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RESEARCH

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Diversity, management, and uses of edible plants in a Ñäñho community of Southern Querétaro, Mexico

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Abstract

Background Mexico is one of the countries with the highest cultural, biological, and agrobiological diversity. However, an accelerated process of ancestral knowledge loss, related to the management of agrobiodiversity, native seeds, and other edible plant species management is affecting food sovereignty. This process of knowledge loss was documented at the Ñäñho region, of southern Querétaro, where our study took place. Our objective was to document the diversity of edible plant diversity, management, and use as well as the agroecosystems from which they are obtained.

Methods Semi-structured interviews were conducted over 2 years (2021–2023) with 50 informants selected through a snowball sampling. Informal interviews and participant observations were also used with these and other people from the same community. Herbarium specimens and seed accessions were collected and photographed.

Results In total, 119 edible plant species were identified. The richest families were Solanaceae, Rosaceae, Cactaceae, and Asteraceae. The edible species occur in 11 agroecosystems with 58.6% of the species native to Mexico, and 41.4% introduced. The orchard, rustic greenhouse, house "milpa," mountain hill, and backyard, have the highest species diversity. The main management types were sowing and gathering plants. Eighty-five plant names were recorded in the Hñäñho language. The plant parts used were fruits (60.5%) and stems (46.2%). The gastronomic categories with the highest species percentage were stews, beverages, and refreshments, while the highest species number used in the gastronomic categories were cacti stalks or "nopales" (*Opuntia* spp.), maize (*Zea mays*), and amaranth (*Amaranthus* spp.).

Conclusions The records in Southern Querétaro of edible plants and agroecosystems diversity were high. The plants, local knowledge documentation, and species management provide the basis for promoting projects focused on the Ñäñho biocultural wealth. Efforts are needed to encourage the least represented regional species. Community development programs are needed for food security and sovereignty; these are based on the local biocultural resources.

Keywords Agrobiodiversity, Agroecosystems, Amealco, Food sovereignty, "Milpa", Otomí, San Miguel Tlaxcaltepec

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Background

Mexico is among the countries with the greatest cultural, biological, and agrobiological diversity [1], an essential part of the people biocultural heritage, who manage it through a variety of dietetic uses. An important number of edible species can be listed for several human groups. However, the importance of agrobiodiversity as the basis of gastronomic diversity is recognized when the consumption diversity and the preparation methods are taken in account. Agrobiodiversity generates cultural wealth and vice versa [2].

Many human societies share more or less homogeneous landscapes with similar agrobiodiversity. However, "they can manage to build very different gastronomies by applying religious, ideological, worldview aspects and intellectual filters to the food, with which they manage to effectively differentiate themselves from the others" [3]. Also, agrobiodiversity is threatened by various factors such as climate change, biodiversity loss and alteration (including domesticated species and varieties), ecosystems degradation, social and economic inequality, territorial conflicts, migration, and aging of the farmer population [4].

Regional agrobiodiversity is safeguarded in different environments and managed by the people, which allow different domestication degrees among the plant species used by the community. Among the indigenous agricultural systems (agroecosystems) of Mexico, at least three different spaces (cultural landscapes) of plant domestication and management are important: the managed natural vegetation, the *"*milpa*"* (traditional Mesoamerican polyculture of maize, beans, and squash, associated with other species), the agroforestry systems associated to milpas and home gardens [5, 6].

A wide range of management practices are applied to plant species. These include gathered or collection, toleration, promotion or enhancing (deliberate propagation of some plants), and protection, as well as the propagation of wild plants by transplanting whole individuals or dispersing sexual and/or vegetative propagules (sowing) [7].

More than 2,000 edible plant species have been registered in Mexico [8]. From these, 29 species, especially "quelites" (edible wild greens), have been listed as priority taxa for their conservation and sustainable use [9]. For the indigenous Otomí ("Ñäñho") indigenous territory, a recent study described the "quelites" species richness and its cultural importance in the community of San Pedro Arriba, Temoaya, in the State of Mexico [10]. The authors found 64 species recorded as "quelites."

For the state of Querétaro, a study on wild edible plants uses in La Barreta, municipality of Querétaro documented 47 edible species from 21 families [11]. They listed six gastronomic categories mentioned by the interviewees: snacks (16 species), fruits (15), "quelites" (11), desserts (8), sauces and condiments (7), and beverages (4).

In the municipality of Amealco, Querétaro, studies related to agricultural production have focused mainly on maize productivity and social cycles [12]. They were conducted at the Santiago Mexquititlan and San Ildefonso Tultepec regions, recognized as predominatly indigenous communities [13]. The study found that 53% of useful plants in both regions useful plants are edible, of which 43% of the Ñäñho plant species used as wild, 32% cultivated in the "milpa," gardens or yards, and 25% are allochthonous (purchased in markets).

Studies on native and naturalized seeds in Amealco have described formal and informal seed systems [14]. More than 90% of the farmers use native seeds in rainfed agriculture, using primarily three local maize races such as Chalqueño, Cónicos, and Elotes Cónicos, and secondarily six races, Celaya, Cacahuacintle, Palomero Toluqueño, Elotes Occidentales, and Ancho [15, 16].

In San Miguel Tlaxcaltepec (SMT), the study site of the present work, maize is the main Ñäñho dietary supplement and is produced in the "milpa" with ancestral native seed cultivars [17]. In the "ejido" collective lands property plots, the commercial white maize seed is planted using agrochemicals, fertilizers, and herbicides [18].

The ancestral agrobiodiversity management knowledge in Amealco is rapidly decreasing. This process has been also documented in other Mexican regions [6]. The process is strongly influenced by the Hñäñho indigenous language erosion and their dietary patterns changes [13]. However, Amealco is still a very important biocultural region, since 42% of the state's native people live there [19].

In Amealco, there is a significant loss of the traditional food, native seeds, and milpa agrobiodiversity components. This is due to changes in rainfall patterns and the use of agrochemicals [17]. However, several social, ecological, technological, economic, and cultural factors surely have certainly also had an impact.

The situation possesses a threat to the self-sufficiency, food security, and sovereignty in the community, as well as to the local nutritious food availability [20, 21]. It is therefore important to document the local knowledge about food resources and their role in nutrition. The objective of this study is to document the edible plants and the agroecosystems where they are obtained, their management type, the local names, the plant parts used, forms, and consumption categories in SMT, Amealco, Querétaro, Mexico.

Methods

Study area

The municipality of Amealco is located in southern Querétaro in the Trans-Mexican Volcanic Belt [22]. The area is characterized by mountain ranges interspersed with valleys. The elevation varies between 2000 and 3300 m. The agroecosystems include rainfed (46%) and irrigation agriculture (3.9%). The vegetation types are oak forest (9.8%), pine forest (4.6%), oak-pine forest (3.5%), chaparral (0.6%), subtropical scrub (0.2%), desert scrub (0.001%), induced grassland (11.29%), natural grassland (9.6%), unvegetated areas (3.9%), urban areas (5.8%), and wetlands (0.8%) [19]. Despite its cultural and biological diversity, Amealco is considered by CONEVAL (National Council for the Evaluation of Development) as one of the ten state municipalities where 25–50% of the population has difficulty obtaining food [23].

The SMT community is located in the southwestern part of Amealco (Fig. 1), bordering the states of Mexico and Michoacán. It is one of the six municipality demographic microregions, and half of its population suffers from some degree of poverty and is a highly marginalized microregion [24]. The SMT barrios are La Cruz, La Ladera, El Pueblito, El Lindero, Agua Buena, Ojo de Agua, El Barco, El Picacho, Los Árboles, and El Terrero. The SMT ejido, according to the Registro Agrario Nacional (National Agrarian Registry), covers 3225.32 hectares with 471 "ejidatarios," making it the largest ejido in the Amealco municipality [18].

Diversity of edible plants in agroecosystems

To compile the list of edible plants with their names and growing areas, we interviewed 25 men and 25 women. The interviewees age ranged from 23 to 97 years old, but most were over 60. They lived in the *barrios* of La Cruz, El Pueblito, El Picacho, El Potrero, El Barco, Barrio Centro, Chitejé de Garabato, El Varal, Cerro del Gallo, and Las Salvas (Fig. 3). Participants were selected using the snowball sampling technique [25]. We started with the members of the Organizing Committee of the Native Corn and "milpa" Fair. Semistructured interviews were carried out to identify the recorded plants local names, uses, and management. Nine Ñäñho language speakers collaborated in the interviews with help of a translator, Diego Ugalde de Haene, who is a native language professor in the community. These collaborators are recognized by the community for their knowledge of edible plants, and with their help, the plant recorded names were transcribed [13, 26].

Botanical specimens were collected in the natural vegetation and the agroecosystems mentioned by the interviewees [27]. The APG IV plant classification system was used, and the scientific names were verified in Tropicos (tropicos.org) [28] and Plants of the World (powo.

