin	Herb
Polygonaceae	*Rumex crispus* L.	Quelite agrio o lengua de vaca	Xokokilitl	Herb
Portulacaceae	*Portulaca oleracea* L. *	Verdolaga	–	Herb
Solanaceae	*Jaltomata procumbens* (Cav.) J.L. Gentry	Jaltomate	Xaxaltohkilitl	Herb
Solanaceae	*Solanum nigrescens* M. Martens & Galeotti	Hierba mora	Tomakilitl	Herb
Solanaceae	*Solanum tuberosum* L.	Hojas de papa	Kamohkilitl	Herb

The woman responsible for cooking in each of the 20 families was asked about how she prepared each *quelite* species. Also, each family cook was asked for a specific *quelite* recipe, for which the name, number of portions, ingredients and their quantities, and the preparation was registered.

Consumption of *quelites* was estimated through two sets of data – recall interviews and a food diary. For the first set, we asked the family cook about the number of times that each species of *quelite* mentioned in the interviews was consumed per month during the main season. To estimate quantities, we measured the informally used units (example: *manojo*, a handful) for one or two species with each family. For the rest of the species, the amounts consumed were estimated based on these measurements. *Quelites* that were used as condiments, particularly *epazote* and coriander, were not considered, as only a few leaves were used. Purchased green vegetables were also not considered, as their consumption was relatively rare and estimating quantities more difficult.

For the second data set that included purchased non-*quelite* vegetables, we asked the families to keep food diaries for 3 weeks from the end of June to the first week of July of 2015. Of the 20 families selected, only 19 collaborated because in one family no member was literate. Older school children often kept the food diary, and they received a symbolic compensation (e.g., school supplies); the diaries were revised weekly with the first author. The food diary included all foods consumed by all members of the family: breakfast, lunch, dinner, and food eaten between meals. Quantities were not considered, only frequency.

To elucidate the motives that influence the knowledge and attitudes toward *quelites* among children and young people, we interviewed the students of the last grade of a primary, a secondary and a high school (Ignacio Zaragoza Elementary School, 21 students, Secondary Technical Agriculture and Preparatory School # 137, 66 students, and the College of Scientific and Technological Studies of the State of Veracruz, 44 students), in each case with the permission of the director and the class teacher. Students, both male and female, indicated their age, listed the *quelites* they knew, their favorites, and explained motives for consumption or non-consumption.

Socioeconomic Data

Interviewees were questioned about their age, main occupation, years of schooling and language proficiency (Nahuatl monolingual = 1, speaks Nahuatl but understands Spanish = 2, speaks Nahuatl and Spanish more or less equally = 3; there were no interviewees that were more proficient in Spanish than in Nahuatl). Occupations were also codified. The 20 families interviewed were classified into 3 socioeconomic levels (low, medium, and high), according to local criteria, mainly based on characteristics of their houses (size, material, appliances) and the ownership of vehicles. The categories were adjusted so that each class contained about one-third of the families. This classification was used to analyze the relationship between the use of *quelites* and socioeconomic status.

Data Analysis

The data collected on consumption frequency, quantities, and sources were first summarized with descriptive statistics. Their relationship with sociodemographic data (gender, age, schooling, occupation, level of linguistic competence, and socioeconomic level) were analyzed using the statistical program SPSS Statistics 21 with different methods.

For the relationship between the number, quantities, and frequencies of species used and the socioeconomic level, first, the normality and homogeneity of variances were confirmed. Then, the variation of data was analyzed with an ANOVA. Finally, the relationships between knowledge, gender, age, occupation, socioeconomic level, linguistic competence, and schooling were calculated with a multiple correlation analysis.

For the sample of school children, normality and homogeneity of variance of the data on the number of known species and the number of years of schooling were confirmed. After an analysis of variance (ANOVA), we asked if girls or boys knew more species of *quelites* with a t-test.

Results

General Observations on the Food System

The families usually had two or three formal meals a day (breakfast, lunch – usually in the afternoon – and dinner). The food for breakfast and lunch was similar, generally consisting of a noodle-tomato soup, eggs prepared in various ways, beans, rice, *quelites*, cactus pads (*nopales*), potatoes, lentils, soya, *chicharrón* (pork rind) in chili sauce, sardines, tuna, zucchini, and other vegetables. Maize tortillas were always present. Beverages included coffee, herbal tea, water, or soft drinks for breakfast, whereas soft drinks usually accompanied lunch. Some families did not have a formal dinner, others had bread or sweet bread with coffee, milk, or *atole* (a liquid maize gruel with sugar and other condiments), and some ate leftovers from the day.

