Ixcatec Ethnobotany: Plant Knowledge in the Mountains Surrounding the Tehuacán Valley

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Abstract

Peoples' knowledge about their natural surroundings is tightly linked with practices to appropriate natural components, ecological processes occurring in the ecosystems, and to their cosmovision. Peoples and their surroundings are mutually transformed through management practices and the influence of landscapes on peoples' culture. A portion of the peoples' knowledge is codified by languages as names, classification systems, word meanings, and the contexts in which these words are pronounced. The loss of languages, therefore, leads to the risk of losing an essential part of peoples' memories. Santa María Ixcatlán is a town located in the state of Oaxaca, Mexico, with a population of nearly 500 inhabitants, with an alarming risk of disappearance of the Ixcatec language (only eight Ixcatec speakers) and the loss of knowledge about the environment that it implies. Ethnobotanical documentation may contribute to safeguarding the invaluable memory of the Ixcatec people. In this chapter, we provide a summary of our records about the people-plant interactions in this town. Our study attempts to understand how a rich biocultural legacy has been built in one of the most biodiverse zones in the semiarid mountains of Mexico. Also, to analyzing the challenges the Ixcatec people face to maintain this legacy and provide an account of the ways in which they confront them. We reviewed the literature with

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information about the Ixcatec people and their interactions with plants, and analyzed the published and unpublished results of ethnobotanical and ethnoecological work conducted by our research team from 1999 to the present. In Santa María Ixcatlán, agriculture is the axial activity around which all other productive activities and the community's ceremonial life are organized. Local farmers grow the basic staple foodstuffs consumed throughout the year like maize, beans, and supplementary crops like wheat and squash. They also manage edible weedy plant species that are essential for the local gastronomy. They use a total of 627 plant species to satisfy food, medicine, construction, handcrafts, fodder, and other needs. We analyze these aspects in this chapter. In addition, they manage 401 species through practices for ensuring their availability including tolerance (206 spp.), protection (251 spp.), transplanting (139), enhancement (34 ssp.) and ex situ propagation (155 spp.). In addition, they practice the gathering of 299 spp., and the raising of livestock that forage 243 plant species in different ecosystems of their territory. People mentioned 94 plant names corresponding to 129 species that are considered essential for living, and we centered our attention on these species. The Ixcatec ethnobotanical knowledge is possibly the most deeply documented in the Tehuacán-Cuicatlán region. However, we identified a process of loss of local knowledge associated to the substitution of local products for others, the loss of knowledge codified in the Ixcatec language, and the high rate of migration, especially the young people. Improving the conditions of interchange through organizational processes as well as the innovation of productive practices to generate profitable products are viable ways identified by local people to enhance local inhabitants to remain linked to the community. We refer to the initiatives of *Xula Palma Artesanal* collective and the *Ixcateco* collective brand, which have provided new opportunities to improve the lives of some households and demonstrated to be effective to maintain appropriate ways to manage plants and vegetation and to value the Ixcatec culture. For the members of *Xula* and *Ixateco*, their experience may be the base to strengthening customs and cultural aspects that give identity to their products. This experience illustrates the importance of documenting and understanding the local productive processes through ethnobotanical studies. In this way, ethnobotany may contribute to support the local efforts to improve life and maintain the valuable biocultural heritage of the Ixcatec people.

Introduction

Through their interactions with the environment, peoples construct a body of knowledge, perceptions, beliefs, emotions, worldviews, attitudes, and practices on which they base their coexistence with the natural surroundings. These factors strongly influence processes of using and adapting components and functions of ecosystems to satisfy different human needs (Casas et al. 2014). As a result, peoples and their surroundings are mutually transformed. Management practices act on individual organisms modifying their populations, and landscapes are transformed by changes in their biophysical conditions as a consequence of their utilization.

Conversely, the available resources in managed landscape contribute to modulate the peoples' lifestyles, costumes, social interactions, and culture (Boege 2008; Toledo and Barrera-Bassols 2008; Casas et al. 2015).

According to Berkes (1999) and Toledo (2002), peoples' knowledge about their natural surroundings (the *corpus*) is tightly linked both to their practices to appropriate natural components, ecological processes, and ecosystems (the *praxis*), and to their beliefs, values, and cosmovision (the *kosmos*). The *kosmos* modulates how human beings conceive themselves relative to the natural environment and determine the ways in which they interact with it. *Corpus*, *praxis*, and *kosmos* conform the systems of traditional knowledge that are maintained and transmitted through generations by management practices, use forms, tales, stories, and chronicles (Berkes et al. 2000; Gadgil et al. 1993; Toledo 2002). Therefore, all people possess a particular history and unique legacy, from which humanity is and has been benefited. A portion of the peoples' knowledge is codified by languages as names, classification systems, word meanings, and the contexts in which these words are pronounced (Wehi et al. 2009). The loss of languages, therefore, leads to the risk of losing an essential part of peoples' memories. When a language is abandoned, a part of the original knowledge is transmitted or translated, but there is a partial loss of this knowledge (Zent 2001; Harrison 2007; Si 2016). Additionally, the loss of knowledge is increased by the gradual loss of peoples' original interactions with natural components because of changes in their activities and lifestyles. These are for instance the loss of food habits and healthcare practices, the transformation of ecosystems, or the modification of other socioecological elements.

Santa María Ixcatlán is a town located in the state of Oaxaca, Mexico, with a population of nearly 500 inhabitants, which is currently undergoing the continual emigration of youngsters. The town is the only place where the Ixcatec people exist as a community linked to its ancestral territory (INEGI 2020). The Ixcatec is one of the 48 endangered languages in Mexico, with less than 10 people recognized as speakers of the native language (Eberhard et al. 2022; Embriz and Zamora 2012).

The undeniable and alarming risk of disappearance of the Ixcatec language and the loss of their knowledge about the environment make ethnobotanical documentation a way to contribute to safeguarding the invaluable memory of the Ixcatec people. It is crucial to identify and understand the processes that drive the loss, the way of transmission, and the innovation of the environmental knowledge of the Ixcatec people. Such aspects would contribute criteria and tools to face the challenges involved in managing the ecosystems and plant species they considered essential for their subsistence strategies. Also, these aspects would aid their initiatives to vindicate their identity, language, and culture.

In this chapter, we provide a summary of our records about the people-plant interactions in Santa María Ixcatlán. Our study attempts to understand how a rich biocultural legacy has been built in one of the most biodiverse zones in the semiarid mountains of Mexico. Also, to documenting the challenges the Ixcatec people face to maintain this legacy and provide an account of the ways in which they confront them. For these purposes, we reviewed the literature with information about the Ixcatec people and their interactions with plants, and analyzed the published and unpublished results of ethnobotanical and ethnoecological work conducted by our

research team from 1999 to the present. Also, we show a panorama of our collaboration with community members in events, actions, and projects directed to support the recognition of the value and maintenance of the Ixcatec biocultural heritage (Rangel-Landa et al. 2014, 2016a, b, 2017; Smith-Aguilar et al. 2016; Swanton 2022). The methods we used in this research were: (i) open and semi-structured interviews and free listing of plants used for different purposes; (ii) participant observation in the different activities of local households; (iii) sampling of the different vegetation types in order to evaluate distribution, abundance, and ecological importance of plant species in the local environmental contexts; (iv) documentation of Ixcatec botanical knowledge through sessions with local experts and Ixcatec speakers, by using fresh and herborized plant vouchers as prompts; (v) field trips and sampling to document the floristic composition of home gardens, agricultural fields, and relevant anthropized areas; (vi) exchanges of local experiences of plant management with other peoples; and (vii) follow-up of experiments for the innovation of management practices. Further details about the methodology and analyses can be consulted in Rangel-Landa et al. (2016a, 2017), and in Smith-Aguilar et al. (2016).

The Ixcatec and Their Territory

The Ixcatec are settled in what is presently known as the town and municipality of Santa María Ixcatlán in the state of Oaxaca. Santa María Ixcatlán is located in the mountains surrounding the Southeastern Tehuacán-Cuicatlán Valley, a semiarid zone with an exceptional biocultural diversity. For this reason, the region was decreed in 1998 as the Tehuacán-Cuicatlán Biosphere Reserve (CONANP 2013). In this region, nearly 36 plant associations harbor over 3000 vascular plant species, more than 565 vertebrate species, and a high diversity of little-studied invertebrates. Human populations have found refuge and sustenance in the Tehuacan-Cuicatlán Valley since at least 12,000 years ago, when hunter-gatherer groups left remains that have allowed archaeologists documenting their presence in the area (MacNeish 1967; CONANP 2013; Dávila et al. 2002). At present, the region is inhabited by Popolocan, Chocholtec, Chinantec, Mazatec, Cuicatec, Ixcatec, Mixtec, Nahua, and mestizo people and it harbors a large biocultural diversity with more than 2000 useful plant species. Until now, over 600 plant species have been recorded whose permanence and abundance is secured by agricultural and silvicultural management practices incorporated into ecological and productive systems covering a wide range of agroforestry practices (Casas et al. 2007; Blancas et al. 2010, 2013; Larios et al. 2013; Lira et al. 2009; Moreno-Calles et al. 2010; Vallejo-Ramos et al. 2016).

