Botanical Sciences 100 (1): 120-138. 2022
DOI: 10.17129/botsci.2831

Received: December 29, 2020, Accepted: April 14, 2021
First online: September 21, 2021

Ethnobotany / Etnobotánica

Edible flowers commercialized in local markets of Pachuca de Soto, Hidalgo, Mexico

Flores comestibles comercializadas en mercados locales de Pachuca de Soto, Hidalgo, México

Carmen Julia Figueredo-Urbina[1*], Gonzalo D. Álvarez-Ríos[2], Laura Cortés Zárraga[3]

[1] Cátedras CONACYT-Laboratorio de Genética, Área Académica de Biología, Instituto de Ciencias Básicas e Ingeniería. Universidad Autónoma del Estado de Hidalgo, Hidalgo, México.
[2] Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México, Morelia, Michoacán, México.
[3] Instituto de Biología-Jardín Botánico. Universidad Nacional Autónoma de México, Ciudad de México, CDMX. México.
*Author for correspondence: figueredocj@gmail.com

Abstract

Background: Edible flowers are important food resources due to their high content of nutrients and bioactive compounds. In Mexico these resources have been part of the diet of indigenous and mestizo, and are also important sources of income for the families that cultivate, gather and sell them.
Questions: What are the species of edible flower commercialized in local markets in Pachuca de Soto, Hidalgo, Mexico? How are they prepared? What are their nutritional contents and conservation risk categories according to literature?
Studied species: *Agave salmiana*, *A. mapisaga*, *Aloe vera*, *Arbutus xalapensis*, *Chenopodium berlandieri* subsp. *nuttalliae*, *Cucurbita pepo* ssp. *pepo*, *C. moschata*, *Dasylirion acrotrichum*, *Erythrina americana*, *Euphorbia radians*, *Myrtillocactus geometrizans*, *Phaseolus coccineus*, *Yucca filamentosa*.
Study site and dates: Local markets of Pachuca de Soto, Hidalgo, Mexico. January 2019 to March 2020.
Methods: Interview-purchase with sellers and direct observations in markets. Bibliographic review of the nutritional contents of the recorded species and their conservation status.
Results: We recorded 13 species of edible flowers and eight preparation methods. Five species are cultivated, five are gathered from the pine-oak forest or xerophilous scrub ecosystems and three are obtained from crops and natural ecosystems. The *gualumbos* (*Agave salmiana* and *A. mapisaga*) are the most commercialized flowers and had the most forms of preparation (six). Seven of the species traded are placed in a conservation risk category.
Conclusions: The diversity of edible flowers used, and their preparation methods exemplify the traditional knowledge of the groups that handle them and their importance as food and economic sustenance.
Keywords: functional foods, *quelite*, traditional cuisine, traditional knowledge

Resumen

Antecedentes: Las flores comestibles son importantes recursos alimenticios por su contenido de nutrientes y compuestos bioactivos. En México estos recursos son parte de la dieta de indígenas y mestizos, son importantes fuentes de ingresos para las familias que las cultivan, colectan y comercializan.
Preguntas: ¿Cuáles son las especies de flores comestibles comercializadas en mercados locales de Pachuca de Soto, Hidalgo, México? ¿Cuáles son sus formas de preparación?, ¿Cuáles son sus contenidos nutricionales y categoría de riesgo de acuerdo con la literatura?
Especies de estudio: *Agave salmiana*, *A. mapisaga*, *Aloe vera*, *Arbutus xalapensis*, *Chenopodium berlandieri* subsp. *nuttalliae*, *Cucurbita pepo* ssp. *pepo*, *C. moschata*, *Dasylirion acrotrichum*, *Erythrina americana*, *Euphorbia radians*, *Myrtillocactus geometrizans*, *Phaseolus coccineus*, *Yucca filamentosa*.
Sitio y años de estudio: Mercados locales de Pachuca de Soto, Hidalgo, México. Enero de 2019 a marzo de 2020.
Métodos: Entrevista semiestructurada-compra a vendedoras y observaciones directas en mercados. Revisión documental sobre los contenidos nutricionales y su estatus de conservación.
Resultados: Registramos 13 especies y ocho formas de preparación. Cinco son cultivadas, cinco son recolectadas de los ecosistemas bosque de pino-encino o matorral xerófilo y tres se obtienen de cultivos y ecosistemas naturales. Los *gualumbos* (*Agave salmiana* y *A. mapisaga*) son las más comercializadas y con más formas de preparación (seis). Ocho de las especies comercializadas se encuentran en categoría de riesgo de conservación.
Conclusiones: La diversidad de flores comestibles y los métodos de preparación son muestra del conocimiento tradicional de los grupos que manejan y la importancia que tienen como sustento alimentico y económico.
Palabras clave: alimento funcional, cocina tradicional, conocimiento tradicional, *quelite*.

This is an open access article distributed under the terms of the Creative Commons Attribution License CCBY-NC (4.0) international.
https://creativecommons.org/licenses/by-nc/4.0/

Flowers are the reproductive structures of angiosperms, which appeared in the plant kingdom 130 to 250 million years ago (Soltis *et al*. 2011, Doyle 2012, Hochuli & Feist-Burkhardt 2013, Magallón *et al*. 2013, Sauquet *et al*. 2017). Flowers consist of a perianth, which is the striking part of the flower made up of the petals and tepals, the androecium (masculine reproductive parts), and they gynoecium (feminine reproductive parts) (Zomlefer 1994).

Due to their aesthetic, organoleptic, innocuous, nutritional, and medicinal characteristics, flowers have been incorporated into the diet of multiple cultures as a food resource (Lu *et al*. 2016, Zheng *et al*. 2018). Edible flowers' relevance in the diet is due to their bioactive compounds, which have effects on the human body and modify its function. Many of these compounds are secondary metabolites that are produced by plants as a defense mechanism against herbivores; these compounds include alkaloids, terpenes, flavonoids, glycoside, saponins, among others (Barros *et al*. 2010, Wongwattanasathien *et al*. 2010, Kaisoon *et al*. 2011, Lu *et al*. 2016, Zheng *et al*. 2018). Flowers also contain high contents of pigments such as carotenoids and anthocyanins, which are responsible for their colors and have the function of attracting pollinators. These anthocyanins, polyphenols, flavonoids, and carotenoids have been associated with antioxidant and anti-inflammatory activities and prevention of chronic degenerative diseases (Kaisoon *et al*. 2011, 2012, Benvenuti *et al*. 2016, Pires *et al*. 2018).

Given the presence of these bioactive compounds, the consumption of flowers has generated interest in the field of health. Their nutritional and functional characteristics provide physiological benefits, which contribute to improving health and may reduce the risk of certain diseases (Loizzo *et al*. 2016). It is therefore important to conduct studies on the bioactive substances present in these resources, since they allow us to determine their quality and nutraceutical and medicinal potential (Mlcek & Rop 2011, Zheng *et al*. 2018).

In Mexico, of the 26,000-30,000 higher plants that have been described, about 2,168 are edible (Villaseñor 2016, Ulloa *et al*. 2017). Flowers are consumed from 67 of these species, which belong to 49 genera from 25 families, mainly the families Asparagaceae (23 species of the subfamily Agavoideae), Fabaceae (23 species), Cactaceae (12 species), Arecaceae (5 species) and Cucurbitaceae (4 species) (Mapes & Basurto 2016).

The use of flowers as food in Mexico dates back to pre-Hispanic times and was documented in the texts of chroniclers and evangelizers. Examples include flowers that were eaten directly, such as *huauhquílitl* (*Chenopodium berlandieri* subsp. *nuttalliae* (Saff.) H.D. Wilson & Heiser), pumpkin and zucchini flowers, called *ayoxochquílitl* (*Cucurbita* spp.), as well as flowers used to give aromas and flavors to beverages, such as *quauhxiúhtic*, *itzcuinyoloxóchitl* and *eloxochiquáhuitl* (Sahagún 1999). Flowers are still consumed in Mexico, especially in rural and indigenous communities, where the practices for their harvest, production, use, and preparation were developed and have been maintained (Ordoñez & Pardo 1982, Rangel 1987, LaFerriere *et al*. 1991, Mares 2003, Centurión *et al*. 2004, Chávez 2010). In Mexico, edible flowers are considered to belong to the category of *quelites* (from *Nahuatl quilitl* = edible herb), a generic term used to refer to edible stems, leaves and flowers, which includes seasonal food collected from the wild or associated to other main crops such as maize (Bye 1981, Mapes & Basurto 2016).