Meat was eaten 5–6 times in the 3 weeks per family, that is, once or twice a week. The most common meat was chicken, followed by beef, pork, fish and, rarely, mutton.

Quelite Species and Sources

Families in Tetlazinga knew and consumed 35 species of *quelites*; they belonged to 29 genera and 17 botanical families (Table 1). Of these, only six were regularly bought in local fixed or weekly markets.

Most species were obtained from maize fields (milpa) (Fig. 2). Examples were pigweed (*quintonil, Amaranthus hybridus*), lamb's quarter (*quelite cenizo,*

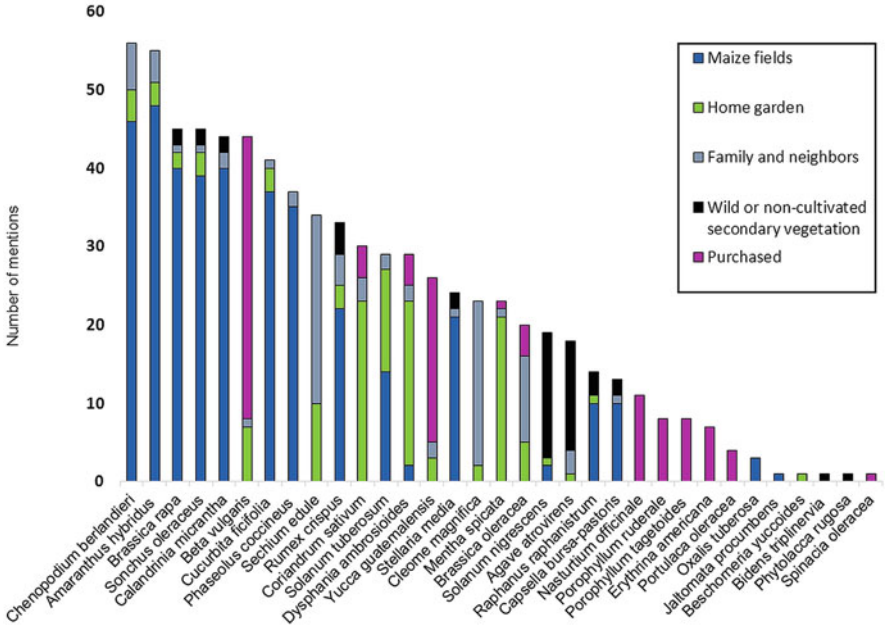

Fig. 2 Sources of 33 species of quelites (two species not used by the selected families are omitted)

Chenopodium berlandieri), turnip (*nabo, Brassica rapa*), and *quelite de borrego* (*Calandrinia ciliata*).

The second most common source of *quelites* were the homegardens, particularly for condiments: coriander (*cilantro, Coriandrum sativum; epazote, Dysphania ambrosioides*) and spearmint (*hierba buena, Mentha spicata*). Other plants obtained from homegardens were potato greens (*Solanum tuberosum*), *chayote* (*Sechium edule*), and chard (*acelga, Beta vulgaris*).

The gardens of family and neighbors were another source of *quelites*, usually as a gift. Examples were *chayote, quelite de cinco hojas* (*Cleome magnifica*), and cabbage leaves (*Brassica oleracea*). Not all family members liked *Cleome* because of its bitter taste. However, some people reported specific cravings for this plant, despite the fact it requires many hours of cooking to make it edible.

Another, but less common source of *quelites* was the wild or non-cultivated secondary vegetation. Examples of species collected in this type of place were *hierba mora* (*Solanum nigrescens*) and agave flower buds (*Agave atrovirens*).

Finally, a few species in high demand or not available in the region were bought from neighbors, or at fixed or weekly markets (*tianguis*). Examples of these species were: *izote* flowers (*Yucca guatemalensis*), chard, *pápalo* (*Porophyllum ruderale*), and *pipitza* (*Porophyllum linaria*).