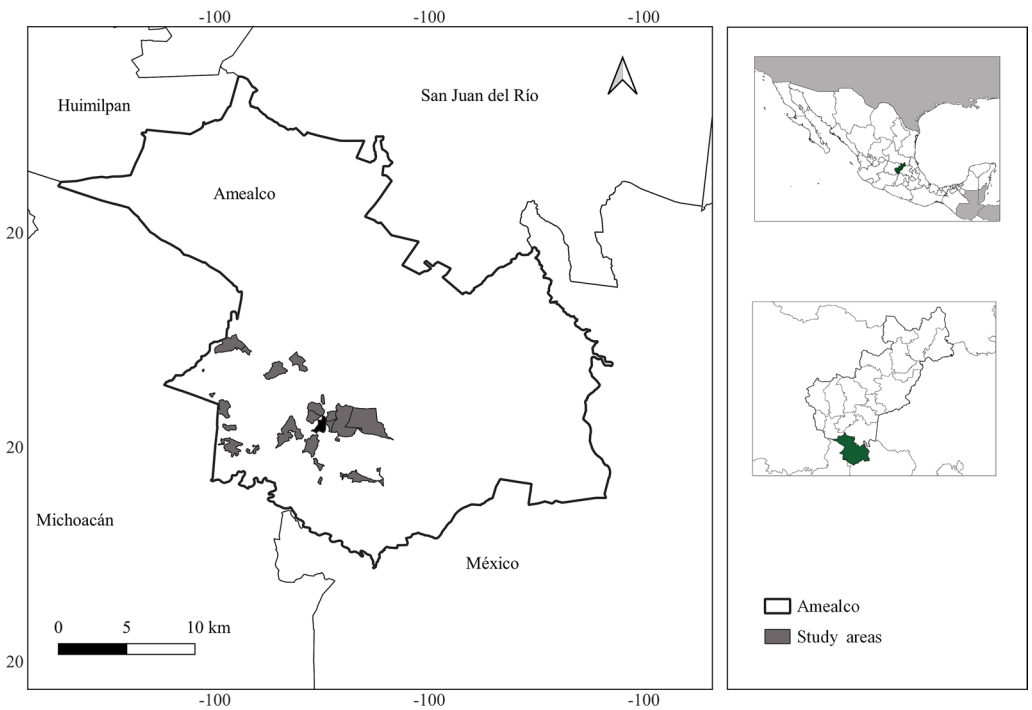

Fig. 1 Map of the indigenous communities in the municipality of Amealco, southern Querétaro, bordering to the states of México and Michoacán. In black the SMT community, surrounded by its "barrios."

science.kew.org) [29]. The specimens were deposited in the QMEX Herbarium of the Universidad Autónoma de Querétaro. In addition, cultivated species seeds such as maize, beans, squash, and some "quelites," were collected for the UAQ germplasm bank, following the methodology of Rao et al. [30].

Management and use of food plants

The semi-structured interviews conducted included questions about environmental modifications carried out by people in the area. Comprising practices are fertilization, moisture regulation, light incidence, temperature, competitors management, predators, pollinators, and dispersers management [5, 7]. To complement this information, participant observations were made in the community for two years. Most of the edible plant information was obtained through informal meetings and participant observations at the study area. For this, we create a database with all the information about the management details of uses, such as plants structures consumed and food processes. We analyze the data-making pivot tables in excel to obtain species and uses percentages.

Results

Edible plant diversity

We found a total of 820 edible plants records for 119 species belonging to 82 genera and 41 families from 11 agroecosystems in the community (Appendix). The most diverse genera are *Opuntia* (seven species), *Prunus* (five), and *Solanum* (five). The families more represented are Solanaceae (13 species, 11%), Rosaceae (11, 9.2%), Cactaceae (eight, 6.7%), and Asteraceae (seven, 5.9%) (Fig. 2). Nearly 60% of the species used in the community are native to Mexico, and ca. 40% were introduced but culturally assimilated since they arrived with the Spaniards from the sixteenth century, due to their gastronomic importance (Table 1). Unfortunately we found no records for the species introduction to the Ñäñho communities.

During the interviews and tours, 196 herbarium specimens and 188 seed accessions were collected and photographed.

Plant names in the Ñäñho language

From the 820 records, a list was compiled of 270 common names in Spanish and Hñäñho was compiled. Since most of the speakers were over 60 years old (Fig. 3), when asked for the specific names of the plants, many mentioned that they knew them many years ago, but because they do not have anyone to practice their language with, they have forgotten them. The corresponding names of some plants are provided in the Appendix.

Fig. 2 Edible plant species by family. In addition to those shown in the figure, 18 families had only one edible species (see the species list in the Appendix)

Table 1 Origin of the edible plants in the biocultural landscape of San Miguel Tlaxcaltepec, Amealco, Querétaro

Origin	Number of species	% of species
Introduced	44	41.4
Native	75	58.6
Total	119	100

Agroecosystems scenarios of the food plants origin

People obtain their edible plants from 11 agroecosystems: stream banks, mountain hills, orchards, rustic greenhouses, plains or pastures, springs or wells, home "milpa," ejidal "milpa," "nopaleras" (group of *Opuntia* spp. individuals), plots around the dam, and backyards or gardens (Fig. 4 and Table 2). Some species occur in more than one agroecosystem (Fig. 5). Most species are found in the orchard (14 spp.), the rustic greenhouse (13), the home "milpa" (12), and the mountain hill (11). This includes those that occurred only in each specific agroecosystem.

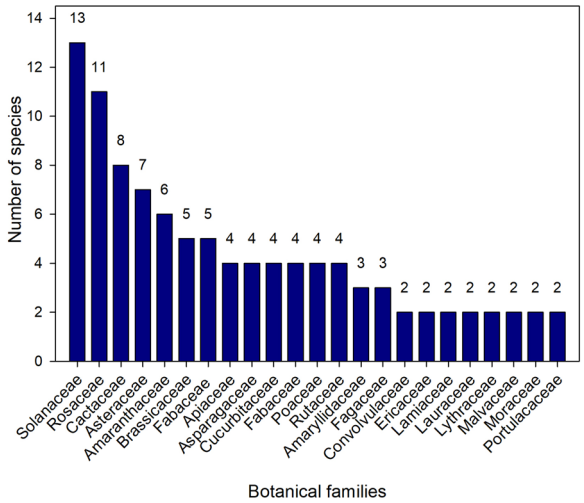

Fig. 3 Interviews with the people of San Miguel Tlaxcaltepec

Edible plant management

The management categories for the edible plant species are (a) gathered or collected, (b) tolerated, (c) promoted, (d) transplanted, and (e) sown or planted (Table 3). The gathered category had 31 species, but when we consider the species gathered also in another category, the number increases to 57 species (49% of the total). This is because some species are managed in more than one way. The agroecosystems with the highest number of gathered plants are the hill, the home "milpa," and the backyard (Fig. 6).

The management type "sown or planted" was the most common with 58 species (49% of the total). However, when another type of management is present in addition to seeding or planting, the number increases to 67 species, or 56% of the total. The greenhouse, the orchard, and the backyard are the biocultural landscapes where the highest number of edible plant species is sown or planted (Fig. 6).

The management types of analysis, based on the origin of the edible species, show that among the native species, 38.6% are exclusively gathered or collected. However, for those collected and managed in another way, the percentage increases to 67.2% (Table 3). The sown or planted species represent 81.3% of the introduced species, while the gathered species (6.3%), and other managed types have lower percentages (Table 3).

Consumed parts of the edible plants

Fruits are the most consumed plant part (72 spp., 60.5%), followed by stems, including modified stems such as the potato tubers (55, 46.2%), then flowers, (43 spp., 36.1%), and leaves (41 spp., 34.5%). Smaller percentages correspond to roots (six spp., 5%), stem sap (six spp., 5%), and flower nectar (two spp., 1.7%) (Fig. 7). The total percentage of consumed parts exceeds 100% because different parts of some species are used at the same time, e.g., in the "laurel" (*Litsea glaucescens* Kunth) and some "quelites," where the entire aerial part is used (leaves, stems, flowers, and seeds). "Quelites" are eaten before flowering for a better taste and texture. This is also true

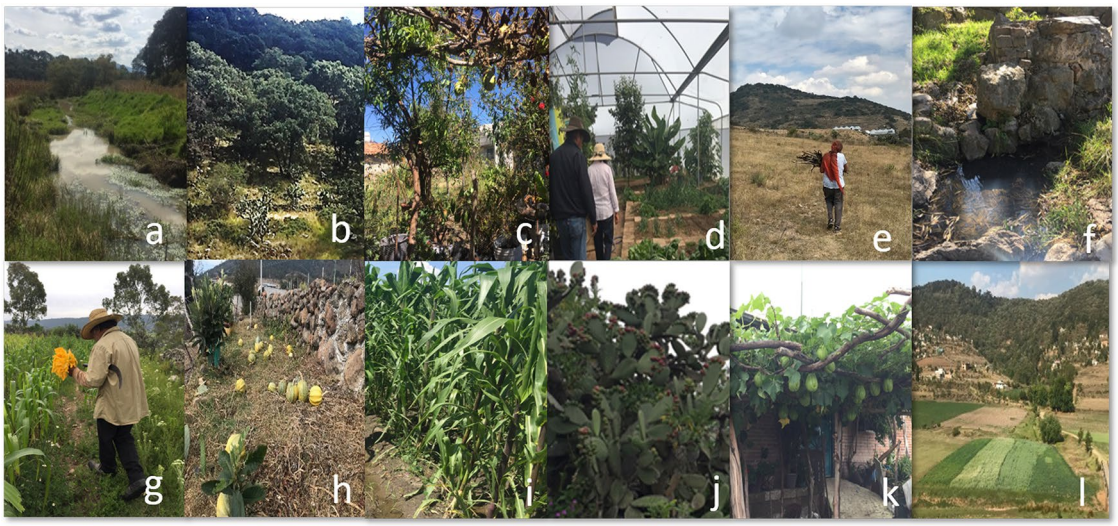

Fig. 4 Agroecosystems for the edible plant species in the community of San Miguel Tlaxcaltepec, Amealco, Queretaro. **a** Stream bank ("bancos de arroyo"), **b** mountain hill ("cerro"), **c** orchard ("huerto"), **d** rustic greenhouse ("invernadero rústico"), **e** plain/pasture ("llano"), **f** spring or well ("manantial/pozo"), **g** and **h** house "milpa" ("milpa de casa"), **i** ejido "milpa" ("milpa de ejido"), **j** group of prickly pear cactus, *Opuntia* spp. ("nopalera), **k** backyard ("traspatio"), and **l** plots around the dam ("parcelas de la presa")

