



# Traditional medicinal plant knowledge and biocultural relevance in a rural community of Veracruz, Mexico

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## Research

### Abstract

**Background:** Traditional medicinal plant knowledge is a key component of biocultural heritage and remains central to primary health care in many rural communities. Ongoing social and environmental changes underscore the urgency of documenting and analyzing this knowledge.

**Methods:** We documented and quantitatively assessed the diversity, cultural relevance, and therapeutic structure of medicinal plants used in a rural community of central Veracruz, Mexico. Semi-structured surveys were applied to 150 adult residents selected through snowball sampling. Data on health conditions, plant uses, plant parts, preparation methods, and species origin were recorded. Use value (UV), informant consensus factor (ICF), and principal component analysis (PCA) were employed to evaluate cultural importance and therapeutic associations. A complementary literature-based toxicological screening was conducted.

**Results:** Forty medicinal plant species were recorded. Use reports were concentrated in a limited group of culturally salient species, with *Artemisia absinthium* (UV = 0.20), *Justicia spicigera* (UV = 0.17), and *Psidium guajava* (UV = 0.13) showing the highest cultural relevance. Digestive and respiratory conditions represented the most prominent therapeutic domains. PCA revealed both generalist use patterns and selective associations at the family level. Toxicological screening identified documented risks in six species, primarily dose- or preparation-dependent.

**Conclusions:** The medicinal system documented is structured, socially shared, and centered on culturally salient species. Integrating quantitative ethnobotanical metrics with safety considerations provides a baseline for future pharmacological research and biocultural conservation strategies.

**Keywords:** Ethnobotany; Traditional knowledge; Biocultural conservation.

## Background

Traditional knowledge related to the use of medicinal plants constitutes a fundamental component of the relationship between human communities and their natural environment. Globally, a substantial proportion of the population continues to rely on plant-based remedies as primary therapeutic resources, particularly in rural and marginalized areas where access to formal health services is limited (Cupido *et al.* 2024). International organizations, including the World Health Organization, have recognized the importance of traditional medicinal plant use for public health and have emphasized the need to document and preserve this knowledge, especially in regions experiencing rapid social and environmental change (World Health Organization, 2023).

Ethnobotany examines the interactions between human societies and plants, encompassing medicinal, food, ritual, and symbolic uses. While early ethnobotanical studies focused mainly on descriptive inventories of useful species, contemporary research increasingly integrates ecological, cultural, and quantitative approaches to better understand patterns of plant use and knowledge transmission (Mekonnen *et al.* 2022; Vibrans *et al.* 2022). Such integrative perspectives are essential for assessing biocultural diversity and for identifying culturally significant species within local knowledge systems (Siraj 2022).

Mexico is recognized as a megadiverse country, harboring approximately 25,000 species of vascular plants, more than 4,500 of which are estimated to have medicinal uses (Lucía *et al.* 2021; Sosa *et al.* 2023). Despite this richness, only a limited proportion of these species has been examined in detail, and traditional medicinal knowledge remains unevenly documented across regions (Davis and Choisy 2024; Rodríguez-Hernández *et al.* 2022). In many rural areas, medicinal plant use persists as part of everyday health practices and cultural identity rather than being restricted to specialized healers (Baez *et al.* 2024). Within this national context, the state of Veracruz stands out as one of the most floristically diverse regions, with an estimated 7,500 species of vascular plants (CONABIO 2021). Its environmental heterogeneity and cultural diversity have fostered a wide range of plant uses, particularly in mountainous settings where traditional healing practices remain active (Martínez-Hernández *et al.* 2022; Reimers *et al.* 2019). Jilotepec, a rural community located in the central highlands of Veracruz, hosts more than one thousand recorded vascular plant species (Reyes-Castillo 2014; Vázquez Torres 2000); however, despite the availability of floristic information, traditional knowledge related to medicinal plant use in this local context has not been systematically documented.

Ethnobotanical studies that combine qualitative data collection with quantitative indices, such as use value and informant consensus factor, have proven effective for identifying culturally important species and understanding patterns of medicinal plant use within communities (Awan *et al.* 2021; Juárez-Vázquez *et al.* 2013; Lloyd *et al.* 2021). In Veracruz, previous studies in communities such as Ixhuatlancillo and Jamapa have documented between 40 and 90 medicinal plant species, highlighting the continued reliance on herbal medicine to treat common ailments including gastrointestinal disorders, respiratory infections, wounds, and nervous system conditions (Castro Guzmán *et al.* 2021; Hernández Lozano *et al.* 2022; Salazar-Gómez and Alonso-Castro 2022). In this context, the present study aims to document and analyze the diversity and cultural importance of medicinal plants used in a rural community of Veracruz, Mexico. By applying quantitative ethnobotanical approaches, this research contributes to the documentation of local traditional knowledge and provides baseline information to support biocultural conservation and the sustainable management of medicinal plant resources.

## Materials and Methods

### Study area

The study was conducted in the central settlement of Jilotepec, located in the mountainous region of central Veracruz, Mexico (Fig. 1), between 19°35' and 19°39' N latitude and 96°50' and 96°59' W longitude. Elevation ranges from 860 to 1,900 m a.s.l., within the Trans-Mexican Volcanic Belt physiographic province. The prevailing climate is semi-warm to temperate humid, with rainfall distributed throughout the year and mean annual temperatures between 16 and 22 °C. Annual precipitation varies from 1,400 to 1,600 mm.

Dominant soil types include Phaeozem, Leptosol, and Andosol, developed over volcanic formations, mainly basalt. Original vegetation includes remnants of cloud forest, low deciduous forest, and grasslands; however, approximately 45 % of the area is currently devoted to agricultural activities. Hydrologically, the region belongs to the Papaloapan River basin and includes perennial streams, such as the Naolinco River, as well as seasonal watercourses. Jilotepec comprises 32 local settlements and has a total population of approximately 13,653 inhabitants according to the 2010 census; the central settlement has about 3,097 inhabitants.



Figure 1. Location of the study area in Jilotepec, Veracruz, Mexico. Map created by the authors using QGIS. Satellite imagery from Sentinel-2 (Copernicus Programme, European Space Agency), 2026.

#### Sampling and interview methods

A semi-structured, written, self-administered survey was applied to 150 residents of the study area as part of an exploratory ethnobotanical study on medicinal plant use. Snowball sampling was employed, prioritizing adult residents with long-term residence in the area, as they are more likely to possess and transmit traditional knowledge. Prior to participation, all respondents were informed about the objectives of the study, and informed consent was obtained in accordance with ethical standards for ethnobotanical research.

The survey was organized into three sections. The first section gathered sociodemographic information. The second addressed the most common health conditions reported by participants, the type of medical attention sought as a first option (including the use of medicinal plants), and the number of plant species known. The third section focused on medicinal plant use, documenting local names, plant parts used, preparation methods, dosage, frequency of use, therapeutic indications, and the origin of the plants (wild-harvested or cultivated).

