Chapter

Medicinal Plants Used by Indigenous Communities of Oaxaca, Mexico, to Treat Gastrointestinal Disorders

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Abstract

The use of medicinal plants for the treatment of gastrointestinal disorders and ethnodiseases such as diarrhea, stomachache, dysentery, "empacho" (blockage), and bile is a common strategy among indigenous communities. It is estimated that approximately 34% of medicinal plants are used to treat diseases of the digestive tract. In Mexico, gastrointestinal infections caused by bacteria, parasites, or viruses represent one of the main causes of death in children in rural populations. Our objective was to document the use of medicinal plants used by the indigenous groups of Oaxaca, Mexico, for the treatment of gastrointestinal disorders, based on previous studies, experiences, and field observations in indigenous communities and supplemented with bibliographic references. In Oaxaca, there are 16 indigenous groups, the largest being the speakers of the Zapoteco, Mixteco, Mazateco, Mixe, Chinanteco, Amuzgo, Tacuate, Chatino, and Cuicateco languages. In this review of the medicinal plants used for gastrointestinal disorders, 186 species were grouped into 147 genera and 71 botanical families, among which the largest number of species belonged to Asteraceae (29), Fabaceae (15), Euphorbiaceae (9), Solanaceae (9), and Lamiaceae (9). Different pharmacological studies showed potential for preventing microbial and fungal pathogens that cause gastrointestinal disease.

Keywords: ethnodiseases, bioculture, indigenous knowledge, plant diversity

1. Introduction

Medicinal plants are key elements of traditional medicine because they are part of the collection of knowledge and cultural heritage of sociocultural communities. Communities are often repositories and users of medicinal plants, and both rural and urban social groups with rural or indigenous origins have knowledge of these plants. Based on ethnobotanical, ethnomedicinal, and ethnopharmacological studies, the plants that are used by different healers and families of the Tarahumara, Yaqui, Chontal, Nahuatl, Mazahua, Otomi, Mixteco, Zapoteco, Mixe, Maya and Tzotzil groups, and all Mexican indigenous groups are symbolic [1].

In Mexico, gastrointestinal diseases are common in communities that are highly marginalized and poverty-stricken and are often transmitted through the fecal-oral route and the consumption of contaminated water and food. The infant population is the most vulnerable, both in terms of incidence and vulnerability [2]. In 2012, approximately 20% of the population of Chiapas, Guerrero, and Oaxaca did not have access to an adequate quality of water. This problem was exacerbated because only between 65 and 75% of houses have adequate waste management systems. Gastrointestinal diseases in children under 5 years of age directly affect mortality rates (19.2–19.4%) and mainly occur in marginalized communities [3]. These observations suggest that minimizing gastrointestinal diseases is dependent on the social environment of the community, access to clean water and food safety. As such, the symptoms and syndromes of diarrhea, stomachache, gastric atrophy, and enteric fever are associated with bacterial, fungal, parasitic, and rotavirus agents [2], and the frequency of these symptoms among children varies from community to community.

Medicinal plants are commonly used by communities for the treatment of gastrointestinal disorders through plant infusions, maceration, chewing, poultices, and different types of extracts (alcoholic or aqueous) [1]. Some studies have documented the traditional uses of medicinal plants by healers, their conservation, and their cultural importance in different indigenous groups [4–9]. Other studies have contributed ethnobotanical knowledge of medicinal plants [10–12]. The evaluation of phytochemical compounds with medicinal activity is also a subject of interest [13–16]. One aspect in which different authors have devoted a great amount of attention to is the antiparasitic and antimicrobial effects of medicinal plants for the treatment of diarrhea and other gastrointestinal disorders [17–25].

Research in natural products is often based on ethnobotanical information. One goal of ethnopharmacology is to improve the understanding of the pharmacological effects of plants on health, especially for indigenous communities that are highly marginalized and poverty-stricken. In this study, we examined plants used for the treatment of gastrointestinal disorders such as diarrhea, dysentery, and abdominal pain. The objective of this work was to document the use of medicinal plants used by the indigenous groups of Oaxaca, Mexico for the treatment of gastrointestinal disorders, based on previous unreported studies, experiences, and field observations in indigenous communities. Our results are supplemented with bibliographic reviews.

2. Sociocultural and ethnographic context of Oaxaca, Mexico

Mexico has an indigenous population of 12.25 million (10.1% of the total), of which 7.38 million speak an indigenous language [26]. It is estimated that there are 1.2 million speakers in Oaxaca over 3 years of age that speak an indigenous language. Oaxaca is the state with the largest indigenous population (32.2% of its total population) and has 245 municipalities where more than 40% of the population speaks indigenous languages [26–28]. However, in Mexico, 24.4 million people consider themselves indigenous [26, 29], a figure that is higher than the total number of inhabitants of several European countries and is of great importance in the preservation of culture, biodiversity, and biocultural heritage. Indigenous peoples are also associated with the use of medicinal plants.

Based on the vegetation, ecosystem, biome, and indigenous settlement maps, Toledo et al. [30] identified 26 indigenous regions in Mexico. These regions coincide with the zones of greatest biodiversity and pluriculturality or indigenous settlements and are also where protected natural areas are located. In Oaxaca, eight

indigenous regions were identified: Mixteca, Cañada, Papaloapan, Sierra Norte, Istmo, Costa, Sierra Sur, and Valles Centrales Different indigenous communities can be found in each of these regions. The Mixteca region is dominated by the Mixteco, Triqui, Chocho and Nahuatl groups, the Cañada by the Cuicateco and Mazateco groups, and so on. The topography of the mountainous areas and valleys of Oaxaca is rugged, with contrasting climates ranging from humid temperate at 2000–3000 masl, to temperate to subtemperate in intermediate zones from 1000 to 2000 masl, to tropical and subtropical regions (<1000 masl) [31]. Thus, indigenous communities are located in various climates, altitudes and vegetation, and consequently have access to and knowledge of different medicinal plants. We should note that among Oaxaca indigenous regions, the differences are not extreme in terms of climatic conditions, flora, fauna, topography, crops, handicrafts, and the use of traditional medicinal plants (**Table 1**); however, there are sociocultural differences in the knowledge associated with the use of plants for treating ethnodiseases and diseases with clinical diagnoses.

Among indigenous communities from distant ethnic regions and origins, and occupying different geographical territories, the use of plants for the treatment of gastrointestinal disorders is different, even though the symbolic or cosmological meanings may be the same. Thus, there is similar understanding of how plants are

Indigenous region (n[1])	Main indigenous groups	Climate and precipitations	Altitude (m)
Mixteca (155)	Mixtecos, Triquis, Nahuas	Tropical subhumid, semitropical subhumid to temperate subhumid, annual precipitation from 550 to 2177 mm. Includes a semi-dry region	1200–2800
Cañada (45)	Mazatecos, Cuicatecos, Ixcatecos, Nahuas	Semidesert with variations of very warm, semiwarm and temperate in high areas, annual precipitation from 372.8 to 643.7 mm	1180–2700
Papaloapan (20)	Chinantecos, Zapotecos, Mazatecos, Mixes	Tropical humid, semitropical humid to humid temperate, and precipitation from 2000 to 4500 mm. The rainiest region of Oaxaca	0–2000
Sierra Norte (68)	Zapotecos de la Sierra, Mixes, Chinantecos, Mazatecos, Cuicatecos	Tropical subhumid, semitropical subhumid to temperate subhumid, annual precipitation from 1000 to 3000 mm	1000–3200
Valles Centrales (121)	Zapotecos de Valles, Mixtecos, Mixes	Subtropical to semidry, annual precipitation from 600 to 800 mm	1000–2000
Istmo (41)	Zapotecos, Huaves, Zoques, Chontales	Tropical subhumid to semitropical subhumid, annual precipitation from 800 to 2500 mm.	0–1600
Sierra Sur (70)	Zapotecos de la Sierra Sur, Amuzgos, Mixtecos, Chatinos, Triquis	Tropical subhumid, semitropical subhumid to humid temperate, annual precipitation from 800 to 2000 mm	1000–2600
Costa (50)	Zapotecos de la Costa, Mixtecos, Amuzgos, Chatinos, Chontales	Tropical subhumid, semitropical subhumid to temperate, delimited region by Sierra Madre del Sur, annual precipitation from 731.9 to 2050 mm	0–2000