The origin and history of the Ixcatec people is little known, but based on Fernández et al. (1959) estimation of the period presumably elapsed since the Ixcatec language differentiated from the Otomanguean languages most related to the Ixcatec (the Chocholtec, Popolocan, and Mazatec), whose speakers coexist in the region together with the Cuicatec and Mixtec speakers. We may assume it has had a long interaction with its present territory during at least the past 1300 years (Fig. 1). The Ixcatec people

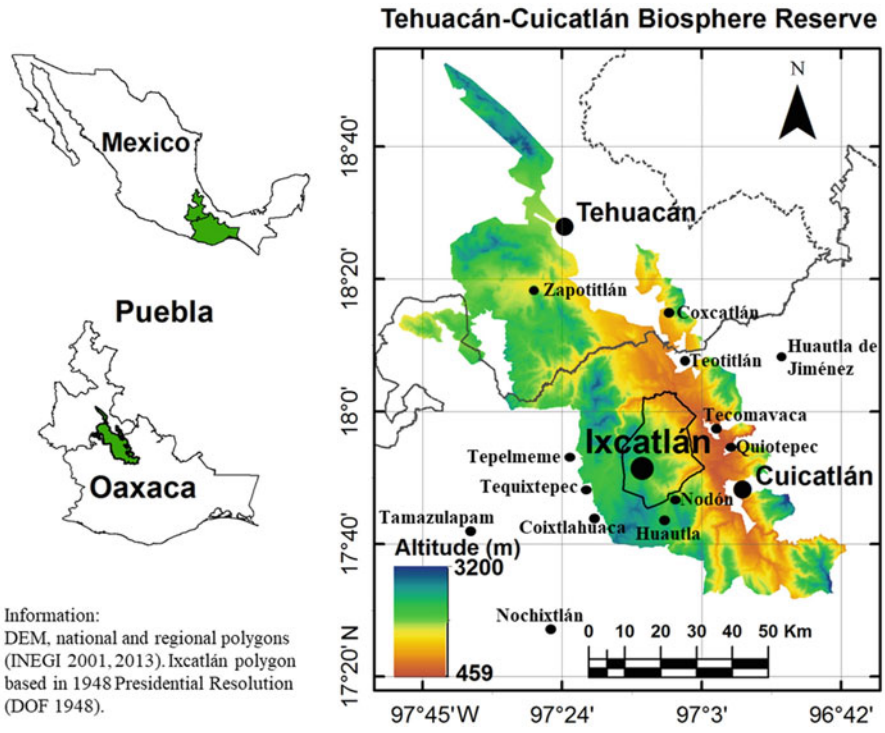

Fig. 1 Location of the community of Santa María Ixcatlán, Oaxaca, and neighboring towns

are recognized as an indigenous community governed by the "uses and costumes" regime, through which the community assembly designates its own civic and agrarian authorities by choosing them among the community members. The assembly also makes most of the decisions regarding the community's management of the territory, civic life, and even part of its religious organization (Nava and Romero 2007).

According to Cook (1958) and Hoppe and Weitlaner (1969), the Ixcatec population was approximately 10,000 inhabitants at the time of the arrival of the Spaniards (Hironymous (2007). Since that time, due to diseases, the bad conditions in mines owned by Spanish encomenderos, among other factors, by 1803, the population decreased to 361 inhabitants. In 1945, the population reached its maximal recovery with 1113 inhabitants, and has been decreasing since then (Cook 1958; Hironymous 2007). INEGI (2020) reported the present population to be 461 inhabitants, grouped in 163 households. The continued population decrease since the mid-twentieth century has been due to a high emigration rate caused by conflicts with the neighboring community of San Miguel Huautla, which had violent expressions between the 1940s and 1960s (Cook 1958; Hironymous 2007). After that period, emigration has been mostly driven by the search for employment and providing economic support to family members that remain in the community (parents, younger siblings, and grandparents). In addition, the birth rate decreased mostly due to the Mexican government's birth control campaigns (Hironymous 2007; Nava and Romero 2007).

Anthropologists and linguists considered that the Ixcatec population became bilingual in 1956, when some inhabitants began to abandon the Ixcatec language (Swanton 2008). In early 2022, eight inhabitants older than 50 years, and five of them older than 80, were fluent speakers of Ixcatec. In addition, several adults older than 50 years remembered some words and short phrases they listened to from their grandparents, but they declared not being able to speak the language (Swanton 2022). Some youngsters and children had learned some basic words and phrases in the Ixcatec language recovery courses and workshops carried out by several institutions since 1993 (Molina 2010).

According to official documents, the Ixcatec territory has an area of 41,530 ha (DOF 1948). The whole territory is mountainous, with elevations ranging from 800–2600 m. The three zones in the Ixcatec territory characterized by altitudinal range, climate, and vegetation are: (i) temperate zone, located between 1600 and 2000 m, where the town of Santa María Ixcatlán is settled, having temperate climate, oak forests dominated by *Quercus liebmani* Oersted and *Q. laeta* Liebm., microphyllous scrub (locally called *mexical*), palm scrubland dominated by *Brahea dulcis* (Kunth) Mart., and gallery forests with *Taxodium mucronatum* Ten.; (ii) cold zone, located in the highlands at elevations between 2000 and 2600 m, with a cooler temperate climate with presence of fog during the rainy season and winter, mixed oak forests with *Q. urbanii* Trel., *Q. castanea* Née, *Q. conspersa* Benth., and a diverse community of epiphytic plants; and (iii) warm zone, located in the elevations from below 800 to about 1600 m, dry and warm climate, dominated by a great variety of small-sized trees and shrubs such as *Bursera* spp., *Pistacia mexicana* Kunth, *Sarcomphalus amole* (Sessé & Moc.) Hauenschild, *Cephalocereus columna-trajani* (Karw. ex Pfeiff.) K.Schum., *Yucca periculosa* Baker, *C. fulviceps* (F.A.C. Weber ex K.Schum.) H.E.Moore, *Pseudalcantarea grandis* (Schltdl.) Pinzón and Barfuss, *Agave potatorum* Zucc., *Lindleya mespiloides* Kunth, and *Lippia origanoides* Kunth in tropical deciduous forests, thorn scrub, and cacti forests (Rangel-Landa et al. 2016a; Fig. 3).

The limits and settlements of Santa María Ixcatlán have been dynamic throughout history, mainly in response to environmental factors like droughts, and, as mentioned above, to population decrease. The Ixcatec people came to constitute a seigniory with seven dependent towns, but since the sixteenth century only Santa María Ixcatlán has remained as the only permanent settlement (Hironymous 2007). The pre-Hispanic settlements are represented by several vestigial constructions and irrigation and soil management infrastructure (Hironymous 2007) (Fig. 2). Elder members of the community reported that, until nearly 50 years ago, some families from the community inhabited these sites for some months or years to take advantage of the more fertile and resource-rich land. These land occupations by small families were called *ranchos* and have preserved the memory of landscape domestication processes (Fig. 2). Examples of these occupations are places with the presence of scrubland dominated by *Brahea dulcis* (*palma criolla*) – a type of secondary vegetation favored by management (Illsley et al. 2001; Rangel-Landa et al. 2014; Rzedowski 1978). Also, small patches of plants like *Leucaena esculenta* (DC) Benth. (*guaje*), *Lophocereus marginatus* (DC.) Backeb. (*órgano*), *Opuntia huajuapensis* Bravo (*nopal*), *Agave salmiana*

Fig. 2 Landscapes in pre-Hispanic settlements Santa María Ixcatlán. (**a**) Vestiges of constructions used until the middle of the mid-twentieth century for the production of mescal in the Santiago River near the pre-Hispanic settlement of La Iglesia; (**b**) cross-channel dam in El Bartolo, near the settlement of Santa María Ixcatlán; (**c**) and (**d**) pre-Hispanic settlement of San Juan Viejo where the low-intensity harvest of leaves maintains the palm grove *Palmonar* of *Brahea dulcis*, other plants associated with settlements are present, such as *Leucaena esculenta*, *Lophocereus marginatus*, *Opuntia huajuapensis*, and *Agave salmiana* subsp. *tehuacanensis*. (Photos: Selene Rangel-Landa)

subsp. *tehuacanensis* (Karw. ex Salm-Dyck) García-Mend. (*maguey*), *Morus celtidifolia* Kunth (*moral*), and *Celtis caudata* Planch. (*moralillo*) were mentioned by people to have been important resources for a long time. These species are still abundant in homegardens (locally known in Spanish as *solares*) and agricultural fields that conform agroforestry systems (Figs. 2 and 3).

The lifestyles and livelihoods of rural people are defined by two environmental factors: precipitation and the predominant soil type. In Santa María Ixcatlán, precipitation is low (646 mm per year on average) with a marked canicule, and frequent interannual drought periods (SMN-CONAGUA n.d.). The predominant soil type at intermediate elevations is of calcareous origin, which is known to be of low suitability for agriculture. In the memory of the inhabitants of Santa María Ixcatlán, "rainfall is lessening." However, the aridity of this region was one of the first observations reported in the sixteenth century by Velazquez de Lara (1579), who described the settlement as lacking permanent water sources except for seasonal streams. Likewise, Cook's (1958) description in the 1940s mentions low and irregularly distributed precipitation. According to meteorological records of the SMN-CONAGUA (n.d.) from 1955–2016 and considering the 33 year period with

Fig. 3 Agroforestal systems and management practices. (**a**) and (**b**) Agricultural fields around the town, where several wild species are kept, constituting the agroforestry complex *Milpa-palmonar* of *Brahea dulcis*; (**c**) milpa cultivation on *solares* (yards and backyards); (**d**) space in the backyard of the family garden (*corral*) dedicated to the care of plants; (**e**–**g**) sites where mescal is prepared (*palenque*), where plants associated with springs such as *Taxodium mucronatum* are maintained,

complete data, the average annual precipitation in the region is 646 mm (SD = 186 mm), with a maximum of 1069 mm and a minimum of 291 mm, becoming as low as under 200 mm, as recorded in 1938 (Cook 1958). At present, two springs supply drinking water for the community's household members, and their livestock drink from five small artificial reservoirs.

A Subsistence Strategy Based on Diversity

In Santa María Ixcatlán, agricultural production is the axial activity around which all other productive activities and the community's ceremonial life are organized. Local farmers grow the basic staple foodstuffs consumed throughout the year like maize – known as *maíz criollo*, pole and bush black beans –*frijol negro enrredador* and *frijol negro de mata* or *de tierra*, and supplementary crops like wheat and squash. They also manage edible weedy plant species that are essential for the local gastronomy like *Physalis philadelphica* Lam. (*miltomate*), *Amaranthus hybridus* L. (*quelite tintonil*), and *Dysphania ambrosioides* (L.) Mosyakin and Clemants. Crops are grown in plots near the town, where several wild species are managed within home gardens, or in yards transformed into agricultural plots during the rainy season (Fig. 3).