Preparation

The plant parts commonly used for food were leaves and stems; flowers and young shoots were less frequent. Preparation was, in order of importance, by boiling, frying, blanching, only washing and consuming raw, and roasting (Fig. 3). Some recipes required two types of preparation, for example, first boiling or blanching, then frying.

If the *quelites* were boiled, salt and a piece of onion or garlic were usually added. They were also cooked with eggs or other foods, as well as in tomato or other sauces. Some recipes called for a combination of species. Fried *quelites* were usually prepared with onion and chili.

Blanched *quelites* were cooled with water and then formed into balls; these were eaten with salt and lemon juice. Some species were eaten raw directly, outside in the field, or washed if consumed at home. Only the flowers of *Beschorneria yuccoides* were roasted on a *comal* (griddle), covered with a maize tortilla. When they started to release the juice, some salt was added, they were left for a few more minutes and then eaten in *tacos* with maize tortillas.

Preparations of similar recipes varied between families. Comments by the interviewees pointed to active learning and instruction between generations, as well as modifications to recipes. We also documented innovation: one woman, who had lost her husband and had to find ways to feed a large family with very little money,

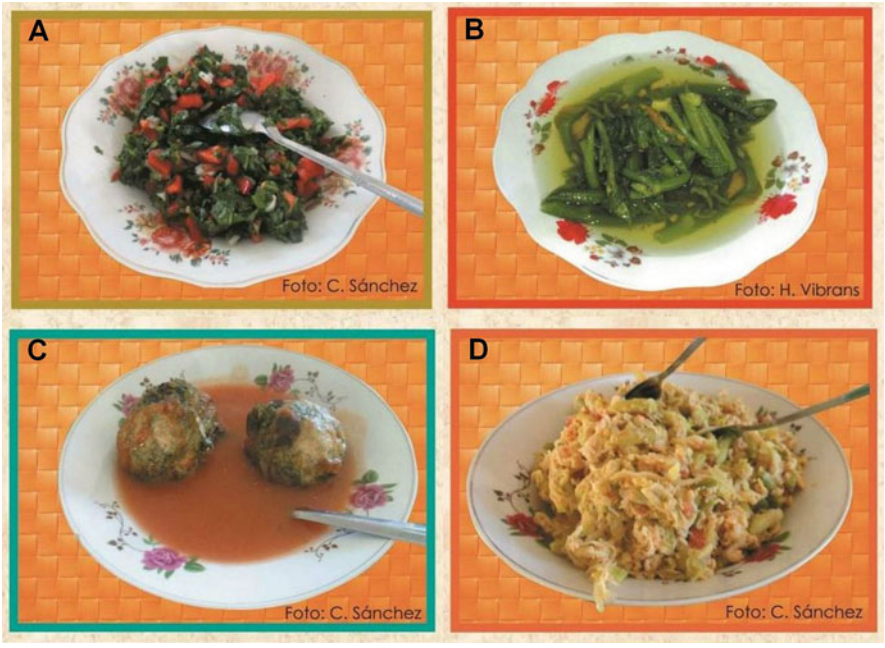

Fig. 3 Dishes. (**a**) Sowthistle salad; (**b**) Soup of squash shoots and flowers; (**c**) *Huauzontle* in tomato sauce; and (**d**) *Yucca* flowers with scrambled eggs. (Photos by the authors)

invented a very good-tasting salad of young sowthistle leaves, tomato, onion, and chili with no model for a similar dish within the community.

Purchased vegetables fell into two groups. The first group consisted of tomatoes (*Solanum lycopersicum*), husk tomatoes (*Physalis philadelphica*), onions, garlic, and chili, which were needed practically daily for sauces and condiment and had a long history, but were rarely the basis of dishes. These were not included in this study because of the difficulties in quantifying their use. The second group included the other commercial vegetables, which were introduced only recently and bought occasionally. They were mostly obtained at the market in Ciudad Mendoza, Veracruz.

The commercial vegetables (zucchini, cauliflower, head cabbage, green beans, lettuce, and radishes, mainly) were mostly boiled or cooked in sauces with other foods in different ways, including with meat. For example, cauliflower was boiled with potatoes in a tomato sauce with dry *guajillo* chili. The zucchinis were eaten *a la mexicana*, that is, with tomatoes, onion, and chili; green beans and head cabbage was cooked with chicken or beef. Lettuce and radishes were eaten raw with lemon juice and salt.