[1]*Number of municipalities; sources: Arellanes et al. [31].*

Table 1.
Ecogeographic descriptions of eight indigenous regions of Oaxaca, Mexico.

used to treat stomach, intestinal, diarrhea, or psychosomatic diseases (e.g., "susto" (fright), stomachaches, "mal aire" (bad air) with vomiting, and "empacho" (blockage), but the species of plant used, form of use, and application differ significantly between ethnic groups. In severe cases of illness, indigenous peoples resort to the community healers or alternate among medical professionals, pharmaceutical medicine, and the use of medicinal plants recommended by the family or healers [32, 33].

3. Relationship between indigenous groups and endemic medicinal plants used for gastrointestinal disorders

Among rural and indigenous communities, the concept of health and disease is holistic. As such, the human body develops its organic and metabolic functions without physical deterioration and includes mental, mystical-spiritual, and psychological aspects (symbolic reality). Social, cultural, and ethnic concepts are implicit in the perceptions of health and disease, and based on these concepts, the healing-therapeutic benefits of medicinal plants are sought. From the indigenous perspective, the causal explanations of illness are complex. The body suffers symptomatic imbalances resulting from physical, emotional, or mental deterioration, which are consequences of "susto" (fright), anger, interpersonal conflicts, cold currents, harmful foods (cold, hot, types of meat, cravings, etc.), sexual relations, witchcraft, etc. [34–38]. Consequently, the factors that produce imbalances in the body, in this case stomach problems, are to be avoided.

The knowledge and use of medicinal plants in indigenous communities is changing due to the introduction of pharmaceutical products recommended by health professionals. Giovannini et al. [39] note two trends in support of this fact: the complete displacement of medicinal plants by pharmaceutical products and the coexistence between clinical medicine and the use of medicinal plants. Thus far, local indigenous knowledge for the treatment of cardiovascular diseases, cancers, diabetes, and other prevalent diseases has been disseminated, which is why patent medicine is used. However, there are some examples of healing via the use of medicinal plants. In cases of chronic diarrhea caused by pathogens, the use of plants has been beneficial, such as plants used to treat diarrhea caused by *Salmonella* spp. [24]. In Oaxaca, acute diarrhea and acute respiratory infections are the main causes of mortality in children under 5 years of age [40].

The prevalence among Oaxacan children of microbial or parasitic gastrointestinal diseases, which cause acute diarrhea and other problems, has forced communities to resort to medicinal plants. Consequently, under these circumstances, there is a set of common species among indigenous communities that are used similarly, provided that their ecological conditions are also similar. It should also be noted that knowledge may be treated differently between different ethnic communities, especially when faced with common health problems. For example, the Mixe, Mixteco, and Zapoteco groups of the Sierras, located in temperate regions, commonly use *Chenopodium graveolens*, *Lantana achyranthifolia*, *Baccharis salicifolia*, and *Miconia mexicana*, although the local names used by each region are different. Additionally, the Chinanteco groups and Zapoteco of the Istmo use similar plant species (**Table 2**).

3.1 Healers and medicinal plants

Within Oaxacan indigenous groups, the healers play essential roles as therapists or ethnopractitioners and are not referred to as shamans, witch doctors, or herbalists. Here, we only refer to the cures or treatments using plants recommended by healers for the treatment of gastrointestinal disorders. The indigenous healers have

Indigenous group (climate at the communities)	Species	Spanish name	References
Mixtecos, Mixe, Zapotecos de las Sierras (temperate)	*Chenopodium graveolens* Willd.	Epazote de zorrillo	[14, 17]
Mixtecos, Mixe, Zapotecos de las Sierras (temperate)	*Lantana achyranthifolia* Desf.	Cinco negritos, Hierba mariposa	[8, 16]
Mixtecos, Mixe, Zapotecos de las Sierras (temperate)	*Baccharis salicifolia* (Ruiz & Pavón) Pers.	Jara, cacho de venado	[1, 4, 5, 13]
Mixtecos, Mixe, Zapotecos de las Sierras (temperate)	*Miconia mexicana* (Bonpl.) Naudin	Itswa	[21]
Mixe, Mixtecos (temperate)	*Loeselia mexicana (*Lam.) Brand.	Espinosilla	[21, 41]
Chinantecos, Zapotecos del Istmo (tropical and subtropical)	*Gomphrena serrata* L.	Cabezona, amor seco, amor de soltero	[1, 42, 43]
Chinantecos, Zapotecos del Istmo (tropical and subtropical)	*Byrsonima crassifolia* (L.) Kunth	Nanche amarillo (corteza)	[6, 14, 24, 41]
Chinantecos, Zapotecos del Istmo (tropical and subtropical)	*Cuphea pinetorum* Benth.	Cenicilla, Hierba de gallina	[18, 25]
Chinantecos, Mixe, Zapotecos del Istmo (tropical and subtropical)	*Gouania lupuloides* (L.) Urb.	Bejuco de reuma	[17, 44, 45]

Table 2.
Common plants used by indigenous groups for the treatment of gastrointestinal disorders in Oaxaca, Mexico.

social recognition in the communities as persons of knowledge, skills, and healing practices. These healers have the facilities to explain the physical and nonphysical causes of diseases through a symbolic, verbal and corporal language, and resort to deities to exercise healing techniques. The body of knowledge is a legacy inherited or acquired from their ethnic medical culture and becomes a depository with the capacity to incorporate medical experiences regarding the descriptions of diseases, anatomy, and physiology of the human body [1, 34, 38, 46, 47].

The healer's diagnosis is based on the spirit, soul, and body, which are closely interconnected, to define health and disease. In Oaxacan communities, Mixe and Mazateco healers use psychotropic or hallucinogenic plants and mushrooms for successful diagnoses and healing. These hallucinogens are used as a mechanism to access supernatural forces and as interlocutors to ward off malignant agents [34, 46, 47]. The remedies or treatments recommended by healers for gastrointestinal problems vary from diets, teas, maceration or poultices of medicinal plants, changes in eating habits such as avoiding foods considered "hot" or "cold," avoiding animals or people, sun exposure, or environmental changes in temperature, such as avoiding cold water, etc.

María Sabina was a well-known healer among the Mazateco Indians of the Sierra de Huautla de Jiménez in Oaxaca and throughout Mexico. After her death, she was recognized as a symbolic character of the Mexican healers. She used mushrooms (e.g., *Psilocybe zapotecorum and Psilocybe mexicana*) and hallucinogenic plants (e.g., *Salvia divinorum*) to obtain divine powers both to diagnose and to restore the health of the patient. In the case of gastrointestinal diseases, all recommendations are preventive/curative and are accompanied by psychospiritual rituals of protection, reintegration, and cleanliness of the soul. She is known to have said, "The health services provided by healers and Western medicine should not be lucrative," [48, 49].