Although agricultural production is essential for the subsistence strategy of the inhabitants of Santa María Ixcatlán, it is insufficient. For example, in the year 2000, the local production of maize was only enough to cover 37% of the local consumption of this staple food, and it was 20% in 2012, while the production of bean covered only 46% and 49% of the community's needs for the same years, respectively (Rangel-Landa et al. 2016a).

People's concern regarding uncertainty in the agricultural cycle is expressed in their worries about whether rainfall will be sufficient, if it will occur before August so that crops can be harvested before mid-October when temperature decreases. Also, if crops seedlings will survive after seed germination, or if once plants have bloomed, there will be enough precipitation for the development of fruits and seeds (Hironymous 2007; Rangel-Landa et al. 2016a).

Uncertainty and an unfavorable balance between costs and benefits have led to the loss of some crops. The former cultivation of the *maíz de cajete* – a slow-growth maize variety sown early in the year in canyons – is registered in the elders' memory and records of the mid-twentieth century (Hoppe and Weitlaner 1969). However, the crop was abandoned due to the lack of winter rainfall and conflicts with the neighboring community of San Miguel Huautla for land where the crop was grown. Some households cultivated potato, barley, and peas in the high-elevation

Fig. 3 (continued) and plants whose maintenance is only possible in these sites such as avocado; (**h**) sites in the oak forests called paddocks (*potreros*) conditioned for the maintenance of cattle; (**i**) "cold land" dominated by oak forest; and (**j**) *Cephalocereus columna-trajani* shrubland and tropical deciduous forests in the "warm land". (Photos: Selene Rangel-Landa)

temperate zones (Fernández 1950), until these crops were abandoned in the early 1990s. Their abandonment was caused by repeated droughts and because the effort of traveling for several hours or days to work in these upper lands surpassed the benefits of the harvest. In addition, these crops became available in local stores at accessible prices.

Many elders expressed the hardships they experienced for subsisting in this uncertain scenario. But local people have managed to survive using sociocultural strategies including: (i) maintaining strong family and community links to ensure mutual support in case of emergencies; (ii) diversifying household's members activities; and (iii) using and managing diverse plant species, productive systems, and territorial units (Blancas et al. 2013, 2014; Rangel-Landa et al. 2017).

The diversification of productive activities within households is one of the main socioeconomic strategies for ensuring enough income to satisfy their members' needs (Rangel-Landa et al. 2016a). Besides providing the households with maize, beans, and other crops, agricultural production includes management of weedy plant species to supplement the basic diet of people, and crop wastes that are a significant input of fodder.

The use of 627 plant species and the management of 401 species through practices for ensuring their availability provide the base for maintaining the local population's productive activities. Plant management includes tolerance (206 spp.), protection (251 spp.), transplanting (139), enhancement (34 ssp.) and ex situ propagation (155 spp.), as well as the gathering of 299 spp., and the foraging of 243 spp. by livestock. These practices allow satisfying the basic needs of foodstuffs, healthcare, firewood, construction, tools and utensils manufacturing, ornament, shade, living fences, as well as ritual and ceremonial inputs (Table 1; Rangel-Landa et al. 2016a). The products of some plant species supply currency to community members, such as firewood from *Quercus* spp., leaves from the palm *B. dulcis*, and resin from *Bursera* spp. trees (*copal*). There is an agreement among people of the community to restrict the sale of unprocessed natural products with other members of the community. The only exception are leaves of the palm *B. dulcis* that are allowed to be bartered for maize, fruits, vegetables, and other products offered by a small number of traders visiting the community.

The basic productive activities of the community are agriculture, manufacture, and trading of hats and artisanal products made with *Brahea dulcis* leaves, the elaboration of artisanal mescal from stems of *Agave potatorum*, and small-scale extensive livestock production of cattle, goats, and sheep. Hats are traded or bartered in local stores and mescal is mostly retailed to local inhabitants and visitors, but in a growing amount. Palm-woven handicraft products are sold outside the community and some mescal producers are distributing their product through wholesale traders who sell it in regional, domestic, and foreign markets. For most households in the community, livestock grazing in common use areas represents a source of saving money for engagements or emergencies, and only less than 3% of households depend on it for income to satisfy basic needs.

Other activities unrelated with the use and management of natural resources, but that are essential for the community's subsistence strategy, are the occupation in communitarian services like commerce, masonry, music, day labor, and others.

Table 1 Useful plant species of Santa María Ixcatlán. (Based on Rangel-Landa et al. (2016a))

Use	Native	Introduced	Total
Fodder	238	30	268
Ornamental	160	110	270
Medicinal	166	53	219
Edible	72	66	138
Ceremonial	73	55	128
Firewood	44	2	46
Utensils	29	4	33
Living fences	24	6	30
Timber products and construction	27	2	29
Shade	12	11	23
Food additive (flavor)	9	6	15
Handcrafts	10	1	11
Insects repellent	8	0	8
Soil control	6	2	8
Animals medicine	5	1	6
Facilitator	3	2	5
Toys	5	0	5
Alcoholic beverages	2	1	3
Cosmetic	2	1	3
Soap	2	1	3
Paint	3	0	3
Weather predictors	2	0	2
Aromatizing	1	0	1
Tannin source	1	0	1
Water attracter	1	0	1
Glues	1	0	1
Poisons	1	0	1
Useful species	439 (Ixc)	154 from other regions 31 from other areas of the Tehuacan-Cuicatlán Valley 3 of unknown origin	627
Unknown use	150	3	153
TOTAL	589	191	780

These activities, for the majority of the community members, are temporal or occasional. Remittances are especially important for emergency expenses and communitarian engagements, and the support from governmental programs has gained importance for the community members' subsistence strategy. The latter source of income provides the local inhabitants resources for covering their daily needs, as we observed during the coronavirus pandemic in 2020 and 2021. In this period, the regional trade of palm hats was completely stalled, and many families depended on it for acquiring maize and other basic foodstuffs. Then, the remittances were crucial for the maintenance of local people's life.

The Essential Plants for Livelihood

Although there is a perception that all plants and everything that is part of the mountains are important, when we asked people about the plants that were essential for living, they mentioned 94 plant names corresponding to 129 species (Fig. 4). Oaks *Quercus* spp. (*yange* in Ixcatec) were among the 30 most valued species. They provide the highest quality firewood (essential for cooking, mescal production, and bread baking), acorns to feed livestock and wild animals, lumber for building houses, and because they provide shade and fresh air – these are expressed as: "... they give life to the land . . ." and "... they attract and hold water." *Q. acutifolia* Née and *Q. conspersa* Benth are particularly valued for women's healthcare, *Juniperus flaccida* and *Morus celtidifolia* Kunth are especially appreciated, the former tree for providing shade in agricultural fields and the latter in homegardens, besides for other benefits (Rangel-Landa et al. 2016a).

The members of households that we surveyed included within the most essential plants for livelihood basic crops like *Zea mays* L., *Phaseolus vulgaris* L., and *Triticum aestivum* L., and other edible plants that form part of their basic diet like *Opuntia* spp., *Leucaena* spp., *A. hybridus*, and *Dysphania ambrosioides*. Also, they mentioned the economically important plant species *Brahea dulcis* and *Agave potatorum* (Table 1; Appendix 1; Fig. 4).

People also included in the list plants used in healthcare like *Grindelia inuloides* Willd., *Mentha* x *piperita* L., *Aloe vera* (L.) Burm.f., *Casimiroa edulis* La Llave and Lex., and *Lippia oaxacana* B.L.Rob. and Greenm. (Table 1; Fig. 4). People of Ixcatlán value grass species as source of fodder and because they cover the ground and give life to the mountains. They also mentioned plants used in rituals, as it is the case of *Litsea glaucescens* Kunth whose branches are used to make bouquets with which they start processions and adorn the church facade.

Of the 35 Ixcatlán inhabitants we interviewed, 20% included water in the list. Oak trees in the forests surrounding the settlement are highly valued for their relationship with water, which suggests that local people associate forests with the water cycle. This connection appears to have an influence on their decision-making about the management of plants and vegetation.

Nourishment and Edible Plants

Of the plant species we recorded in the community, 138 were edible and nearly 50 were basic for the local people's diet (Rangel-Landa et al. 2016a; Table 1; Appendix 1). The inhabitants of Santa María Ixcatlán eat their meals in the morning and in the afternoon, and, in some households, their members also eat a light meal at night. Like centuries ago, maize and beans are part of the everyday meals (Velazquez de Lara 1579; Appendix 1). Breakfast includes *tortillas*, cooked beans flavored with *Dysphania ambrosioides* (*epazote*), eggs, sauces prepared with *Capsicum annuum* L. (chili) and miltomate (*Physalis philadelphica*), coffee or *atole*, and bread. The afternoon meal includes a soup, stew or broth with *tortillas*, and beans. The nocturnal light meal consists of coffee or *atole* accompanied by bread, or a small serving of beans with *tortillas*.