Frequency and Quantity of Consumption

Based on the recall data, each family consumed on average about 10 kg of fresh *quelites* (untrimmed) in two meals per week during the main season for most species (May–July). That is, each *quelite* meal consisted of between 3 and 4 kg of these plants (fresh, after trimming). If divided by the number of family members (74 for the 20 families, including children under 10 years old), the per capita consumption was 1.6–2.2 kg per week or 230–310 g per day during the *quelite* season. Amounts consumed varied strongly between families (Fig. 4), as they depended on family tastes and composition (minimum 1.5 kg and maximum 22 kg per week) with a slight correlation between the number of family members and amounts consumed.

The main *quelites* recorded in the three-week food diary were *Chenopodium berlandieri, Amaranthus hybridus*, flowers and shoots of squash (*Cucurbita ficifolia*), *Calandrinia ciliata, Brassica rapa*, flowers and shoots of runner bean (*Phaseolus coccineus*), tender shoots of chayote, sowthistle (*Sonchus oleraceus*), potato leaves, *Beta vulgaris*, and *Cleome magnifica*. No new *quelite* species were recorded in this data set.

Quelites were consumed much more frequently than purchased vegetables (Fig. 5) and were the main vegetables during the first half of the rainy season.

Quelite consumption and socioeconomic level. Families with fewer economic resources knew and consumed more species on average ($\overline{X} = 15.4$) than families with medium ($\overline{X} = 13.0$) and relatively high resources ($\overline{X} = 13.2$). However, this difference was not statistically significant ($p = 0.442$) with an ANOVA, based on the first group of data (recall interviews). The data on consumption frequency (food diary) and quantity (recall) also showed no significant differences.

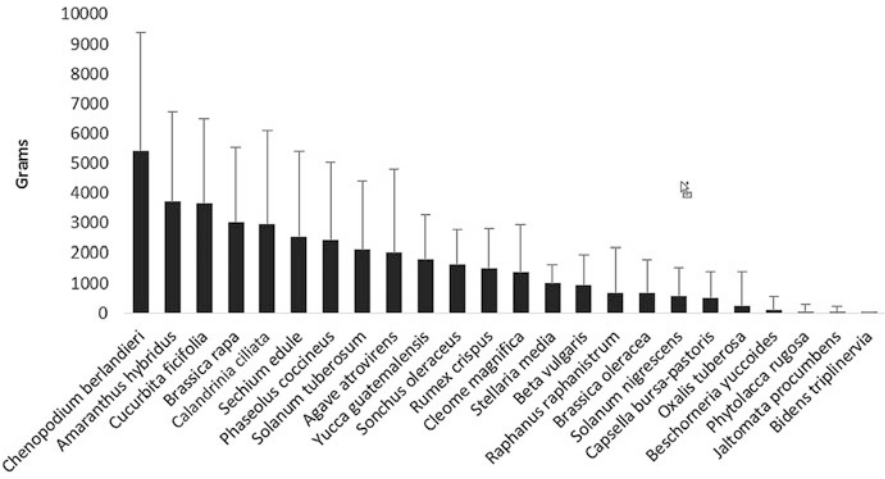

Fig. 4 Monthly consumption of 24 quelite species – average and standard deviation. The species used for condiment and purchased species were not included (see methods)