#### Ethnobotanical data analysis and diversity indices

Survey data were compiled into a binary presence-absence matrix (0/1) using Microsoft Excel®, indicating whether each informant reported the use of a given plant species. Data analysis was conducted in RStudio (version 2026.01.0+392) using the packages *vegan* and *BiodiversityR*. True diversity indices were calculated, including  $q_0$  (species richness) and  $q_1$  (exponential of the Shannon index), using the function *diversity* to characterize the diversity profile of medicinal plants used in the study area. A rank-abundance curve was generated to identify the most frequently used species. Species identification was verified at the Institute of Biological Research and the Faculty of Biology of the Universidad Veracruzana.

#### Use value, informant consensus factor, and fidelity level

The use value (UV) of each species was calculated as the number of use reports for a given species ( $U_i$ ) divided by the total number of informants ( $n$ ), following the equation:

$$UV = \frac{U_i}{n}$$

The informant consensus factor (ICF) was calculated for each reported health condition using the number of use reports for a given ailment ( $N_{ur}$ ) and the number of plant species used to treat that ailment ( $N_t$ ), according to the equation:

$$ICF = \frac{N_{ur} - N_t}{N_{ur} - 1}$$

The fidelity level (% F) was calculated to assess the degree of specificity of a plant species for a particular health condition. This index was obtained by dividing the number of informants who mentioned a given plant for a specific ailment ( $N_p$ ) by the total number of informants who cited plants for that ailment ( $N$ ), multiplied by 100:

$$\% F = \frac{N_p}{N} \times 100$$

#### Principal component analysis

To explore the association between medicinal plant use and reported health conditions, a principal component analysis (PCA) was performed. We built a matrix of families (rows) by health conditions (columns) using report counts based on survey data. PCA was conducted using the function `prcomp()`. All variables were centered and scaled to standardize values and prevent differences in measurement scales from influencing the ordination. The first two principal components (PC1 and PC2) were retained for interpretation, and the percentage of variance explained by each axis was reported.

## Results

### Sociodemographic characteristics and medicinal plant knowledge

Interviewed participants ranged from 20 to 88 years of age, with individuals around 50 years old representing the most frequent age group (8 %). Women comprised 90 % of respondents, while men accounted for 10 %. The predominance of female participants reflects their central role in household health care and the transmission of medicinal plant knowledge. The most common occupations reported were housewives (68 %) and employees (34 %), followed by laborers, teachers, drivers, and carpenters (2 % each). Regarding educational level, 2 % of respondents reported no formal schooling, 28 % had completed primary education, 44 % secondary education, 20 % upper secondary education, and 6 % university-level studies.

Ethnobotanical uses were concentrated in a limited number of health conditions. Epigastric pain was the most frequently reported use (11.76 %), followed by anxiety disorders and bronchitis (8.82 % each). When grouped, respiratory ailments (including bronchitis, influenza, flu, catarrh, pharyngitis, and dyspnea) accounted for approximately 25 % of all use reports, while digestive conditions (epigastric pain, dyspepsia, gastroenteritis, dysentery, and biliary or liver disorders) comprised 23 %. Inflammatory and pain-related conditions represented 14 %, and nervous system-related uses accounted for 12 %. All other categories individually represented less than 5 % of total reports.

Knowledge of medicinal flora was unevenly distributed among participants. Fourteen percent reported knowing more than six medicinal plant species, 10 % between four and six species, 68 % between two and four species, and 8 % between one and two species. This pattern indicates that while in-depth knowledge is concentrated among a smaller group, basic medicinal plant use is widespread within the study area.

### Ethnobotanical diversity and frequently used species

A total of 40 medicinal plant species were recorded in the study area (Tab. 1). Species richness ( $q_0$ ) was 40, while effective diversity ( $q_1$ , exponential of the Shannon index) was 27 species, indicating a sampling coverage of approximately 93 %. Rank-abundance analysis (Fig. 2) showed that a limited number of species accounted for the majority of use reports. The most frequently cited species included *Bougainvillea spectabilis* Willd., *Artemisia absinthium* L., *Matricaria chamomilla* L., *Mentha spicata* L., *Aloysia citrodora* Peláú, *Oenothera rosea* L. Hér. ex Aiton, *Ocimum basilicum* L., *Oxybasis glauca* (L.) S. Fuente Uotila & Borsch, *Psidium guajava* L., and *Bidens alba* (L.) DC. These species constitute the core of the local medicinal repertoire and were selected for further quantitative analyses.

In terms of growth form, herbs predominated (62.5 %), followed by shrubs (22.5 %) and trees (15 %). The prevalence of herbaceous species reflects accessibility, rapid growth cycles, and ease of harvesting, characteristics commonly associated with plants incorporated into household-based medicinal systems. Regarding origin, introduced species represented 52.5 % of the total flora, native species accounted for 35 %, and endemic taxa for 12.5 %. This composition highlights the dynamic integration of both local biodiversity and historically introduced species into the medicinal repertoire.

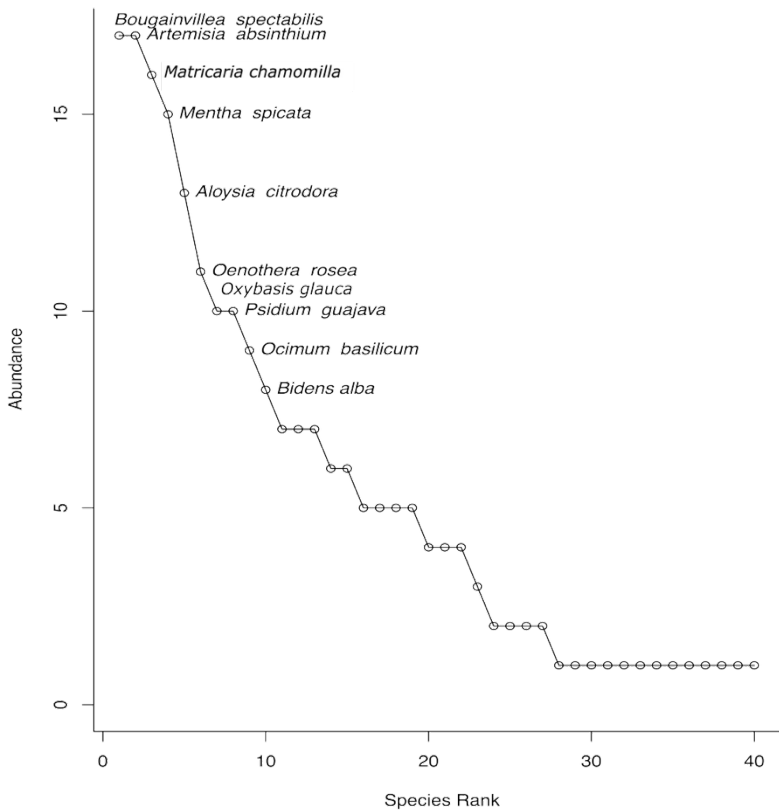


Figure 2. Rank-abundance curve of medicinal plant species reported in the study area of Jilotepec, Veracruz, Mexico.