In the arid zones of Mexico, most of the flowers consumed are from cacti and agaves, while in tropical climates, they are mainly palm flowers (Arecaceae) (Mapes & Basurto 2016). Most of these are native and wild, and therefore are extracted from natural ecosystems. These genetic resources represent an important usable biological material, since in addition to the great genetic diversity contained, they play a crucial role in the daily life of many people. They are self-consumption resources, form part of the daily diet, are elements of the identity of cultural groups, and generate income for families when they are sold (Casas & Parra 2017).

Generally, these resources are commercialized locally by small producers or gatherers, mostly women, in local and traditional markets. Local and traditional markets are spaces where products native to the regions where they are established are commercialized and exchanged, and they are a source of knowledge of the biological and cultural diversity of rural and indigenous communities (Bye & Linares 1983).

In recent decades, the consumption of flowers has presented a strong dichotomy. On the one hand, because they are a seasonally gathered food and historically consumed by rural or indigenous populations, they have been assigned negative stigmas and prejudices, disparaging their consumption. This has led to the decrease in commercialization

and consumption of many of these products (even in the localities where they are produced), which is accompanied by a loss of traditional knowledge including the methods for obtaining flowers (*e.g.*, timing of collection, the forms of harvesting, and propagation), as well as the methods and recipes for consuming them. At the same time, there has been growing interest in this food group, which has led to gourmet restaurants featuring flower dishes and an increase in the publication of recipe books with these recipes. The gastronomy of "floriphagia" has become popular for offering visually attractive and fresh dishes with exotic aromas and delicate flavors (Pires *et al*. 2018, Fernandes *et al*. 2019).

Under this scenario, edible flowers are simultaneously being abandoned by the cultures that have developed the body of knowledge necessary for their production, and subject to a growing demand from cities due to their great nutritional potential. The combination of these two phenomena could lead to overexploitation of these resources. Without adequate management strategies to ensure their maintenance, this could lead to the decline of the populations of these resources and a deterioration of the ecosystems to which they belong (López 2008).

The objectives of this research were 1) to document the edible flowers that are commercialized in local markets of the city of Pachuca de Soto, Hidalgo (central Mexico), 2) to describe their forms of preparation, 3) to synthesize their nutritional contributions to the diet and conservation category and criteria through a bibliographic review. We analyze the state of management and conservation of these genetic resources and aimed to contribute to the revaluation of these foods and the people who produce them.

Materials and methods

Study site. For this research, three flower marketing points were visited-the *Mercado 1ro. de Mayo*, *Mercado Benito Juárez*, and a street vendor in the *Cajas Reales* area. These spaces have been in operation for over 70 years in the city of Pachuca de Soto. The sales spaces studied were movable street stalls that are concentrated on weekends, located around the perimeter of the market buildings (Figure 1).

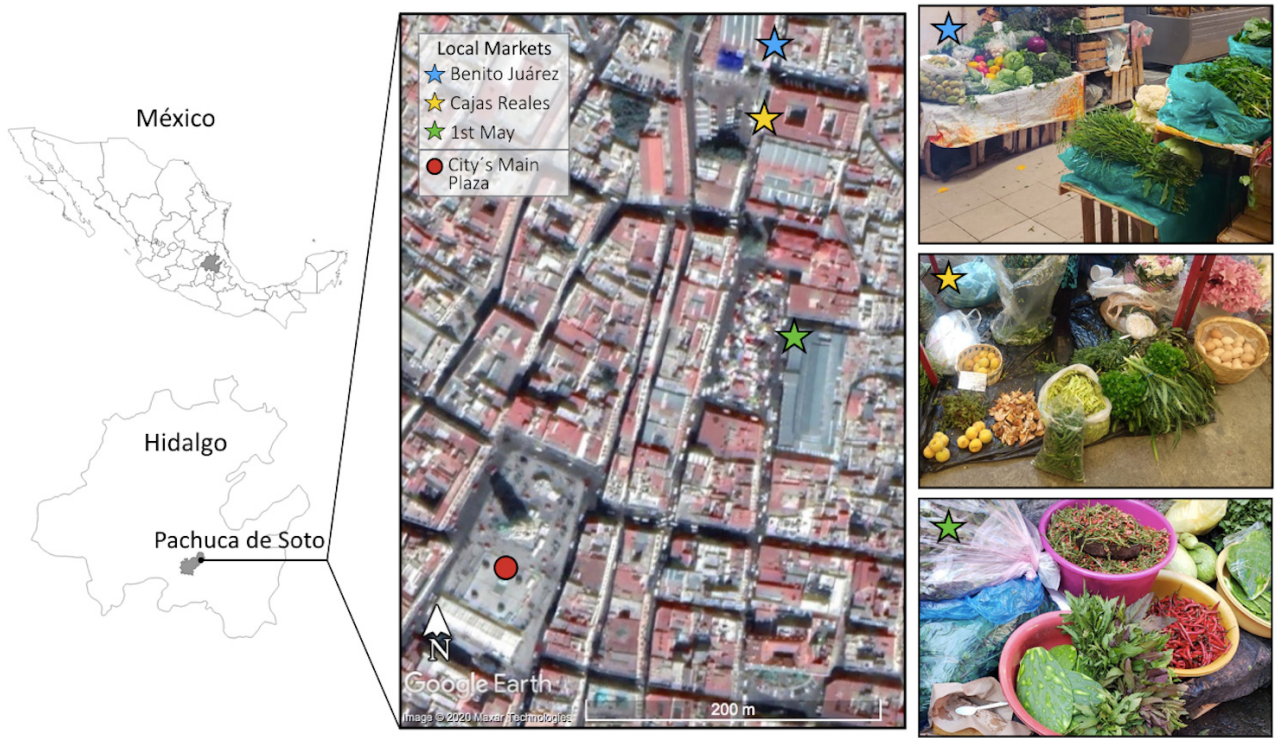

Figure 1. Local markets studied of Pachuca de Soto, Hidalgo, Mexico. (Photos CJ Figueredo-Urbina).

The number of stalls selling edible flowers varied over time; of the 11 stalls identified, we considered only the six stalls that were constant. Four were in *Cajas Reales*, one was in the *Mercado Benito Juárez*, and one in the *Mercado 1ro de Mayo*.

Market visits and information gathering. At the beginning of the research, we established contact with the vendors, presented the study project, its aims and methods and asked their consent to collaborate with us. The written testimonies and photographs were taken only after receiving verbal permission. This research was carried out following the Latin American Society of Ethnobiology's (SOLAE) the Code of Ethics for research, action research, and ethnoscientific collaboration in Latin America. From January 2019 to January 2020, two visits were made per month. The purchase interview technique was carried out (Bye & Linares 1983), and semi-structured interviews (n = 40, Bernard 1995) were conducted in order to investigate biocultural data on the edible flowers, organized into the following questions: 1) the common names by which the flower is known, 2) how to prepare it, 3) source of the resource, i.e., if the flower was cultivated or collected from the wild, and 4) locality where the flower originated. In addition, direct observations were made, and we photographed the edible flowers that were for sale. We used the online platform Naturalista (www.naturalista.mx), the book "Plantas útiles del estado de Hidalgo" (Villavicencio & Pérez 2006), and the dichotomous keys in Flora Fanerogámica del Valle de México (Rzedowski & Rzedowski 2005), to identify the flowers to the species level.

Nutritional content and conservation status. The nutritional information of the flowers was compiled by reviewing the literature. The Ethnobotanical Plant Database of Mexico (*Base de Datos Etnobotánicos de Plantas de México*, (Caballero *et al*. 2020 BADEPLAM) was consulted to compare with the records obtained in this study. BADEPLAM is a database of the current state of knowledge of plant-human interaction, was created by Dr. Javier Caballero, renowned ethnobiologist at the Botanical Garden of UNAM, Mexico, where information has been compiled for some 30 years (Clement *et al*. 2021).

NOM-059 (SEMARNAT 2010), the International Union for Conservation of Nature (IUCN 2020) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) were consulted to determine the conservation status of the wild species.

Results

Markets and vendors. The largest number of vendors were present during weekend days, although some sold their products every three days depending on the availability and quantity of flowers they managed to obtain. The information from the six main vendors studied is shown in Table 1. The vendors had been attending these local markets to sell their products for decades, and they belonged to different ethnic groups from neighboring rural communities (Table 1). The main town of origin of the vendors, as well as the locality where they obtained their products, was San Miguel Cerezo in the Pachuca de Soto municipality.

The unit of sale of small flowers was the *lata* (tin) these are 425-gram net weight. They were also sold in plastic bags containing one or two *latas*. Larger flowers were sold by *manojo* (bundle, 100 to 300 g). Flower prices ranged from 10-15 Mexican pesos (0.5-0.75 USD) per unit (*manojo* or *lata*). When the flower season was over and their abundance therefore decreased, the unit price increased to 20-25 Mexican pesos (1 USD). The vendors collected the flowers from xerophilous scrub, which they refer to as the *cerro* (the hill) and from pine-oak forests, which they call the *monte* (the mountains) or cultivate them in their *milpa* or homegardens.

