

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences



**Faculty of Tropical
AgriSciences**

**Medicinal plants used for gastrointestinal
disorders and their commercialisation in the
municipality of Isidro Fabela, State of Mexico**

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled “Medicinal plants used for gastrointestinal disorders and their commercialisation in the municipality of Isidro Fabela, State of Mexico” independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 15.04.2024

.....

Alessandra Condac

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Abstract

In the exploration of traditional medicinal practices within the municipality of Isidro Fabela, State of Mexico, this thesis emphasizes the ethnobotanical significance of medicinal plants and the application of traditional knowledge. Focusing on gastrointestinal disorders, a prevalent health concern in Mexico, the research identifies 28 plant species utilized within local communities. These species, encompassing 17 different botanical families, are primarily sourced from the surrounding natural environments, reflecting a deep connection between the community's health practices and their ecological surroundings.

This relationship is not only medicinal but also economic, as the study delves into the commercial aspects of these plants within local markets, introducing aspects about the sustainability of current harvesting practices.

The plants are most commonly used for treating ailments such as stomach pain, indigestion, and diarrhoea, symptoms that are prevalent in the community. The preparation methods of these plants, primarily through infusions, highlight the traditional techniques passed down through generations. The research underscores the importance of conserving this traditional knowledge to sustain the local culture and biodiversity, recommending further studies to explore the commercial viability and ecological impacts of medicinal plant use in the area.

Key words: ethnobotany, medicinal plants, Mexico, native species, traditional knowledge

Table of Contents

1. Introduction	1
2. Literature Review	2
2.1. Mexico	2
2.1.1. Biodiversity	3
2.1.2. Cultural diversity	4
2.2. Traditional knowledge	4
2.3. Ethnobotany in Mexico	5
2.4. Traditional Mexican Medicine	6
2.4.1. Medicinal plants	7
2.4.2. Medicinal plants in Mexico	7
2.5. Traditional markets and commerce of medicinal plants in Mexico	8
2.6. Health status in Mexico	9
2.6.1. Gastrointestinal disorders	9
3. Aims of the Thesis	11
4. Methods	12
4.1. Study area	12
4.2. Methodology	13
4.2.1. Ethnobotanical study	13
4.2.2. Economic study	13
5. Results and discussion	14
5.1. Sociodemographic aspects	14
5.2. Ethnobotanical study	15
5.2.1. Plant families	15
5.2.2. Species	18
5.2.3. Part of the plant used	20
5.2.4. Methods of preparation	20
5.2.5. Origin of the plant	21
5.2.6. Gastrointestinal disorders treated	22
5.3. Economic study	23

6. Conclusions	24
7. References	25

List of tables

TABLE 1 LIST OF MEDICINAL PLANTS MENTIONED.....	16
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List of figures

FIGURE 1 STATE DIVISION OF MEXICO	3
FIGURE 2 LOCATION OF ISIDRO FABELA IN THE STATE OF MEXICO	12
FIGURE 3 NUMBER OF RESPONDENTS BY GENDER.....	14
FIGURE 4 NUMBER OF RESPONDENTS BY AGE GROUP	14
FIGURE 5 DOMINANT PLANT FAMILIES	15
FIGURE 6 MENTIONED SPECIES	19
FIGURE 7 PART OF PLANT USED	20
FIGURE 8 METHOD OF PREPARATION	21
FIGURE 9 ORIGIN OF PLANT SPECIES	21
FIGURE 10 GASTROINTESTINAL DISORDERS CURED.....	22

List of the abbreviations used in the thesis

GIDs: Gastrointestinal Disorders

TEK: Traditional Ecological Knowledge

TMM: Traditional Mexican Medicine

WHO: World Health Organisation

1. Introduction

Mexico is one of the nations with the richest plant vegetation in the world. Flora grows there in multiple diverse habitats such as mountains, tropical rainforests, and grazing lands. There are over thirty types of vegetation, and the nation is home to at least 30,000 species of higher plants. That accounts for 10% of all plants worldwide (Cruz-Jiménez et al. 2014).