Table 1. Floristic composition and functional traits of medicinal plant species used in the study area.

| Family        | Species                                  | Vernacular name            | Origin     | Growth form | Part used                        | Method of preparation                         | Ethnobotanical use   | UV   |
|---------------|--|----------------------------|------------|-------------|----------------------------------|---|--|------|
| Asteraceae    | <i>Artemisia absinthium</i> L.           | <b>Hierba maestra</b>      | Introduced | Herb        | Leaves and stems                 | Infusion, decoction and compress              | Anxiety disorders, diabetes, dysmenorrhea, epigastric pain, bile disorders, gallbladder problems | 0.20 |
| Acanthaceae   | <i>Justicia spicigera</i> Schlttdl.      | <b>Muicle</b>              | Native     | Shrub       | Leaves                           | Infusion                                      | Anemia, anxiety disorders, depression, diabetes, gastroenteritis, liver conditions               | 0.17 |
| Myrtaceae     | <i>Psidium guajava</i> L.                | <b>Guayaba</b>             | Native     | Tree        | Leaves                           | Infusion                                      | Epigastric pain, influenza, bronchitis   | 0.13 |
| Asteraceae    | <i>Bidens alba</i> (L.) DC.              | <b>Mozote blanco</b>       | Native     | Herb        | Leaves, flowers and stems        | Infusion, decoction, compress and raw (snack) | Catarrh, pain, pulpitis, thrombocytopenia  | 0.13 |
| Lamiaceae     | <i>Ocimum basilicum</i> L.               | <b>Albahaca</b>            | Introduced | Herb        | Leaves and stems                 | Infusion, decoction, poultice and baths       | Dyspnea, pain, epigastric pain, insomnia   | 0.13 |
| Nyctaginaceae | <i>Bougainvillea spectabilis</i> Willd.  | <b>Bugambilia</b>          | Introduced | Tree        | Bracts                           | Infusion, vapors                              | Pharyngitis, influenza, bronchitis   | 0.10 |
| Verbenaceae   | <i>Aloysia citrodora</i> Paláu.          | <b>Cedrón</b>              | Introduced | Shrub       | Leaves and branch with flowers   | Infusion and herbal baths                     | Epigastric pain, muscle spasms, gastroenteritis  | 0.10 |
| Onagraceae    | <i>Oenothera rosea</i> L. Hér. ex Aiton. | <b>Hierba de golpe</b>     | Native     | Herb        | Leaves, flowers, stems and roots | Infusion, compress and poultice               | Anxiety disorders, anti-inflammatory uses, epigastric pain                                       | 0.10 |
| Polemoniaceae | <i>Loeselia mexicana</i> (Lam.) Brand.   | <b>Espinosilla</b>         | Endemic    | Herb        | Leaves and branch with flowers   | Infusion and decoction                        | Flu, influenza, bronchitis   | 0.10 |
| Lamiaceae     | <i>Coleus amboinicus</i> Lour.           | <b>Orégano gordo</b>       | Introduced | Shrub       | Leaves and flowers               | Infusion, maceration and decoction            | Pharyngitis, otitis, bronchitis  | 0.10 |
| Solanaceae    | <i>Brugmansia candida</i> Pers.          | <b>Floripondio</b>         | Introduced | Shrub       | Leaves and flowers               | Poultice, baths and vapors                    | Arthralgia, pain, insomnia   | 0.10 |
| Rubiaceae     | <i>Hamelia patens</i> Jacq.              | <b>Hierba de la virgen</b> | Native     | Shrub       | Leaves                           | Infusion, poultice and wound washing          | Dysentery, influenza, bronchitis   | 0.10 |
| Lamiaceae     | <i>Mentha spicata</i> L.                 | <b>Hierbabuena</b>         | Introduced | Herb        | Leaves                           | Infusion, syrup and poultice                  | Dysmenorrhea, epigastric pain, nausea, vomiting  | 0.08 |

## Ethnobotany Research and Applications

|               |  |                         |            |       |                                |   |  |      |
|---------------|--|-------------------------|------------|-------|--------------------------------|---|--|------|
| Amaranthaceae | <i>Oxybasis glauca</i> (L.) S. Fuente Uotila & Borsch. | <b>Epazote zorrillo</b> | Introduced | Herb  | Leaves, stems and whole plant  | Infusion, decoction and compress                  | Dyspepsia, gastroenteritis             | 0.08 |
| Asteraceae    | <i>Matricaria chamomilla</i> L.                        | <b>Manzanilla</b>       | Introduced | Herb  | Leaves, flowers and stems      | Infusion and compress                             | Epigastric pain, influenza, bronchitis | 0.08 |
| Lauraceae     | <i>Litsea glaucescens</i> Kunth.                       | <b>Laurel</b>           | Native     | Tree  | Leaves                         | Infusion  | Epigastric pain, inflammation          | 0.08 |
| Verbenaceae   | <i>Lippia dulcis</i> Trevir.                           | <b>Hierba dulce</b>     | Native     | Herb  | Leaves and branch with flowers | Infusion, decoction                               | Dysmenorrhea, pharyngitis              | 0.08 |
| Viburnaceae   | <i>Sambucus canadensis</i> L.                          | <b>Sauco</b>            | Native     | Shrub | Leaves, flowers and fruits     | Infusion, syrup, baths, vapors and poultice       | Fever, shortness of breath             | 0.08 |
| Rutaceae      | <i>Citrus x aurantium</i> L.                           | <b>Naranja agrio</b>    | Introduced | Tree  | Leaves and flowers             | Infusion  | Anxiety disorders, bronchitis          | 0.08 |
| Lamiaceae     | <i>Salvia rosmarinus</i> Spenn.                        | <b>Romero</b>           | Introduced | Herb  | Leaves and branch with flowers | Infusion, baths, vapors and poultice              | Anxiety disorders, shortness of breath | 0.08 |
| Asphodelaceae | <i>Aloe vera</i> (L.) Burm. f.                         | <b>Sábila</b>           | Introduced | Shrub | Leaf gel                       | Skin application                                  | Wounds, burns                          | 0.08 |
| Rutaceae      | <i>Ruta graveolens</i> L.                              | <b>Ruda</b>             | Introduced | Herb  | Leaves and branch              | Infusion, maceration and decoction                | Dysmenorrhea, labor inducer            | 0.08 |
| Malvaceae     | <i>Tilia mexicana</i> Schtdl.                          | <b>Tila</b>             | Endemic    | Shrub | Leaves, flowers and bracts     | Infusion, decoction and baths                     | Anxiety disorders, bronchitis          | 0.08 |
| Lamiaceae     | <i>Melissa officinalis</i> L.                          | <b>Toronjil</b>         | Introduced | Herb  | Leaves and flowers             | Infusion  | Anxiety disorders, epigastric pain     | 0.08 |
| Lamiaceae     | <i>Agastache mexicana</i> (Kunth) Lint & Epling.       | <b>Toronjil morado</b>  | Endemic    | Herb  | Leaves and flowers             | Infusion  | Anxiety disorders, epigastric pain     | 0.08 |
| Asteraceae    | <i>Heterotheca inuloides</i> Cass.                     | <b>Árnica</b>           | Endemic    | Herb  | Flowers                        | Compress, maceration and oil                      | Inflammation, pain, healing capacity   | 0.04 |
| Malvaceae     | <i>Malva parviflora</i> L.                             | <b>Malva</b>            | Introduced | Herb  | Leaves, flowers and stems      | Infusion, decoction, compress, poultice and baths | Inflammation, healing capacity         | 0.04 |
| Burseraceae   | <i>Bursera simaruba</i> (L.) Sarg.                     | <b>Palo mulato</b>      | Native     | Tree  | Bark, leaves and branch        | Infusion, decoction and baths                     | Fever                                  | 0.04 |