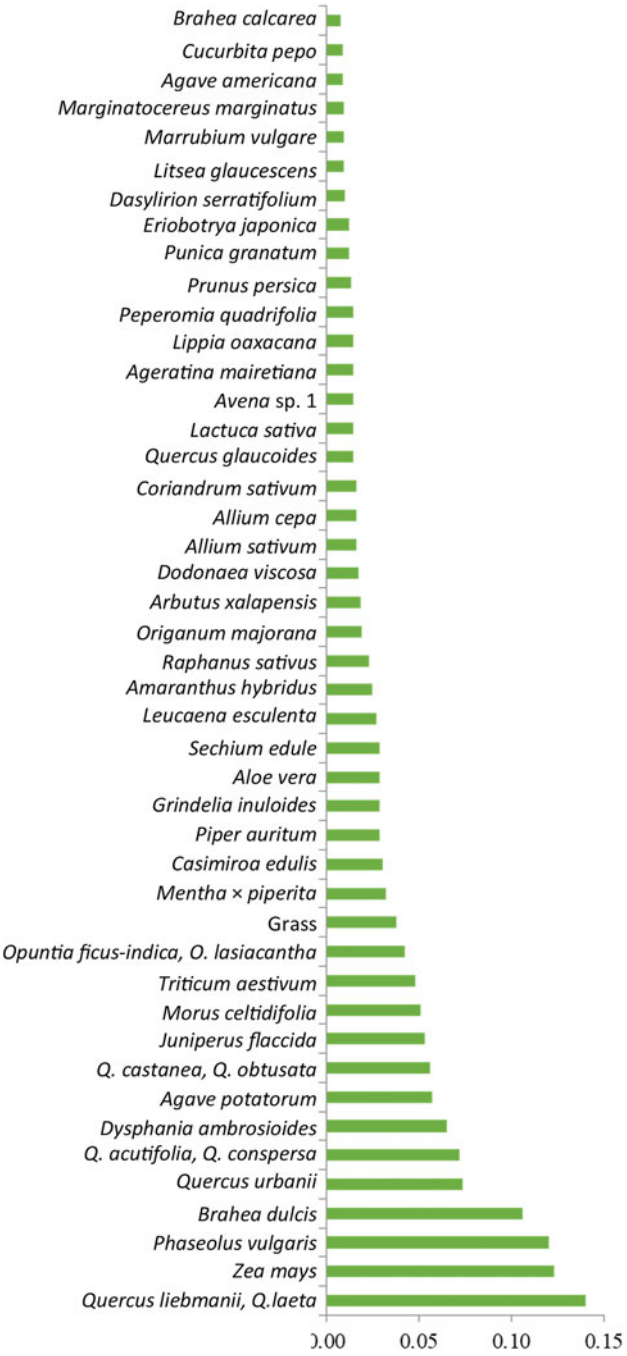

Fig. 4 The essential plants for livelihood. Cognitive prominence values expressed as Sutrop relative prominence index (S), where S = F/(N mP), where F represents the frequency of the species, N the total number of interviewed people per use category, and mP is the medium position in which the term or species was named (Sutrop 2001)

Tortillas, beans, and sauces are consumed daily in all households, and are always present in festive meals, for which they can be considered as the core of the diet and gastronomic culture in Santa María Ixcatlán. The stews and broths vary and may include meat or vegetables acquired in the local stores, produced in home gardens, or gathered in agricultural fields or wild vegetation. Other foodstuffs available the year-round like eggs, rice, pasta soup, and chicken soup are consumed in most households at least once a week. Because of their nutritional contribution to the local people's diet, these fodds can be considered as part of the basic local diet (Appendix 1).

The most frequent dishes served in traditional festivities include *barbacoa* (beef cooked in earth ovens) and *tesmoles* (chili-based sauces generally served with chicken). For the *Todos los Santos* (Day of the Dead) festivity, *totopos* – a special kind of dry tortilla – are always present in the altars set for the symbolic consumption by the deceased people, together with the *pan de muerto* (a kind of bread) prepared by community members (Fig. 5).

Festive foodstuffs have a cultural significance as part of local tradition but are also important because they are shared during celebrations to acknowledge the community members that collaborated in their preparation. Participation in religious festivities and giving support to mayordomos (community members in charge of organizing activities of religious celebrations) allow members of less prosperous households, unable to purchase meat, to have access to a significant source of animal protein. The religious ceremonies take place at least once a month, and every one or two weeks, the mayordomos of the community's patron saint festivity must organize and provide supplies for celebration events called *calendas* (Hironymous 2007).

Game animals are another supplement of the community members' diet. The consumption of deer (*Odocoileus virginianus* Zimmermann, 1780) and collared peccaries (*Dicotyles tajacu* Linnaeus, 1789) has been part of the diet of people in the region since about 10,000 years ago and it continues to be practiced. However, since the designation of the Biosphere Reserve in 2012, the conservation policies promoted by the Reserve's administrative authorities have diminished the consumption of these species and other wild mammals and insects (Cook 1958; Flannery 1986; Solís and Casas 2019; Velazquez de Lara 1579; Zarazúa-Carbajal et al. 2020). Other wild animals and their products continue to be consumed by community members, or at least they acknowledge their consumption. These are the cases of *D. tajacu*, small wild mammals – mainly squirrels and rabbits (*Sylvilagus* spp.; *Lepus* spp.; *Spermophilus variegatus* Erxleben, 1777; *Sciurus aureogaster* F. Cuvier, 1929), pigeons (*Zenaida* spp.), and insects like *Eucheira socialis* Westwood, 1834 (*madrone worms*), honey and bee larvae, especially of *Apis mellifera* Linnaeus, 1758, and of *Brachygastra* spp. (*panal de tierra*; Appendix 1). The consumption of wild animals is occasional and depends on when activities conducted in the field provide the opportunity to hunt or gather them. The exception is gathering of honeycombs of *A. mellifera*, since it is carried out during expeditions to the warm zones for obtaining copal, which together with honey forms part of the Day of the Death offerings. Other exception is the hunting of deer and collared peccaries. These activities require specialized knowledge about the environment and about the animal

species, and are carried out exclusively by males, except from some households that have recently allowed the participation of young women.

Among the gathered wild plants, the most outstanding are *quelites*, called *nyiya* in Ixcatec, which are edible plants whose tender leaves are consumed boiled or fried (Costaouec and Swanton 2015; Rangel-Landa et al. 2016b) including *Amaranthus hybridus* (*quelite tintonil, nyiya xacújù*), *Chenopodium berlandieri* Moq. (*quelite de manteca, nyiyaxije*), and *Anoda cristata* (L.) Schltdl. (*violeta, nyiya ñundu*). Of these three species of quelite, *A. hybridus* was consumed by members of all the households interviewed in 2000, and in 95% of the households enquired in 2012. Local people said to consume it from one to five times a week during the season when it is available (Appendix 1). The consumption of *C. berlandieri* has decreased drastically. In 2000, it was eaten by members of 30% of the surveyed households, and, in 2012, the members of only 15% of the surveyed households said to consume it. The use and knowledge of *A. cristata* is being lost. In 2012, only the members of one household said to have consumed it in the past 10 years. At present, only the elders that consumed *A. cristata* 20 years ago could relate its consistency with the Ixcatec name, whose epithet means slimy, referring to the consistency of broths and stews prepared with it. Like other plant species consumed as *quelites* having nutraceutical, nutritional, and antimicrobial properties, *A. cristata* is a present and future valuable resource (Gomez-Chang et al. 2018; Mateos-Maces et al. 2020). However, the memory of the interaction of local people with *A. cristata* is at risk of being lost because of changes in diet and the forgetting of the name of this plant in Ixcatec, which codifies the knowledge associated with plant use.

The availability of edible plants is closely associated with practices carried out to ensure their availability for use and improve their quality. Native plant species managed in home gardens and cropland include several species of *Opuntia* spp. (*nopales or ñunda* in Ixcatec), *A. hybridus, Porophyllum linaria* (Cav.) DC. (*pepitza* or *xaxcunyà*), *P. ruderale* var. *macrocephalum* (DC.) Cronquistand (paploquelite or *myeni*), and *Leucaena* spp. (*guaje* or *nyatsje*), which are important components of the household members' diet (Fig. 5). Although the local availability of these species lasts for only one to four months, these are consumed once per month to three times per week because people procure them from markets or stores outside Ixcatlán (Appendix 1). Other plants having short production seasons like *Sideroxylon palmeri* (Rose) T.D.Pennm.(*tempesquisle* or *chixu*), whose edible fruits are valued for their use in religious ceremonies and require a laborious preparation, are commonly obtained through interchange with sellers coming from outside the community.

The inhabitants of Ixcatlán use 15 plants to flavor food or beverages (Table 1), some of which provide a substantial supply of nutrients. These condiments include some used for dishes prepared for celebrations, like *Piper auritum* Kunth used for *tamales* and *Origanum majorana* L. that confers mole a distinctive taste. *A. hybridus* must be cooked with *P. linaria* (Cav.) DC (*pepitsa* or *xaxcunyà*). The leaves of *A. salmiana* subsp. *tehuacanensis* (*maguey cimarron*) confer to the barbacoa a particular flavor. In addition, the cuticle of these leaves function as a utensil for wrapping the meat, thus preventing it from burning, dehydrating, or coming into contact with the hot stones of the oven (Fig. 5).

Fig. 5 Uses of plants for daily life and celebrations in Santa María Ixcatlán. (**a**) Altar during the celebration of the Day of the Dead in which *Laelia anceps*, *Tagetes erecta*, *T. lunulata* Ortega, and copal resin (*Bursera* spp.) are offered to deceased relatives; (**b**) *Tenates de flor* with candles that will be offered to be lit on deceased family graves or given to relatives and friends for their deceased; (**c**) lit trunk in front of the church on the nights of the Day of Death celebration; (**d**) leaves of *A. salmiana* subsp. *tehuacanensis* in the oven for barbacoa cooking; (**e**) bunch of palm leaves *Brahea dulci*s adorned with flowers *Prosthechea karwinskii* (Mart.) J.M.H. Shaw

The relationship between people's cultural values and the perception of risk in the availability of edible plants motivate management practices. These practices are directed to ensure the availability of products to satisfy their needs, as was documented by Rangel-Landa et al. (2017) for the cases of *P. philadelphica*, *A. hybridus*, and *D. ambrosioides*. Having useful plants nearby "*tenerlas a mano*" and ensuring their quality are factors that drive people's management practices like cultivation. For example, the Ixcatec inhabitants perceive that *P. linaria* is abundant, but since it is necessary to collect the plant from crop fields far from the house, they cultivate them in their homegardens to ease their availability (Fig. 5). They also cultivate *Solanum lycopersicum* L. (*jitomate*), *Opuntia* spp., and *Coriandrum sativum* L. because they consider that their cultivated plants have better flavor and are healthier than plants purchased in stores.

In the period between 2000 and 2012, we identified a trend of change in the local people's food patterns expressed as the decrease of the average weekly consumption per household of maize (from 14.7 ± 8.3 to 13.5 ± 6.3 kg) and bean (3 ± 1.7 to 2.2 ± 1.9 kg), and an associated increase in the consumption of eggs and meat. Our observations suggest that households are changing their food patterns, although that trend occurs at different rates among households.