Medicinal plants are considered an irreplaceable element of traditional medical systems in Mexico. They are typically thought of as indigenous wisdom within the culture and are highly appreciated (Heinrich et al. 1998). The region of the State of Mexico is culturally very diverse. It is home to various ethnic groups. Particularly, in the municipality of Isidro Fabela, Otomí and Náhua groups are present, and they are known to have extensive knowledge of medicinal plants (Lara et al. 2022).

Nowadays, more than 5000 plants are used for their healing properties in traditional Mexican medicine (Cruz-Jiménez et al. 2014). Plant infusions and preparations for curing have been used in Mexico for many centuries. Their effectiveness has been acknowledged in many studies (García-Alvarado et al. 2001). Nevertheless, no more than one-fifth of medicinal plants in Mexico have undergone scientific research to evaluate their use. This can be caused by the preferred selection of widely distributed and more regularly used species. Mexico has many endemic plants, which are not known or utilized anywhere else (García-Alvarado et al. 2001).

Indigestion, ulcers, diarrhoea, dysentery, and stomach pain are the most frequent gastrointestinal illnesses. They are caused by contaminated food, nutritional deficiencies, or pathogens including viruses, bacteria, and parasites. In developing nations like Mexico, where this issue still manifests in high rates of morbidity and mortality, treating gastrointestinal disorders is crucial. More than 50% of medicinal herbs are used to treat gastrointestinal disorders (Cruz-Jiménez et al. 2014).

Medicinal plants in Mexico are oftentimes bought from traditional markets called *tianguis*. These markets hold specific cultural value in the country. It is estimated that

medicinal plants are used as primary method of healing by 80% of the population in developing countries. Commercialisation of medicinal plants requires the implementation of sustainable practices to prevent overexploitation. The first step in doing that is to acknowledge and document the ethnobotanical importance of the plants found in the area (Arellanes et al. 2013).

This thesis aims to add to the richness of ethnobotanical studies by doing an ethnobotanical inventory of the medicinal plants used for gastrointestinal problems in the municipality of Isidro Fabela. Furthermore, to get an insight into commercial aspects of management medicinal plants in order to understand the socio-economic value of the plants.

2. Literature Review

2.1. Mexico

Mexico, officially United Mexican States, is a country located in the southern part of Northern America. Its capital is Mexico City. The country is bordered by the United States of America, Gulf of Mexico, Caribbean Sea, Belize, Guatemala, and Pacific Ocean (see Figure 1).

Mexico is composed of 32 states with its population being 126 million people. The most populated states are State of Mexico, Mexico City and Jalisco. The main language is Spanish and at least 68 other languages are spoken in the country.

80% of the population lives in urban areas, in fact almost 30% of it lives in the metropolitan areas of Mexico City, Guadalajara, Monterrey and Puebla-Tlaxcala (INEGI 2015).