3.2 Plants used in indigenous communities for the treatment of gastrointestinal disorders

Medicinal plants are essential natural resources in the indigenous communities of Oaxaca, Mexico; they are easily accessible and there is a high diversity of species and forms of use for the treatment of diseases of the digestive tract. The region has the greatest level of diversity and endemism of species of phytotherapeutic use [50]. Based on a bibliographical compilation and field notes of visits to the indigenous communities of Oaxaca, a short list of medicinal plants used for gastrointestinal disorders was obtained (**Table 1A**). The compilation consists of 71 botanical families, among which the greatest number of species is in the families Asteraceae (29), Fabaceae (15), Euphorbiaceae (9), Solanaceae (9), Lamiaceae (9), Verbenaceae (6), Myrtaceae (5), Malvaceae (5), and Fagaceae (5). These families included 147 genera and 186 endemic species [50]. The genera used most frequently were *Croton* (5), *Quercus* (4), *Piper* (4), *Psidium* (3), *Ocimum* (3), and *Tagetes* (3). The medicinal species introduced to Mexico were excluded from this list, despite being widely used by Oaxacan indigenous groups.

Among indigenous communities, plants are grouped according to gastrointestinal physiological alterations, among which the most common refer to diarrhea (112 plants), stomach pain (90 plants), and dysentery (79 plants). Acute diarrhea is a symptom of gastrointestinal tract infection, which is commonly caused by pathogenic bacteria (e.g., *Escherichia coli*, *Salmonella* spp., *Vibrio cholerae*, *Clostridium perfringens*, *Bacillus cereus*, *Staphylococcus aureus*, *Vibrio parahaemolyticus*, *Campylobacter jejuni, Campylobacter coli, Shigella* spp*., and Aeromonas* spp*.)*, viruses (rotavirus, adenovirus, enterovirus, and norovirus), or parasites (*Giardia lamblia* and *Entamoeba histolytica)* and is frequently accompanied by abdominal pain, stomach pain, fever, and vomiting [51]. For the treatment of vomiting, constipation and parasites, between 28 and 31 plant species are used. For the condition known locally as "empacho" (gastrointestinal disease) as well as for indigestion, ulcers and gastritis, between 17 and 39 species are utilized (**Table 1A**). It is important to note that we refer to the local descriptions of symptoms and the disease names that are used by Oaxacan indigenous communities.

The indigenous knowledge of medicinal plants includes the different phases of use, correct identification of the species (although they do not have systematic botanical studies), wild or cultivated origin, collection time (morning, noon, afternoon, or night), plant part to be used, and processing required for use. Each of these elements affects the effectiveness of the plant [8, 17, 51]. The leaves, stems and flowers are the most used parts, and the bark, roots and seeds are used less often (**Table 1A**). The form of use or extraction preparation ranges from infusion and cooking in water, maceration in ethyl alcohol (*Dorstenia drakena* L. and *Barkleyanthus salicifolius* (Kunth) H. Rob. & Brettell) or cane alcohol (*Saccharum officinarum* L.) and consumed as tea (oral), or as a topical application between the stomach and intestines. Additionally, the fresh crushed leaves or leaves macerated in ethyl alcohol can be ingested or applied topically (rubbed onto the affected part). Plants for treating dysentery are used as purgatives or for treating constipation as rectal washes and include *Eryngium foetidum* L., *Capraria biflora* L., *Prosopis laevigata*, and *Solanum rostratum* Dunal (**Table 1A**).

Bark is often cooked or used as an infusion in hot or cold water; it is a common treatment for diarrhea, dysentery and related symptoms. The bark of *Semialarium mexicanum* (Miers) Mennega*, Hymenaea courbaril* L., *Quercus oleoides, Hintonia latiflora*, and *Guaiacum coulteri* is used to treat ulcers or gastritis, and the bark of *Amphipterygium adstringens* is used to treat stomach cancer. The roots of some plants have shown to be beneficial to treat diarrhea, stomach pain, and intestinal

infection. In addition, the use of fruits and seeds to treat diarrhea, dysentery, constipation, and "empacho" is mentioned. For example, the fruits and seeds of the chili pepper (*Capsicum annuum* L.) are used for the treatment of dyspepsia (inflammation of the digestive tract), diarrhea, and dysentery. An infusion of guava leaves and roots (*Psidium* spp.) is used to treat diarrhea, dysentery, stomach pain, flatulence, and vomiting. The peel of the fruits of *Curatella americana* L. and *Persea americana* Mill. and the stigmas of the corn flower (*Zea mays* L.) are made into an infusion to treat stomachaches. The seeds of *Carica papaya* L. are used to treat diarrhea, vomiting, fever, intestinal inflammation, and parasites (**Table 1A**).

"Empacho" is a digestive ethnodisease recognized by traditional Mexican people. This disorder primarily occurs in children and does not correspond to a specific clinical diagnosis, but is culturally recognized in all Mexican rural communities. Empacho is characterized by discomfort caused by the intake of food that is difficult to unfold, and the healer or mother of the child indicates that food is "stuck" to the stomach or intestine. Symptoms include abdominal pain, lack of appetite, diarrhea, flatulence, and vomiting. The treatment includes the use of ash- or salt-containing oral plant infusions, purgatives, and massages [52]. Some traditional treatments recommend infusions made from the bark and/or leaves of *Guazuma ulmifolia* Lam. complemented with spoonful of castor oil and massages (sobadas) that "release the empacho" [53].

Another ethnodisease associated with gastrointestinal disorders is "bile or bile leakage." The healer and adults report "pounding" (vibrations) from an area near the stomach, which is accompanied by pain in the esophagus. Symptoms include loss of appetite, headache, feeling of "bitterness" in the mouth upon waking up, and fatigue. *Pseudognaphalium attenuatum* DC., *Agastache mexicana* spp. Xolocotziana, *Hintonia latiflora*, *Loeselia mexicana*, *Tecoma stans*, *Zornia thymifolia*, *Anoda cristata*, *Oenothera rosea*, *Verbena litoralis*, and *Calea ternifolia* var. *Ternifolia* are used to treat bile (**Table 1A**). For gastrointestinal intestinal disorders in children, *Psidium guajava*, *Byrsonima crassifolia*, and *Quercus* spp. are used [53]. Mixe communities use fruit and bark infusions of *G. ulmifolia* to treat diarrhea and hemorrhages [14], whereas *Cestrum nocturnum* is used among the Zapotecas from the southern highlands and the Chinantecos of Oaxaca [53, 54].

Several studies have shown the importance of flavonoids, tannins, terpenoids, and alkaloids present in medicinal plants used for the treatment of gastrointestinal diseases. Other mechanisms of action include antispasmodic activity, delaying of intestinal transit, suppression of intestinal motility, stimulation of the adsorption of water, and a reduction in the secretion of electrolytes [20]. The compounds most frequently reported are terpenoids (monoterpenes, sesquiterpenes, di-, and triterpenes), flavonoids (flavones, flavonols), tannins (condensed and hydrolysable), and volatile compounds, which are derived from the essential oils in aromatic plants.

Root extracts of *Tagetes erecta* have shown to have high efficacy against Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus subtilis*, and *Micrococcus luteus*), Gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*), and fungi (*Candida albicans* and *Aspergillus niger*). Flowers of *T. erecta* have been shown to contain thiophene derivatives, terpenoids, alkaloids, flavonoids, and carotenoids [55]. Similarly, methanol extracts of *Tagetes lucida* yielded coumarins with high antimicrobial activity against Gram-positive and Gram-negative bacterial strains, with greater inhibition of *V. cholerae* as well as antifungal activity. The antifungal activity of *T. lucida* results from the presence of dimethoxy: 6,7-dimethoxy-4-methylcoumarin and scoparone (6,7-dimethoxycoumarin) [56] and is effective against *Helicobacter pylori* [57]. In traditional Oaxacan medicine, the anthelminthic effects of *Chenopodium ambrosioides* (epazote) along with the epimastigotes of *Trypanosoma cruzi* have demonstrated efficacy against *Entamoeba histolytica* infections due to the effect of limonene [58].