Emergency foodstuffs formerly used in times when maize became scarce remain in the collective memory of the current inhabitants of Santa María Ixcatlán. The most important plants used in the past as emergency foodstuffs are agaves. The cooked scapes, flower buds, and stems of agave were mixed with cooked maize to prepare tortillas. The boiled and cooked flower buds of *A. potatorum* and *A. kerchovei* Lem, the stems of *A. potatorum* prepared with leaves of *Oxalis* aff. *latifolia* Kunth, and agave stems cooked in underground ovens were appreciated energy-rich foodstuffs in the past. The consumption of agave was recorded in the archaeological studies in the region from at least 9000 years ago (MacNeish 1967), and for Ixcatlán, it was described in written records of the sixteenth century (Velazquez de Lara 1579; Cook 1958). However, the use of agave as food has decreased during the last 30 years, partly because of the use of *A. potatorum* for producing mescal, and partly because harvesting flower buds is recently seen as a practice affecting the conservation of agave populations. Social factors also appear to have played a role in the decreased consumption of agave products, as we observed in the Ixcatlán inhabitants associating that habit with poverty. Something similar could have happened with the consumption of the flowers of *Opuntia* spp., which was recorded in the sixteenth century (Velazquez de Lara 1579), but that we failed to observe in our study.

Fig. 5 (continued) (*monjita amarilla*), which will be blessed in the celebration of Palm Sunday; (**f**) *Leucaena esculenta* pods and *Porophyllum linaria* herbs; (**g**) construction of a kitchen roof with *B. calcarea* leaves; (**h**) *P. ruderale* bouquet to accompany the food during the celebration of the *Señor de las Tres Caídas*; and (**i**) transport of *Tillandsia* spp. (*Soluche*) collected in oak forests to feed pack animals in the dry season. (Photos: Selene Rangel-Landa)

Other plants like *Peperomia quadrifolia* (L.) Kunth – an epiphyte distributed in oak forests in the highest elevations of the territory – and the tender inflorescences of *Dasylirion serratifolium* (Karw. ex Schult. & Schult.f.) Zucc. Hook. are highly valued by the inhabitants of Santa María Ixcatlán for their flavor, and because they recognize them as healthy foodstuffs. Both species are consumed by most households in Santa María Ixcatlán at least once or a few times per year, even by household members that cannot gather them. In the latter cases, these products are shared by relatives, neighbors, or friends, which play a role in maintaining reciprocal relationships for strengthening the bonds among community members (Rangel-Landa et al. 2017).

Plants and Healthcare

Before the establishment in Ixcatlán of a public health clinic of the Mexican Institute for Social Security (IMSS for its acronym in Spanish) in 1990, the community members attended their health issues mainly through traditional medicine practices (Hironymous 2007). Since then, a sort of hybrid healthcare system has operated in Ixcatlán. Currently, practically all household members make use of public health services within or outside the community. But, depending on the type of illness, the household's economic resources, and the household members' trust in each type of treatment, they also use traditional medicine to complement physician's prescribed treatments, or when they consider the latter to be ineffective (Rangel-Landa et al. 2017).

The most common health issues reported by the inhabitants of Santa María Ixcatlán are cold symptoms, stomachache, fever, headache, earache, traumatisms, and culture-specific illnesses like *empachos* (stomach inflammation, loss of appetite, and constipation), *sustos* and *aires* (general discomfort caused by strong impressions, envies, or having had contact with ill or deceased persons), and *alferecía* affecting children (irritability, loss of appetite, and weakness). Cardiovascular diseases, obesity, and diabetes have been increasingly manifested among the current inhabitants of Santa María Ixcatlán, which could be due in part to changes in their exercise and dietary habits during recent years. For example, the increasing consumption of sweet industrial beverages (*refrescos*) – one to seven times a week or twice a month – was practiced by 29% of the household members in 2000, and by 81% in 2012.

Within households, the older women are the most experienced and knowledgeable of traditional healthcare treatments, and – both in cases of culture-specific illnesses or when supplementing physician's prescriptions – they decide when they are able to treat the ill household members, or when to consult a healer. These experts are in charge of the traditional medical practice, make cleanings, prescribe specialized remedies, therapeutic massages (*sobas*), and steam house baths (*baño de temazcal*).

In Ixcatlán, we recorded 219 species of medicinal plants (Table 1, Fig. 4). Among the plants recognized as basic for life the Ixcatec indicated the red oak species *Quercus acutifolia* and *Q. conspersa*, *Casimiroa edulis*, *Ageratina mairetiana* (DC.)

R.M.King and H.Rob, and *Clinopodium mexicanum* (Benth.) Govaerts. All these plants are used in temascal baths for recovering women after childbirth. Except for *C. edulis*, that is cultivated, all the medicinal plant species we recorded were wild and are gathered from forests when needed (Rangel-Landa et al. 2016a, 2017).

The inhabitants of Santa María Ixcatlán maintain some of the plants they consider basic in home gardens (65 species) and crop fields (79 species). The forms of management of medicinal plants can be cultivation, like in the cases of *Matricaria chamomilla* L., *Mentha* × *piperita* L., *Aloe vera* (L.) Burm., and *A. potatorum*. Also, tolerance, enhancing protection, or removal for controlling their abundance, as in the cases of *Marrubium vulgare* L., *Malva parviflora* L., and *Ricinus communis* A. Gray.

Other wild plants like *Grindelia inuloides* Willd., *Lippia oaxacana* B.L.Rob. and Greenm., *Tagetes lucida* Cav., *Turnera diffusa* Willd. ex Schult., *Artemisia ludoviciana* Nutt., and *Chrysactinia mexicana* A. Gray are gathered, dehydrated, and stored to use them when needed. Although some people have tried to cultivate the abovementioned medicinal plants in homegardens, gathering is the main practice to obtain them, and some plants like *T. lucida* are difficult to cultivate. In general, people consider that when these wild plants are cultivated could be less effective than plants gathered from the wild because they lose their scent when they are removed from the mountain ("*pierden su aroma al sacarse del monte*").

Ceremonial Plants

Very little is known about the religious beliefs and practices of the Ixcatec people before the arrival of the Spanish colonizers, but the available information underscores the interaction between plants and their ritual life. Velazquez de Lara (1579) mentioned that during one of the four main celebrations, called *Malinaltzi*, which was dedicated to fire, the most important offering was composed of plants. In this celebration a fire was lit with wood of several trees and incensed with copal. The main deities were two, *Ocelotl* and *Acatl* (meaning ocelot and reed in Nahuatl, respectively), whose representations were displayed in the temples to be seen by people who gave offerings consisting in flowers.

Santa María Ixcatlán is currently considered a Catholic community, but the use of offerings consisting of flowers and copal incense, and the lighting of ritual fires using tree trunks, continues to form part of local religious ceremonies and rites.

Currently, during the Day of Dead celebration, a ritual is carried out in which young men go to the forest surrounding the town to cut oak logs (*Quercus* spp.), drag them to town, carry them to the church through the main streets, and gather all the trunks together to light a big fire to warm the dead ("*calentar a los muertos*"; Fig. 5).

As in the sixteenth century, people who die are shod with ceremonial sandals elaborated with leaves of the palm *Brahea dulcis*, which are blessed during the Palm Sunday. Blessing of palms is associated with the catholic rite representing the entering of Jesus to Jerusalem, but also with the pre-Hispanic rite of putting shoes to the deceased persons for their walk away from life. In addition, the ritual is related

to a procession during the dry season asking God to continue making available the palm and other products obtained from the mountain.

Offering flowers has been an ongoing practice in all religious ceremonies and funerals in Santa María Ixcatlán, as a way to demonstrate devotion and thanking the saints whose images people place in their home altars and in the church. We recorded 128 plant species used in ceremonies and rites in Santa María Ixcatlán, 43 of them exotic and cultivated in home gardens (Table 1). Among the native species, Santa María Ixcatlán inhabitants also cultivate the orchids *Laelia albida* Bateman ex Lindl. and *L. anceps* Lindl. because of their beauty and to be offered in home and church altars during the celebration of the Day of the Dead (Rangel-Landa et al. 2016a, 2017). Another plant cultivated for the latter celebration is *Tagetes erecta* L. (*cempasuchil* or *tsjucájà*), which, together with copal, is essential (Fig. 5).

Maintaining home altars is a main motivation for cultivating many of the plants found in home gardens. The mayordomos make a commitment of continuously providing fresh flowers to maintain the ornamentation of church altars, a commitment they achieve involving a complex network of social relations and organization. Also, through the use of other local resources to generate the required income for having fresh flowers for the saints of the community.

Bursera spp. resin (*copal* or *ska* in Ixcatec) is highly appreciated as an offering for the saints and dead people, and to clean the environment and the body of negative feelings and culture-specific illnesses like *aires* or *sustos.* Management and care of the species of the genus *Bursera* from which this resin is obtained, mainly *Bursera biflora* (Rose) Standl. and *B. fagaroides* (Kunth) Engl., have the purpose to protect these plants and ensure the quality of the aroma and amount of resin they produce. The common practice in other copal producing regions is to make incisions in the trunk and branches of trees to promote resin exudation. But this practice is uncommon in Santa María Ixcatlán, since people consider it as bad because it damages the trees. Cultivation of copal trees is not practiced in Santa María Ixcatlán since people consider that the only good resin is that which is naturally produced by trees after being perforated by lepidopteran larvae (Rangel-Landa et al. 2017; Blancas et al. 2022). Other plants highly valued for their use in ceremonies and whose management involves carefully avoiding overharvesting are *Litsea glaucescens* and *Beaucarnea stricta* Lem., from which gatherers extract only some branches, and *Dasylirion serratifolium* (Karw. ex Schult. & Schult.f.) Zucc. and *P. grandis*, from whose populations the gatherers extract a few individual plants to obtain their leaves that are used for ornamenting the celebrations.

Ornamental and Luxury Plants

We identified 270 plant species considered by Ixcatlán inhabitants as plants that have the purpose of enhancing the homes' and home gardens' appearance and feeling of comfort. These plants give satisfaction and pride to household members, and their role is described by people as "for adding luxury" (*para dar lujo*). Some of these plants are in the forest and beautify the sites where they grow, while some grow in

the village and people appreciate them because of their beauty (Rangel-Landa et al. 2016a, 2017).