Edible flowers. Twelve types of edible flowers were recorded, corresponding to 13 taxonomic entities (Table 2). The plant family with the largest number of edible flowers recorded in the markets was Asparagaceae, with four species. The most frequently sold flower was the *Gualumbo (Agave salmiana* Otto ex Salm-Dyck and *A. mapisaga* Trel.); it was marketed in five of the six stalls at quantities of more than 15 kilogram (kg) per week. The flower that was available

Table 1. Characteristics of the vendors studied in the markets of Pachuca de Soto, Hidalgo.

Vendor	Local market	Locality of origin	Gender	Age	Cultural group	Edible flowers for sale
1	*Benito Juárez*	Santiago de Anaya, Hgo.	Female	80	Hñähñu	*Gualumbo, flor de sotol, flor de palma, garambullo, huauzontles, flor de calabacita, flor de madroño*
2	*Cajas Reales*	Acaxochitlán, Hgo.	Female	50	Nahua	*Flor de ayocote, pemuches*
3	*Cajas Reales*	San Miguel Cerezo, Hgo.	Female	50	Mestizo	*Gualumbo, flor de sotol, flor de palma, flor de sábila, garambullo, flor de calabacita, flor de madroño*
4	*Cajas Reales*	San Miguel Cerezo, Hgo.	Female	55-60	Mestizo	*Gualumbo, flor de sotol, flor de palma, garambullos, flor de calabacitas, flor de madroño, flor de cuaresma*
5	*Cajas Reales*	San Miguel Cerezo, Hgo.	Male	27	Mestizo	*Gualumbo, flor de palma, garambullo, huauzontles, flor de calabacita, flor de madroño*
6	*1ro. de Mayo*	San Miguel Cerezo, Hgo.	Female	80	Hñähñu	*Gualumbo, flor de sotol, flor de palma, huauzontles, flor de calabacita, flor de calabaza grande.*

for the largest portion of the year (seven months) was the *Huauzontle* (*Chenopodium berlandieri* subsp. *nuttalliae*). The characteristics of each recorded flower and its associated nutrients and bioactive compounds are described below:

Huauzontle.- These consist of the tender stems and tiny flower clusters with greenish petals of *Chenopodium berlandieri* subsp. *nuttalliae*. These were most often sold by the *manojo* (bundle), although there are other vendors who sell by weight (Figure 2A). They contain high contents of vitamins A, B, C, and E, as well as iron, phosphorus, and calcium (Román-Cortés *et al*. 2018). They are frequently prepared during the religious dates of Lent and Holy Week. All recipes begin with boiling them for a few minutes to eliminate bitter flavors. They are mainly prepared in a savory pancake with or without tomato broth, egg-battered with or without tomato broth, or used as an ingredient in salads.

Gualumbos.- Their other common names include *golumbos*, *flor de quiote* or *flor de maguey*. In the Mezquital Valley, they are called *nthembo* (from the *hñähñu* language) and in other regions of the country are known as *cacayas* or *bayusas*. These flowers are collected from *maguey manso* or *maguey pulquero* (*Agave salmiana* and *A. mapisaga)*. Once collected, all of the greenish-yellow flower buds are defoliated and cleaned, removing the pistil, stamens, and ovary, selling only the petals or tepals (Figure 2B). They are displayed in plastic bags weighing about 10 kg, and the sales unit is the tin or in plastic bags that contain one or two tins. They are also offered in fists or *manitas*, which are the clusters of the flowers or raceme that have not been cleaned. Other species of the genus are also consumed, such *as A. marmorata* in Puebla or *A. inaequidens* in Michoacán. These flowers provide fiber, protein, minerals, carotenoids, ascorbic acid and saponins (Sotelo *et al*. 2013, Pinedo-Espinoza *et al*. 2020). Saponins can have a bitter or spicy flavor, so the flowers are soaked or boiled for a few minutes at the beginning of their preparation. This was the flower for which the largest number of preparation methods were reported (six; Table 2).

Flor de sotol.- These are collected from the plant known as *sotol* or *cucharilla* (*Dasylirion acrotrichum* Zucc.). These flowers were rare (Figure 2C), and they were sold by the *lata* or *puñado* (handful) and in small quantities. The green-brown flower buds from the racemes are sold. We did not find records of the nutritional content of these flowers. In the Mezquital Valley, they are consumed in a sauce prepared with *xoconostle* (*Opuntia joconostle* F.A.C. Weber ex Diguet) (Peña & Hernández 2014).

Table 2. Edible flowers recorded in the local markets studied of Pachuca de Soto, Hidalgo.

Common name	Family	Species	Origin	Managemet	Cooking method	Temporality	Consumption in other states	NOM-059	IUCN	CITES
Huauzontle	Amaranthaceae	*Chenopodium berlandieri* subsp. *nuttalliae*	N	Cultivated	4, 5, 7	March to September	Baja California, Guerrero, Oaxaca	NO	NE	NE
Gualumbo	Asparagaceae	*Agave salmiana*	N	Wild harvest (xeric shrublands) and cultivated	1, 2, 3, 4, 6,8	March to May	Puebla	NO	LC	NE
	Asparagaceae	*A. mapisaga*	N	Cultivated	1, 2, 3, 4, 6,8	March to May	Ciudad de México, Tamaulipas	NO	NE	NE
Flor de sotol	Asparagaceae	*Dasylirion acrotrichum*	N	Wild harvest (xeric shrublands)	2, 4	February	Puebla	A	NE	NE
Flor de palma	Asparagaceae	*Yucca filamentosa*	N	Wild harvest (xeric shrublands)	1, 2, 3, 4, 8	February to July	Aguascalientes, Nuevo León, Puebla	PR	NE	NE
Flor de sábila	Asphodelaceae	*Aloe vera*	I	Cultivated	3, 8	September	Puebla	NO	NE	NE
Garambullo	Cactaceae	*Myrtillocactus geometrizans*	N	Wild harvest (xeric shrublands)	1, 2, 3, 4, 5, 6	March to May	Puebla	NO	LC	Appendix 2
Flor de calabacita	Cucurbitaceae	*Cucurbita pepo* ssp. *pepo*	N	Cultivated	2, 3	June to August	Chiapas, Guerrero, Oaxaca, Puebla, Veracruz	NO	NE	NE
Flor de calabaza grande	Cucurbitaceae	*C. moschata*	N	Cultivated	2, 3	August	-	NO	-	NE
Flor de madroño	Ericaceae	*Arbutus xalapensis**	N	Wild harvest (pine-oak forest)	4	February to April	Chihuahua	PR	LC	NE

Common name	Family	Species	Origin	Managemet	Cooking method	Temporality	Consumption in other states	NOM-059	IUCN	CITES
Flor de ayocote	Fabaceae	*Phaseolus coccineus*	N	Wild harvest (pine-oak forest) and cultivated	4	January, July to September	Chiapas, Puebla, Tlaxcala	NO	LC	NE
Pemuches or *colorín*	Fabaceae	*Erythrina americana*	N	Wild harvest (pine-oak forest) and cultivated	4	November to February	Estado de México, Guanajuato, Guerrero, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, San Luis Potosí, Tabasco, Veracruz	A	NE	NE
Flor de cuaresma	Eupphorbiaceae	*Euphorbia radians*	N	Wild harvest (pine-oak forest)	4, 7	March	-	NO	NE	NE

Origin: N= native, I= introduced.

Cooking method: 1 = *asados en el comal* (roasted on the griddle), 2 = *guisados a la mexicana* (stewed *Mexican-style*), 3 = *guisados en quesadillas* (stewed, then added to *quesadillas*), 4 = *tortitas con o sin caldillo de jitomates* (savory pancake with or without tomato broth), 5 = *capeados con o sin caldillo de jitomate* (egg-battered, with or without tomato broth), 6 = as an additional ingredient of meat stews, 7 = added to salads, 8= with scrambled eggs. NOM-059: PR = subject to special protection, A = threatened, NO = not listed. IUCN: LC = least concern, NE = not evaluated. CITES: Appendix 1 = endangered species, trade is authorized only under special circumstances, Appendix 2 = species that are not necessarily endangered, trade should be controlled NE = not evaluated. *could also be the species *A. bicolor*.