|               |   |                       |            |       |                                       |  |  |      |
|---------------|---|-----------------------|------------|-------|---------------------------------------|--|--|------|
| Asteraceae    | <i>Iostephane heterophylla</i> Benth.           | <b>Cachana</b>        | Endemic    | Herb  | Root and whole plant                  | Decoction                                    | Catarrh  | 0.04 |
| Poaceae       | <i>Cymbopogon citratus</i> (DC.) Stapf.         | <b>Zacate limón</b>   | Introduced | Herb  | Leaves                                | Infusion and decoction                       | Dyslipidemia, gastrointestinal disorders             | 0.04 |
| Verbenaceae   | <i>Verbena carolina</i> L.                      | <b>Verbena</b>        | Native     | Herb  | Leaves, flowers and branch            | Infusion, decoction, bath and poultice       | Epigastric pain and treat wounds                     | 0.04 |
| Boraginaceae  | <i>Borago officinalis</i> L.                    | <b>Borraja</b>        | Introduced | Shrub | Leaves and flowers                    | Infusion and decoction                       | Eruptive diseases                                    | 0.04 |
| Loasaceae     | <i>Gronovia scandens</i> L.                     | <b>Chichicaste</b>    | Native     | Herb  | Leaves and root                       | Infusion and poultice                        | Pain and inflammation                                | 0.04 |
| Euphorbiaceae | <i>Acalypha alopecuroides</i> Jacq.             | <b>Chinahuatillo</b>  | Native     | Herb  | Leaves and stems                      | Bath and poultice                            | Treat wounds   | 0.04 |
| Asteraceae    | <i>Taraxacum officinale</i> F.H.Wigg.           | <b>Diente de león</b> | Introduced | Herb  | Leaves, flowers, root and whole plant | Infusion and decoction                       | Treat wounds, liver and renal conditions             | 0.04 |
| Asteraceae    | <i>Artemisia ludoviciana</i> Nutt.              | <b>Estafiate</b>      | Native     | Herb  | Leaves, flowers and branch            | Infusion and decoction                       | Epigastric pain and liver conditions                 | 0.04 |
| Rutaceae      | <i>Citrus aurantiifolia</i> (Christm.) Swingle. | <b>Lima</b>           | Introduced | Tree  | Leaves and fruit                      | Infusion, decoction, juice and roasted fruit | Anxiety disorders, bronchitis, flu                   | 0.04 |
| Apiaceae      | <i>Foeniculum vulgare</i> Mill.                 | <b>Hinojo</b>         | Introduced | Herb  | Branch with leaves and flowers        | Cold infusion, eye washes                    | Conjunctivitis                                       | 0.04 |
| Lamiaceae     | <i>Marrubium vulgare</i> L.                     | <b>Marrubio</b>       | Introduced | Herb  | Branch with leaves and flowers        | Infusion and decoction                       | Digestive, hepatic, biliary and respiratory ailments | 0.04 |
| Piperaceae    | <i>Piper auritum</i> Kunth.                     | <b>Santa maría</b>    | Native     | Shrub | Leaves                                | Infusion                                     | Diuretic   | 0.04 |

The medicinal plant species documented in the study area belonged to 23 botanical families (Fig. 3). Asteraceae and Lamiaceae were the most represented families (17.5 % each), followed by Rutaceae and Verbenaceae (7.5 % each). The remaining families were represented by one or two species ( $\leq 5$  % each), indicating moderate taxonomic diversity with dominance of lineages widely recognized in Mexican ethnomedicine.

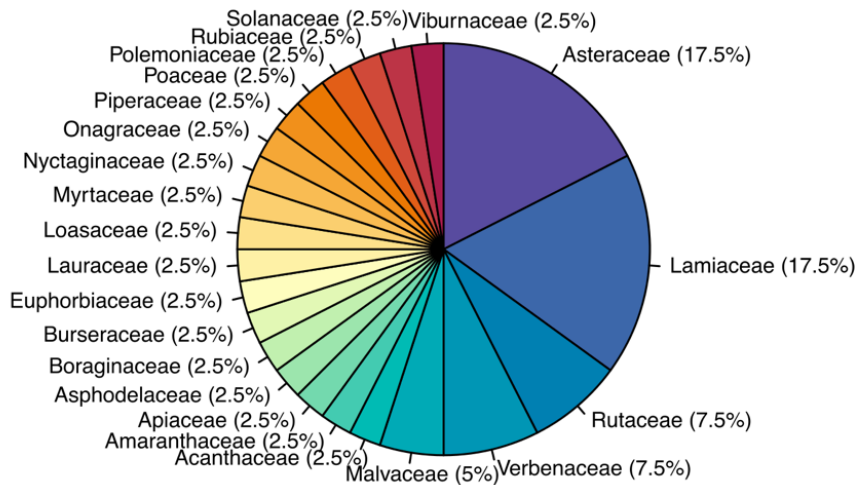


Figure 3. Percentage distribution of medicinal plant species by botanical family in the study area

In relation to these patterns, PCA explained 45.7 % of total variance, with Dim1 accounting for 29.1 % and Dim2 for 16.6 % (Fig. 4). Dim1 separated digestive and respiratory conditions from less frequently reported categories, whereas Dim2 distinguished systemic and inflammatory conditions from nervous system-related ailments. Most botanical families were positioned near the center of the ordination space, while Asteraceae and Lamiaceae showed greater separation along the axes.