4. Antipathogenic efficacy of medicinal plants

A natural question about the use of medicinal plants for treating gastrointestinal disorders is: how effective are the uses of plants in controlling or preventing infections by pathogenic agents? Several in vitro studies have been conducted that aimed to evaluate the biological activity of plant extracts against enteropathogenic bacteria (*Escherichia coli, Shigella sonnei, Shigella flexneri, Salmonella*, *and Campylobacter*) and parasites (*Giardia lamblia and Entamoeba histolytica*) responsible for diarrhea, dysentery and/or gastric disorders [59–61]. Several chemical compounds (alkaloids, tannins, flavonoids, and terpenes) responsible for the pharmacological effects of these plants have been identified and isolated [62, 63]. Examples of biological activity of native plants of Oaxaca, Mexico, used for the prevention and control of gastrointestinal disorders are listed in **Table 3**.

The experiences in the communities of Oaxaca indicate that the roots and aerial parts of *Geranium mexicanum* Kunth and the flowers of *Chiranthodendron pentadactylon* are effective to treat diarrhea, dysentery, and stomach pain (**Table 3**). The methanolic or aqueous extracts of these plants showed high antibacterial activity against *Shigella flexneri* and *Shigella sonnei* at minimum inhibitory concentrations of 8 mg/mL. Both extracts can be considered an alternative strategy to treat enteric pathogens resistant to common drugs [60]. In biological experiments using mice, it was demonstrated that the molecule (−)-epicatechin, which is isolated from *Geranium mexicanum*, has high antiprotozoal activity (*Giardia lamblia*) in concentrations of 0.072 μmol/kg, which is the dose required to kill 50% of microorganisms [59].

Calzada et al. [69], found that (−)-epicatechin and tiliroside, isolated from extracts of *C. pentadactylon* flowers, were effective against *E. histolytica, G. lamblia*, *E. coli, S. sonnei, S. flexneri, Salmonella* sp., and *Vibrio cholerae*. In another work, Calzada et al. [11] determined that root extracts of *G. mexicanum* had a greater hyperperistaltic effect than the extracts of *Lygodium venustum*, *Chenopodium ambrosoides*, and *C. pentadactylon*, which was similar to the effect of the drug loperamide, which is used to control acute and constant diarrhea associated with intestinal inflammation. In experiments with mice, the methanolic extracts of *G. mexicanum*, *Bocconia frutescens*, and *C. pentadactylon* in a concentration of 300 mg/kg of body weight had high inhibitory or intestinal antisecretory activity against *V. cholerae*. The activity of these extracts exceeds the effect of the drug loperamide [72]. A similar effect was determined with extracts of *C. pentadactylon* flowers [73]. *B. frutescens* also showed inhibitory activity against *S. aureus* and *E. coli* [60]. These results show that *G. mexicanum, C. pentadactylon*, and *B. frutescens* have medicinal properties and are effective for the treatment of diarrhea, among other gastrointestinal problems (**Table 3**).

The methanolic extracts *Ocimum basilicum* and *Artemisia ludoviciana* have inhibitory effects against *V. cholerae*, and the minimum bactericidal concentration varies from 0.5 to 3.0 mg/mL. The extracts have a degradative effect on the cellular membranes of *V. cholerae*, which increases membrane permeability, decreases cytoplasmic pH, hyperpolarizes the membrane, decreases the cellular ATP concentration, and consequently causes cell death [65]. This result indicates a chemical modification of the growth medium and induction of the death of the pathogen. For example, Hussain et al. [62] reported that basil contains essential oils (linalool, epi-α-cadinol, α-bergamotene, and γ-cadinene) that exert antimicrobial activity against *S. aureus* and *B. subtilis*. Similarly, the essential oil of *A. ludoviciana* contains camphor, 1,8-cineole, and camphene, which were effective against *Acanthamoeba castellanii*, *Leishmania infantum,* and *Trichomonas vaginalis* [66].

Plant species	Gastro-intestinal disorders (parts[1])	Chemical compounds	Antimicrobial activity	References
Ambrosia artemisiifolia L.	Stomachache and intestinal parasites (All)	Isabelin (germacranolide sesquiterpene dilactone)	*S. aureus* *C. albicans*	[64]
Artemisia ludoviciana Nutt	Chronic active gastritis and peptic ulcer (St, L)	Camphor, 1,8-cineole and camphene, sesquiterpene lactones, and flavonoids	*V. cholerae* *H. pylori* *A. castellanii,* *L. infantum* *T. vaginalis*	[57, 65–67]
Geranium mexicanum Kunth	Diarrhea, dysentery, and stomachache (R, St, L)	(−)-Epicatechin	*S. flexneri* *S. sonnei,* *E. histolytica* *G. lamblia*	[59–61]
Ocimum basilicum	Diarrhea, dysentery, stomachache and vomit (St, L)	Linalool, epi-α-cadinol, α-bergamotene, and γ-cadinene	*V. cholerae* *S. aureus* and *B. subtilis*	[62, 65]
Lantana achyranthifolia Desf.	Gastro-intestinal disease (AP)	Carvacrol, isocaryophyllene, α-bisabolol, bisabolene, and 1,8-cineole	*V. cholerae,* *S. boydii,* *Y. enterocolitica* *F. moniliforme*	[8, 68]
Chiranthodendron pentadactylon	Antimicrobial and antidiarrheal activities (F)	Epicatechin and tiliroside	*S. flexneri* *S. sonnei* *E. histolytica* *G. lamblia* *E. coli* *Salmonella* spp. *V. cholerae.*	[60, 69]
Anoda cristata	Stomachache (L)	Acacetin and diosmetin	*H. pylori*	[63, 70]
Bocconia frutescens	Diarrhea, dysentery stomachache ulcers (L)		*E. coli* and *S. aureus.*	[63]
Lippia graveolens H.B.K.	Diarrhea, dysentery, indigestion (AP)	Carvacrol, α-terpinyl acetate, m-cymene, and thymol	*R. solani* *E. coli* *P. aeruginosa* *S. aureus*	[68, 71]
Guaiacum coulteri A. Gray	Chronic active gastritis and peptic ulcer (OB)	Alkaloids	*Helicobacter pylori*	[57]

[1]*All, all parts; AP, aerial parts; L, leaf; St, stem; and OB, outer bark.*

Table 3.
Antimicrobial activity of native medicinal plants of Oaxaca, Mexico.

Aqueous extracts of *A. ludoviciana ssp. Mexicana* and methanolic extracts of *Guaiacum coulteri* showed high growth inhibitory activity against *Helicobacter pylori* at minimum inhibitory concentrations of 125 and < 15.6 μg/mL, respectively [57].

H. pylori is the etiological agent of chronic active gastritis and peptic ulcer and is related to gastric carcinoma. It was also shown that *A. ludoviciana* has activity against *Campylobacter jejuni* and *C. coli* at minimum bactericidal concentrations of 0.5 mg/mL [74]. Ruiz-Cancino et al. [67] determined that the sesquiterpene lactones (douglanin, ludovicin A, 1α, 3α-dihydroxyarbusculin B, santamarin, arglanin, artemorin, chrysartemin B, armefolin, ridentin, eudesmanolide 3α-hydroxyreynosin, etc.) and flavonoids (eupatilin and jaceosidin) of *A. ludoviciana* spp. *mexicana* are the molecules responsible for the inhibitory properties against the nuclear transcription factor kappa B, NF-κB [14]. NF-κB is involved in critical mechanisms related to the development of cancer. The signaling cascades of NF-κB may be the main malignant gastrointestinal mediators that favor esophageal, gastric, and colon cancer [75].