Figure 2. Edible flowers commercialized in the local markets studied of Pachuca de Soto, Hidalgo, Mexico. A) *Huauzontle*, B) *Gualumbos*, C) *Flor de sotol*, D) *Flor de palma*, E) *Flor de sábila* (Photos CJ Figueredo-Urbina).

Flor de palma.- This flower does not actually come from a palm, but rather from plants in the family Asparagaceae (*Yucca filamentosa* L., Figure 2D). In the stalls these flowers were displayed in 10 to 15 kg plastic bags and sold by the *lata* or *puñado*. The flowers are greenish-white in color and contain ascorbic acid, calcium and protein as well as saponins, (Peña & Hernández 2014, Pinedo-Espinoza *et al*. 2020), which give them a bitter and slightly spicy flavor, so they are soaked or boiled for a few minutes when preparing them. The vendors commented that exposing the flowers to the sun for a few hours eliminates the bitter taste.

Flores de sábila.- *Aloe vera* (L.) Burm.f. is not native to Mexico; it is native to Africa and was introduced to America by European contact and is now widely cultivated around the world (Figure 2E). The flowers were offered as *manojos*; its sale was rare and in low quantities. These flowers have high fiber content and medium protein content, contain minerals like phosphorus, and have low antioxidant activity (Pinedo-Espinoza *et al*. 2020).

Garambullos.- Also called *clavel de garambullo*, these are the flowers of the columnar cacti of the same name (*Myrtillocactus geometrizans* Console) (Figure 3A). These flowers have white petals, are delicate and wilt quickly. They were presented at market stalls in small open bags, sold by the *lata* or the bag. They contain high concentrations of potassium and calcium and have phenolic compounds and antioxidant activity (Pinedo-Espinoza *et al*. 2020). In the Mezquital Valley, they are the base of many dishes, such as *sopa de frijol quebrado con garambullos*, *gorditas*, *quesadillas* and scrambled eggs (Peña & Hernández 2014).

Flor de calabacita.- Zucchini flowers (*Cucurbita pepo* ssp. *pepo*) were frequently commercialized in the market (Figure 3B). However, on one occasion one of the vendors offered large pumpkin flowers (*C. moschata* (Duchesne ex Lam. Duschesne ex Poir, 1818), both of which were sold by the *manojo*. The flowers are yellow and contain the precursor compounds of vitamins A and C, in addition to high levels of fiber, folic acid, riboflavin, niacin, and minerals such as calcium, phosphorus, iron and potassium (Sotelo *et al*. 2013).

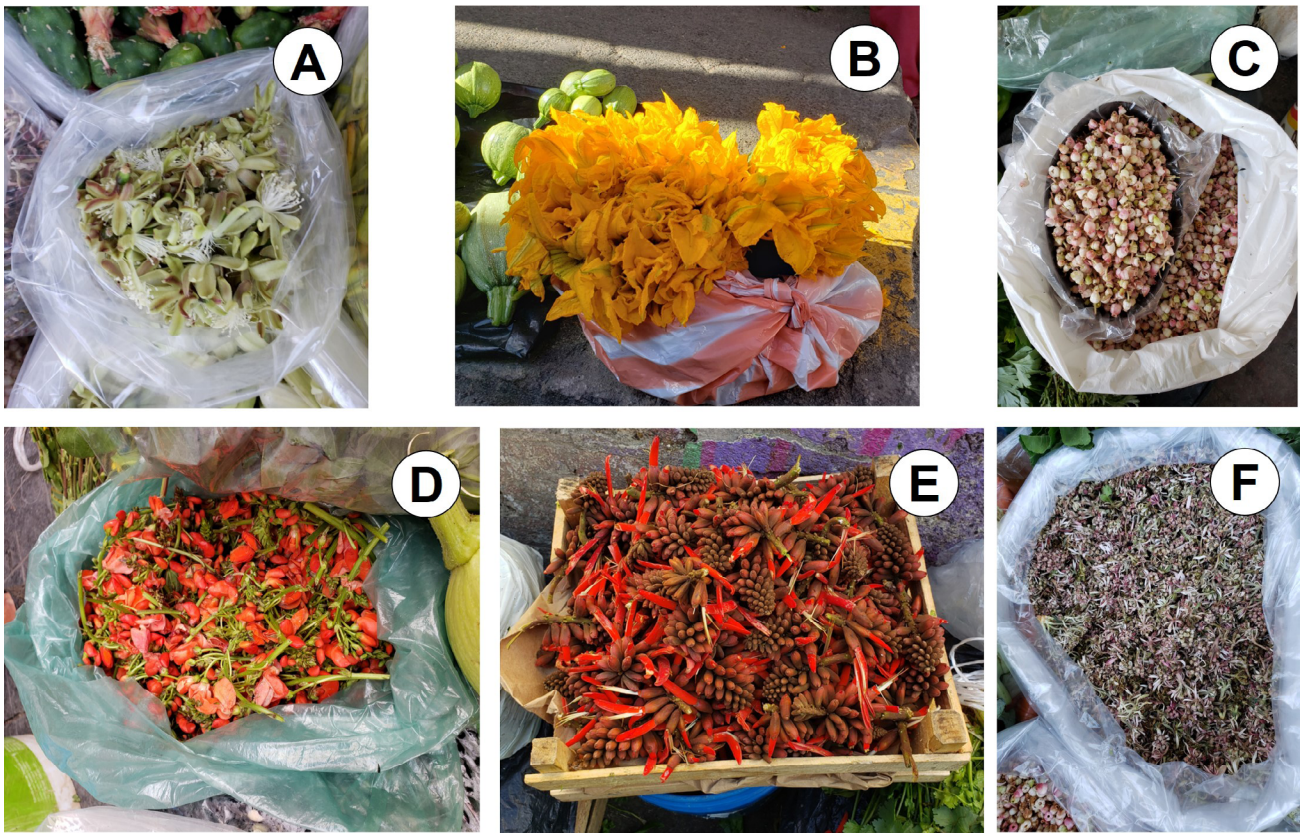

Figure 3. Edible flowers commercialized in the local markets studied in Pachuca de Soto, Hidalgo, Mexico. A) *Garambullos*, B) *Flores de calabacita*, C) *Flores de madroño hembra*, D) *Flor de ayocote*, E) *Pemuches,* F) *Flores de cuaresma* (Photos CJ Figueredo-Urbina).

Flores de madroño.- These are the flowers of the species *Arbutus xalapensis* Kunth (Figure 3C). They were transported in kitchen utensils such as strainers or plastic bags and sold by the *lata*. The flowers are bell-shaped, and two types of these flowers, differentiated by color, were identified: the white *machos* were more common than the pink *hembras*. The flowers have high levels of fiber and minerals, but low protein content (Sotelo *et al*. 2013).

Flor de ayocote.- These are the flowers of *Phaseolus coccineus* L., called *ayocote*, *ayecote* or *ayocotli*, *Nahuatl* root words. They were sold in plastic bags or by the *puñado*. They are red or orange in color due to their anthocyanin content, compounds which have antioxidant activity (Figure 3D). The traditional way of preparing these flowers is as *tortitas en caldillo de jitomate* (Table 2).

Pemuches or colorín.- These flowers are obtained from the tree *Erythrina americana* Mill. (Figure 3E). They were sold by the *lata* or *puñado*. The flowers are red and grouped in a cluster. The flower buds and open flowers are consumed, in both cases removing the pistils and stamens because they have a bitter taste. They are mainly prepared as savory pancakes (Table 2). The flowers contain bioactive compounds such as alkaloids, although in lower concentrations than the seeds of the plant, so they also have medicinal uses. They also contain high levels of calcium (Sotelo *et al*. 2013, Pinedo-Espinoza 2020). The flowering coincides with the religious celebration of Holy Week when people abstain from meat the consumption, and it is sometimes known as *carne de vigilia* (abstinence meat).

Flor de cuaresma.- These flowers are collected from *Euphorbia radians* Benth., an herb that reaches 25 cm in height (Figure 3F). These flowers are grouped in a structure called the cyathium, surrounded by bracts or pink hypsophylls,

and are modified unisexual flowers. They were brought to the markets in plastic bags and sold by the *lata*. This flower is consumed during the celebration of Lent (*cuaresma*) and Holy Week, hence its name. The vendors identified two types of flowers, normal and large, determined by the size of the petals (bracts). These flowers are collected in shady places in the pine-oak forest. They have high protein and fiber contents (Sotelo *et al*. 2013).

Recipes. Eight forms of flower preparation were recorded (Table 2, Figures 4, 5). Here we describe two of the recipes collected, which were the most frequently mentioned and that can be used to prepare most of the reported flowers.