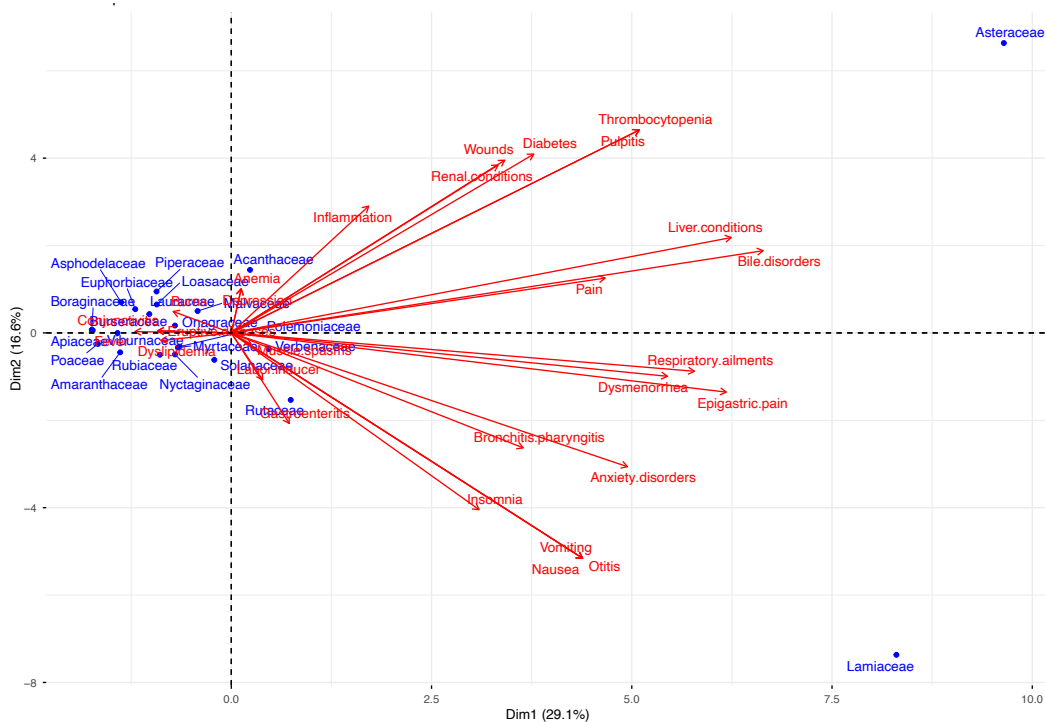


Figure 4. Principal component analysis showing the association between medicinal plant families and reported health conditions in Jilotepec, Veracruz, Mexico.

Plant parts most frequently used were leaves (present in 70 % of species), followed by flowers (30 %), stems/branches (25 %), roots (10 %), bark (5 %), and whole plants (15 %) (Fig. 5). The predominance of leaves suggests selective harvesting practices that may reduce destructive impacts on plant populations. With respect to preparation techniques, infusion was

the most common preparation method (reported in 72.5 % of species), followed by decoction (55 %), poultices (27.5 %), compresses (20 %), baths (17.5 %), and vapors (12.5 %) (Fig. 6). Water-based extraction methods clearly dominated, consistent with accessible and low-cost preparation practices.

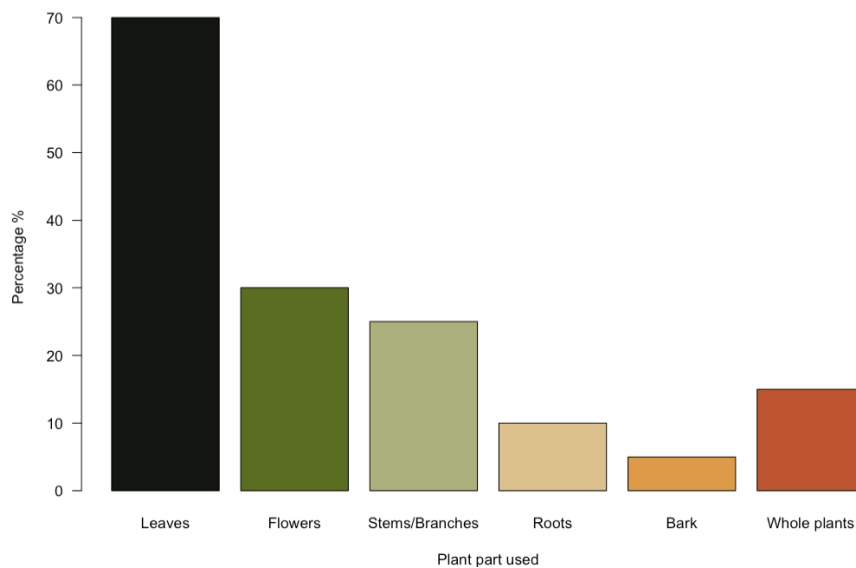


Figure 5. Percentage distribution of medicinal plant species by botanical family in the study area

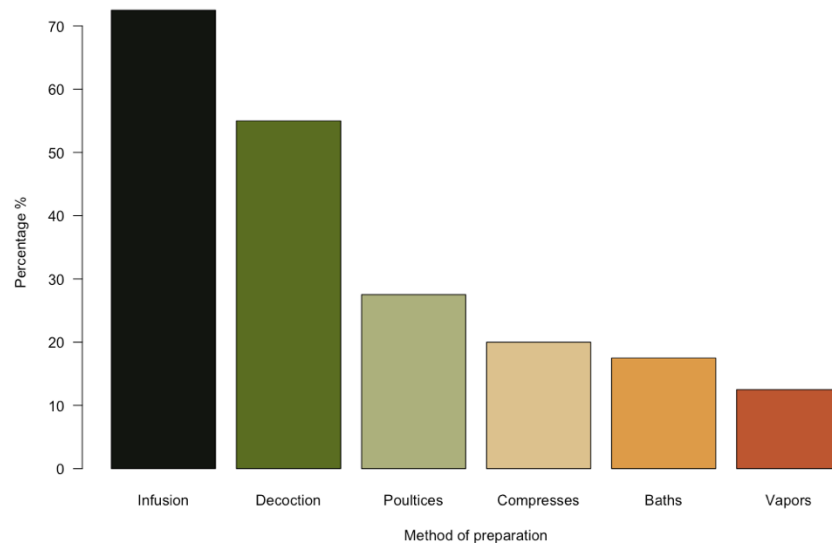


Figure 6. Percentage distribution of medicinal plant preparation methods reported in the study area

#### Use value, informant consensus factor, and fidelity level

Use value analysis revealed a strongly uneven distribution of cultural importance among the recorded species (Tab. 1). The highest UV was observed for *Artemisia absinthium* L. (0.20), followed by *Justicia spicigera* Schltld. (0.17), while *Psidium guajava* L., *Bidens alba* (L.) DC., and *Ocimum basilicum* L. each reached values of 0.13. These species were associated with multiple therapeutic categories, particularly digestive, respiratory, and nervous system-related conditions, indicating broader functional versatility within the local medicinal system. In contrast, more than half of the recorded species presented a UV of 0.04, reflecting more specific or less frequently reported uses. Overall, only 30 % of the documented flora exhibited UV values  $\geq 0.10$ , suggesting that cultural relevance is concentrated in a relatively small subset of medicinal plants, while the majority play complementary or specialized roles within the medicinal repertoire.