Of these plant species, 190 are considered as house luxury plants (*lujo de las casas*), 99 of them are native, like *Agave potatorum* and *Plumeria rubra* L, and some of them are cultivated since a long time ago, like the orchids *Laelia albida* and *L. anceps* (Fig. 5). Other 139 plant species are perceived to adorn the landscape. People of Santa María Ixcatlán describe them as elements of "forest luxury" (*lujo de monte*), as are animals such as deer, or sites like springs. These plants include dominant forest trees, plants with beautiful flowers, species of grass and herbs covering the ground, and some like *Quercus* spp. and *Tillandsia* spp. are occasionally transplanted to home gardens.

The concept of luxury varies among households' members, but those people having more ornamental plants in their homegardens are recognized as a motive of pride. The Ixcatlán inhabitants' love for plants and their beauty is linked with their ceremonial life, so it is not surprising that they use 58 plant species considered to be beautiful both for adorning their houses and to be offered to the saints.

The Feeding and Care of Domestic Animals

The inhabitants of Santa María Ixcatlán refer to livestock as animals (*animales*) and they recognize and name to use over 260 plant species for feeding them. Nearly 25% of the community households raise cattle, goats, and sheep, and 85% own backyard livestock including donkeys, mules, horses, poultry, and pigs (Table 1).

Cattle mostly obtain their feed from herbs and the young branches, pods, and acorns of wild plant species in zones dominated by oak forest and the transition of this vegetation type with tropical dry forest. Sheep and goats are herded by shepherds in areas close to the town, especially in scrubland dominated by *B. dulcis*, thorn scrub, and oak forests. Shepherds sometimes drive large goat herds away from the settlement for several days or weeks. Donkeys, mules, and horses consume a broad spectrum of plants, but their main sources of fodder are maize and the leaves and stalks from maize, wheat, beans, oat, and barley crops, which is supplemented by herbs managed in backyards, crop fields, and homegardens. This fodder stock is only enough for 6 months of the year. People's need of ensuring fodder for their animals helps to understand why it is important to maintain a high diversity of herbs, shrubs, and trees in agroforestry systems, and why maize is cultivated even though the need for human food is not met (Moreno-Calles et al. 2012, 2013; Vallejo et al. 2014).

In the homegardens and crop fields of Ixcatlán, we recorded 114 plant species used as fodder, nearly 20 of which are agrestal plant species that the cultivators remove from inside the crop field but allow their growth in its edges. Some plant species recognized for its good quality as fodder are tolerated, such as *Tithonia* spp., *Viguiera* spp., *Bidens* spp., *Perymenium* spp., *Mirabilis jalapa*, *Malva parvifolia*, *A. hybridus*, and *A. salmina* subsp. *tehuacanensis*.

Livestock owners in Ixcatlán consider some wild species as good sources of fodder; these are for instance the cases of the epiphytes *Tillandsia gymnobotrya*

Baker, *T. recurvata* (L.) L., and *T. usneoides* (L.) L., and *Hechtia oaxacana* Burt-Utley, Utley and García-Mend., and *P. grandis* (Fig. 5). During fodder shortage periods, when leaves and stalks of crops are scarce (from March to June), backyard livestock owners gather the abovementioned plants and acorns from the forests, which is the only economically viable source of fodder for 25% of the households. The need for forest fodder plant species contributes to explain why Ixcatlán inhabitants assign high value to oaks, epiphytes, and the forests where they grow.

Livestock owners in Ixcatlán value six plants used for the healthcare of their animals (Rangel-Landa et al. 2016a). The most frequently cause for applying treatment to livestock (and dogs) is snake bite.

Firewood

People of Santa María Ixcatlán use 48 plant species as fuelwood. Although gas stoves are increasingly being used for cooking, their use is limited because gas is difficult to in this remote rural area and expensive. Therefore, most households in Santa María Ixcatlán use firewood for making tortillas and cooking their meals. The most appreciated firewood is produced by the 11 species of oak growing in the community because it burns for a longer time and produces less smoke. The stems and branches of shrubs (called *varejón* in Spanish) are used for igniting the fire. We identified a decrease in the consumption of firewood for cooking from 143.4 $\pm$ 11.3 in 2000 to 18.8 $\pm$ 12 kg per week in 2012, which people attribute to the recent use of firewood-saving stoves.

The communal statute of Santa María Ixcatlán allows community members to extract firewood for cooking and other productive activities, and to trade it within the community. Commercialization of firewood outside the community or at regional level is prohibited. The statute contains the practices that community members must follow for firewood extraction, which include only cutting dead trees or branches. When green firewood or firewood from live trees are required, only cutting the branches is allowed (C. Santa María Ixcatlán 2009). Despite the sale of firewood outside the community remains under control, the number of community members having access to chainsaws and trucks has recently increased. These tools make harvesting easier, and allow their users attending the growing demand for oak firewood for the production of mescal, which increased from 16.2 t in 2000 to 63.36 t per year in 2012. Although not recently evaluated, it is possible to say that the current increase of mescal production has determined an even more drastic increase of firewood extraction.

Some Ixcatlán community members involved in mescal production are experimenting with cutting techniques allowing regeneration of oak trees after harvesting firewood with chainsaws and promote the follow-up of practices to ensure tree survival and regeneration (Fig. 6). However, some mescal producers and other community members do not follow the firewood extraction practices prescribed in the community's statute, and the assembly has not developed yet appropriate control mechanisms (Rangel-Landa et al. 2016a).

Fig. 6 Innovation for facing the challenges involved in the palm and maguey trades in Santa María Ixcatlán. (**a**) *Agave potatorum* stand generated by transplanting some individuals and seed spreading; (**b**) production of *Agave potatorum* seedlings in backyards by mescal producers; (**c**) green firewood cutting technique that favors the regeneration of branches; and (**d**) palm handicrafts with contemporary design made by members of *Xula Palma Artesanal*. (Photos: Selene Rangel-Landa)

Housing

In the last 30 years, the houses in Ixcatlán have changed substantially, which contrasts with the few changes in house construction observed in studies made between the mid-twentieth century and the early twentyfirst century (Cook 1958; Hironymous 2007). At present, the houses in the community range between those preserving all the architectural elements and materials of traditional housing and recently built houses following modern architectural styles. The latter include brick walls, concrete roofs, the kitchen, rooms, and bathroom constructed within the same building. Most houses combine both extremes of techniques, in which the household members aim at preserving the functionality of traditional houses but incorporating the resistance and convenience of modern materials and construction practices.

In traditional houses, the kitchen, rooms, latrine, storerooms, granaries, corrals, and other facilities are in separate buildings (Fig. 5). Most houses preserve the traditional kitchen built with a wood structure (*Quercus* sp. and *Juniperus flaccida*), palm (*Brahea calcarea* Liebm. or *B. dulcis*) or clay tile roof, walls made of trunks (*B. dulcis*) or scapes (*Agave scaposa* Gentry or *A. salmiana* subsp. *tehuacanensis*), and earthen floor (Fig. 5). In some houses built using modern architecture and materials, the traditional kitchens are maintained because they provide better ventilation for cooking with firewood, or to cook large amounts of food.

In traditional houses, rooms are in a building separated from the kitchen, usually in numbers going from one to three. One of the rooms has a space for the home altar where saints are venerated. These rooms are used to store valuable goods such as seed to be sown in the next agricultural cycle and is where guests are received and entertained. In most houses, room buildings have tin or clay tile roofs and walls are built with limestone blocks extracted within the community's territory. A decreasing number of houses maintain room buildings built using trunks and *Agave* scapes, and in many of these households their members wish they could rebuild them with long-lasting materials. The other buildings of traditional houses, all within the household's premises (*solar*), are the latrine, a dugout cave or cellar for storing harvested palm leaves and for weaving them, a granary (*troja)* for maize, a small storeroom, and corrals for livestock. There is a trend in Santa María Ixcatlán to build the latrines closer to the rooms.

Wood from tree trunks and branches, flowering stalks (scapes), and fiber from 29 plant species provide materials to the inhabitants of Santa María Ixcatlán for constructing the abovementioned house buildings and spaces, and for making doors (Rangel-Landa et al. 2016a). Live fences on the limits of household's premises include 30 species of trees and shrubs, including *Lophocereus marginatus*, *Condalia mexicana* Schltdl., *Opuntia* spp., and *Agave* spp. (Rangel-Landa et al. 2016a). A zone close to the kitchen serves as a space to do laundry, wash dishes, and grow plants to take advantage of gray water produced in domestic activities. In the open-air spaces used by household members for domestic activities and livestock management, we recorded 20 tree and shrub species that provide shade, which improves the environment and allows growing shade plants. *Celtis caudata* Planch. and *Morus celtidifolia* Kunth. are the most common trees in household premises in Santa María Ixcatlán.

The open places in the household premises are versatile, during celebrations serving as gathering areas, and during favorable rainy seasons as crop fields. In the mid-twentieth century, Cook (1958) observed that nearly half of the households in Ixcatlán sowed maize in homegardens (Fig. 3). At present, we recorded that milpa (the multicrop system of maize, bean, and squash) is present in the homegardens of nearly 25% of the households in the community. Mostly in households whose members are elders or women who are unable of cultivating a field outside of the town because of the time, labor, or physical effort that this practice would require.

Utensils and Other Uses

We recorded 34 plant species used as domestic utensils or tools (Rangel-Landa et al. 2016a). Oak (*Quercus* spp.) wood is appreciated by Ixcatlán inhabitants for its hardness and durability, in particular for making agricultural tools and the mallets used in mescal production (Fig. 4). The leaves of *Malacomeles denticulata* (Kunth) Decne. *Forestiera rotundifolia* (Brandegee) Standl., locally called *tlasisle*, are used for lining steam-cooked foodstuffs like tamales to avoid water coming into contact with them.

Some plants have infrequent uses associated with specialized activities like the treatment of bovine, ovine, and caprine skins, and for repelling insects and poisoning wild animals that are harmful to livestock (Table 1). For example, *Aralia humilis* Cav. is appreciated by honey gatherers for producing a smoke that tranquilizes and repels bees.