Table 2 General characteristics of the 11 agroecosystems (alphabetical order) mentioned by the respondents

Agroecosystem	Description
Ejidal "milpa"	Monocultures of native and hybrid commercial corn. Small and medium scale, distant from home, use of agrochemicals such as herbicides in large quantities. Low diversity of herbaceous plants
Mountain hill	In areas with steep slopes, dominated by trees such as oaks (*Quercus* spp.), madrone (*Arbutus* sp.), and ash (*Fraxinus udhei*). It may have a well or spring
House "milpa"	A small-scale cultivation that forms a continuum with the backyard and orchard. It is an area dedicated to maize "criollo" (*Zea mays*), chilacayote (*Cucurbita ficifolia*), pumpkin (*Cucurbita* spp.), and beans (*Phaseolus* spp.). Chemicals are avoided, the only fertilizer used is urea, often combined with manure. Herbicides are avoided
"Nopalera"	Area dominated by *Opuntia* ("nopales") species. Found on rocks, between hillsides, or along roadsides, on steep slopes
Orchard	Cultivation area mainly for trees, near the house, sometimes as part of the backyard or as a separate area a little further from the house. "A place where many trees of few varieties are planted," for example, apple, pear, or peach fruit trees
Plain/pasture	Area without trees, usually flat or with little slope. Subject to periodic burning to encourage new grass growth. In the past, there were abundant occurrences of "talayotes" or "puerquitos" (*Matelea pedunculata*) and wild eggplant (*Lycianthes moziniana*), edible wild fruits. Wild burning areas have been observed as the reason for the disappearance of these species. In the plain, drought-tolerant "quelites" can be found, such as "quelite de sol" or "quelite de la mal casada" (*Tauschia nudicaulis*), which blooms in April before the rains
Plots around the dam	At the end of the dry season (March–May), when the reservoir water decreases due to the intermittent irrigation of the communal plots, "cleared" lands appear on the banks of the reservoir, and are used for Planted with the moisture remaining at its bottom. Foder crops such as oats (*Avena sativa*) and milpas are also planted
Rustic greenhouse	Cultivation space on the ground protected by a structure of metal profiles covered with plastic. It is uncommon but present for about the last 10 years. Owned by people with higher purchasing power who are originally from the area but who have lived in a city and returned. The greenhouses are managed agroecologically (for pests and fertilizers), but with a drip irrigation system. One is for family consumption, and the other for "nopales" production and vegetables for sale. Medicinal plants and "quelites" appear due to the humidity conditions and herbicides lack
Spring or well	Area with permanent humidity throughout the year. It can be natural or induced from a moisture vein from the mountain hill. "quelites" such as watercress (*Nasturtium officinale* and *Hydrocotyle* sp.) grow here, and found on the hillside or along a road
Stream bank	A medium-sized river fed by the Epigmenio González Reservoir and flows into the Tecolote reservoir, irrigating the ejidal lands of San Miguel Tlaxcaltepec through "punteo" irrigation. People cultivate plants at the stream banks

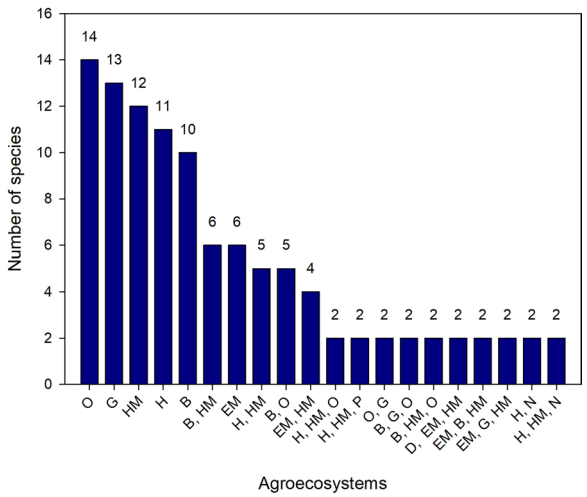

Fig. 5 Number of edible plant species identified by agroecosystem (B = Backyard, D = Dam plots, EM = Ejidal "milpa," G = Greenhouse, H = Mountain hill, HM = Home "milpa," N = "Nopaleras," O = Orchard, P = Plain). In addition to what is shown in the graph, there are two agroecosystems (stream bank and "nopaleras"), and 11 combinations of agroecosystems with only one species recorded

for the two nectar species, the "trompetilla" (*Bouvardia terniflora* (Cav.) Schltdl.) and the "espinosilla" (*Loeselia Mexicana* (Lam.) Brand), which grow as ruderals and are most commonly consumed during walks and fieldwork. In both species, a portion of the entire corolla is consumed when extracting the nectar. Another example is the "dalia" (*Dahlia coccinea* Cav.), and its tuber or "jicama" (root) is eaten, but petals were sometimes added to increase the volume of corn dough for "tortillas" or provide color.

Multiple part plans used on the same species were recorded. Then, 55 species (46.2%) of the species had only one part used, 30 (25.2%) provided two useful parts, 22 (18.5%) three parts, and 11 species (9.2%) four parts (Fig. 8).

Gastronomic categories and consumption forms

The consumption categories and forms mentioned by the informants, as well as the percentages based on the species numbers, are shown in Fig. 9. The highest percentages were stews, followed by beverages, snacks, and fruits. In addition, the gastronomic categories with the greatest diversity are "nopales" (*Opuntia* spp.), corn (*Zea mays* L.), and amaranth (*Amaranthus* spp.).

Table 3 Managed edible plant species in SMT, based on the classification of management types proposed by Casas et al. [5]

Types of management	Introduced species	Native species	Number of species	%
Sowing	39	19	58	48.7
Gathering	3	28	31	26.1
Gathering and tolerance	3	6	9	7.6
Gathering, tolerance, enhancing and transplanting	1	4	5	4.2
Gathering and transplanting	1	5	6	5
Gathering, tolerance and enhancing	1	1	2	1.7
Gathering, tolerance and sowing	0	2	2	1.7
Tolerance	0	2	2	1.7
Transplanting	0	2	2	1.7
Gathering, tolerance, enhancing, sowing and transplanting	0	1	1	0.8
Gathering and sowing	0	1	1	0.8
Total			119	100

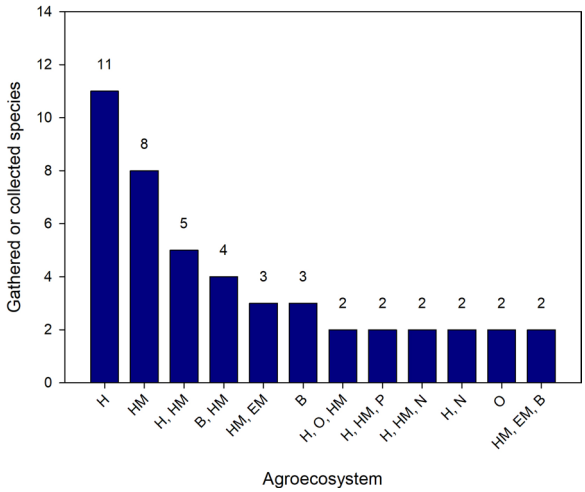

Fig. 6 Number of sowed or planted edible plant species managed by agroecosystem (B = Backyard, D = Dam plots, EM = Ejidal "milpa," G = Greenhouse, H = Mountain hill, HM = Home "milpa," N = "Nopaleras," O = Orchard). In addition to the graph, seven combinations of agroecosystems have just one species

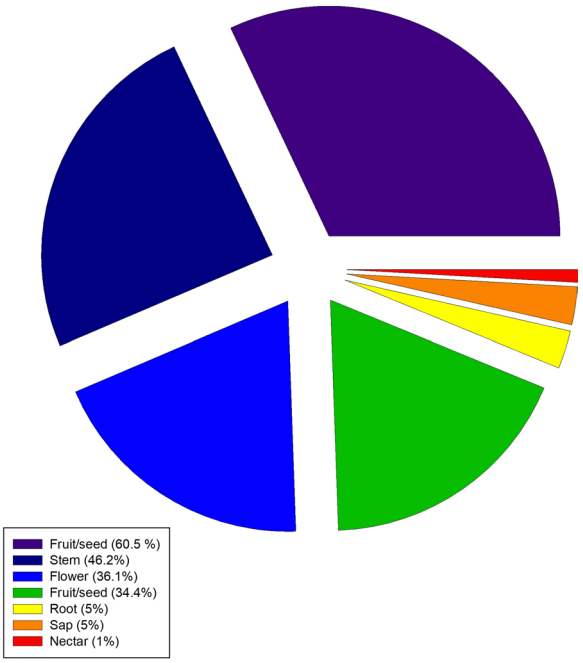

Fig. 7 Percentages of the consumed parts of the 119 edible plant species recorded in the community of SMT

Snacks

This category refers to plants generally eaten raw during daily walks or during fieldwork. It is important to note that this category includes the consumption of four parts of the plant in different species such as roots, flowers (petals), and nectar, as well as specialized structures such as some oaks galls or "panchihuas" (*Quercus* spp.) (Fig. 9).