Informant consensus factor values showed generally high agreement among participants across health conditions (Tab. 2). Several ailments reached maximum consensus (ICF = 1.00), including anemia, arthralgia, conjunctivitis, dyspepsia, depression, dysentery, diuretic uses, dyslipidemia, muscle spasm, hyperthermia, pulpitis, burns, thrombocytopenia, otitis,

and tissue injury. High consensus was also observed for frequently treated conditions such as anti-inflammatory uses (ICF = 0.96), bronchitis (0.94), insomnia (0.93), epigastric pain (0.92), gastroenteritis (0.92), diabetes (0.91), and dysmenorrhea (0.90). Lower ICF values were recorded for wounds (0.75) and biliary dyskinesia (0.80), indicating greater variation in the selection of plant species for these conditions.

Fidelity level values revealed marked differences in therapeutic specificity (Tab. 2). Several health categories were associated with a single species showing 100 % fidelity (e.g., *Justicia spicigera* for anemia and depression; *Oxybasis glauca* for dyspepsia; *Aloe vera* for burns and tissue injury; *Bidens alba* for pulpitis and thrombocytopenia; *Bursera simaruba* for hyperthermia). In contrast, more frequently treated and culturally widespread conditions exhibited distributed fidelity values across multiple taxa. For example, epigastric pain was primarily associated with *Matricaria chamomilla* (28 %), *Aloysia citrodora* (20 %), and *Mentha spicata* (19 %), while bronchitis was largely associated with *Bougainvillea spectabilis* (70 %), with several additional species showing lower fidelity percentages. It should be noted that several categories with ICF = 1.00 were based on a single use report (Nur = 1), which mathematically results in maximum consensus. These values should therefore be interpreted cautiously, as they do not necessarily reflect broad agreement among informants.

Table 2. Health conditions treated with medicinal plants, informant consensus factor, and fidelity level of associated species in Jilotepec, Veracruz, Mexico.

| Health condition              | Nur | Nt | ICF  | Species  | Fidelity level (%F) |
|-------------------------------|-----|----|------|--|---------------------|
| Anti-inflammatory uses        | 81  | 4  | 0.96 | <i>Oenothera rosea</i> L Hér. ex Aiton.                | 30 %                |
|                               |     |    |      | <i>Malva parviflora</i> L.                             | 30 %                |
|                               |     |    |      | <i>Heterotheca inuloides</i> Cass.                     | 35 %                |
|                               |     |    |      | <i>Litsea glaucescens</i> Kunth.                       | 5 %                 |
| Anxiety                       | 51  | 8  | 0.86 | <i>Artemisia absinthium</i> L.                         | 27 %                |
|                               |     |    |      | <i>Oenothera rosea</i> L Hér. ex Aiton.                | 16 %                |
|                               |     |    |      | <i>Citrus aurantiifolia</i> (Christm.) Swingle.        | 5 %                 |
|                               |     |    |      | <i>Justicia spicigera</i> Schltld.                     | 5 %                 |
|                               |     |    |      | <i>Citrus x aurantium</i> L.                           | 21 %                |
|                               |     |    |      | <i>Salvia rosmarinus</i> Spenn.                        | 16 %                |
|                               |     |    |      | <i>Aloe vera</i> (L.) Burm. f.                         | 5 %                 |
| <i>Melissa officinalis</i> L. | 5 % |    |      |  |                     |
| Anemia                        | 3   | 1  | 1.00 | <i>Justicia spicigera</i> Schltld.                     | 100 %               |
| Arthralgia                    | 3   | 1  | 1.00 | <i>Brugmansia candida</i> Pers.                        | 100 %               |
| Catarrh                       | 21  | 4  | 0.85 | <i>Iostephane heterophylla</i> Benth.                  | 55 %                |
|                               |     |    |      | <i>Loeselia mexicana</i> (Lam.) Brand.                 | 15 %                |
|                               |     |    |      | <i>Psidium guajava</i> L.                              | 15 %                |
|                               |     |    |      | <i>Bidens alba</i> (L.) DC.                            | 15 %                |
| Conjunctivitis                | 3   | 1  | 1.00 | <i>Foeniculum vulgare</i> Mill.                        | 100 %               |
| Diabetes                      | 12  | 2  | 0.91 | <i>Artemisia absinthium</i> L.                         | 75 %                |
|                               |     |    |      | <i>Justicia spicigera</i> Schltld.                     | 25 %                |
| Dyspnea                       | 18  | 3  | 0.88 | <i>Ocimum basilicum</i> L.                             | 34 %                |
|                               |     |    |      | <i>Salvia rosmarinus</i> Spenn.                        | 33 %                |
|                               |     |    |      | <i>Sambucus canadensis</i> L.                          | 33 %                |
| Dysmenorrhea                  | 30  | 4  | 0.90 | <i>Mentha spicata</i> L.                               | 37 %                |
|                               |     |    |      | <i>Lippia dulcis</i> Trevir.                           | 45 %                |
|                               |     |    |      | <i>Artemisia absinthium</i> L.                         | 9 %                 |
|                               |     |    |      | <i>Ruta graveolens</i> L.                              | 9 %                 |
| Dyspepsia                     | 9   | 1  | 1.00 | <i>Oxybasis glauca</i> (L.) S. Fuente Uotila & Borsch. | 100 %               |
| Depression                    | 3   | 1  | 1.00 | <i>Justicia spicigera</i> Schltld.                     | 100 %               |
| Dysentery                     | 3   | 1  | 1.00 | <i>Hamelia patens</i> Jacq.                            | 100 %               |
| Diuretic uses                 | 3   | 1  | 1.00 | <i>Piper auritum</i> Kunth.                            | 100 %               |
| Dyslipidemia                  | 3   | 1  | 1.00 | <i>Cymbopogon citratus</i> (DC.) Stapf.                | 100 %               |
| Pain                          | 36  | 5  | 0.89 | <i>Ocimum basilicum</i> L.                             | 40 %                |
|                               |     |    |      | <i>Gronovia scandens</i> L.                            | 20 %                |