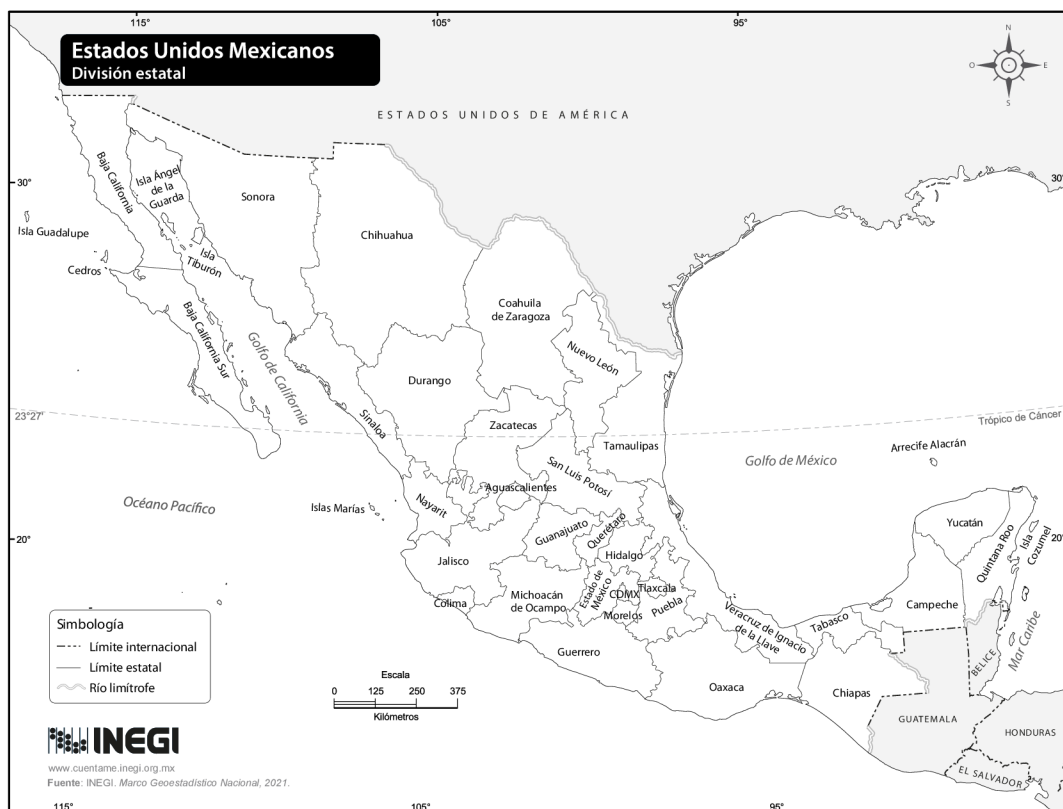


Figure 1 State division of Mexico

2.1.1. Biodiversity

Mexico is the fourth country with the highest biodiversity in the world after Indonesia, Brazil, and Colombia. It is considered a megadiverse country, as it hosts 10 to 12% of the world’s biodiversity (Vidal & Brusca 2020). One important feature of Mexico’s flora is that many plant species are endemic, which means that they are exclusively present in Mexico (Bye et al. 1995).

Owing to its geographical position and the presence of elements from both temperate and tropical climates, Mexico is an exceptionally biologically rich nation. The richness is demonstrated in numerous vegetation types including conifer and oak forest, desert shrubs, grassland vegetation and tropical deciduous forests (Bye et al. 1995).

As noticed in other areas of the world, the regions with the most species in Mexico are the ones with tropical areas, such as Oaxaca, Chiapas, Veracruz, Guerrero, and Michoacán (Vidal & Brusca 2020).

Although Mexico counts with a high biodiversity, there are many threats to it. Some of the biggest ones are destruction of habitat, overexploitation, invasive species, and climate change (Vidal & Brusca 2020).

2.1.2. Cultural diversity

The biodiversity of Mexico is reflected into its cultural diversity. There has been shown to be a correlation between biological and cultural diversity, in fact the percentage of ethnic groups is directly proportional to the biodiversity richness. Areas with high biodiversity are also those where the most languages are present (Vidal & Brusca 2020).

Indigenous people make up for 21% of Mexico's population and the country hosts 68 different ethnic groups. Mexico is also one of the countries with the most linguistic diversity with 364 linguistic varieties identified. The linguistic groups with most speakers are Náhuas, Maya, Mixteco and Zapotec. The regions of Oaxaca, Chiapas, Veracruz, Guerrero, Hidalgo, State of Mexico and Yucatán host 77% of indigenous people in Mexico. (Vidal & Brusca 2020).

Indigenous people in Mexico still face different difficulties nowadays. The percentage of poverty is almost double in the indigenous-speaking population than in the non-indigenous speaking. Half of them live in rural area with a population of less than 2,500 people. (CONEVAL 2012).

2.2. Traditional knowledge

Traditional knowledge can be considered as the intersection of knowledge, skills and practices selected and accumulated collectively during thousands of years, that are transmitted through generations in oral, practical, or written way. Traditional knowledge varies based on ethnic, language, social, cultural, or religious characteristics.

More specifically, traditional ecological knowledge (TEK) is the understanding of resource and ecosystem dynamics and related management techniques held by members of communities who have long-term, daily interactions with ecosystems for their livelihood and benefit. It includes systems of classification, observation of the local environment and a system for managing natural resources.