Among the useful plants we recorded in Ixcatlán, 14 species have uses (ludic, cosmetic, soap, dyes, or glue) that are becoming less frequent or have been abandoned. Mostly because currently people have access to products to replace them. For example, the resin of *Bursera* spp. was used as a glue for repairing pots, the fruits of *Comarostaphylis polifolia* (Kunth) Zucc. ex Klotzsch was used for dyeing, and *Lysimachia arvensis* (L.) U.Manns and Anderb. and *Cucurbita pedatifolia* L.H. Bailey were used for personal care and as soap for washing clothes.

The Palm: From Mats, Baskets, and Hats to Artisanal Contemporaneous Designs

Of the 10 plant species used for manufacturing objects that the Ixcatec consider as handicrafts, palms *B. dulcis, B. calcarea*, and its hybrid *B. dulcis* x *B. calcarea* (*palma* or *tjen*;) are the most important (Table 1; Rangel-Landa et al. 2014). In the region, there is archaeological evidence of human use of *B. dulcis* dating to 11,959 years ago (Smith 1967). During the sixteenth century, weaving of palm mats (*petates*) and palm baskets (*tenates*) were among the main economic activities in Ixcatlán, and palm mats were paid as tribute and exchanged for gold, which was also a part of the tribute paid by the community (Velazquez de Lara 1579). No record exists about the time when hat weaving started in Ixcatlán, but based on eighteenth century documents, Cook (1958) estimated the activity to have been practiced since approximately 250 years ago.

Hat weaving is an essential activity within the survival strategy of the households in Santa María Ixcatlán. Although the income obtained per woven hat is low (US$ 0.17 in 2000, US$0.23 in 2012, and US$0.20 in 2022), the activity has represented a reliable and constant income for households in Santa María Ixcatlán. Except for during extraordinary eventualities like the COVID-19 pandemic, this activity allows bartering palm products for maize and other groceries in local stores for satisfying the daily needs or sell them for money (Cook 1958; Rangel-Landa et al. 2014).

Compared with palm hats, palm basket weaving provides very little income to the community of Ixcatlán but is culturally important for its presence in everyday life as a container of tortillas, bread, bean, maize, and other things. Decorated palm baskets, called flower palm baskets (*tenates de flor*), express a colorful representation of the local nature and costumes of Ixcatlán (Fig. 5). These are made by a few palm weavers recognized by the community as artisans because of their skill and ingenuity to create elaborate designs going beyond simple hat weaving. The *tenates de flor* are culturally important; there is a tradition of weaving and using them for the first time to carry the candles shared by the inhabitants of Ixcatlán during their visits to cemeteries in the Day of the Dead (Fig. 5).

Also considered as handicrafts, some palm weavers create purses, small boxes, covers for mescal bottles, and animal figures traditionally used in the community of Ixcatlán as toys or pendants. Palm baskets and the abovementioned handicrafts are normally sold among community members, relatives, and visitors. These products have a higher economic value than hats, and provide a higher profit for the weavers relative to hat weaving because they use less palm, and obtain a higher profit with less invested time. However, when comparing the price of these handicrafts in markets outside Ixcatlán, the local prices continue to be low and do not compensate for the work invested in their manufacture, nor the impact of the extraction of the raw material.

The palm hat weavers in Ixcatlán are not worried about having enough supply of palm leaves because they have a reserve of over 100 ha where they obtain the raw matter. However, they are concerned about events of palm leaf scarcity with repeated years of drought, as they remember it happened in the 1960s. Instead, artisans require longer and stronger fibers than those used by palm hat weavers, the latter being scarce in *palmonares* near the town. Palm weavers in Santa María Ixcatlán attributed the scarcity of long palm leaves near the town to the continued harvest by the community members, because of which artisans solve the problem by going to farther away areas where the rate of leaf extraction is lower.

The main concerns of palm hat weavers in Ixcatlán are focused on their low income and the possibility of palm hat wholesalers losing their interest in acquiring their production. During the COVID-19 pandemic, the large hat stores in Tehuacán, Puebla, stopped buying the palm hats woven in the region, because the distribution centers where palm hats are processed – boiled, molded, and adorned – and sold are located in tourism facilities that were closed.

Since 2014, community's palm hat weavers in association with the nonprofit Weaving Alliances Civil Association (*Tejiendo Alianzas A.C.*) began a project to organize, innovate, and promote the local palm weaving trade, which gave rise to the *Xula Palma Artesanal* collective. The *Xula* collective is currently integrated by five families of palm weavers and traders of palm handicrafts with contemporary design who have found an opportunity to be recognized as artisans, both within and beyond the community (Fig. 6). This fact provides them a higher and more reliable income from their work, in comparison with palm hat weaving and other palm handicrafts (Hanson 2022).

The abundance of *B. dulcis* leaves, on which palm weavers in Ixcatlán depend, is the product of landscape management. It goes from carefully harvesting the leaves during the full moon, avoiding damaging the apical meristem (*cogollo*), tolerating palms in the edges of houses or maize fields, and promoting and protecting the palms (Rangel-Landa et al. 2014). Wild palm stand management has a long history that led to the formation of a scrubland dominated by palms (Rzedowski 1978; Valiente-Banuet et al. 2009). This vegetation type is known by the Ixcatec as *palmonar*, which covers the landscapes surrounding the town of Santa María Ixcatlán, and the areas of abandoned settlements like San Juan Viejo, where palm leaves harvest continues albeit at a low intensity (Figs. 2 and 3). *Palmonares* are landscape units in which people's management involves the interaction of the harvest of palms and other 104 species and where agricultural fields and small livestock herding are also included (see chapter ▶ "Agroforestry Complexes in the Mountain Regions of Mexico"). The management of palm-dominated scrubland allows the continuity between anthropic landscapes and forests and maintains several essential ecosystem services and benefits for the landscape managers. However, it also causes a loss of biodiversity and processes like soil erosion which limit agricultural productivity (Cook 1958; Rangel-Landa et al. 2014; Vallejo et al. 2014; Moreno-Calles et al. chapter ▶ "Agroforestry Complexes in the Mountain Regions of Mexico" Fig. 3).

Maguey as Sources of Sacred and Spirituous Drinks

Agave species have been sources of food and fiber for the inhabitants of the Tehuacán-Cuicatlán Valley region since at least 12,000–14,000 years ago (MacNeish 1967). In the sixteenth century, the aguamiel producing magueys were abundant, providing a drink rich in sugar, minerals, and probiotics during drought periods, and a commodity sold or bartered to pay tribute (Velazquez de Lara 1579). Currently, we identified 11 species of the genus *Agave* (*maguey* or *tsu*), of which *A. americana* L. provides aguamiel. Some inhabitants of Ixcatlán remembered that, over 50 years ago, aguamiel was also extracted from *A. applanata* K.Koch and *A. salmiana* subsp. *tehuacanensis*, and that the cultivation of *A. americana* had been decreasing in the past two decades. *A. americana* was recorded in ten of the 21 homegardens sampled in this study; in eight of them the owners hoped to obtain pulque and only in 1 we recorded more than one variety of *A. americana* and individuals of different size. Despite the current scarcity of *A. americana* in Santa María Ixcatlán, its inhabitants prepare a traditional drink called *tepache* during the festivities in December. This beverage is prepared with unrefined sugar (*panela*), and pulque acquired from neighboring communities. The decrease in pulque consumption by Santa María Ixcatlán inhabitants might be due to the present availability of drinking water and beer, the consumption of which they associate with a higher economic and social status relative to drinking pulque. The availability of beer in Santa María Ixcatlán could have started in the 1980s, when local store owners acquired their first motor vehicles, and it intensified with the inauguration of the Cuacnopalán-Oaxaca

highway in 1994, as it happened in other regions of the country (Ramírez-Rodríguez 2018).

Another agave-derived drink with biocultural importance for the Ixcatec people is mescal (*ndamasalíyè*), and according to the collective memory of Ixcatlán, its production dates back to at least generations. In the mid-twentieth century, Cook (1958) described that the inhabitants of Santa María Ixcatlán elaborated and consumed mescal in ceremonies. In Santa María Ixcatlán, mescal has been produced following a tradition of materials and practices – which gives it a distinguishing quality. It is mostly prepared with *A. potatorum* but occasionally also supplemented with wild individuals of *A. angustifolia* Haw. (Rangel-Landa et al. 2016b; Alvarado-Álvarez and Toolan n.d.). The growth of the international trade of agave distilled beverages in recent years has boosted the economic role of mescal elaboration in Santa María Ixcatlán, its value incrementing by nearly tenfold in the past 20 years (US$ 2.5 in 2000, US$ 6 in 2011, US$ 9 in 2015, and US$ 22.5 in 2022; Rangel-Landa et al. 2016a). Most of the local mescal production is retailed among households and visitors within Ixcatlán and sold to local and neighboring towns' stores. However, since 2015, most of the mescal produced in Ixcatlán has been traded in regional and national markets. Since 2018, a Santa María Ixcatlán mescal producer gained access to the international markets through registration of the *Ixcateco* trade name. This was achieved in collaboration with wholesale distributors of artisanal spirits that promote the environmental responsibility of producers and consumers, shortening the distribution chains, and increasing the income of producers. The producers currently export their product to the USA, the UK, and France (Alvarado-Álvarez and Toolan n.d.).

The increase in price of mescal has led to a larger demand of the inputs needed for its production in Santa María Ixcatlán, in particular of firewood as mentioned above, and of maguey stems. For 2011, we estimated that the whole community produced 192 mescal batches using 91.14 ± 9.78 agaves per batch, which means a total of nearly 17,500 agave plants per year, while for the year 2000 we estimated the use of 4900 individuals, that is, nearly a fourfold increment in 9 years (Rangel-Landa et al. 2016a). By 2000, mescal producers in Santa María Ixcatlán and the community assembly expressed their concern about the scarcity of the agave plants necessary for their trade, and made the first attempts to find ways of management that improved the availability of the input, but without encouraging results. It was until 2012 when several mescal producers in Ixcatlán began to exchange experiences with other communities that propagated the agave plants in nurseries. As a consequence, they began propagating the plants in their homegardens and also increased their participation in institutional programs aimed at the management of agave plants (Fig. 6). However, unlike the *Xula* collective, the organization of mescal production in Ixcatlán is still incipient because facing the challenges implied in ordering the activity requires the participation of the whole community. Compared to palm weaving, the artisanal spirit trade is subjected to stronger constraints from market interests and foreign institution regulations (Álvarez and Laird 2021). The lack of appropriate legislation and institutions directed to real protection of products such as the Ixcatec mescal allowed that in 2019 wholesale distributors usurped the name of

the community to give value to their products in the American market. These events violate the rights of the Ixcatec people but have gone unpunished and the marketers covered up by the institutions that regulate the commercialization of mezcal. The conflict has enhanced a process of organization of several producers who, in addition to taking advantage of the collective brand, began to take an interest in the collective management of the agave (MILPA 2020).