The essential oils of *Lantana achyranthifolia* consist of monoterpenes and sesquiterpenes (carvacrol, isocaryophyllene, α-bisabolol, α-bisabolene, and 1,8-cineole), have antibacterial activities against Gram-positive and Gram-negative bacteria, *V. cholerae, Shigella boydii*, and *Yersinia enterocolitica* [76]. The antibacterial activity results from the compounds carvacrol, 1,8-cineole and linalool [77]. The essential oils of *L. achyranthifolia* and *Lippia graveolens* have antifungal activity [68] and contain carvacrol, α-terpinyl acetate, β-caryophyllene, geranyl acetate, terpinyl acetate, bornyl acetate, and limonene [77, 78]. More research is required on other medicinal species with similar potential.

The extracts of *Cnidoscolus aconitifolius*, *Crotalaria pumila*, and *Anoda cristata* (**Table 3**) inhibit bacterial growth. The flavonoids acacetin and diosmetin from *A. cristata* have been shown to inhibit up to 90% of *H. pylori* growth. These data suggest that, through the use of nutraceutical food plants, *H. pylori* infections can be prevented [70]. *Ambrosia artemisiifolia* L. is used to treat stomach pain and contains isabelin, a germacranolide sesquiterpene dilactone with antimicrobial activity against *S. aureus* and *Candida albicans* [64].

5. Remarks

Medicinal plants continue to play an indispensable role in the daily life of rural and urban communities. However, their use is controversial, and they are often only used in teas or hot drinks; they are not associated with healing properties. Through interactions with the indigenous communities of Oaxaca, Mexico, it was found that all households use the inherited knowledge of medicinal plants. In the regions furthest from the urban centers where the hospitals are located, medicinal plants are part of the survival strategy.

In the communities of Oaxaca and other regions of Mexico, healers (the generic name for traditional practitioners) are called "yerberos" (herbalists) because they only use plants. The consultation or intervention of the healers occurs when the symptoms of the disease or ethnodisease continue after the patient takes the "remedies" (teas, crushed, chewed, potions, etc.), which are prepared by the adults of the family. We define ethnodisease as a disorder that has no somatic symptoms, description of organic or metabolic dysfunction, or association with clinical symptomatology. Thus, "empacho" is often associated with indigestion, but has a broader sociocultural description than a gastroenterological disorder.

Based on our field notes and previous documentation of the indigenous communities in Oaxaca, Mexico, as well as our bibliography, a brief list of medicinal plants used for gastrointestinal disorders was compiled. This list comprises 71 botanical families, among which the most speciose were Asteraceae (29), Fabaceae (15), Euphorbiaceae (9), Solanaceae (9), Lamiaceae (9), Verbenaceae (6), Myrtaceae (5),

Malvaceae (5), and Fagaceae (5). The families included 147 genera and 186 endemic species. The most frequently used genera were *Croton* (5), *Quercus* (4), *Piper* (4), *Psidium* (3), *Ocimum* (3), and *Tagetes* (3) (**Table 1A**). The medicinal species introduced to Mexico were excluded from this list, despite being widely used by Oaxacan indigenous groups.

The use of antibiotics for infectious gastrointestinal diseases is unconscionable among the users of pharmacological medicine and has generated collateral damage, including antibiotic resistance of pathogenic microorganisms. Cases of antibiotic resistance are increasingly frequent, and thus, medicinal plants will fill an important niche once their antibacterial, antiprotozoal, antisecretory, spasmolytic, and anti-inflammatory protective effects are demonstrated. In addition to these benefits, antiradical and antioxidant activity effective against gastroenterological disorders have been shown after the frequent consumption of teas. Advances have been made in the knowledge of antipathogenic effects of medicinal plants and their association with specific compounds. However, not all plants used by the indigenous groups of Mexico and Latin America are being studied and documented.