The "mountain dalias" (*Dahlia coccinea)* tuberous roots are called "jícamas" and are eaten as soon as they have been dug up, and removing the outer skin, called "cascarita." The water they contain is sucked, and the pulp is squeezed out, similar to the way juice is extracted from maize stalks. The long narrow roots of the "jícama de puerco" (*Cologania angustifolia* Kunth) and the "jicamita" (*Macroptilium gibbosifolium* (Ortega) A. Delgado) are consumed the same way. The raw consumption of a species called "liendre" has been recorded. It has small underground bulbs that resemble tiny coconuts called "cocomites." We were not able to identify the plant, but because of the bulbs name, it is possibly a species of the genus *Tigridia*.

Other species in this category are two that are consumed for the flower nectar because they are "sweet"

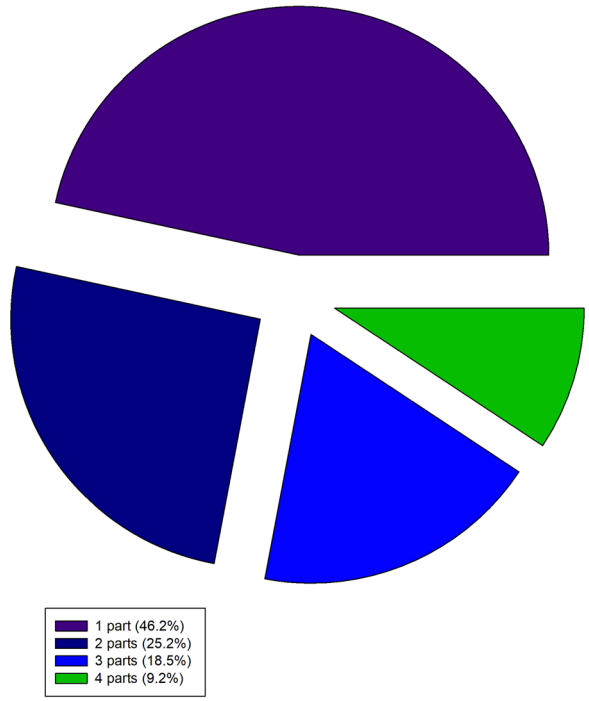

Fig. 8 Number (percentage) of the consumed plant structures

(*Bouvardia terniflora* and *Loeselia mexicana*). The "panchihuas" or "lulitos" (oak trees galls from the branches and leaves) are eaten raw but must be "green," or unripe to be edible. In this state, they have an apple-like flavor.

Although some tree species such as the "capulin" (*Prunus serotina* Ehrh.) and the "tejocote" (*Crataegus mexicana* DC.) are also eaten as snacks, they are included in the fruit category. The same applies to the "talayotes" or "puerquitos" (*Matelea pedulculata* (Decne.)), which grow in the plains. They can be eaten raw as a snack only if they are unripe. Otherwise, they need to be fried or roasted before consumption.

For prickly pears ("tunas") it is important to know how to pick them without getting pricked by the thorns. Some "tunas" are sweeter than others. Also, some produce more seeds, some have more water, and some taste sour, but all the "tunas" from any "nopal" are edible and appreciated. Seven species of the genus *Opuntia* were recorded, six of which have edible fruits consumed as snacks: *O. lasiacantha* Pfeiff., *O. robusta* H.L.Wendl. ex Pfeiff, *O. tomentosa* Salm-Dyck, *O. hyptiacantha* F.A.C. Weber, *O. streptacantha* Lem., and *O. joconostle* F.A.C. Weber ex Diguet (Fig. 9). The last species, known as "coconoxtle," is found in the hills where people collect firewood. The fruit is usually eaten with added salt.

Fig. 9 Some of the species consumed raw as a snack during working days in the fields or mountain hills. **a** Oak gall or "panchihuas" or "lulitos" (*Quercus* spp.), **b** colibrí flower or "espinocilla" (*Loeselia mexicana*), **c** prickly pears of "nopal bondó" (*Opuntia robusta*), **d** prickly pear of "nopal chamacuero" (*Opuntia tomentosa*), **e** white prickly pears (*Opuntia* sp.) and "tuna hartona" (*O. streptacantha*)

Beverages

Two traditional fermented beverages recorded in the region are in danger of disappearing, because few people know how to prepare them: “colonche” and “sendichó or senditó.” The former is made with the prickly pear variety known as "sangre de toro" (*Opuntia ficus-indica* (L.) Mill.), which was found in the backyard of one of the interviewees but not elsewhere. The latter is a fermented maize beverage made from sprouted seeds and consumed during feasts and celebrations.

The daily use of infusions for pleasure in the absence of illness was recorded. These include the consumption of eight species: "muicle" or "muitle" (*Justicia spicigera* Schltdl.), elderflower (*Sambucus mexicana* C.Presl ex DC.), “pericón” (*Tagetes lucida* Cav.), “anís de monte” (*Tagetes filifolia* Lag.), “tejocote” (*Crataegus mexicana*-), “naranjo” (*Citrus*×*aurantium* f. *aurantium),* “ortiga” (*Urtica* sp.), “cedrón” (*Aloysia citrodora* Paláu), and "tlachicote" or mountain tea (*Clinopodium macrostemum* (Moc. & Sessé ex Benth.) Kuntze). The latter was used as a morning decoction before coffee and became popular in the community. Another interesting beverage is the "granada de guía" or "platanito" (*Passiflora tripartita* (Juss.) Poir.), whose fruit is sometimes eaten raw, but because of its sour taste, it is preferably consumed in fresh water with a little sugar (Fig. 10).

“Quelites” (edible wild greens)

At least seven species have been identified as “quelites” (Fig. 11). Those belonging to the genus *Amaranthus* are eaten before flowering, because the taste becomes unpleasant. "nabo quelite" (*Brassica rapa* L.) stems acquire a sweet taste when roasted ("sweated"). Some “quelites” such as "hyadi k’ani" (sun “quelite”), "mal

Fig. 10 On the left, herbarium specimen of "tlachicote" or mountain tea (*Clinopodium macrostemum*) collected in a backyard from an original plant found on a mountain hill in the neighborhood of Ojo de Agua, San Miguel Tlaxcaltepec. On the right, "granada de guía" or "platanito" (*Passiflora tripartita*) collected in an orchard in Chitejé de Garabato, SMT

Fig. 11 “Quelites” from San Miguel Tlaxcaltepec. **a** purslane (*Portulaca oleracea*), **b** white goosefoot (*Chenopodium berlandieri*), **c** watercress (*Nasturtium officinale*), **d** wild borage (*Sonchus oleraceus*), **e** common mallow (*Malva parviflora*), **f** "patita de pájaro" or "chivitas" (*Calandrinia ciliata*), and **g** "quelite de burro" (*Tauschia nudicaulis*)

casada" ("badly married"), or "burro quelite" (*Tauschia nudicaulis* Schltdl.) grow either in the rainy season or in the dry season, and can be eaten with their flowers. Some "quelites" such as "patitas de pájaro" or "chivitas" (*Calandrinia ciliata* (Ruiz & Pav.) DC.) are eaten raw, as a salad with added lemon. Most of them are boiled and cooked with onion, garlic, and some sauce, and eaten in maize tortilla tacos.

Sweets/desserts

This category includes species used in the preparation of various preserves such as syrups of figs (*Ficus carica* L.), pears (*Pyrus communis* L.), apples (*Malus domestica* (Suckow) Borkh.), black cherries (*Prunus serotina*), and quince (*Cydonia oblonga* Mill.). It also includes syrup elderberry jam (*Sambucus mexicana*), compotes, and desserts made with *piloncillo* (unrefined whole cane sugar) and pumpkin (*Cucurbita* spp.), chilacayota (*Cucurbita ficifolia* Bouché), tejocote (*Crataegus mexicana* DC.), or amaranth (*Amaranthus* spp.) delicacies.

Fruits

This category includes species whose fruits that are eaten raw and are naturally sweet, such as pears (*Pyrus communis*), apples (*Malus domestica*), "capulínes" (*Prunus serotina*), "tejocotes" (*Crataegus mexicana*), prickly pears (*Opuntia* spp.), and "garambullos" (*Myrtillocactus geometrizans* (Mart. ex Pfeiff.) Console).

Condiments or spices

Species classified as condiments or spices are added in small amounts to stews or soups to enhance the flavor and include "epazote" (*Dysphania ambrosioides* (L.) Mosyakin & Clemants) and Mexican bay leaf (*Litsea glaucescens*). However, species such as "anis de monte" (*Tagetes filifolia* Lag. and *T. micrantha* Cav.) are also used to enhance the flavor of raw, freshly cut maize canes which are eaten by sucking the juice from the stalks and rubbing them with the fresh aniseed.