Gualumbos a la mexicana (Mexican Style Gualumbos).- Ingredients for 4 servings: 2 tomatoes (*Solanum lycopersicum*), 1 medium white onion (*Allium cepa*), 2 tablespoons of your choice of oil, 1 serrano pepper (*Capsicum annuum*) (two, if you like it hotter), two *latas* of cleaned *gualumbos* (about 300 grams) and a few sprigs of coriander (*Coriandrum sativum*) or epazote (*Dysphania ambrosioides*). Preparation: 1) Bring water to a boil in a pot; once

Figure 4. Some of the culinary flower preparations recorded in this study: A) Fresh *gualumbos* ready to cook, B) *Gualumbos* cooked in the Mexican Style, C) Mexican Style flower preparations: 1) *flores de madroño*, 2) *gualumbos*, 3) *garambullos*, D) Fresh *garambullos* ready to cook, E) Flower preparation: 1) Mexican Style *garambullos*, 2) Roasted *gualumbos* with garlic and onion, F) Fresh *flores de madroño macho*, G) Mexican Style *flor de madroño*, H) Tacos with Mexican Style *gualumbos* with egg, i) *Quesadilla de flor de calabacitas* (Photos CJ Figueredo-Urbina, GD Álvarez-Ríos).

boiling, add the *gualumbos* and leave them for 5 minutes or until the color of the petals clears. 2) Remove from the heat and drain. 3) Clean and chop the onion. 4) In a frying pan add two tablespoons of oil and fry the onion. 4) Wash and chop the tomatoes, add them to the onions. 5) Wash and devein the chilies, chop, add to the pan, and stir. 6) Add the *gualumbos*, stir, and cook for 15 minutes over low heat, placing a lid on the pot. 7) Wash and chop the coriander or epazote, add to the mixture, salt to taste, turn off the heat, and cover. Serve in *tacos*, *quesadillas*, mixed with eggs, or added to meat stews (Figure 4A, B, C).

Tortitas de huauzontles con caldillo de miltomate (Savory Huauzontle pancakes in miltomate broth).- Ingredients for 4 servings: two *manojos* of *huauzontles* (280 grams approx.), 4 eggs, ½ cup of wheat flour, 1 teaspoon of baking powder, 2 *lata* of tomatoes (S. *lycopersicum*), ½ onion (*A. cepa*), a few sprigs of epazote *(D. ambrosioides*), oil for frying. Optional: cumin (*Cuminum cyminum*), pepper (*Piper nigrum*) and chili (*C. annuum*). Preparation for the broth: 1) Boil the whole tomatoes for five minutes. 2) Remove from the heat, let cool, blend whole with a small amount of the boiling liquid, and set aside. Preparation of the savory pancakes: 1) Separate the *huazontle* flowers from the main stem, place in a bowl. 2) Add the eggs and beat. 3) Sift the flour and add to the mixture along with the teaspoon of baking powder and beat. 4) Add salt, pepper, and/or cumin. 5) Add plenty of oil in a frying pan; when the oil is hot, take ¼ cup of the mixture and fry on both sides. 6) Drain the savory pancakes on absorbent paper. 7) Heat the tomato sauce, wash and chop the epazote and add to the sauce, stir, turn off the heat, and cover. To serve, place the *tortitas* in a bowl and add the broth (Figure 5A, B, C).

Risk and conservation categories. Of the 13 species recorded in this study, four appear in Mexico's conservation legislation, NOM-059 (SEMARNAT 2010); two are in the category of Subject to Special Protection (PR): *flor de madroño* (*Arbutus xalapensis*) and *flor de palma* (*Yucca filamentosa*). These species could increase their risk status if the factors that negatively affect their viability are intensified. The other two species are in the Threatened category

Figure 5. Some of the culinary flower preparations recorded in this study: A) *Huazontles* ready to cook, B) Tomato variety known as *miltomate* (*Solanum lycopersicum*), C) Dish of *tortitas huauzontles con caldillo de miltomate*, D) Fresh *flores de ayocote*, E) *Tortitas de ayocote*, F) Dish of *tortitas de flor de ayocote* with *miltomate* broth and rice. (Fotos C.J. Figueredo).

(A), *pemuches* (*Erythrina americana*) and *flor de sotol* (*Dasylirion acrotrichum*), which could be in danger of disappearing in the short or medium term if habitat deterioration or modification continues or the size of their populations decreases. On the IUCN (2020) red list, four species were listed in the least concern category (LC)-the *gualumbos* (*Agave salmiana*), *flor de madroño* (*Arbutus xalapensis*), *garambullo* (*Myrtillocactus geometrizans*) and *flor de ayocote* (*Phaseolus coccineus*), therefore their populations are not considered seriously affected, the rest are not evaluated. The only species that was classified in Appendix II of CITES was *Myrtillocactus geometrizans*; while the wild populations are not threatened by extinction, they suggest that the sale of these flowers is subject to regulation.

Discussion

The edible flowers in these markets were mainly commercialized by women, as has been reported by De la Peña & Illsley (2001) in other regions of the country. Other studies in Europe indicated that gathering of plants was usually regarded as an activity for women (Pieroni 1999, Christanell *et al.* 2010). The studies that have been carried out on food in Mexico have made it possible to highlight the importance of women, and particularly indigenous women, in the transmission of knowledge from generation to generation, which ranges from instruments for collecting food, to the transport to the house and the markets for their sale, to the methods for preparing these products. In this study, even though it is a local market in the main city of the state, we show that indigenous women play a fundamental role in maintaining the knowledge and tradition around edible flowers.

For the species documented in this study, we found 59 records in BADEPLAM, record of its consumption in 16 states of the Mexico (Table 2). No records were found for the species *Cucurbita maxima* and *Euphorbia radians*. Specifically, for the state of Hidalgo, there were 38 BADEPLAM records that included 30 plant species belonging to 15 botanical families whose flowers are consumed or used in culinary preparations as colorants or flavorings for beverages (Table 3). The numbers of flowers that are commercialized in the local markets of Pachuca de Soto is about 20 % of the number of flowers consumed nationwide (according to Mapes & Basurto 2016) and in the state (according to the records in BADEPLAM). We can comment that the differences in the number of edible flowers registered for the state (according BADEPLAM) and those registered in this study, could be due to: a) low availability of the resource (of some particular species), b) difficulty of collecting the resource, d) low demand in the markets, and/or e) very local or traditional consumption. It may also be due to the scale of the studies, that is, a greater number of markets and different bibliographic sources. Furthermore, the number of edible flowers recorded in this study was lower than those recorded in traditional markets in Oaxaca (n = 17), where *Huazontles*, *Flor de calabacitas* and *Flor de Ayocote* were also sold.

Squash flowers are the most consumed edible flower in Mexico. They are produced on a larger scale and sold in markets throughout the country, and in local markets in other regions of Mexico, the flowers of the *pipiana* squash (*C. argyrosperma* C. Huber) and *chilacayote* (*C. ficifolia* Bouché) are also consumed.

A larger number of flowers were marketed during the season of Lent, since flowers represent a food option for this time of year when meat consumption is limited in the case of the Catholic religion.

The large volumes of *Gualumbo* flowers that are offered in the markets suggest that there is high demand, and larger volumes are sold weekly than other flowers. This fact may be because *Agave* plants produce an inflorescence with a large number of flowers (up to 12 kg), which may be more profitable for sellers and be easier to collect (Figueredo 2020). In this sense, the collection of wild plants differs in the amount collected when it is for self-consumption from those that are used for commercial purposes, where significant volumes are harvested (Blancas *et al*. 2020). For the *Gualumbos* it has been recorded that the collection for commercialization can become aggressive, including cutting the entire floral scape, compared to the self-consumption in which the form of collection is less aggressive and of lower quantities, since only the amount that will be consumed is taken on a given day (Figueredo 2020). However, for these flowers and other genetic resources, there is a lack of information on the consequences of this use to self-consumption and commercialization (Blancas *et al*. 2020, Figueredo 2020)

The consumption of flowers in Mexico is an activity that was already the custom of the people present before Spanish colonization (Sotelo *et al*. 2013). Currently, the activity is maintained and is becoming more and more popu-

Table 3. Recorded plant species for the state of Hidalgo whose flowers are consumed or used as flavorings and dyes in various traditional culinary preparations. Source: 1) this study and 2) BADEPLAM.