Acknowledgements

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A. Appendix

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Acanthaceae			
Justicia spicigera Schltdl.	Stomachache, diarrhea, dysentery, nausea, cramps (L, St, F)	Phenolics, flavonoids, lignans	[14, 17, 51, 53, 79–81]
Amaranthaceae			
Dysphania ambrosioides (L.)	Diarrhea, vomiting, stomach pain and inflammation, parasites (AP, L)	Terpenoids, flavonoids	[4, 11, 53, 54, 60, 82–85]
Dysphania graveolens (Willd.) Mosyakin & Clemants	Stomach pain, diarrhea, parasites, dysentery, indigestion, *empacho*, vomiting (AP)	Terpenoids, flavonoids	[17, 53, 57, 86]
Anacardiaceae			
Amphipterygium adstringens (Schltdl.) Standl.	Ulcers, stomach cancer, gastritis, stomach pain, intestinal infection, and inflammation (Se, St, Bark)	Triterpenes, phenolic, lipids	[41, 53, 57, 87, 88]
Spondias mombin L.	Diarrhea, stomach pain, dysentery, *empacho* (OB)	Phenols, flavonoids, saponins	[53, 89–91]
Spondias purpurea L.	Diarrhea in children (OB, R)	Phenols, flavonoids, tannins, phenolic acid derivatives, terpenoids	[14, 17, 41, 92, 93]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Annonaceae			
Annona glabra L.	Dysentery, diarrhea (R, L, Sh)	Flavonoids, diterpenoids	[53, 94, 95]
A. reticulata L.	Diarrhea, stomach pain, intestinal pain (bark, L, Sh)	Acetogenins, terpenoids, alkaloids, phenols	[14, 53, 92, 96–100]
Apiaceae			
Donnellsmithia juncea (Spreng.) Mathias & Constance	Diarrhea, vomiting (All)		[53]
Eryngium foetidum L.	Diarrhea, dysentery, stomach pain (L)	Tannins, saponins, terpenoids, flavonoids, phenols, eryngial	[53, 54, 92, 101–103]
Apocynaceae			
Plumeria rubra L.	Intestinal parasites, diarrhea, purgative (Steam latex)	Terpenoids, iridoids, phenols, flavonoids	[53, 104, 105]
Thevetia ahouai (L.) A. DC.	Ulcers, purgative (All)	Cardenolide glycosides	[53, 106]
Araceae			
Anthurium schlechtendalii Kunth ssp. Jimenezii	Diarrhea (All)		[92]
A. schlechtendalii Kunth ssp. Schlechtendalii	Diarrhea (All)		[92]
Aristolochiaceae			
Aristolochia leuconeura Linden	Diarrhea, colics (All)		[84]
Asclepiadaceae			
Asclepias curassavica L.	Intestinal parasites, purgative (AP)	Cardenolides, glycosides, protease	[14, 92, 107]
Asteraceae			
Ageratum conyzoides L.	Stomach pain (All)	Terpenoids, flavonoids, benzofuranes, and coumarins	[92, 108, 109]
Ambrosia artemisiifolia L.	Stomach pain, intestinal parasites (L)	Terpenoids, sterols	[53]
Artemisia ludoviciana ssp. mexicana Nutt.	Stomach pain, vomiting, dysentery, colic, parasites, indigestion, diarrhea, flatulence (L, St)	Sesquiterpene lactones, flavonoids	[4–6, 10, 11, 14, 53, 57, 60, 67, 72, 84]
Baccharis conferta Kunth	Diarrhea, vomiting, indigestion, colic, and stomach pain (All)	Flavonoids, terpenoids	[10, 41, 43, 53, 110]
B. salicifolia (Ruiz & Pav.) Pers.	Stomach infection, stomach pain; diarrhea, dysentery (All)	Flavonoids, terpenoids	[5, 9, 13, 53]
Barkleyanthus salicifolius (Kunth) H. Rob. & Brettell	Vomiting, diarrhea, fever (St, L)	Terpenoids, alkaloids, flavonoids	[9, 53, 111]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Bidens pilosa L.	Diarrhea, vomiting, stomach pain, and inflammation, ulcers (F, L, B)	Terpenoids	[53, 112]
Calea ternifolia Kunth var. *ternifolia*	Stomach pain, diarrhea, indigestion, malaria, *bilis* (L)	Terpenoids	[10, 53, 113]
C. urticifolia (Miller) DC.	Dysentery, diarrhea, malaria, stomach pain, heartburn (All)	Terpenoids	[14, 17, 53, 92, 113]
Chaptalia nutans L. Pollak	Dysentery, intestinal parasites (R, L, St)	7-O-beta-D-glucopyranosyl-nutanocoumarin	[17, 41, 53, 114]
Chrysactinia mexicana A. Gray	Diarrhea, dysentery, colic (AP)	Terpenoids	[11, 53, 60, 115–117]
Dyssodia papposa (Vent.) Hitchc.	Diarrhea, stomach pain, vomiting (All)		[53]
Heterotheca inuloides Cass	Gastritis, ulcers (AP)	Terpenoids, flavonoids, phenolics, steroids	[53, 57, 118–120]
Koanophyllon albicaule (Sch. Bip. ex Klatt) R.M. King & H. Rob.	Diarrhea (L)	Sterols, flavonoids, tannins	[53]
Melampodium divaricatum (Rich.) DC	Dysentery, vomiting, nausea (All)	Terpenoids, coumarins, glycoside derivatives	[53, 121]
Mikania houstoniana (L.) B.L. Rob.	Stomach pain (St)		[53]
Parthenium hysterophorus L.	Stomach pain, fever, *empacho*, malaria, parasites (All)	Resin, alkaloids	[53]
Pinaropappus roseus (Less.) Less.	Constipation (L, R, F)		[53]
Piqueria trinervia Cav.	Intestinal infections, diarrhea, typhoid, *empacho*, stomach pain, purgative, parasites, malaria (F, L, R)	Terpenoids	[53, 122]
Pluchea odorata (L.) Cass.	Vomiting, stomach pain (L)	Flavonoids, terpenoids	[41, 53, 123]
Porophyllum macrocephalum DC.	Laxative (R, L)	Terpenoids, sulfur compounds	[10, 53]
Pseudognaphalium attenuatum DC.	Stomach pain, gastritis, *bilis* (AP)		[53, 92]
Sanvitalia procumbens Lam.	Diarrhea, dysentery, indigestion, vomiting, stomach pain (All)	Terpenoids	[53]
Tagetes erecta L.	Stomach pain, *empacho*, diarrhea, colic, vomiting, indigestion, parasites (L, F)	Thiophene derivative, terpenoids, flavonoids, carotenoids	[53, 54, 124–126]
T. filifolia Lag.	Stomach pain, flatulence (All)	Terpenoids	[41, 53, 127]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
T. lucida Cav.	Stomach pain, colic, diarrhea, dysentery, *empacho*, typhoid, vomiting (L, F)	Coumarins, terpenoids, flavonoids	[53, 56, 57, 92, 124]
Tithonia diversifolia (Hemsl.) A. Gray	Vomiting, stomach pain, diarrhea, malaria (L)	Terpenoids, flavonoids, phenols	[5, 10, 57, 84, 128]
Vernonanthura patens (Kunth) H. Rob.	Dysentery (L, Sh, B)	Terpenoids	[53, 129, 130]
Zinnia peruviana L.	Diarrhea, stomach pain (All)		[53, 131]
Bignoniaceae			
Dolichandra uncata (Andrews) L.G. Lohmann	Intestinal inflammation, fever (L, B9		[53]
Parmentiera aculeata (Kunth) Seem.	Dysentery, *empacho* (Bark, Fr)	Flavonoids, sterols, tannins	[7, 41, 53, 132]
Tabebuia rosea (Bertol.) A. DC.	Dysentery, fever, stomach inflammation (Bark)		[41, 43, 53]
Tecoma stans (L.) Juss ex Kunth	Stomach pain, dysentery, *bilis*, gastritis, poor digestion, *empacho*, intestinal atony (L, St, B, OB)	Alkaloids, terpenoids, flavonoids, phenolic acids	[6, 22, 41, 53, 133, 134]
Brassicaceae			
Nasturtium officinale R. Br.	Indigestion (All)		[53]
Burseraceae			
Bursera microphylla A. Gray	Stomach pain (B, gum)	Lignans, terpenoids, flavonoids	[53, 135]
Bursera simaruba L. Sarg.	Dysentery, stomach pain, diarrhea, intestinal infection, purgative (OB)	Tannins, flavonoids, saponins	[41, 53, 135]
Caricaceae			
Carica papaya L.	Diarrhea, dysentery, colic, intestinal parasites, constipation (Fr, L, Se, Latex)	Papain	[6, 11, 53, 72, 92]
Celastraceae			
Semialarium mexicanum (Miers) Mennega	Ulcers, stomach pain, colic, diarrhea, dysentery (R)	Terpenoids	[11, 53, 60]
Chrysobalanaceae			
Chrysobalanus icaco L.	Diarrhea, dysentery (Se, Fr)		[53]
Convolvulaceae			
Ipomoea bracteata Cav.	Diarrhea (T)		[53, 54]
Ipomoea pes-caprae (L.)	Dysentery (L)	Aromatic compounds	[41, 53]
Cruciferae			

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Lepidium virginicum L.	Diarrhea, dysentery, stomach pain, flatulence, colic, vomiting, indigestion, *empacho*, purgative, intestinal parasites (All)		[53]
Cucurbitaceae			
Cucurbita pepo L.	Intestinal parasites (Se)	Steroids, alkaloids, flavonoids, terpenoids, glycosides, pyrrolidine, sterols	[53]
Sechium edule (Jacq.) Sw.	Intestinal parasites, vomiting, constipation (L)		[6, 92]
Dilleniaceae			
Curatella americana L.	Stomach pain, diarrhea (Fr, L)	Flavonoids, terpenoids	[41, 53]
Eduphorbiaceae			
Phyllanthus niruri L.	Diarrhea, stomach pain (All)		[53]
Ericaceae			
Arctostaphylos pungens Kunth	Diarrhea, stomach pain, *empacho* (L, Fr)	Pyrocatechin, resin, and tannins	[53]
Euphorbiaceae			
Acalypha alopecuroidea Jacq.	Diarrhea, ulcers (All)	Flavonoids, polyphenols, saponins, tannins	[53]
Croton ciliatoglandulifer Ortega	*Empacho*, intestinal inflammation, purgative (All)	Isoquinoline derivatives	[53]
C. draco Schltdl. & Cham.	Diarrhea, vomiting, stomach pain, *empacho* (OB)		[41, 53, 96]
C. glandulosus L.	Stomach pain	Terpenoids, alkaloids	[92]
C. repens Schlecht.	Diarrhea, dysentery (R)		[53, 92]
C. soliman Cham. & Schltdl.	Intestinal inflammation, parasites (R)		[53]
Euphorbia tithymaloides L.	Intestinal parasites, purgative, gastritis (Latex)	Alkaloids, steroids, sterols, terpenoids	[53, 92]
Hura polyandra Baill.	Stomach pain, constipation, intestinal parasites, purgative (Se)		[10, 53, 92, 96]
Jatropha curcas L.	Diarrhea, vomiting, constipation (R)		[53, 136]
Fabaceae			
Chamaecrista hispidula (Vahl) H.S. Irwin & Barneby			[84]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Crotalaria longirostrata Hook. & Arn.	Indigestion (L, B)		[41, 53]
Desmodium incanum DC.	Diarrhea, stomach pain (L)		[53]
Diphysa carthagenensis Jacq.	Diarrhea, dysentery (OB)		[53]
Enterolobium cyclocarpum (Jacq.) Griseb.	Diarrhea, purgative, indigestion (Fr, gum, bark)	Terpenoids	[53]
Gliricidia sepium (Jacq.) Kunth ex Walp.	*Empacho*, parasites (L, St)	Flavonoids	[41, 53, 96]
Hymenaea courbaril L.	Dysentery, diarrhea, ulcers (OB, L)	Tannins flavonoids, terpenoids	[41, 53, 92]
Leucaena diversifolia (Schltdl.) Benth.	Parasites (All)		[53]
Machaerium floribundum Benth.	Diarrhea (All)		[43, 53, 92]
Mimosa albida Humb. & Bonpl. Ex Willd.	Diarrhea, dysentery (B)		[41, 53]
Pithecellobium dulce (Roxb.) Benth.	Diarrhea, stomach pain, dysentery, constipation, indigestion (OB)	Flavonoids, glucoside derivatives, sterols, terpenoids	[53]
Prosopis juliflora (Sw.) DC.	Stomach pain, dysentery, indigestion, purgative, parasites (L)	Alkaloids, terpenoids, flavonoids	[53]
P. laevigata (Humb. & Bonpl. ex Willd.) M.C. Johnst.	Colic, intestinal inflammation, dysentery, stomach pain (OB)		[53]
Senna skinneri (Benth.) H.S. Irwin & Barneby	Dysentery, *empacho*, fever (L)		[53]
Vachellia farnesiana (L.) Wight & Arn.	*Empacho*, dysentery, dyspepsia, diarrhea, typhoid (All)	Sterols, alkaloids, flavonoids, phenols	[53]
Zornia thymifolia Kunth	Stomach pain, *bilis*, ulcer (St, L)		[53, 92, 96]
Fabaceae			
Quercus crassipes Bonpl.	Diarrhea (OB)		[53]
Q. glaucescens Bonpl.	Diarrhea (OB)	Tannins	[92]
Q. oleoides Schltdl. & Cham.	Diarrhea, gastritis, *empacho* (OB)	Tannins	[17, 53, 92]
Q. sapotifolia Liebm.	Diarrhea (OB)	Tannins	[92]
Geraniaceae			
Geranium mexicanum Kunth	Diarrhea, dysentery, stomach pain (R, AP)	Sterols, flavonoids, tyramine	[11, 53, 60, 61, 72]
Gesneriaceae			
Sinningia incarnata (Aubl.) D.L. Denham	Diarrhea, dysentery (T)		[14, 92]
Heliconiaceae			