Stews

Most stews are eaten in tacos. Newly harvested potatoes, or "white potatoes" (*Solanum tuberosum* L.), were preferably roasted on the stove and served with fresh milk for children's breakfast. Today, potatoes are incorporated into the stews with meat (Fig. 12a), sauces, or with nopales (*Opuntia* spp. cladodes). "Talayotes" or "puerquitos" (*Matelea pedulculata* (Decne.) Woodson) grow during the rainy season, and although they can be eaten raw (as a snack), they are preferably eaten roasted. "Talayotes" and "puerquitos" can be eaten even if they are not tender. The "quelites" are also often used in stews (Fig. 12e).

Sauces

Informants mentioned that about 30 years ago many plants of "chimpinas" or wild eggplants (*Lycianthes moziniana* (Dunal) Bitter) could be found in the maize fields

Fig. 12 Stews and sauces in a *molcajete* (mortar and pestle) from the SMT edible plants. **a** "white potatoes" (*Solanum tuberosum*) with meat; **b** cooked "nopalitos" (Opuntia spp.) for "tacos"; **c** "chilacayote" (*Cucurbita ficifolia*) stew; **d** "chile manzano" (*Capsicum pubescens*) hot sauce; **e** "quelite cenizo" (*Chenopodium berlandieri*) patties

and surrounding areas. People could collect so many that they would braid them together by weaving the fruit stems. These braids were eaten raw like tomatoes. Apparently, they lasted for many weeks because the braids were hung in the kitchens to have the "chimpinas" available when making a chili sauce.

Another highly valued species for sauces is the "coconoxtle" (*Opuntia joconostle*), with different fruit colors: white, orange, red, and pink, some with a more acidic taste than others. They also mention the "aguses" (*Physalis* spp.) as being important for the preparation of green sauces when used raw (orange or yellow when ripe) because they have a very pleasant taste a little sweet like the "chimpinas".

The sauces are made with "chiles" from the communities. The "chiles manzanos" (*Capsicum pubescens* Ruiz & Pav.) are the most common in backyards, although the "chile piquín" (*C. annuum* var. *glabriusculum*) and the "chile campana" (*C. baccatum* L.) are grown in greenhouses (Fig. 12d).

"Hacer rendir la masa" (increasing the corn dough volume)

Another category is considered for the plants that are used as additives in the dough when there is not enough corn have been harvested to make tortillas. Thus, parts of some plants are added to the dough, such as the male maize spikes (*Zea mays*), "dalia" flowers (*Dahlia coccinea*), "lengua de vaca" seeds (*Rumex* sp.), and "tumbavaqueros" flowers (*Ipomoea stans* Cav.). These four species are not currently used as such, but it was common for people between the ages of 40 and 60 to mention them as a strategy used by their parents when poor harvests left families without enough maize, thus leading to hunger.

Soups

In the past, it was usual to cook white potatoes (*Solanum tuberosum*) especially in a "white soup" to ward off the cold. The "coconoxtle" prickly pear is used to prepare broths with meat and the guajillo chili (*Capsicum annum*) to enhance the flavor. Pumpkin flowers (*Cucurbita pepo*) were used in the past to thicken soup broths as if it were chicken broth.

Seeds (grains)

The two bean species (*Phaseolus vulgaris* L. and *P. coccineus* L.) occurring in the area, play a fundamental role in the diet. For *P. vulgaris*, at least 18 varieties were mentioned by respondents. These are known by common names such as "San Franciscano," "vaquita," "negro vaquita," "rojo," "ojo de cabra," "negrito," "moro," and "amarillo" (Fig. 13). With regard to maize (*Zea mays*), 15 types were mentioned, corresponding to seven identified races (Table 4).

This category contains broad-leafed cultivated plants species such lettuce (*Lactuca sativa*) or garden "quelites," such as "patita de pájaro" (*Calandrinia ciliata*), which can be eaten raw and are used in various dishes.

Bread/cookies

Sweet bread is made with one of the two anise species, *Tagetes filifolia* or *T. micrantha*, especially from their seeds.

Secondary uses of some edible species

In addition to the direct consumption of most of the edible species, the interviews revealed three plant species associated with other culturally important food resources, "huitlacoche" (*Ustilago maydis* (DC.) Corda), "panchihuas" or "lulitos" (*Quercus* spp. galls), and madrone worms. The first case, it is the fungus associated with the ears of corn (*Zea mays*). The second case is the oak galls caused by various wasp species which promote a special tissue in response to the wasps' oviposition. Galls are called "panchihuas" or "lulitos" which means fruits in Hñäñho (Otomi). The third name refers to the caterpillars of a particular butterfly species found on the madrone tree (*Arbutus* sp.), which many years ago were roasted and eaten in tacos with salsa. To extract the caterpillars, the "little bag," full of them needs to be open. This resource is now extinct in the area because madrone trees became progressively scarce and no new plants have appeared.

Among some plants used to preserve food, is the "pextó chiquito" (*Brickellia veronicifolia* (Kunth) A.Gray). Although is not directly consumed, it is used to put it in a hole excavated in the rosette top left after to cut off the inflorescence stalk of "maguey"" (*Agave* spp.) in order to extract the sap that we call "aguamiel." This plant prevents spoiling the sap "aguamiel" used for fermentation to prepare pulque. It is worth noting that this "pextó" species has medicinal uses due to its bitter taste and probably contains antibiotic compounds that prevent the proliferation of fermenting microorganisms in the freshly extracted "aguamiel."

Potentially toxic species and their way of use

Out of the 119 species recorded in the study area, some have edible parts that are completely harmless. Other plants have edible parts that should be consumed in small quantities to avoid toxicity, such as "madroño" (*Arbutus* sp.) fruits. Some other species have toxic parts that must not be eaten, such as the "congrá" or "congora" (*Phytolacca icosandra* L.), whose tender shoots, before flowering, are eaten as greens. However, the leaves must be

Fig. 13 Some types of beans produced in the fields and plots of SMT. **a**–**g** *Phaseolus vulgaris*, **h**–**i** *Phaseolus coccineus*

beaten on a stone and then boiled, drained, and stewed before consumption. The fruits of this species, which resemble cherries, should not be eaten as they are highly poisonous. The fruits were used in the past as a stain remover and laundry detergent.

Discussion

Importance of species diversity compared to other studies

Our study gives highlights about the edible plants management in a *ñäñho* area, which has been scarcely investigated from the plant uses perspective. In this research we found that 51.3% of the edible plants are not cultivated and they are managed like wild or weedy plants. These results contrast with a recent publication of Casas et al. which report that 21.9% of the edible plant species are wild and weedy edible plants in some indigenous areas in the mountains of Mexico [31].

In this study, 119 edible species were recorded in the SMT community, occurring in different agroecosystems. Of these, 64 (54%) were also found by Núñez [13], who identified 116 edible species in the Ñäñho communities of San Ildefonso and Santiago Mexquititlán. The author mentions six species with medicinal use only, such as "cedrón" (*Aloysia citrodora*), nettle (*Urtica dioica*), "trompetilla" (*Bouvardia ternifolia*), oak (*Quercus* sp.), "tumbavaqueros" (*Ipomoea stans*), and "pericón" (*Tagetes lucida*), but these species are also recorded as edible in the present study. In addition, he mentions only one species with ornamental use (*Dahlia* sp.), although it is edible. For the "nopales" (*Opuntia* spp.) and "magueys" (*Agave* spp.), the author did not specify the different species, and they were considered as one species.

We found 56% of the edible plants reported by Balcázar-Quiñonez [10] of the "milpa" and its surroundings in the Otomi community of San Pedro Arriba, municipality of Temoaya, state of Mexico. This indicates a significant similarity in the knowledge and use of edible plants in the two states, although with some variations, which also implies a considerable cultural and gastronomic diversity related to agrobiodiversity.

The fact that the majority of species were found in five agroecosystems (orchard with 14 spp., greenhouse with 13, household "milpa" with 12, mountain hill with 11, and backyard with 10) implies that these

Table 4 Local names for corn races and varieties

Local name for the variety	Corn race/variety
Ajo	Cónico
Amarillo	Chalqueño
	Cónico
Blanco	Ancho
	Celaya
	Celaya-chalqueño
	Chalqueño
	Chalqueño (elotes chalqueños)
	Chalqueño-celaya
	Chalqueño-cónico
	Cónico
	Cónico-chalqueño
	Cónico-palomero toluqueño
Morado	Chalqueño
Morado-tinto	Elotes cónicos
Negro	Chalqueño
	Chalqueño (elotes chalqueños)
	Chalqueño (elotes chalqueños)-elotes cónicos
	Elotes chalqueños
	Elotes cónicos
	Elotes cónicos-chalqueño
Negro de cerro	Chalqueño (elotes chalqueños)
Pinto	Chalqueño
	Chalqueño-celaya
	Chalqueño-cónico
	Cónico
	Chalqueño (elotes chalqueños)- celaya
Pozolero blanco	Cacahuacintle
Rojo	Chalqueño (elotes chalqueños)
	Elotes cónicos
	Elotes cónicos-chalqueño
	Elotes occidentales
	Chalqueño (elotes chalqueños)-cacahuacintle
Rojo temporal	Cónico-chalqueño
Rosa	Elotes cónicos
Rosado	Chalqueño (elotes chalqueños)
	Elotes cónicos
San Franciscano	Cónico
Sangre de Cristo	Cónico variegado

agroecosystems are agrobiodiversity reservoirs. To preserve them, efforts should be made to keep them as heterogeneous as possible but complementary to the biocultural landscape, including wild areas, which host a wealth of local foods.