Family	Species	Common Name	Source
Amaranthaceae	*Chenopodium berlandieri* subsp. *nuttalliae*	*Huahquilitl, tlahuahquilitl, huauzontle*	1, 2
Asparagaceae	*Agave americana*	*Maguey blanco*	2
	A. applanata	*Maguey cenizo*	2
	A. lechuguilla	*Amole*	2
	*A. salmiana**	*Maguey manso*	1, 2
	A. striata	*Tha'mni*	2
	Dasylirion acrotrichum	*Sotol, manita*	1, 2
	Nolina parviflora	*Palma*	2
	Yucca filifera	*Palma*	1, 2
	Y. gigantea	*Izote*	2
Asphodelaceae	*Aloe vera*	*Sábila*	1
Cactaceae	*Myrtillocactus geometrizans*	*Garambullo*	1, 2
Convolvulaceae	*Ipomoea stans***	*Pexpo*	2
Crassulaceae	*Sedum goldmanii*	*Chisme*	2
Cucurbitaceae	*Cucurbita moschata*	*Ra demu*	1, 2
		Calabaza grande	
	C. pepo	*Calabacitas*	1
Ericaceae	*Arbutus xalapensis*	*Madroño*	1, 2
	Arctostaphylos pungens	*Madreselva*	2
Euphorbiaceae	*Cnidoscolus multilobus*	*Ortiga, totopo*	2
	Euphorbia radians	*Cuaresma*	1
Fabaceae	*Erythrina americana*	*Pemuches, colorín, quiquimite*	1, 2
	Leptospron adenanthum	*Ra thengabonju*	2
	Prosopis laevigata	*Mezquite*	2
	Phaseolus coccineus	*Ayocote*	1,2
Marcgraviaceae	*Souroubea exauriculata*	*Ra donts'andämmbe*	2
Orobanchaceae	*Castilleja moranensis*	*Hierba del conejo de llano*	2
	Conopholis alpina	*Mazorca de zorra*	2
Rubiaceae	*Bouvardia longiflora*	*Flor de San Juan*	2
Solanaceae	*Physalis coztomatl*	*Guarumbo*	2
Violaceae	*Viola painteri*	*Clavelito de campo*	2

*flavoring; **only dye

lar in avant-garde gastronomy. There are important cookbooks that collect cultural information about edible flowers and their recipes, as part of the safeguarding of this national heritage. This list includes "Las flores de la cocina mexicana" which compiles 122 recipes of approximately 35-40 different types of flowers, mostly native (except for the *Rosas* (*Rosa* spp. L., 1753), *Sábila* (*A. vera*) and *Flores de Plátanos* (*Musa* x *paradisiaca* L.) (Torres 2014). We also find the work of Sánchez (2017), "Las flores en la cocina Veracruzana" with 163 recipes of 40 flower species, which also includes the previously mentioned non-native species and the *flores de Azahar* (*Citrus* spp. L., 1753), *Jamaica* (*Hibiscus saddariffa* L., 1753), *flor de haba* (*Vicia faba* L., 1753*), Framboyan* (*Delonix regia* (Bojer ex Hook.) Raf.), flor de sacramento (*Calathea marantifolia* Standl.*)* and *Gardenias* (*Gardenia jasminoides* J. Ellis). Particularly for the state of Hidalgo, there is the book "Tradiciones de la cocina hñähñu del Valle del Mezquital" (Peña & Hernández 2014), which includes a total of 281 recipes, where 61 correspond to recipes with flowers of approximately 28 different taxa, either as the main ingredient or a secondary ingredient in the dish.

Flowers have been important elements of traditional cuisine worldwide, both in ancient times and today. For the South American region, data on edible flowers are scarce or non-existent. Recently, in the work of Clement *et al*. (2021), information is given on plants with edible uses in the Central Andes region (n = 424) and lowlands (n = 1719), but it is not specified how many correspond to edible flowers. Some works have carried out investigations that evaluate the nutrient content in flowers. In China, Zheng *et al*. (2018) and Li *et al*. (2014), have evaluated the antioxidant capacity of more than 60 species of flowers. In western Assan, India, 31 species of edible flowers have been recorded (Deka & Nath 2014), which contrasts with the records for the Mandal-Chopta Forest in Uttarakhand, India, where only five were recorded (Agarwal & Chandra 2019). The research of Khomdram *et al*. (2019) documented 59 species of edible flowers that are consumed by indigenous people of Mizoram in the Northeast of India.

In the Valais region of Switzerland, 98 species of traditionally consumed wild plants have been identified where the main part of the plant consumed is the flower (26 %) of 22 species, mainly prepared in teas (Abbet *et al*. 2014). Guiné *et al*. (2019), in Portugal, found that edible flowers have little tradition among the population and the main form of preparation is in drinks, while traditional dishes do not mention flowers as part of their ingredients, with the exceptions of cauliflower, broccoli and artichoke. However, in the northwest of the Iberian Peninsula (Spain and Portugal) flowers are consumed from 9 of the 97 species of edible plants (de Santayana *et al*. 2007). In the Mediterranean region of Garfagnana, Italy, 113 wild plants consumed as food have been recorded, of which only four correspond to flowers (Pieroni 1999). These data from various regions of the world reflect the high global diversity of edible flowers, which in some cases coincides with the numbers recorded in Mexico. This type of research is relevant in the context of food security, since it allows the identification, documentation and dissemination of information on edible flower species that offer affordable options for human nutrition (Takahashi *et al*. 2019). Unfortunately, with globalization and population growth, eating habits such as fast food has been adopted, mainly among the young population, which in part seem to be leading to the disappearance of knowledge about the traditional and cultural use of edible flowers. Rescuing this knowledge is a way of exploring the dietary diversity and the economic potential that wild species of edible flowers provide, preserving biodiversity and traditional knowledge (Takahashi *et al*. 2019, Harmayani *et al*. 2019).

It is important to highlight that edible flowers are a genetic resource with great economic and medical potential. An excessive demand for these resources would generate overexploitation, affecting the size and viability of their populations, as well as altering the biotic interactions with other organisms that sustain these resources (López 2008). For example, *gualumbos* are a valuable food resource for a wide spectrum of visitors including insects, birds, and bats. Intensive collection could reduce the number of flowers, affecting the populations of all of these species and of these plants themselves. The impacts of the overexploitation of these genetic resources could occur at three scales: 1) reduction or loss of the genetic diversity of the plant due to extraction or impeding sexual reproduction and dispersal of seeds of a certain genotype, 2) demographic impacts from the reduction or extinction of populations and 3) impacts on ecological communities and interaction networks with the loss of ecosystem functions and processes (Hall & Bawa 1993, López 2008). The increase in the commercialization and consumption of some flowers could

lead to their decrease, which would affect the species, the ecosystems where they are found and the communities that use them.

This depletion of the resource could be an underlying cause of loss of diversity or lead to species being placed in alarming categories such as endangered (Broad *et al*. 2003, Stewart 2003). Furthermore, the overexploitation of the resource may lead to the economic decline of the families of managers and vendors themselves, who depend on the economic income from the sale of these resources.

For the most part, for the genetic resources commercialized in the markets studied, the total quantities sold and current state of the wild populations under extraction are unknown. Likewise, social aspects of harvesting are not known, such as the precise practices of obtaining flowers, the contribution to the family economy of the sale of flowers, and the cultural motivations that influence the sale of certain flowers over others. It is necessary to generate this type of information so that the status of these resources can be evaluated through social and ecological indicators in order to propose sustainable management and conservation plans (Sheil & Wunder 2002).

Edible flowers are an important genetic resource, providing economic income to vendors, and the diversity of their preparation reflects the great traditional knowledge of these groups. Despite the fact that the majority of the recorded species are not currently in risk categories, they are frequently collected from natural ecosystems and are the reproductive part of the plant, so an increase in demand could have consequences for the long-term permanence of these plants. However, before establishing management and conservation strategies, the ecological and demographic status of these genetic resources must be documented. Their ecological importance is added to their cultural importance, since edible flowers are an important source of nutrients and part of the cultural identity of indigenous and mestizo groups, both in rural contexts where they are obtained and in urban contexts where they are commercialized.

Acknowledgements

We thank the vendors of the *1ro. de Mayo*, *Benito Juárez* and *Cajas Reales* markets, who always showed interest and willingness to support us in this research, responding with kindness and enthusiasm to our doubts, even while attending to their work. All the information presented was generated with the informed consent of all the participants. This work was self-funded by the first author and is part of the project Cátedras CONACYT-1245-*Genética de la conservación de la biodiversidad en el estado de Hidalgo*.

Literature cited

Abbet C, Mayor R, Roguet D, Spichiger R, Hamburger M, Potterat O. 2014. Ethnobotanical survey on wild alpine food plants in Lower and Central Valais (Switzerland). *Journal of Ethnopharmacology* **151**: 624-634. DOI: https://doi.org/10.1016/j.jep.2013.11.022

Agarwal R, Chandra V. 2019. Diversity of wild edible plants in the Mandal-Chopta forest, Uttarakhand. *Journal of Medical Plants Studies* **7**: 89-92.