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Heliotropium indicum L.			[84]
Krameriaceae			
Krameria paucifolia (Rose) Rose	Diarrhea (AP)		[137]
Lamiaceae			
Agastache mexicana Bye, E.L. Linares and Ramam.	Colic, stomach pain, *bilis* (F, L, St)	Terpenoids, oleic acid, flavonoids	[138, 139]
A. mexicana ssp. *Mexicana*	Colic, stomach pain, intestinal pain, *empacho*, indigestion (L)	Terpenoids, flavonoids	[138, 140–142]
Clinopodium macrostemum var. laevigatum (Moc. & Sessé ex Benth.) Kuntze	Stomach pain, dysentery, hangover (L, F)	Terpenoids	[14, 53, 143]
Ocimum basilicum L.	Diarrhea, dysentery, stomach pain, vomiting, *empacho* (AP)		[9, 11, 41, 43, 53, 57, 60, 72, 140, 144]
O. campechianum Mill.	Intestinal inflammation, ulcers, gastritis, fever, dysentery, *empacho*, vomiting, stomach pain vermifuge (L, B)	Terpenoids	[53, 54, 145, 146]
O. carnosum (Spreng.) Link & Otto ex Benth	Stomach pain, flatulence, diarrhea, dysentery, abdominal pain and intestinal parasites (L)	Phenols, terpenoids	[53]
Salvia hispanica L.	Diarrhea (Se)	Unsaturated fatty acids, flavonoids	[53, 147, 148]
S. microphylla Kunth	Diarrhea, dysentery, *empacho*, infection and inflammation of the stomach, vomiting (B)	Terpenoids, alkaloids, tannins	[53, 146]
Vitex mollis Kunth	Colic, intestinal inflammation, diarrhea, dysentery, stomach pain (L, Sh)		[53]
Lauraceae			
Litsea glaucescens Kunth	Stomach pain, *empacho*, children's diarrhea, indigestion (L)	Terpenoids	[53, 54, 149, 150]
Persea americana Mill.	Stomach pain, parasites, diarrhea, dysentery, constipation, flatulence, vomiting (Fr, L)	Terpenoids	[41, 57, 92, 151–153]
Liliaceae			
Milla biflora Cav.	Vomiting, stomach pain, nausea, diarrhea (F)		[53]
Loganiaceae			
Buddleja americana L.	Stomach pain, stomach infection, ulcers (L)	Lignans, flavonoids, alkaloids, tannins	[14, 53, 92]
Lygodiaceae			