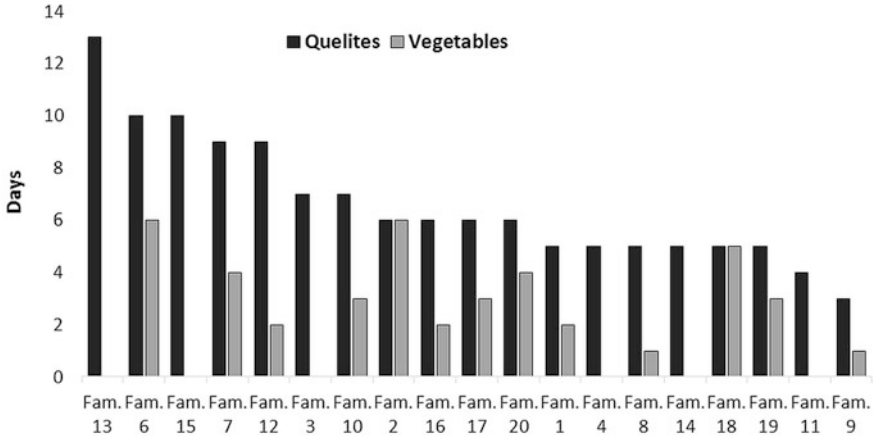

Fig. 5 Consumption frequency of quelites (collected and purchased) and the group of recently introduced vegetables in the three-week food diary of 19 families

Relationship Between Sociodemographic Factors and Quelite Knowledge and Use

A multiple correlation analysis of the number of species known to the interviewees found low but significant correlations related to gender ($R^2 = 0.254$, $p < 0.001$), age ($R^2 = 0.201$, $p < 0.001$), and occupation ($R^2 = 0.075$, $p = 0.007$). However, no correlation was found with the socioeconomic level ($R^2 = 0.003$, $p = 0.559$),

understood or spoken languages ($R^2 = 0.005$, $p = 0.474$), and years of schooling ($R^2 = 0.000$, $p = 0.828$). The total model, including the statistically non-significant variables, had a corrected R^2 of 0.479; that is, it explained about half of the variation found.

Most families valued the *quelites* and thought that they were tasty and healthy. Eleven of the 20 family cooks mentioned unprompted that talks at the clinic (which were obligatory for the recipients of some governmental programs) had emphasized the importance of consuming vegetables and specifically *quelites*.

Quelite Preferences and Knowledge Among Children and Young People

In the comments on preferences, less than 10% (12 of 131) of the interviewed students said they did not like *quelites*. The main reason given was their strong taste. Their favorite species were *Amaranthus hybridus, Chenopodium berlandieri, Brassica rapa, Rumex crispus, Calandrinia ciliata*, and *Beta vulgaris*, in this order, which corresponds well with the consumption data of the families.

Primary school students knew a higher number of species on average ($\overline{X} = 8.43$) than secondary school ($\overline{X} = 6.62$) and high school students ($\overline{X} = 4.66$). The difference between the three levels of schooling was significant ($F2, 128 = 15.107$, $p < 0.001$) with an ANOVA. The difference had a $p = 0.023$ between primary and secondary school students, while all the other differences had a p equal to or lower than 0.001. Males had less knowledge of species of *quelites* on average ($\overline{X} = 5.43$) than females ($\overline{X} = 6.97$). This difference was confirmed as significant with a t-test.

Discussion

Quelite Species

The number of *quelite* species consumed by the population of Tetlatzinga (35 species) was close to that of regions with a similar temperate-humid climate. In Naupan, a village in the humid mountains of northern Puebla, 37 species were recorded as *quelites*, and in Zoatecpan, Xochitlan de Vicente Suárez, in the same Sierra Norte de Puebla, 36 species (Basurto et al. 2011; Molina 2000). A mountainous area near Mexico City on the slopes of the Sierra Nevada around Ozumba had 35 species (Linares et al. 2017). Mota-Cruz et al. (2011) found a total of 46 species of *quelites* in Tepepan de Zaragoza and La Guacamaya, a region in Oaxaca south of our study area, but these were two villages with different ethnic groups. In Talea de Castro, also in a very humid area of northern Oaxaca, about half of 70 collected wild food species were leafy vegetables (Manduna 2008). These data appear to indicate that there is some regularity to the number of species used as *quelite* in this vegetation type.

The leaves of *kuilakochi* (*Bidens triplinervia*), shepherd's purse (*kilkolex; Capsella bursa-pastoris*), chickweed (*momatilana; Stellaria media*), and oka (*Oxalis tuberosa*) are new records for *quelites* in Mexico. However, *Capsella* and *Stellaria* are known as edible in their region of origin, Europe (Paoletti et al. 1995; Tardío et al. 2006). The high regard for the flowers of various agave relatives (*maguey, Agave atrovirens; izote, Yucca guatemaltensis*; and *patahmolkahkaya*, *Beschorneria yuccoides*) was notable.