|                    |     |    |      |   |        |
|--------------------|-----|----|------|---|--------|
|                    |     |    |      | <i>Brugmansia candida</i> Pers.         | 20 %   |
|                    |     |    |      | <i>Bidens alba</i> (L.) DC.             | 20 %   |
|                    |     |    |      | <i>Ocimum basilicum</i> L.              | 5 %    |
|                    |     |    |      | <i>Aloysia citrodora</i> Paláu.         | 20 %   |
|                    |     |    |      | <i>Artemisia ludoviciana</i> Nutt.      | 2 %    |
|                    |     |    |      | <i>Psidium guajava</i> L.               | 10 %   |
|                    |     |    |      | <i>Mentha spicata</i> L.                | 19 %   |
| Epigastric pain    | 108 | 10 | 0.92 | <i>Artemisia absinthium</i> L.          | 9 %    |
|                    |     |    |      | <i>Oenothera rosea</i> L Hér. ex Aiton. | 3 %    |
|                    |     |    |      | <i>Litsea glaucescens</i> Kunth         | 2 %    |
|                    |     |    |      | <i>Matricaria chamomilla</i> L.         | 28 %   |
|                    |     |    |      | <i>Melissa officinalis</i> L.           | 2 %    |
| Muscle spasm       | 3   | 1  | 1.00 | <i>Aloysia citrodora</i> Paláu.         | 100 %  |
|                    |     |    |      | <i>Bougainvillea spectabilis</i> Willd. | 20 %   |
| Pharyngitis        | 15  | 3  | 0.86 | <i>Lippia dulcis</i> Trevir.            | 20 %   |
|                    |     |    |      | <i>Coleus amboinicus</i> Lour.          | 60 %   |
|                    |     |    |      | <i>Aloysia citrodora</i> Paláu.         | 12.5 % |
| Gastroenteritis    | 27  | 3  | 0.92 | <i>Oxybasis glauca</i> (L.) S.          | 75 %   |
|                    |     |    |      | <i>Justicia spicigera</i> Schltld.      | 12.5 % |
| Hyperthermia       | 15  | 1  | 1.00 | <i>Bursera simaruba</i> (L.) Sarg.      | 100 %  |
|                    |     |    |      | <i>Verbena carolina</i> L.              | 34 %   |
| Wounds             | 9   | 3  | 0.75 | <i>Acalypha alopecuroides</i> Jacq.     | 33 %   |
|                    |     |    |      | <i>Taraxacum officinale</i> F.H.Wigg.   | 33 %   |
|                    |     |    |      | <i>Ocimum basilicum</i> L.              | 50 %   |
| Insomnia           | 15  | 2  | 0.93 | <i>Brugmansia candida</i> Pers.         | 50 %   |
| Pulpitis           | 3   | 1  | 1.00 | <i>Bidens alba</i> (L.) DC.             | 100 %  |
| Burns              | 3   | 1  | 1.00 | <i>Aloe vera</i> (L.) Burm. f.          | 100 %  |
|                    |     |    |      | <i>Bougainvillea spectabilis</i> Willd. | 70 %   |
|                    |     |    |      | <i>Loeselia mexicana</i> (Lam.) Brand.  | 4 %    |
|                    |     |    |      | <i>Psidium guajava</i> L.               | 10 %   |
| Bronchitis         | 84  | 6  | 0.94 | <i>Hamelia patens</i> Jacq.             | 4 %    |
|                    |     |    |      | <i>Citrus x aurantium</i> L.            | 4 %    |
|                    |     |    |      | <i>Coleus amboinicus</i> Lour.          | 4 %    |
|                    |     |    |      | <i>Tilia mexicana</i> Schltld.          | 4 %    |
| Thrombocytopenia   | 18  | 1  | 1.00 | <i>Bidens alba</i> (L.) DC.             | 100 %  |
| Otitis             | 3   | 1  | 1.00 | <i>Coleus amboinicus</i> Lour.          | 100 %  |
| Tissue injury      | 3   | 1  | 1.00 | <i>Aloe vera</i> (L.) Burm. f.          | 100 %  |
| Biliary dyskinesia | 6   | 2  | 0.80 | <i>Artemisia absinthium</i> L.          | 100 %  |

#### Safety considerations in the local medicinal repertoire

A complementary toxicological screening based on published pharmacological and clinical literature indicated that 6 of the 40 recorded species (15 %) present documented adverse effects under specific conditions, particularly at high doses, in concentrated extracts, or during prolonged use. *Brugmansia candida* is associated with well-characterized anticholinergic toxicity due to tropane alkaloids (atropine, scopolamine, hyoscyamine), producing central and peripheral symptoms such as delirium, tachycardia, hyperthermia, and urinary retention (Barrete *et al.* 2016; Kerchner and Farkas *et al.* 2020). *Ruta graveolens* has been linked to phototoxic dermatitis and uterotonic effects, while *Borago officinalis* contains pyrrolizidine alkaloids with recognized hepatotoxic potential (López *et al.* 2016; Luo *et al.* 2024; Moges, 2021; Sattler *et al.* 2025). *Artemisia absinthium* shows dose-dependent hepatotoxic and neurotoxic effects attributed mainly to thujone, with rare human reports of toxic hepatitis (Batiha *et al.* 2020; Keser *et al.* 2025).

The safety profile of *Aloe vera* depends on the plant fraction used: inner leaf gel is generally better tolerated, whereas latex and whole-leaf preparations contain anthraquinones associated with laxative effects, electrolyte imbalance, and reported hepatotoxicity (Nalimu *et al.* 2021). *Citrus x aurantium* is considered to have low intrinsic toxicity in traditional contexts, although its sympathomimetic compound p-syneprine may pose cardiovascular risk when consumed in concentrated

formulations or combined with other stimulants (Christian Ezeigwe *et al.* 2022). For the remaining taxa, the literature suggests no recurrent severe adverse effects when used as traditional aqueous preparations, although toxicological evidence remains limited for several species.

## Discussion

The medicinal flora documented in Jilotepec reveals a structured, yet culturally concentrated medicinal system characterized by moderate taxonomic diversity and strong consensus around a limited subset of therapeutically salient species. Although 40 species were recorded, use reports were unevenly distributed, with a relatively small group of plants accounting for most medicinal applications. This pattern of concentration, widely observed in ethnobotanical studies across Mexico and Latin America (Aparicio Aparicio *et al.* 2021; García De Alba García *et al.* 2012; López-Gutiérrez *et al.* 2014; Martínez López *et al.* 2021), reflects processes of cultural selection in which species perceived as effective, accessible, and reliable become embedded in local health practices through intergenerational transmission. The effective diversity value ( $q_1 = 27$ ) further indicates that knowledge is not randomly distributed but rather shared across informants, suggesting a collectively maintained medicinal system rather than isolated individual experimentation.