Table 5 Comparison between the total plant diversity recorded in previous studies and the present study focused on the diversity of edible plants

Diversity in the Amealco municipality	Rzedowski and Bedolla (2021)	Hernández-Sandoval and Pantoja (in press)	This study
Records		725	196
Species	580	499	119
Families		104	41
Species percentage	100%	86%	20%

The importance of wild species for the cultivated agrobiodiversity

Agrobiodiversity represents a pool source of genes for new plant varieties. Wild species serve as genetic diversity reservoirs, providing variable responses to an increasingly uncertain environment due to climate change and knowledge loss [32]. In this study, three species of wild domesticated crop relatives were found (*Phaseolus coccineus, P. vulgaris*, and *Physalis phiadelphica*), as well as a congeneric species (*Physalis cinerascens*) that could exchange genes with crops to increase their genetic diversity. Both cultivated and apparently wild plants of the "bayocote" bean (*Phaseolus coccineus*) were found. They grew on the edges of oak forests and were not used for food because of their tiny seeds. In terms of intrageneric diversity, more than one species of *Agave, Amaranthus, Tagetes, Opuntia, Cucurbita, Phaseolus, Quercus, Physalis,* and *Solanum* were found. The potential gene exchange and genetic affinity among the species within each genus should be investigated.

Percentage of edible species in relation to the municipal flora.

The number of species included in this work is 119, based on the collection of 196 herbarium specimens. Considering the work of Hernández-Sandoval and Pantoja (in press), who documented 499 species based on 725 herbarium specimens for the entire municipality of Amealco, 25% of the plant diversity recorded for the municipality are edible (Table 5). Considering the study by Rzedowski and Bedolla [33], who reported the presence of 580 species in the municipality, the edible plants in this study represent 20% of such diversity.

People knowledge

The knowledge index was not a study goal. However, the people collaborating in the research showed an important plant cultural background + baggage. They knew the Ñäñho plant names, uses, places where they grow, and recipes among other information. Most of the time, they were happy and proud to share all of what they knew

about the plants. Unfortunately, since most of them are more than 60 years old, their knowledge is at risk of being lost. A major effort is needed to preserve not only the edible plant species used, but also the people's knowledge and cultural values. This study aspires to be a contribution to action in favor of conserving the local cultural memory.

It is important to consider the cultural practices surrounding food consumption around the more significant plant species and their varieties. During field work, especially in the informal interviews and participant observations, we documented some dietary practices related to traditional festivities in the community. A relevant example is the preparation and consumption of the traditional fermented beverage of maize called "senditó." It is consumed traditionally in May and September during the patron saint festivities of San Miguel Arcangel, in December during Christmas day, and on the last day of the year. Other interesting beverages, related to specific cultural moments, are the orange leaf tea consumed during the Day of the Dead in November and the "atole de masa" (not fermented beverage made with maize dough) that are consumed by the women in the puerperium. Some of the interviewees mention that some years ago the tortillas consumed during the baptism party had to be made with red or pink maize. Now, it is very difficult to obtain this color of maize.

Agrochemicals and the disappearance of edible plants

The "quelite patita de pájaro" (*Calandrinia micrantha*) was found in a greenhouse located on land where a "milpa" had been cultivated many years ago. People mentioned that it was abundant before the arrival of herbicides, but now is very rare. Another group of plants that are practically extinct in the study area are the "papas de "milpa" ("milpa" potatoes, *Solanum* spp.). They are also known as "papas de monte" (wild potatoes) and sometimes called "papas de coyote" when they grow on the hillside. These species were eradicated from the "milpa" after the use of herbicides.

There is an urgent need to develop propagation and reintroduction projects for the species that were known in the past as important for food, but are no longer easily found in the field. These species include the "chivitas" or "patitas de pájaro" (*Calandrinia micrantha*), "chimpinas" or "berenjenas de monte" (*Lycianthes moziniana*), "talayotes" or "puerquitos" (*Matelea pedulculata*), "auguses" (*Physalis chenopodifolia*), "papas de "milpa" (*Solanum* spp.), and some maize and bean cultivars that are no longer cultivated, such as red or pink maize (*Zea mays*), which are drought-tolerant.

The species found in different agroecosystems and vegetation types and the importance of their conservation

The study revealed a significant diversity of edible plant species growing in different agroecosystems and vegetation types. The food potential inherent in each ecosystem or agroecosystem is exploited by farmers through the strategy of "multiple use," an approach that recognizes and utilizes the productive ecosystems capacities. Though the study objective was to document plant agrodiversity, the results refer to the appropriation of multiple ecosystems, with many species producing different products through a variety of production practices, thus ensuring food diversity [34].

In this regard, the SMT inhabitants obtain edible plant species from different environments (agroecosystems) in addition to the "milpa," the backyard, and natural vegetation (the mountain hill), [5, 6]. Plants are managed in different ways ranging from gathering to sowing and planting. The environment's combination, plant management type, and their seasonal availability (a topic to be explored in future research), together with local knowledge of their use, constitute an agrobiological and cultural wealth from which to build food sovereignty. Some publications [4, 34] support the idea that "ethno agroforestry systems represent a real commitment to a future that seeks to solve problems of food and raw material supply in a way that is friendly to planetary ecosystems." These authors suggest that agroforestry management is an alternative to modern agricultural models since modern agriculture is one of the main drivers for global environmental change. In particular, the agriculture for products exportation or to support large cities, the industrialization and urbanization tendencies in Southern Querétaro, are impoverishing the productive ecosystems and their diversity. The results of this study provide an insight for supporting alternative food production systems based on local knowledge.

Potential uses of collected species that are not consumed

In addition to the 119 documented edible species, there are others that are consumed outside the study area, but were not reported as edible in SMT. For example, *Anoda cristata* was collected in two "milpas," and although the respondents did not know its name and had not consumed it, they were aware that it was eaten elsewhere. In other parts of Mexico, this species is consumed as a "quelite" and is known as "alache" or wild mallow, recognized for its high protein value [35]. In the study area, the wild mallow refers to a different species, *Malva parviflora*.

Common species in decline and the potential of underutilized species

As mentioned above, some species were important in the diet in the past but now are less consumed, even if they are common in the community landscape. Some other species whose consumption is declining are those considered by the people to be "mountain foods", consumed by people during the working day when collecting firewood from the forest or during pastoral activities, which is mainly done by the children. These include "dalia" (*Dahlia coccinea*) tubers, oaks (at least three species of *Quercus*) galls and flowers, and the mountain prickly pears (*Opuntia* spp.), among which the "coconoxtles" (*O. joconoxtle*) stand out.

According to Bravo et al. [36], plants that are both currently used and those that are no longer used, but were widely consumed in the past, have a significant potential to diversify diets and to improve local economies in the present. In the case of edible oak flowers (*Quercus rugosa* and *Q. eduardii*), "tumbavaqueros" (*Ipomoea stans*), "maguey" (*A. americana* and *A. salmiana*), "colorín" (*Erythrina* sp.), maize (*Zea mays*), "dalia" (*Dahlia coccinea*), madrone (*Arbutus* sp.), and prickly pear (*Opuntia* sp.), their consumption is underutilized.

On the origin of plant species (native vs. introduced)

Introduced species represent 40% of the diversity of edible plants and play an important role in supplementing the basic native species diet. The fact that most introduced species are cultivated, indicates that a diet based on such management requires considerable time and care, i.e., a high-intensity management to obtain food.

Introduced species are mostly present in greenhouses and gardens, indicating that these agroecosystems require high-intensity management intensity. In contrast, native species are abundant in the home "milpa" and in the mountain hills. Some introduced plants come from the Andes, such as the chile "manzano" (*Capsicum pubescens*) and the "granada" (*Passiflora tripartita*), but they are locally highly valued as edible plants.

Importance of edible plants for survival

Species that are gathered or collected are considered to be the basis of a survival diet in emergencies caused by the lack of cultivated species production. The agroecosystems where most of the wild plants are collected are the mountain hills, home "milpa," and the backyard, and to a lesser extent, the ejidal "milpa." It is essential to preserve these agroecosystems as food sources for food security. During the interviews, the importance of the mountain hill prickly pears (*Opuntia* spp.) was highlighted as a staple food during the pandemic period, in the context of economic and commercial food scarcity.

The importance of this work for local nutrition and its contribution to strengthening food sovereignty

Of the 29 listed "quelites" species, 14 genera (*Amaranthus, Hydrocotyle, Brassica, Chenopodium, Tinantia, Ipomoea, Malva, Oxalis, Phytolacca, Rumex, Calandrinia, Jaltomata, Solanum,* and *Urtica*) have been identified by the Quelites network as a national priority for their conservation and sustainable use [9]. National resources can be directed toward the development of projects to promote these species as food.

It is important to compile in a single work information on the diversity, local names, origin, management, and uses of edible plants. This will provide the basis for projects aimed at strengthening food sovereignty processes. These can follow integrated development schemes that include primary production (propagation), processing (diversification of uses and forms of consumption), and local commercialization of derived products (community entrepreneurship projects). Above all, they provide a context for inhabitants of the community to have an adequate diet based on their own culture and agrobiological diversity.

The local production and consumption of these underutilized species can be a source of nutrients and culturally relevant food throughout the year, which are enriched after the rainy season. The local plant agrodiversity, local names, origin, management, and use of edible plants documentation, could work toward both food sovereignty and food security, with an ecological basis for achieving food self-sufficiency [34].