Sources of Quelites

The milpa is not always the main source of *quelites* in Mexico; in other studies, the home garden was more important than the maize field (Mota-Cruz et al. 2011). In the study area, home gardens provided cultivated *quelites* – species that were not easily available otherwise. This division confirms the observation by Larios et al. (2013), that home gardens are spaces to obtain goods that are not available naturally. Perhaps the large number of these plants in maize fields was due to the humid climate.

The culinary importance of *quelites* was underscored by the fact that they were both exchanged and sold. Some were given to or obtained for free from relatives or neighbors; this is a common practice (Blanckaert et al. 2004) and strengthened ties of friendship and family. However, particularly high-value species were sold even within the social network. *Quelites*, both cultivated and collected, were also acquired in markets. This confirms observations of other authors that these plants are widely traded, for example, in the weekly markets of the Tehuacán-Cuicatlán Valley (Arellanes and Casas 2011; Arellanes et al. 2013), Nanacamilpa (González-Amaro et al. 2009), and Ixtlahuaca (Vieyra-Odilon and Vibrans 2001).

Preparation

In the study area, the *quelites* were usually the main focus of the meal and were cooked alone or in combination with other *quelites*, vegetables, eggs, and cheese, but seldom with meat, except for one recipe that calls for the combination of purslane and pork. In other regions of Mexico, *quelites* are considered more of a side dish or additional component of a meat-centered combination. For example, in San Cristobal de las Casas, Chiapas, people almost always cook *quelites* with chicken or beef (own observation). In San Bartolo de Llano, Mexico State, both pigweed and purslane are prepared with pork (Linares and Aguirre 1992; Vieyra-Odilon and Vibrans 2001). These differences in the role of these plants in the meals are interesting and should be explored comparatively. Perhaps the reason is economic or ecological, but it is also possible that these practices are the result of deeper cultural traits, particularly as introduced vegetables are paired with meat more commonly in the study area. However, some preparation methods, such as frying *quelites* with onion and chili, are common elsewhere in central Mexico; also, the preferred species were similar to other regions (Linares et al. 2017).

In some other regions, *quelites* are used to make fresh beverages (*agua fresca*) to drink with meals. We did not record this use in our study area. The experience of the first author in the region indicates that, apparently, there is no *agua fresca* tradition; historically, coffee or hot herbal tea was prepared in the morning and evening, and plain water accompanied daytime meals. There were a few other preparations, for example, chilacayote (*Cucurbita ficifolia*, a squash) cooked with water and sugar, or a nutritious beverage (*atole*) based on maize dough sweetened with agave juice (*aguamiel*). Currently, commercial soft drinks have replaced plain water.

Amounts Consumed

The quantities of consumed *quelites* were relatively high. Basurto et al. (2011) found a daily per capita consumption of on average only 130 g in an ecologically similar area in the Sierra Norte de Puebla, though the frequency (2–3 times per week) was similar. The Rarámuri of Cuiteco, Chihuahua, eat between 11.5 and 51.8 kg per family of four important species (Camou-Guerrero et al. 2008). Casas et al. (2014) recorded annual consumption of almost 17 kg of watercress (*Rorippa nasturtium-officinale*), but only 0.41 kg of the condiment *Porophyllum linaria*, among the Cuicatecos of San Lorenzo Pápalo, Oaxaca. In San Bartolo de Llano, State of Mexico, the consumption of *quelites* per month per family averaged 4.5 kg (Vieyra-Odilon and Vibrans 2001). In Santiago Quiotepec, Oaxaca, average annual consumption per household ranged from 1 to 3 kg per species (Pérez-Negrón and Casas 2007). In other parts of the world, for example, in two villages in Zimbabwe, on average, families consumed 210 g of wild plants 1–5 times per week (Manduna 2008).

The World Health Organization (2003) and the United States Department of Agriculture recommend the consumption of about 400 g of vegetables and fruit daily. There are few concrete recommendations for leafy green vegetables, but USDA does recommend a minimum of 2 cups (equivalent to 400–500 g) per week (http://www.choosemyplate.gov/vegetables). This means that the average 230–320 g per capita daily consumption in our study area far exceeds the recommended minimum, and even low-consuming families were likely to cover their needs. Indeed, during the season, *quelites* covered almost the entire vegetable requirement. If the other bought vegetables are considered (tomatoes, onions, cabbages, etc.), the diet of the population of the study area was quite remarkable for the amount of consumed vegetables.