The taxonomic composition of the recorded species aligns with patterns documented in other rural regions of Mexico, particularly the predominance of families such as Asteraceae and Lamiaceae (Campos Saldaña *et al.* 2024; Rejón Orantes *et al.* 2023). These families combine ecological availability with high phytochemical diversity, which may contribute to their recurrent prominence in traditional medical systems. The dominance of herbaceous growth forms and the frequent use of leaves are also consistent with sustainable harvesting practices documented in comparable contexts, as leaf collection generally exerts lower demographic impact on plant populations than root or bark extraction. Likewise, the predominance of aqueous preparations, particularly infusions and decoctions, reflects low-cost and accessible extraction techniques that are compatible with household-based medicinal systems.

The therapeutic structure observed in Jilotepec mirrors broader health priorities commonly reported in rural settings. Digestive and respiratory conditions collectively accounted for nearly half of all reported uses, with epigastric pain, bronchitis, and related ailments occupying central positions within the medicinal repertoire. Gastrointestinal disorders are consistently identified as dominant use categories in ethnobotanical research (Gómez-Chang *et al.* 2024; Sotelo-Leyva *et al.* 2022), and their prominence in this community likely reflects a combination of dietary factors, occupational exposure, and reliance on self-managed care strategies. The high frequency of treatments for anxiety and related nervous system conditions also highlights the continued relevance of plant-based remedies for psychosomatic and emotional disturbances, a pattern increasingly documented in ethnopharmacological literature (Romero-Cerecero *et al.* 2019; Vidal Gutiérrez *et al.* 2020).

The PCA results suggest that the local medicinal system is both structured and flexible. While digestive and respiratory conditions formed distinct clusters, many botanical families occupied central positions within the ordination space, indicating polyvalent therapeutic associations. Such functional redundancy, particularly evident in wound treatment and inflammatory conditions, may enhance system resilience by allowing substitution among species according to availability or seasonal variation. This flexibility has been recognized as a characteristic feature of adaptive traditional medical systems and contributes to their persistence under changing ecological conditions.

Use value and informant consensus metrics further reinforce the existence of a culturally coherent local medicinal repertoire. Species such as *Artemisia absinthium*, *Justicia spicigera*, and *Psidium guajava* showed elevated UV, reflecting their relative prominence within the community. High ICF values for frequently treated conditions such as epigastric pain and bronchitis indicate substantial agreement among informants, suggesting that these applications are culturally consolidated. At the same time, categories with ICF = 1.00 based on single reports illustrate the mathematical sensitivity of consensus indices and underscore the importance of cautious interpretation in small sample contexts.

From an ethnopharmacological perspective, the presence of species with documented toxicological profiles introduces an additional dimension to the analysis. Approximately 15 % of recorded taxa have reported adverse effects under specific conditions, including well-established anticholinergic toxicity in *Brugmansia candida*, phototoxic and reproductive risks in *Ruta graveolens*, hepatotoxic potential in *Borago officinalis*, dose-dependent effects in *Artemisia absinthium*, anthraquinone-related toxicity in certain preparations of *Aloe vera*, and sympathomimetic activity in concentrated extracts of *Citrus × aurantium*. The coexistence of therapeutic use and documented toxicity underscores the complexity of traditional

medicinal systems, where safety is mediated by preparation methods, dosage knowledge, and contextual use. This dual dimension of efficacy and risk highlights the importance of integrating ethnobotanical documentation with toxicological and pharmacological research, particularly given that fewer than 10 % of angiosperm species worldwide have undergone systematic pharmacological evaluation (Maldonado *et al.* 2020).

Beyond pharmacological considerations, the persistence of this medicinal knowledge must be understood within a broader biocultural framework. Mexico's exceptional medicinal plant richness, estimated at more than 4,500 species (Lucía *et al.* 2021; Sosa *et al.* 2023), is unevenly documented across regions, and several communities remain underrepresented in ethnobotanical research. In Veracruz, despite its floristic diversity (CONABIO, 2021) and documented regional studies (Castro Guzmán *et al.* 2021; Hernández Lozano *et al.* 2022; Juárez-Vázquez *et al.* 2013; Salazar-Gómez and Alonso-Castro 2022), local knowledge in areas such as Jilotepec had not been systematically recorded. Rapid land-use change and sociocultural transformation pose ongoing challenges to the continuity of traditional practices (Yinghe and Yeo-Chang, 2021). Documenting and analyzing these knowledge systems contributes not only to cultural preservation but also to identifying species of pharmacological interest and to informing community-based conservation strategies.

Overall, the medicinal repertoire of Jilotepec appears as a culturally consolidated yet adaptive system structured around recurrent therapeutic domains, supported by shared knowledge, and mediated by accessible preparation practices. Its persistence reflects the dynamic interplay between ecological availability, cultural transmission, and perceived therapeutic efficacy. Integrating ethnobotanical documentation with pharmacological validation and conservation planning may strengthen both public health perspectives and the long-term safeguarding of biocultural heritage.

## Conclusion

This study documents and quantitatively analyzes the medicinal plant knowledge of a rural community in central Veracruz, Mexico, identifying 40 species actively integrated into local health practices. Although taxonomic diversity is moderate, use reports are strongly concentrated in a limited subset of culturally salient species, supported by high use values and substantial informant consensus for recurrent health conditions. These patterns indicate the presence of a structured and socially shared medicinal system centered on digestive, respiratory, inflammatory, and nervous system-related ailments.

The integration of diversity indices, consensus metrics, and multivariate analysis allowed the identification of key species and therapeutic domains within the local repertoire. Additionally, the incorporation of a complementary toxicological screening highlights that a minority of species present documented dose-dependent or preparation-specific risks, underscoring the importance of contextual knowledge in mediating safety. By combining ethnobotanical documentation with quantitative and safety-oriented analyses, this study provides baseline data for future pharmacological, ecological, and conservation research, while contributing to the recognition and safeguarding of biocultural heritage in Veracruz.

## Declarations

**List of abbreviations:** CONABIO - Comisión Nacional para el Conocimiento y Uso de la Biodiversidad; ICF - informant consensus factor; UV - use value; % F - fidelity level.

**Ethics approval and consent to participate:** All participants were informed about the objectives of the study, and their voluntary informed consent was obtained prior to data collection, in accordance with ethical standards for ethnobotanical research.

**Consent for publication:** Not applicable

**Availability of data and materials:** The data used to support the findings of this study are available from the corresponding author upon reasonable request.

**Competing interests:** The authors have no conflicts of interest to declare.

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**Author contributions:** MHL, GEEA, MFOS, and EJCM contributed to the conception of the study. Data collection was carried out by MHL, MFOS, EJCM, and GEEA, with EJCM responsible for monitoring the data collection process and determination of some species. Data analysis was performed by GASO, EJCM, MAVL, and YCCC. MFOS, YCCC, and EJCM wrote the first draft of the manuscript. MHL, MAVL, and GASO contributed to the review and final writing of the manuscript. MFOS and EJCM supervised the study. All authors read and approved the final version of the manuscript.

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