Conclusions

At least 119 species of edible plants from 11 used agroecosystems were identified in the SMT, with the garden, greenhouse, house "milpa," and mountain hills having the greatest diversity. Most of the edible species are native (71 spp., 60%), and almost half of them were collected from different agroecosystems, mainly the mountain hill and "milpa" near the houses. This implies that these spaces are important food sources that require little management and could potentially designing sustainable and culturally relevant diets. The main plant management types are: sowing or planting and gathering, and these species are mainly found in the gardens, backyards, and greenhouses. In contrast, collected species are mainly found in the mountain hills, home "milpa," and backyards. Although 85 names of edible plants were recorded in the Hñäñho language, there is an erosion of the plant names knowledge and their consumption, especially among people younger than 65 years old. In the study area, edible plants are used in different ways by consuming different parts of the plant in different categories and forms of consumption. This indicates the cultural

diversity and richness of the area and the potential to form the basis of local food sovereignty.

Appendix

Edible plants in San Miguel Tlaxcaltepec, Amealco, Querétaro. Agroecosystems (B = Backyard, D = Dam plots, EM = Ejidal "milpa," G = Greenhouse, H = Mountain hill, HM = Home "milpa," N = "Nopaleras," O = Orchard, P = Plain, S = Steam bank). Management type G: Gathered or collected, T: Tolerated, P: Promoted, Tr: Transplanted, S: Sowed and planted. Plants with voucher number in process have photographic records of the species.

Scientific name	Family	Vaucher number	Spanish name	Hñäñho name	Agroecosystem	Type of management	Origin
Agave americana L	Asparagaceae	QMEX00019101	maguey verde	'wada	H, HM	Tr, R	Native
Agave mapisaga Trel	Asparagaceae	in process	maguey	'wada	H, HM	Tr, G	Native
Agave salmiana Otto ex Salm-Dyck	Asparagaceae	QMEX00019097	maguey chino	'wada	H, HM	Tr, G	Native
Allium cepa L	Amaryllidaceae	in process	cebolla	d̲enxi	O, G	S	Introduced
Allium fistulosum L	Amaryllidaceae	in process	cebollin		O	S	Introduced
Allium sativum L	Amaryllidaceae	in process	ajo	axo	O	S	Introduced
Aloysia citrodora Paláu	Verbenaceae	in process	cedrón		B	S	Introduced
Amaranthus hybridus L	Amaranthaceae	QMEX00019107	quintonil blanco, quintonil rayado	xitha	HM, EM, B	G, T, P	Native
Amaranthus hypochondriacus L	Amaranthaceae	QMEX00019080	amaranto		HM, B	S	Native
Apium graveolens L	Apiaceae	in process	apio		G	S	Introduced
Arbutus tessellata P.D. Sørensen	Ericaceae	QMEX00019154	madroño	t'axi (listo), penxi (peludo)	H	G	Native
Arctostaphylos pungens Kunth	Ericaceae	in process	pingüica	pindikua	H	G	Native
Avena sativa L	Poaceae	in process	avena		EM	S	Introduced
Beta vulgaris subsp. *cicla* (L.) Juel, E.Markl. & Örtendahl	Amaranthaceae	in process	acelga		O, G	S	Introduced
Bouvardia ternifolia (Cav.) Schltdl	Rubiaceae	QMEX00019158	trompetilla	d̲o̲t'i	H	G	Native
Brassica oleracea L	Brassicaceae	in process	coliflor, coles, coles de bruselas, brócoli		G	S	Introduced
Brassica rapa L	Brassicaceae	QMEX00019077, QMEX00019105	nabo	nobo, nabo	HM, EM,B	G, T, P, S	Introducida

Scientific name	Family	Vaucher number	Spanish name	Hñäñho name	Agroecosystem	Type of management	Origin
Brikellia veronicifolia (Kunth) A.Gray	Asteraceae	QMEX00019138	hierba del burro, pextó chiquito		H	G	Native
Calandrinia ciliata (Ruiz & Pav.) DC	Montiaceae	QMEX00019103	patita de pájaro	mudu k'ani	G, HM	G, T, P, S, Tr	Nativa
Capsicum annum L	Solanaceae	QMEX00019108	chile jalapeño, chile morrón	'ñii/ 'ii	G	S	Native
Capsicum baccatum L	Solanaceae	in process	chile campana	'ñii/ 'ii	G	S	Native
Capsicum pubescens Ruiz & Pav	Solanaceae	QMEX00019095	chile manzano	'ñii/ 'ii	B	S	Introduced
Casimiroa edulis La Llave	Rutaceae	QMEX00019088	zapote	t'axi mu zaa, mu zaa	O, B	S	Native
Chenopodium berlandieri Moq	Amaranthaceae	QMEX00019124	quelite cenizo blanco y rojo, huazontle	gink'ani, gik'ni	HM, EM, P	G, T, P, S	Native
Citrus × aurantiifolia (Christm.) Swingle	Rutaceae	in process	lima		O	S	Introduced
Citrus × aurantium f. *aurantium*	Rutaceae	in process	naranja	nanxa	O, B	S	Introduced
Citrus × limon (L.) Osbeck	Rutaceae	QMEX00021407	limón		O, HM, B	S	Introduced
*Clinopodium macrostemum (*Moc. & Sessé ex Benth.*)* Kuntze	Lamiaceae	QMEX00019139, QMEX00019155	tlachicote, té de monte		H, B	G	Native
Cologania angustifolia Kunth	Fabaceae	QMEX00019127, QMEX00019159	jícama 2	jwaxo	H	G	Native
Coriandrum sativum L	Apiaceae	QMEX00019141	cilantro		G	S	Introduced
Crataegus mexicana DC	Rosaceae	QMEX00019157	tejocote	p̲eni	O	G, T, S	Native
Cucurbita argyrosperma C.Huber	Cucurbitaceae	in process, seed bank	calabaza pipiana	mu, muu	HM	S	Native
Cucurbita ficifolia Bouché	Cucurbitaceae	in process	chilacayota	d̲emu	HM	S	Native

Scientific name	Family	Vaucher number	Spanish name	Hñäñho name	Agroecosystem	Type of management	Origin
Cucurbita pepo L	Cucurbitaceae	in process	calabaza boluda grande o de castilla, bolita, de rancho, criolla, semillera	mu, muu	HM	S	Native
Cydonia oblonga Mill	Rosaceae	in process	membrillo		O	S	Introduced
Dahlia coccinea Cav	Asteraceae	QMEX00019125, QMEX00019126	jícama de dalia de monte o cimarrona	daliya, mpixidoni o za'do (camote)	H	G	Native
Daucus carota L	Apiaceae	in process	zanahoria		G	S	Introduced
Dysphania ambrosioides (L.) Mosyakin & Clemants	Amaranthaceae	QMEX00019121, QMEX00019121	epazote		B	G, T, P, S	Native
Eriobotrya japonica (Thunb.) Lindl	Rosaceae	in process	níspero		O, B	S	Introduced
Eruca sativa Mill	Brassicaceae	in process	arúgula		G	S	Introduced
Erythranthe geyeri (Torr.) G.L.Nesom	Phrymaceae	QMEX00019145	berro cimarrón		S	G	Introduced
Erythrina americana Mill	Fabaceae	QMEX00019096	colorín		O	G	Native
Ficus carica L	Moraceae	QMEX00019091	higo		O, G, B	S	Introduced
Fragaria sp.	Rosaceae	in process	fresas		G	S	Introduced
Hordeum vulgare L	Poaceae	in process	cebada		EM	S	Introduced
Hydrocotyle sp. Tourn. ex L	Araliaceae	in process	berro ombligo de puerco		S	G	Native
Ipomea batatas (L.) Lam	Convolvulaceae	in process	camote	bujijo	G	S	Nativa
Ipomoea stans Cav	Convolvulaceae	QMEX00021411	tumbavaqueros		HM	G	Native
Jaltomata procumbens (Cav.) J.L. Gentry	Solanaceae	QMEX00019143	jaltomate, negritos, negros y jaltomate blanco	dihpi, depe, 'bodepe	HM, B	G, T	Native
Justicia spicigera Schltdl	Acanthaceae	QMEX00019089	muicle		B	S	Native
Lactuca sativa var. *longifolia*	Asteraceae	in process	lechuga larga		G	S	Introduced
Lathyrus oleraceus Lam	Fabaceae	in process	chícharo	gorju, guluju	HM, EM, P	S	Introduced