Newly introduced, commercial vegetables did not play a large role in the diet in summer and, up to now, did not appear to be preferred or to replace the local *quelites*. Such replacement has been reported from Costa Rica, for example (González 2008). In Zimbabwe, Africa, some elderly people commented that modern vegetables were replacing traditional wild vegetables because young people prefer the taste of (modern) cultivated vegetables (Manduna 2008). Though we found similar sentiments among some schoolchildren, it was not wide-spread.

Socioeconomic and Sociodemographic Factors and Quelite Knowledge and Consumption

Some of the expected factors played a role in *quelite* knowledge, such as gender. Both adult and young females knew more species than males, presumably because of their role in meal preparation. Young boys had more contact with their fathers, who spent most of their time building furniture. The role of age was also confirmed: older people generally knew more, similar to, for example, Isthmus Zapotecs' plant knowledge (Saynes-Vásquez et al. 2016). In Niger, a curvilinear relationship between age and knowledge about herbaceous and woody species was found. The authors suggest that medicinal species knowledge decreases after a certain age (Ayantunde et al. 2008). We did not find this, perhaps because *quelites* were used more often and also included fewer species than medicinal.

Likewise, occupation is known to play a significant role in the knowledge of species. Saynes-Vásquez et al. (2016) found that the farmers, hunters, or collectors of firewood knew more names of plants than storekeepers or professionals, as did Martínez-Ballesté et al. (2006) in a different context.

However, unexpectedly, the consumption of *quelites* was not related to socioeconomic levels in the study area, similar to the results of Vieyra-Odilon and Vibrans (2001). Most interviewees considered them a desirable food source. Any possible negative attitudes had apparently been countered by the recommendations of the local health professionals. So, relatively simple interventions may reverse the negative image of these foods. If *quelite* use declines in this area in the future, it will probably be due to the abandonment of the *milpa* system for economic reasons, rather than cultural attitudes.

Also, bilingualism – as a proxy for the strength of the indigenous heritage – was not a relevant factor in the knowledge of species. In the Isthmus of Tehuantepec, the opposite was true for general wild plant knowledge, with a positive correlation between Zapotec linguistic competence and knowledge of plants (Saynes-Vásquez et al. 2013; Saynes-Vásquez et al. 2016). Again, this may be due to the different cognitive effort required to know a few edible plants versus many wild ones. Also, our study area was more uniform culturally – all inhabitants still spoke Nahuatl, and the majority was bilingual.

Years of schooling did not influence species knowledge among the families of Tetlatzinga. However, among students, age/years of schooling were negatively related with the knowledge of *quelites*. Estrada-Castillón et al. (2014) reported a similar phenomenon: children knew more useful species than young people, knowledge then increased in adults and decreased in the elderly. Apart from changing interests, teenagers are sometimes reluctant to admit knowledge of concepts they consider old-fashioned.

Conclusions and Perspectives

The tradition of *quelite* consumption was alive in our study region. The number of species used was similar to earlier studies of comparable regions. The fact that maize fields were the most important source of these plants underscores the role of these

fields as a provider not only of macro- but also of micronutrients, often neglected in productivity evaluations. The recipes were diverse, and there was active innovation.

We did not find the expected indicators of cultural change in people's relationship with *quelites* in the study area. Relatively well-off people consumed just as many as poor people; there were few signs of newly introduced vegetables being preferred to the traditional ones. *Quelites* were not looked upon as inferior by the general population. We suggest that simple reinforcement by authority figures can play a role in the maintenance of these healthy eating traditions. The fact that *quelites* were considered a main and not a side dish in the region should be explored more intensively.

This study shows that quantitative data are highly informative and provide context for understanding peoples' decisions. They may also contradict commonly held beliefs of investigators.

Acknowledgments We thank the people and the authorities of Tetlatzinga for their time, cooperation, and help. Dr. Abisaí García helped with the identification of Asparagaceae (*Agave*). This study was funded by the Consejo Nacional de Ciencia y Tecnología, Mexico (CONACYT; grant number 638929) through a grant for living expenses to the first author for her graduate studies.

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