Barros L, Carvalho AM, Ferreira IC. 2010. Leaves, flowers, immature fruits, and leafy flowered stems of *Malva sylvestris*: a comparative study of the nutraceutical potential and composition. *Food Chemical Toxicologycal* **48**: 1466-1472. DOI: https://doi.org/10.1016/j.fct.2010.03.012

Benvenuti S, Bortolotti E, Maggini R. 2016. Antioxidant power, anthocyanin content and organoleptic performance of edible flowers. *Scientia Horticulture* **199**: 170-177. DOI: https://doi.org/10.1016/j.scienta.2015.12.052

Bernard HR. 1995. *Métodos de investigación en Antropología. Abordajes cualitativos y cuantitativos*. London United Kingdom: Altamira Press. ISBN: 0-8039-5244-9.

Blancas J, Beltrán L, Maldonado B, Sierra-Huelsz J, Méndez L, Mena F, García Lara F, Fitz I, Hernández J. 2020. Comercialización de especies arbóreas utilizadas en la medicina tradicional y su impacto en las poblaciones sil-

vestres. *In*: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) y Gobierno del Estado de Morelos, eds. *La biodiversidad en Morelos. Estudio de Estado 2. Volumen III*. México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad - Gobierno del Estado de Morelos. ISBN: 978-607-8570-42-3

Broad S, Mulliken T, Roe D. 2003. The Nature and Extent of Legal and Illegal Trade in Wildlife. *In*: Oldfield S, ed. *The Trade in Wildlife. Regulation for Conservation*. Earthscan: Londres, pp. 3-12. ISBN: 1 85383959 0.

Bye R. 1981. Quelites-ethnoecology of edible greens-past, present and future. *Journal of Ethnobiology* **1**: 109-123.

Bye RA, Linares E. 1983. The role of plants found in the Mexican markets and their importance in ethnobotanical studies. *Journal of Ethnobiology* **3**: 1-13.

Caballero J, Martínez-Ballesté A, Cortés L. 2020. Base de Datos Etnobotánicos de Plantas de México (BADEPLAM). México: Jardín Botánico-Instituto de Biología, Universidad Nacional Autónoma de México.

Casas A, Parra F. 2017. Manejo de recursos naturales y ecosistemas: la sustentabilidad en el manejo de recursos genéticos. *In*: Casas A, Torres-Guevara J, Parra F, eds. *Domesticación en el continente americano. Manejo de biodiversidad y evolución dirigida por las culturas del Nuevo Mundo*. Lima, Perú: Fondo Editorial Universidad Nacional Agraria La Molina. ISBN: 978-612-4147-59-3.

Centurión D, Cázares J, Espinosa J. 2004. *Inventario de recursos fitogenéticos alimentarios de Tabasco*. Villahermosa, Tabasco: Universidad Juárez Autónoma de Tabasco. ISBN: 968-574-8357.

Chávez E. 2010. *Plantas comestibles no convencionales en Chiapas*. Tuxtla Gutiérrez: Universidad de Ciencias y Artes de Chiapas. ISBN: 978-607-7510-08-6.

Christanell A, Vogl-Lukasser B, Gütler M,Vogl CR. 2010. The cultural significance of wildgathered plant species in Kartitsch (Eastern Tyrol, Austria) and the influence of socioeconomic changes on local gathering practices. *In*: Pardo de Santayana M, Pieroni A, Puri R. *Ethnobotany in the New Europe: People, Health and Wild Plant Resources*. Berghahn Press, Oxford, UK: ISBN: 978-1-78238-125-9.

CITES. 2020. The Convention on International Trade in Endangered Species of Wild Fauna and Flora. cites.org (accessed October 30, 2020).

Clement C, Casas A, Parra F, Levis C, Peroni N, Hanazaki N, Cortes L, Rangel-Landa S, Alves R, Ferreira M, Cassino M, Deambrozi-Coelho S, Cruz A, Olivera M, Blancas J, Martínez-Ballesté A, Lemes G, Lotero-Velásquez E, Bertin V, Linden M. 2021. Disentangling Domestication from Food Production Systems in the Neotropics. *Quaternary* **4**: 4. DOI: https://doi.org/10.3390/quat4010004

Deka K, Nath N. 2014. Documentation of Edible Fowers of Western Assam. *American Journal of Phytomedicine and Clinical Therapeutics* **2**: 1124-1140.

De la Peña G, Illsley C. 2001. Los productos forestales no maderables: su potencial económico, social y de conservación. *La Jornada*. Sección Ecológica, 27 de Agosto de 2001. https://www.jornada.com.mx/2001/08/27/eco-a.html (consultado septiembre 2021)

Doyle JA. 2012. Molecular and fossil evidence on the origin of angiosperms. *Annual Review Earth Planetary Sciences* **40**: 301-326. DOI: https://doi.org/10.1146/annurev-earth-042711-105313

Fernandes L, Casal S, Pereira JA, Saraiva JA, Ramalhosa E. 2019. An Overview on the Market of Edible Flowers. *Food Reviews International* **36**: 258-275 DOI: https://doi.org/10.1080/87559129.2019.1639727

Figueredo CJ. 2020. Los gualumbos: deleite gastronómico del estado de Hidalgo. *Herreriana* **2**: 26-29. DOI: https://doi.org/10.29057/h.v2i1.5571

Guiné RPF, Florença SG, Ferrão AC, Correia PMR. 2019. Investigation about the consumption of edible flowers in Portugal. *Indian Journal of Traditional Knowledge* **18**: 579-588.

Hall P, Bawa K. 1993. Methods to Assess the Impact of Extractions of Non-Timber Tropical Forest Products on Plant Populations. *Economic Botany* **47**: 234-247. DOI: https://doi.org/10.1007/BF02862289

Harmayani E, Anal AK, Wichienchot S, Bhat R, Gardjito M, Santoso U, Payyappallimana U. 2019. Healthy food traditions of Asia: exploratory case studies from Indonesia, Thailand, Malaysia, and Nepal. *Journal of Ethnic Foods* **6**: 1. DOI: https://doi.org/10.1186/s42779-019-0002-x

Hochuli PA, Feist-Burkhardt S. 2013. Angiosperm-like pollen, and Afropollis from the Middle Triassic (Anisian)

of the Germanic Basin (Northern Switzerland). *Frontiers in Plant Science* **4**: 344. DOI: https://doi.org/10.3389/fpls.2013.00344

IUCN. 2020. The International Union for Conservation of Nature-IUCN Red List of Threatened Species. Version 2021-1. https://www.iucnredlist.org. (accessed October, 302020).

Kaisoon O, Konczak I, Siriamornpun, S. 2012. Potential Health Enhancing Properties of Edible Flowers from Thailand. *Food Research International* **46**: 563-571. DOI: https://doi.org/10.1016/j.foodres.2011.06.016

Kaisoon O, Siriamornpun S, Weerapreeyakul N, Meeso N. 2011. Phenolic compounds, and antioxidant activities of edible flowers from Thailand. *Journal of Functional Foods* **3**: 88-99. DOI: https://doi.org/10.1016/j.jff.2011.03.002

Khomdram S, Fanai L, Yumkham SD. 2019. Local knowledge of edible flowers used in Mizoram. *Indian Journal of Traditional Knowledge* **18**: 714-723.

LaFerriere J, Weber C, Kohlhep E. 1991. Use, and nutritional composition of some traditional mountain Pima plant foods. *Journal of Ethnobiology* **11**: 93-114.

Li AN, Li S, Li HB, Xu DP, Xu XR, Chen F. 2014. Total Phenolic Contents and Antioxidant Capacities of 51 Edible and Wild Flowers. *Journal of functional foods* **6**: 319-330. DOI: https://doi.org/10.1016/j.jff.2013.10.022

Loizzo MR, Pugliese A, Bonesi M, Concetta M, Menichini F, Xiao J, Tundis R. 2016. Edible Flowers: A Rich Source of Phytochemicals with Antioxidant and Hypoglycemic Properties. *Journal of Agricultural and Food Chemistry* **64**: 2467-2474. DOI: https://doi.org/10.1021/acs.jafc.5b03092

López R. 2008. Productos Forestales No Maderable: importancia e impacto de su aprovechamiento. *Revista Colombia Forestal* **11**: 215-231. DOI: https://doi.org/10.14483/udistrital.jour.colomb.for.2008.1.a14

Lu B, Li M, Yin R. 2016. Phytochemical Content, Health Benefits, and Toxicology of Common Edible Flowers: A Review (2000-2015). *Critical Reviews in Food Science and Nutrition* **56**. DOI: https://doi.org/10.1080/10408398.2015.1078276

Magallón S, Hilu KW, Quandt D. 2013. Land plant evolutionary timelines: Gene effects are secondary to fossil constraints in relaxed clock estimation of age and substitution rates. *American Journal of Botany* **100**: 556-573. DOI: https://doi.org/10.3732/ajb.1200416

Mapes C, Basurto F. 2016. Biodiversity and Edible Plants of Mexico. *In*: Lira R, Casas A, Blancas J, eds. *The ethnobotany of Mexico*. *Interaction of people and plants in Mesoamérica*. Springer p. 83-131. ISBN: 978-1-4614-6669-7.