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Lygodium venustum Sw.	Diarrhea, dysentery, nausea (AP)		[11, 53, 60, 72]
Lythraceae			
Cuphea hyssopifolia Kunth	Stomach pain (All)		[53]
Magnoliaceae			
Chiranthodendron pentadactylon Larreat	Diarrhea, dysentery, colic (F)	Flavonoids, steroids, phenols	[11, 53, 60, 72, 133, 144]
Magnolia mexicana DC.	Stomach pain, parasites (F)		[6, 53]
Magnolia schiedeana Schltdl.	Stomach pain (F)		[6]
Malpighiaceae			
Byrsonima crassifolia (L.) Kunth	Diarrhea, dysentery, *empacho*, stomach pain, indigestion, constipation (OB)	Tannins, proanthocyanidines, phenolic acids, terpenoids	[4, 6, 10, 41, 53, 84, 92]
Malpighia mexicana A. Juss.	*Empacho*, diarrhea, dysentery (OB)		[53]
Malvaceae			
Anoda cristata (L.) Schltdl.	Stomach pain, *empacho*, intestinal inflammation, *bilis* (AP, R)		[53]
Malvaviscus arboreus Cav.	Dysentery, diarrhea, stomach pain (AP)	Flavonoids, sterols, tannins	[14, 17, 53, 92, 96]
Pavonia schiedeana Steud.	*Empacho*, diarrhea (L, St)	Sterols, tannins	[53]
Sida acuta Burm. f.	Diarrhea, dysentery, *empacho* (L)		[53]
Sida rhombifolia L.	Stomach pain, gastritis, ulcers, diarrhea, dysentery (B)	Alkaloids	[41, 53, 146]
Melastomataceae			
Conostegia xalapensis (Bonpl.) D. Don	Diarrhea (L)		[41, 53]
Meliaceae			
Swietenia humilis L.	*Empacho*, stomach pain, diarrhea, fever, amoebic dysentery (Se, OB)		[41, 53]
Swietenia macrophylla G. King	Diarrhea, fever (Se)		[53]
Menispermaceae			
Cissampelos pareira L.	Dysentery, diarrhea, snake bite (L, St, R)	Alkaloids, sterols	[14, 17, 53, 54, 92]
Molluginaceae			
Mollugo verticillata L.	Intestinal inflammation, dysentery, diarrhea, *empacho*, colic, and stomach pain (B, L)		[41, 53]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Moraceae			
Dorstenia drakena L.	Diarrhea, dysentery, stomach pain (R)		[6, 53, 137]
Ficus cotinifolia Kunth	Malaria, ulcers (L, latex)		[53]
Muntingiaceae			
Muntingia calabura L.	Diarrhea, stomach pain, *empacho*, vomiting, dysentery, intestinal infection (OB)	Flavonoids	[53, 96]
Myrtaceae			
Eugenia acapulcensis Steud.	Diarrhea, dysentery (L, OB)	Tannins	[14, 17, 92]
E. capuli (Schltdl. & Cham.) Hook. & Arn	Diarrhea, dysentery (B)		[53]
Psidium guajava L.	Diarrhea, stomach pain, dysentery (All)	Sterols, terpenoids, flavonoids, tannins	[4, 6, 14, 43, 53, 54, 84, 92]
P. guineense Sw.	Diarrhea, dysentery, flatulence, vomiting (L, Fr, R)		[53, 92]
P. salutare (Kunth) O. Berg	Diarrhea (Fr, L, R)		[4, 6, 84]
Nyctaginaceae			
Boerhavia coccinea Mill	Purgative (L)		[53]
Mirabilis jalapa L.	Stomach pain, purgative (All)	Terpenoids, sterols, flavonoids, alkaloids	[53, 57]
Oleaceae			
Fraxinus uhdei (Wenz.) Lingelsh.	Diarrhea, infection intestinal, purgante (All)		[53]
Onagraceae			
Oenothera rosea L'Hér. ex	Stomach pain, inflammation or infection, colic, diarrhea, *bilis*, *empacho*, constipation (AP)		[53]
Papaveraceae			
Argemone mexicana L.	Purgative (Se)	Alkaloids, flavonoids y glycosides	[53]
Bocconia frutescens L	Diarrhea, dysentery, stomach pain, ulcers (AP)		[11, 53, 60, 72]
Passifloraceae			
Passiflora exsudans Zucc.	Dysentery (R)		[53]
Phytolaccaceae			
Petiveria alliacea L.	Stomach pain, dyspepsia, *susto* (R)	Alkaloids, sterols	[53]
Pinaceae			
Pinus oocarpa Schiede ex Schltdl.	Dysentery (L)		[53]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Piperaceae			
Piper aduncum L.	Diarrhea (All)		[53]
P. auritum Kunth	Stomach pain, lack of appetite and constipation (L)	Terpenoids	[53, 54, 84, 96]
P. sanctum (Miq.) Schltdl. ex C. DC.	Stomach pain, diarrhea (L)	Aromatic compounds	[53, 54, 154]
Piper schiedeanum Steudel	*Empacho* (All)		[53]
Plantaginaceae			
Scoparia dulcis L.	Diarrhea, colic, stomach pain, dysentery (AP)	Flavonoid, glucosides, terpenoids	[53, 92]
Poaceae			
Lasiacis ruscifolia (Kunth) Hitchc.	Diarrhea (All)		[53, 54]
Zea mays L.	Diarrhea, stomach pain, constipation, dysentery, vomiting (cob, tassel)	Polysaccharides	[6, 17, 41, 53, 92]
Polemoniaceae			
Loeselia mexicana (Lam.) Brand	*Bilis*, dysentery, stomach pain or inflammation, indigestion, typhoid, vomiting, laxative (AP)		[14, 21, 41, 53, 92]
Polygalaceae			
Polygala longicaulis Kunth	Stomach pain (All)		[53]
P. variabilis Kunth	Abdominal pain (All)		[92]
Portulacaceae			
Portulaca oleracea L.	Intestinal infection, constipation, parasites (All)	Tannins, alkaloids, steroids	[53, 155]
Primulaceae			
Myrsine juergensenii (Mez) Ricketson & Pipoly	Stomach pain (All)		[53]
Rhamnaceae			
Karwinskia humboldtiana (Schult.) Zucc.	Dysentery (L)		[53]
Rhizophoraceae			
Rhizophora mangle L.	Dysentery, diarrhea (R, OB)	Phenolics, tannins	[53]
Rubiaceae			
Galium mexicanum Kunth	Stomach pain, *empacho*, diarrhea (All)		[53]
Hintonia latiflora (Sessé & Moc. ex DC.) Bullock	*Bilis*, gastric ulcer, *empacho*, parasites, malaria, gastroenteritis (OB)	Phenylcoumarins, cucurbitacins, glucocucurbitacins	[53, 156]
Randia echinocarpa Sessé & Moc. ex DC.	Diarrhea, malaria (All)		[53]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
Sapindaceae			
Serjania triquetra Radlk.			[53, 84]
Sapotaceae			
Pouteria sapota (Jacq.) H.E. Moore & Stearn	Diarrhea, *empacho*, stomach pain (All)	Phenolics, carotenoids, δ-tocopherol	[41, 53, 96, 157]
Scrophulariaceae			
Capraria biflora L.	Dysentery, inflammation of the stomach, gastroenteritis, intestinal fever (L)	Alkaloids, terpenoids, naphthoquinone	[53, 158, 159]
Russelia sarmentosa Jacq.	Stomach pain (L)		[14, 53, 92]
Selaginellaceae			
Selaginella pallescens (Presl) Spring	Diarrhea (All)		[53, 54]
Smilacaceae			
Smilax laurifolia L.	Diarrhea (All)	Taninos ausentes, 1B	[92]
Solanaceae			
Calibrachoa parviflora (A. Juss.) D'Arcy	Flatulence (All)		[53]
Capsicum annuum L.	Dyspepsia, diarrhea, dysentery (Fr, S)	Alkaloids, capsaicinoids, carotenoids, tocopherols, sapogenins, phenolic acids	[53, 160]
Cestrum dumetorum Schltdl.	Intestinal inflammation (All)	Sterols, tannins	[53]
C. nocturnum L.	Stomach pain (L, St, F)	Sapogenins, coumarins, sitosterols, flavonoids	[41, 43, 53, 54, 161]
Physalis coztomatl Moc. & Sessé ex Dunal	Diarrhea with blood from amoebic infection or other parasites, diarrhea, stomach pain, dysentery (R, B)	Alkaloids, glycosides	[53]
P. lagascea R. & S.	Stomach pain (L)		[53]
Solanum rostratum Dunal	Purgative, stomach pain, diarrhea (L, F)		[53]
S. amictum Moric. ex Dunal.	Stomach pain (L)		[53]
S. torvum Sw.	Diarrhea, dolor de estómago (All)	Sapogenins, alkaloids	[53]
Sterculiaceae			
Guazuma ulmifolia Lam.	Diarrhea, intestinal infection, dysentery, *empacho* (All)	Procyanidins, Tannins	[6, 10, 14, 41, 53, 92]
Melochia pyramidata L.	Purgative (AP)		[53]
Waltheria indica L.	Diarrhea, dysentery, *empacho*, fever (All)	Flavonoids, esters, alkaloids	[53]
Verbenaceae			
Lantana achyranthifolia Desf.	Diarrhea, dysentery, *empacho* (All)	Terpenoids, flavonoids, and phenylpropanoids	[8, 16, 53, 68]

Family/ species[1]	Gastrointestinal disorders (used parts[2])	Bioactive compounds	References
L. camara L.	Stomach pain or inflammation, intestinal pain, parasites, vomiting (L, St)	Terpenoids, flavonoids, phenols	[53, 162–164]
Lippia alba (Mill.) N.E. Br. ex Britton & P. Wilson	Diarrhea, dysentery, stomach pain, colic, indigestion (AP)	Terpenoids	[4, 11, 53, 60, 61, 72, 92, 133, 146]
L. graveolens Kunth	Diarrhea, dysentery, *empacho*, indigestion (AP)	Terpenoids, flavonoids	[53, 165, 166]
Stachytarpheta jamaicensis (L.) Vahl	Stomach pain, intestinal inflammation (L)		[53, 92]
Verbena litoralis Kunth	Stomach pain, *bilis*, vomiting, malaria (L)		[53, 146]
Zygophyllaceae			
Guaiacum coulteri A. Gray	Ulcers (OB)	Alkaloids	[41, 53, 57]

1*Checklist of native vascular plants of Mexico [50].*
[2]L, leaves; St, stem; F, flower; AP, aerial parts; Se, seeds; R, root; All, whole plant; Sh, shoots; B, branches; Fr, Fruit; T, tuber; OB, outer bark.

Table 1A.
List of plants used by the indigenous groups of Oaxaca for the treatment of gastrointestinal disorders.

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