Scientific name	Family	Vaucher number	Spanish name	Hñäñho name	Agroecosystem	Type of management	Origin
Leucaena leucocephala (Lam.) de Wit	Fabaceae	QMEX00019082	guaje de árbol		O	S	Native
Litsea glaucescens Kunth	Lauraceae	QMEX00021410	laurel		O	S	Native
Loeselia mexicana (Lam.) Brand	Polemoniaceae	QMEX00019085	espinocilla		H, HM	G	Native
Lycianthes moziniana (Dunal) Bitter	Solanaceae	QMEX00019149	berenjena de monte, chimpinas	tximpina, nyonge	H, HM, P	G, T	Native
Macroptilium gibbosifolium (Ortega) A.Delgado	Fabaceae	QMEX00019136	jícamita	jwaxo	HM	G	Native
Malva parviflora L	Malvaceae	QMEX00019144	malva, malva de comer	xikoni	HM, EM, B	G, T	Introduced
Malva sylvestris L	Malvaceae	QMEX00019120, QMEX00019152	malva cimarrona		HM, EM	G	Introduced
Matelea pedulculata (Decne.) Woodson	Asclepiaceae	QMEX00019113,QMEX00019114	talayote, puerquitos	txi ts'u̲di	HM	G	Native
Medicago polymorpha L	Fabaceae	QMEX00021413	carretón	karreto	HM, EM	G	Introduced
Morus alba L	Moraceae	QMEX00019078	mora		O	S	Introduced
Musa x *paradisiaca* L	Musaceae	in process	plátano	mu̲zaa, dozaa	G, B	S	Introduced
Myrtillocactus geometrizans (Mart. ex Pfeiff.) Console	Cactaceae	in process	garambuyo	'baxtä	B	T	Native
Nasturtium officinale W.T.Aiton	Brassicaceae	QMEX00019146	berro de comer	'berro	S, M, G	G, Tr	Introduced
Opuntia ficus-indica (L.) Mill	Cactaceae	QMEX00019102	nopal sin espinas o verdulero, sangre de toro	jir doro	O, G, B	S	Native
Opuntia hyptiacantha F.A.C. Weber	Cactaceae	QMEX00019100	nopal chinche		N	Tr	Native
Opuntia joconostle F.A.C. Weber ex Diguet	Cactaceae	QMEX00019099	nopal xoconoxtle	ixkähä	HM	G, TG	Native
Opuntia lasiacantha Pfeiff	Cactaceae	QMEX00019093	nopal aguamielo/ lindó, lindón	Xät'ä, theni kähä	H, N	G	Native

Scientific name	Family	Vaucher number	Spanish name	Hñähño name	Agroecosystem	Type of management	Origin
Opuntia robusta H.L.Wendl. ex Pfeiff	Cactaceae	in process	nopal bondó	'bondó	H, N	G	Native
Opuntia streptacantha Lem	Cactaceae	QMEX00019094	nopal hartón		H, HM, N	G, Tr	Native
Opuntia tomentosa Salm-Dyck	Cactaceae	QMEX00019098	nopal chamacuero	dödé	H, HM, N	G	Native
Oxalis sp.	Oxalidaceae	in process	panocha, agritos	ixi, ixkwa	HM	G	Native
Passiflora tripartita (Juss.) Poir	Passifloraceae	QMEX00019083	granada, platanito		O	S	Introduced
Persea americana L	Lauraceae	in process	aguacate	xit'ani	G	S	Native
Phaseolus coccineus L	Fabaceae	QMEX00019128, QMEX00019131	frijol bayocote, frijol burro, ayocote	burrujú	HM, EM	S	Native
*Phaseolus vulgaris*L	Fabaceae	QMEX00019123	frijol amarillo	bo jú	EM	S	Native
Physalis chenopodiifolia Lem	Solanaceae	QMEX00019110, QMEX00019112	augus	ougú	HM	G	Native
Physalis nicandroides Schltdl	Solanaceae	QMEX00019129	augus	ougú	HM, B	G, T, P, S	Native
Physalis philadelphica Lam	Solanaceae	QMEX00019081	tomate de cáscara, tomate de milpa	t'axdemuxii/ demxii	HM, B	G, T, S	Native
Phytolacca icosandra L	Phytolaccaceae	QMEX00019109, QMEX00019116	congora, hierba del perro	congrá	H, O, HM	G	Native
Pinus cembroides Zucc	Pinaceae	in process	piñón		O	S	Native
Portulaca oleracea L	Portulacaceae	QMEX00019118	verdolaga	verdolaga	G, HM, EM	S, G	Native
Prunus armeniaca L	Rosaceae	in process	chabacano		O	S	Introduced
Prunus cerasus L	Rosaceae	in process	cerezo		O	S	Introduced
Prunus domestica L	Rosaceae	QMEX00019090, QMEX00019140	ciruela	siruelo	O	S	Introduced
Prunus persica (L.) Batsch	Rosaceae	QMEX00019086, QMEX00019092	durazno	ixi	O, HM	S	Introduced
Prunus serotina Ehrh	Rosaceae	QMEX00019161	capulín	dese	H, O, HM	G, T	Native
Psidium guajava L	Lythraceae	in process	guayaba		B	S	Native
Punica granatum L	Lythraceae	in process	granada		B, G	S	Introduced
Pyrus communis L	Rosaceae	in process	pera		O, HM, B	S	Introduced

Scientific name	Family	Vaucher number	Spanish name	Hñähño name	Agroecosystem	Type of management	Origin
Pyrus malus L	Rosaceae	in process	manzana roja arenosa	mansana	O, B	S	Introduced
Quercus eduardi Trel	Fagaceae	QMEX00019119	encino	dozaa	H	G	Native
Quercus microphylla Née	Fagaceae	QMEX00019137	panchihuas/ lulitos	pantxigua	H	G	Native
Quercus rugosa Née	Fagaceae	QMEX00019087	encino roble	zaa 'ro, lulu mba (panchihua de roble)	B	G	Native
Raphanus raphanistrum L	Brassicaceae	QMEX00019111, QMEX00019160	mortaza, mortaza, pedorra, quelite de burro		EM	G, T	Introduced
Rumex crispus L	Polygonaceae	QMEX00019153	lengua de vaca	ixtho	HM, N, B	G	Introduced
Salvia hispanica L	Lamiaceae	in process	chía		B	T	Native
Sambucus mexicana C.Presl ex DC	Viburnaceae	in process	sauco		B	S	Native
Sicyos edulis Jacq	Cucurbitaceae	in process	chayote liso grande y espinudo mediano	O, B	S	Native	Native
Solanum aff. *cardiophyllum* Lindl	Solanaceae	QMEX00019130	papa de milpa	'rok'a hwähi	HM, EM	G	Native
Solanum lycopersicum L	Solanaceae	QMEX00019079, QMEX00019084	jitomate	dädẹmoxi	G	S	Native
Solanum nigrescens M. Martens & Galeotti	Solanaceae	QMEX00019104, QMEX00019135	hierba mora	'pẹxaa	HM, B	G, T, P	Native
Solanum stoloniferum Schltdl	Solanaceae	QMEX00019117, QMEX00019133, QMEX00019134	papa de coyote, papa de monte	'rok'a 'mi'ño	H	G	Native
Solanum tuberosum L	Solanaceae	in process	papa blanca	'rok'a	G, HM, EM	S	Introduced
Sonchus oleraceus L	Asteraceae	QMEX00019147	borraja de milpa	nk'anjö	EM, H, N, HM	G, T	Introduced
Spinacia oleracea L	Amaranthaceae	in process	espinacas		G	S	Introduced
Tagetes filifolia Lag	Asteraceae	QMEX00019115	anís de monte		H, HM, P	G	Native
Tagetes micrantha Cav	Asteraceae	QMEX00019148	anís de monte		H, HM	G, T	Native
Tauschia nudicaulis Schltdl	Apiaceae	in process	quelite de burro, quelite de la mal casada	Mpintho, k'ani'r hyadi	P, HM	G, T	Native
Tagetes lucida Cav	Asteraceae	QMEX00019156	pericón, santa maría	hmijwä	HM	G	Native

Scientific name	Family	Vaucher number	Spanish name	Hñähño name	Agroecosystem	Type of management	Origin
Tigridia sp.	Iridaceae	in process	liendres, cocomite		H	G	Native
Tinantia erecta (Jacq.) Fenzl	Commelinaceae	in process	venaditos		HM	G, T	Native
Triticum sp.	Poaceae	QMEX00021408	trigo lerma y rojo	t'ei	EM	S	Introdiced
Urtica sp.	Urticaceae	QMEX00021412	ortiga	nzäna	B	G, T, P, S	Native
Vicia faba L	Fabaceae	QMEX00021409	haba chica de puerco	däju	EM, HM	S	Introduced
Vicia lens Coss. & Germ	Fabaceae	In process	lenteja		EM	S	Introduced
Yucca guatemalensis Lem	Asparagaceae	in process	palma	denthi, doni denthi	HM, B	Tr	Native
Zea mays L	Poaceae	QMEX00019151, QMEX00019151	maíz	thä	HM	S	Native

Abbreviations

SMT	San Miguel Tlaxcaltepec
B	Backyard
D	Dam plots
EM	Ejidal "milpa"
G	Greenhouse
H	Mountain hill
HM	Home "milpa"
N	"Nopaleras"
O	Orchard
P	Plain
S	Stream bank
G	Gathered or collected
T	Tolerated
P	Promoted
Tr	Transplanted
S	Sowed and planted

Supplementary Information

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Supplementary Material 1.

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Author contributions
KNHP helped in original idea, fieldwork: interviews and plant material collection, data analysis, manuscript writing. LHS contributed to original idea and project conception, plant identification, discussion, manuscript writing and reviewing. RGS was involved in project structuration, fieldwork: interviews and plant germplasm collection, map elaboration. AC helped in project conception, ethnobotanical information revision, manuscript content, and English revision. MM contributed to plant identification, botanical structures used revision, and specific information on Solanaceae, and aquatic plants, manuscript revision. VS was involved in collecting botanical information for Euphorbiaceae, Urticaceae and phytogeographical origin revision, manuscript content, and English revision. All authors read and approved the final manuscript.

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Availability of data and materials
No datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate
The content of the manuscript has not been published or submitted for publication elsewhere. The study information is original and the informants agreed to contribute with their edible plants knowledge and to donate samples from their lands to make herbarium specimens or for the university germplasm bank. Permission was verbally obtained from all participants in this study.

Competing interests
The authors declare that they have no competing interests.

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