For the members of *Xula* and *Ixateco*, the change in the way they relate to their buyers, the organization, the care of the base resources of their productive activity, and the strengthening of customs and cultural aspects that give identity to their products have been key to have better pay. This indicates the importance of documenting, understanding, and encouraging these processes in ethnobotanical studies, so that the work of ethnobotany may contribute support actions looking for the well-being of communities.

Conclusion

The long history of interaction of the Ixcatec people with their environment has conformed a deep biocultural heritage. Nearly 80% of the plant species reported to occur in the area have one or more uses, while 51% of them is managed in one or more ways to take care of them or to maintain or increase their availability and/or quality. Such management has made possible the continuity of the domestication of species that are crucial for the local subsistence, among them the staple crops maize, beans, and squash, as well as *Physalis philadelphica, Dysphania ambrosioides, Cosmos bipinnatus, and Tagetes erecta.*, among other species. In addition, it has favored a complex matrix of landscape units including agroforestry systems like homegardens (*solares*), crop land immersed in palmar vegetation (*Milpa-palmonar* of *Brahea dulcis*), sites where mescal is prepared (*palenque*), and sites of abandoned settlements, which coexist with the diverse forest types described above (Casas and Parra 2016; Rangel-Landa et al. 2016a; Fig. 3).

The Ixcatec ethnobotanical knowledge is possibly the most deeply documented in the Tehuacán-Cuicatlán region (Lira et al. 2009; Blancas et al. 2010, 2013; Casas et al. 2017). This is because all households carry out primary productive activities. However, we identified a process of loss of local knowledge associated to the substitution of local products for others, the loss of knowledge codified in the Ixcatec language, and the high rate of migration, especially the young people.

Improving the conditions of interchange though organizational processes, as well as the innovation of productive practices to generate profitable products is probably a viable way to enhance people to remain linked to the community. Initiatives like those of *Xula Palma Artesanal* collective and the *Ixcateco* collective brand have provided new opportunities to improve the lives of some households, and have demonstrated to be effective to maintain appropriate ways to manage plants and vegetation and to value the Ixcatec culture. These organizational experiences have promoted the propagation of *A. potatorum*, in home gardens, reforestation of areas of communal land, and good practices of gathering palm and agave, and initiated

actions for the vindication of culture and contributing to revitalize the Ixcatec language (Swanton 2022). In both cases mentioned, the maintenance of sustainable productive practices and fair commercialization are great challenges. In all these processes the Ixcatec community has gained the collaboration of external institutions, including civil organizations and scholars, which have contributed to support the local efforts to improve life and maintain the valuable biocultural heritage of the Ixcatec people.

For the members of *Xula* and *Ixateco*, the change in the way they relate to their buyers, the organization, the care of the base resources of their productive activity, and the strengthening of customs and cultural aspects that give identity to their products have been key to get better pay. This indicates the importance of documenting, as well as understanding these processes in ethnobotanical studies, so that the work of ethnobotany may contribute to support programs and actions directed to the well-being of communities.

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Appendix 1

Basic diet of the Ixcatec people: past and present. Data obtained from surveys conducted in 2000 and 2012 and bibliographical review. * Local availability × Coming from outside the community.

Species or food	Main preparations	Temporality				Consumption
		Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	
Zea mays L.	Tortillas	*	* ×	* ×	* ×	2000: 100% daily, 14.7 ± 8.3 kg/week 2012: 100% daily, 13.5 ± 6.3 kg/week In sixteenth century, maize is mentioned as part of the main foods (Velazquez de Lara 1579)

(continued)

Species or food	Main preparations	Temporality				Consumption
		Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	
Phaseolus vulgaris L.	Soup	*	* ×	* ×	* ×	2000: 100% daily, 3 ± 1.7 kg/week 2012: 100% daily, 2.2 ± 1.9 kg/week In sixteenth century, beans are mentioned as part of the main foods (Velazquez de Lara 1579)
Capsicum annuum L.	Fresh or dry chili sauces	* ×	* ×	* ×	* ×	2000: 100% daily, green 1.8 ± 1.4 kg/month and dry 0.63 ± 0.51 kg/month 2012: 90% daily, 10% 1–4/week, green 1.6 ± 1.3 kg/month and dry 0.44 ± 0.38 kg/month
Dysphania ambrosioides (L.) Mosyakin and Clemants	Bean soup condiment	* ×	* ×	* ×	* ×	2000, 2012: 100% daily
Zea mays L., *Triticum aestivum*, oats, and rice	Atoles	*	*	*	*	2000: ND 2012: 100% 1–7 (3.3 ± 2.2) times/week
Egg	Diverse preparations	* ×	* ×	* ×	* ×	2000: 15% daily, 70% 3–5 times/week, 10% 1–2 times/week, 5% 1 time/month 2012: 15% daily, 30% 3–5 times/week, 50% 1–2 times/week, 5% 1 time/month
Rice	Dry soup with tomato sauce	*	*	*	*	2000: 100% 1–3 (1.8 ± 0.9) times/week, 1 ± 0.5 kg/week 2012: 100% 1–4 (2.1 ± 1.0) times/week
Pasta	Pasta soup	*	*	*	*	2000: 100% 1–5 times (2.2 ± 1.1)/week 2012: 95% 1–4 times (2.1 ± 1.1)/week, 5% without consumption
Bread		* ×	* ×	* ×	* ×	2000: 100% 1–7 (4.6 ± 2.4) times/week 2012: 100% 1–7 (4.8 ± 2.5) times/week

(continued)

Species or food	Main preparations	Temporality				Consumption
		Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	
Coffee		*	*	*	*	2000: 95% 1–7 (5.3 ± 2.5) times/week, 5% without consumption 2012: 90% 1–7 (3.4 ± 2.6) times/week, 10% without consumption
Milk		*	*	*	*	2000: 30% 0.25–3 (1 ± 1.2) times/week, 70% without consumption 2012: 90% 0.25–7 (2.8 ± 3.3) times/week, 10% without consumption
Poultry	Soup, mole, and stews	*	*	*	*	2000: 5% 3 times/week, 20% 2 times/week, 40% 1 time/week, 35% 1–2 times/month 2012: 10% 3 times/week, 20% 2 times/week, 25% 1 time/week, 45% 1–2 times/month
Beef, goat, turkey, pork	Baked in earth oven, carnitas (fried), mole, and stews	*	*	*	*	2000: 55% consume them as part of the common diet (1–4 times to month) and celebrations, 45% only consume them at celebrations 2012: 30% consume them as part of the common diet (1–8 times to month) and celebrations, 70% only consume them at celebrations
Soft drink		*	*	*	*	2012: 20% daily, 40% 2–5 times/week, 25% once a week or a month, 15% no usual consumption
Opuntia lasiacantha Pfeiff., *Opuntia tomentosa* Salm-Dyck, *Opuntia ficus-indica* (L.) Mill.	With bean soup, stews	×	* ×	* ×	×	2000: 10% daily, 60% 3–4 times/week, 30% 1–2 times/week 2012: 30% daily, 20% 3 times/week, 45% 1–2 times/week, 5% without consumption

(continued)

Species or food	Main preparations	Temporality				Consumption
		Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	
Leucaena esculenta (Moc. and Sessé ex DC.) Benth., *Leucaena leucocephala* (Lam.) de Wit		×	×	*	×	2000, 2012: 100% consume them, in the L. esculenta season (Aug–Oct) at least 1 time/week
Amaranthus hybridus L.	Boiled and flavored with *Porophyllum linaria*, with sauce and fried			*		2000: 20% 3–5 times/week, 10% 2 times/week, 70% 1 time/week 2012: 15% 3–5 times/week, 35% 2 times/week, 50% 1 time/week
Porophyllum ruderale (Jacq.) Cass.	Fresh		* ×	*		2000: 10% 3–7 times/week, 45% 1–2 times/week, 10% 1–2 times/month, 20% 1–2 times/year, 15% without consumption 2012: 30% 3–7 times/week, 20% 1–2 times/week, 10% 1–2 times/month, 30% 1–2 times/year, 10% without consumption
Roots	Unknown	*			*	In the sixteenth century, roots were mentioned as staple food (Velazquez de Lara 1579). But currently, the only tuber or root that is habitually consumed is the potato, which was cultivated until 30 years ago. Roots of wild plants are currently consumed and even known by few people (Rangel-Landa et al. 2016a)
Wild animals: *Odocoileus virginianus* Zimmermann, *Dicotyles tajacu* Herrera, *Sylvilagus* spp., *Lepus* spp., *Spermophilus variegatus* Erxleben, *Sciurus aureogaster* F. Cuvier, and Zenaida spp. (Zarazúa-Carbajal et al. 2020)	Roasted, mole	*	*	*	*	2012: 20% consumed bush meet. Consumption is occasional, from five to less times per year

(continued)

Species or food	Main preparations	Temporality				Consumption
		Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	
Larvae and honey: Hymenoptera spp., madrone worms *Eucheira socialis* Westwood, *Brachygastra* spp., *Apis mellifera* Linnaeus, meliponini spp., *Comadia redtenbacheri* Hammerschmidt, Lepidoptera spp. *Rhynchosphorus* sp., *Sphenarium* sp. and other unknown species *oak worms* (Zarazúa-Carbajal et al. 2020)	Roasted	*	*	*	*	2012: 45% hymenoptera larvae and/or honey, 10% *Sphenarium* sp., 5% Lepidoptera and other larvae. Consumption is occasional, from five to less times per year

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