Mares A. 2003. Recetario de comida de los Tarahumaras. México DF: CNCA Dirección General de Culturas Populares. ISBN: 970-18-3907-2.

Mlcek J, Rop O. 2011. Fresh edible flowers of ornamental plants e A new source of nutraceutical foods. *Trends in Food Science & technology* **22**: 561-569. DOI: https://doi.org/10.1016/j.tifs.2011.04.006

Ordoñez M, Pardo E. 1982. Estudio etnobotánico de tres especies de flores comestibles de la ciudad de Xalapa, Veracruz. *Biotica* **7**: 305-21.

Pardo-de-Santayana M, Tardío J, Blanco E, Carvalho AM, Lastra JJ, San Miguel E, Morales R. 2007. Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal): a comparative study. *Journal of Ethnobiology and Ethnomedicine* **3:** 27. DOI: https://doi.org/10.1186/1746-4269-3-27

Peña EY, Hernández L. 2014. *Tradiciones de la cocina Hñähñu del Valle del Mezquital. Cocina Indígena y Popular* 63. DF, México: Consejo Nacional para la Cultura y las Artes. ISBN: 978-607-8423-67-5.

Pieroni A. 1999. Gathered Wild Food Plants in the upper Valley of the Serchio River (Garfagnana), Italy. *Economic Botany* **53**: 327-341. DOI: https://doi.org/10.1007/BF02866645

Pinedo-Espinoza JM, Gutiérrez-Tlahque J, Santiago-Saenz YO, Aguirre-Mancilla CL, Reyes-Fuentes M, López-Palestina CU. 2020. Nutritional Composition, Bioactive Compounds and Antioxidant Activity of Wild Edible Flowers Consumed in Semiarid Regions of Mexico. *Plant Foods for Human Nutrition* **75**: 413-419. DOI: https://doi.org/10.1007/s11130-020-00822-2

Pires TCSP, Días MI, Barros L, Calhelha RC, Alves MJ, Oliveira MB, Santos-Buelga C, Ferreira I. 2018. Edible

flowers as sources of phenolic compounds with bioactive potential. *Food Research International* **105**: 580-588. DOI: https://doi.org/10.1016/j.foodres.2017.11.014

Rangel S. 1987. *Etnobotánica de los agaves del Valle del Mezquital*. BSc. Thesis. Universidad Nacional Autónoma de México.

Román-Cortés NR, García-Mateos MR, Castillo-González AM, Sahagún-Castellanos J, Jiménez-Arellanes MA. 2018. Características nutricionales y nutracéuticas de hortalizas de uso ancestral en México. *Revista Fitotecnia Mexicana* **41**: 245-253. DOI: https://doi.org/10.35196/rfm.2018.3.245-253

Rzedowski, G. C. de, J. Rzedowski. 2005. *Flora fanerogámica del Valle de México*. Pátzcuaro, Michoacán: Instituto de Ecología, AC. y Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. (Edición digital: INE-COL 2010). ISBN: 978-970-900-017-7.

Sahagún B. 1999. *Historia general de las cosas de Nueva España*. México: Editorial Porrúa. ISBN: 968-432-265-8.

Sánchez L. 2017. *Las flores en la cocina veracruzana. Cocina Indígena y Popular 75*. México: Consejo Nacional para la Cultura y las Artes. ISBN: 978-607-745-787-9.

Sauquet H, von Balthazar M, Magallón S. Doyle AJ, Endress PK, Bailes EJ, Barroso de Morais E, Bull-Hereñu K, Carrive L, Chartier M, Chomicki G, Coiro M, Cornette R, El Ottra JHL, Epicoco C, Foster CSP, Jabbour F, Haevermans A, Haevermans T, Hernández R, Little SA, Löfstrand S, Luna JA, Massoni J, Nadot S, Pamperl S, Prieu C, Reyes E, dos Santos P, Schoonderwoerd KM, Sontag S, Soulebeau A, Staedler Y, Tschan GF, Wing-Sze Leung A, Schönenberger J. 2017. The ancestral flower of angiosperms and its early diversification. *Nature Communications* **8**: 16047. DOI: https://doi.org/10.1038/ncomms16047

SEMARNAT [Secretaria de Medio Ambiente y Recursos Naturales]. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010 Protección Ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio lista de especies en riesgo. Diario Oficial de la Federación. 26 de noviembre 2010. México.

Sheil D, Wunder S. 2002. The Value of Tropical Forest to Local Communities: complications, Caveats, and Cautions. *Conservation Ecology* **6**: 9. DOI: https://doi.org/10.5751/es-00458-060209

Soltis DE, Smith SA, Cellinese N, Wurdack KJ, Tank DC, Brockington SF, Refulio-Rodriguez NF, Walker JB, Moore MJ, Carlsward BS, Bell CD, Latvis M, Crawley S, Black C, Diouf D, Xi Z, Rushworth CA, Gitzendanner MA, Sytsma KJ, Qiu YL, Hilu KW, Davis CC, Sanderson MJ, Beaman RS, Olmstead RG, Judd WS, Donoghue MJ, Soltis P. 2011. Angiosperm phylogeny: 17 genes, 640 taxa. *American Journal of Botany* **98**: 704-730. DOI: https://doi.org/10.3732/ajb.1000404

Sotelo A, López-García S, Basurto-Peña F. 2013. Content of nutrient and antinutrient in edible flower of Wild Plants in Mexico. *Plant Food for Human Nutrition* **62**: 133-138. DOI: https://doi.org/10.1007/s11130-007-0053-9

Stewart KM. 2003. The African Cherry (*Prunus africana*): Can Lessons be Learned from an Over-Exploited Medicinal Tree? *Journal of Ethnopharmacology* **89**: 3-13. DOI: https://doi.org/10.1016/j.jep.2003.08.002

Takahashi JA, Rezende F, Moura MA, Dominguete LC, Sande D. 2019. Edible flowers: bioactive profile and its potential to be used in food development. *Food Research International* **129**. DOI: https://doi.org/10.1016/j.foodres.2019.108868

Torres R. 2014. *Las flores en la cocina mexicana. Cocina Indígena y Popular 22*. México: Consejo Nacional para la Cultura y las Artes. ISBN:978-607-516-602-5.

Ulloa CU, Acevedo-Rodríguez P, Beck S, Belgrano MJ, Bernal R, Berry PE, Brako L, Celis M, Davidse G, Forzza RC. 2017. An integrated assessment of the vascular plant species of the Americas. *Science* **358**: 1614-1617. DOI: https://doi.org/10.1126/science.aao0398

Villavicencio MG, Pérez BE. 2006. *Plantas útiles del estado de Hidalgo*. Pachuca, México: Universidad Autónoma del Estado de Hidalgo. ISBN: 978-968-634-043-3.

Villaseñor JL. 2016. Checklist of the native vascular plants of Mexico. *Revista Mexicana de Biodiversidad* **87**: 559-902. DOI: https://doi.org/10.1016/j.rmb.2016.06.017

Wongwattanasathien O, Kangsadalampai K, Tongyonk L. 2010. Antimutagenicity of some flowers grown in Thailand. *Food and Chemical Toxicology* **48**: 1045-1051. DOI: https://doi.org/10.1016/j.fct.2010.01.018

Zheng J, Yu X, Maninder M, Xu B. 2018. Total phenolics and antioxidants profiles of commonly consumed edible flowers in China. *International Journal of Food Properties* **21**: 1524-1540. DOI: https://doi.org/10.1080/10942912.2018.1494195

Zomlefer WB. 1994. *Guide to Flowering Plant Families*. North Carolina, USA: University of North Carolina Press. ISBN: 0-8078-2160-8.

Associate editor: José Blancas

Authors contributions: CJFU planned and conceived the study, did the fieldwork, analyzed the data, and wrote the manuscript; GDAR analyzed the data and wrote the manuscript; LCZ reviewed the data in BADEPLAM and revised the manuscript. The authors read and approved the final manuscript.

Supporting Agencies: Cátedras CONACYT-1245-Genética de la conservación de la biodiversidad en el estado de Hidalgo.