In traditional societies it is fundamental to set up a body of knowledge, customs, and beliefs about the utilization of locally accessible natural resources to improve health status. This results in people who have higher level of traditional knowledge displaying better health than people who do not share as much knowledge (Reyes 2010).

Indigenous people are very important stakeholders when talking about traditional knowledge. Their practices passed over generations led them to have a broad understanding of their environment. Due to the fact that their knowledge is mainly transmitted orally, and many languages are disappearing in the last decades, a large part of the knowledge is being lost nowadays. It is fundamental to preserve indigenous knowledge in order to maintain sustainable management practices of natural resources (Vidal & Brusca 2020).

2.3. Ethnobotany in Mexico

Ethnobotany is a scientific discipline that documents and analyses the traditional botanical knowledge that different cultures possess and the interactions and practices they use in managing plant resources. This discipline was born as a combination of botany and anthropology. During the years its purpose became to study the relationship between people and plant environment. One of the aims of ethnobotany is to understand socio-ecological systems since it can help with having a broader understanding of them by creating interdisciplinary bridges (Lira et al. 2016).

Mexico is an important point of attention for ethnobotany. In addition to its high biodiversity, Mexico is also one of the primary spots where agriculture originated (Bye et al. 1995).

There are different management approaches that shape the ways in which humans interact with plant populations. These are: harvesting, silvicultural practices, agricultural management. These traditional methods of using natural resources have sustainability characteristics that need to be recognized and maintained. Harvesting is the main method used in Mexico, with around 90% of plants managed in this way. (Lira et al. 2016).

2.4. Traditional Mexican Medicine

The World Health Organisation (WHO) (2023) stated that “traditional medicine is the sum of knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health and the prevention, diagnosis, improvement or treatment of physical and mental illness”.

In the pre-Hispanic era, traditional Mexican medicine (TMM) was a well-developed discipline that covered topics ranging from knowledge of medicinal plants and the human body to astrology, to aspects that might be referred to as magical. When Mexico was conquered by the Spanish, an enormous portion of TMM was lost due to the colonisation and Christian evangelisation of indigenous people. The part that has been maintained the most up to this day is the one about medicinal plants because it was accepted by the Spanish conquerors due to its proven and tangible therapeutic effect.

One of the principles found most often in TMM is the hot-cold classification. This classification is present in other cultures as well, for example it can be found in traditional Chinese medicine. According to TMM, illnesses start when the equilibrium between hot and cold forces inside of the body is lost. Foods and plants are also divided into hot and cold.

Nowadays TMM is not well defined and there are several different interpretations of it. One of the reasons TMM is not comprehensively studied and systemised today is because many of its concepts are tied to the understanding of the world of Mesoamerican pre-Hispanic cultures and do not coincide with the modern vision of things. Furthermore, as seen in other countries, globalisation is an additional factor to the depreciation of traditional medicine. Many health practitioners see TMM as inferior to western medicine, contributing to increasing the mistrust towards the effectiveness of medicinal plants. In the past century however, the importance of traditional medicine was recognised at a global level and many researchers have conducted studies to document TMM practices, especially regarding the use of medicinal plants (Mendoza 2001).

2.4.1. Medicinal plants

Medicinal plants are a very important part of traditional medicine in every culture. It is safe to say that medicinal plants are as old as human beings are, since they have always been essential to our survival (Mendoza 2001).

As WHO (2023) stated, traditional medicine, spiritual treatments, and ancestral healing traditions including the use of medicinal plants are the main sources of health for 80% of the population in developing countries.

The importance of traditional medicine was recognised by WHO only in 1978. This slowly increased the trust in the beneficial effects of medicinal plants by individuals and health practitioners worldwide. The shift also made it easier for more people to improve their health for a lower price compared to conventional medicines (Mendoza 2001).

One of the health problems in rural areas is the high price or shortage of conventional medicines, hence medicinal plants are used more compared to urbanised areas. Higher incomes are also related to less knowledge about medicinal plants (Lara et al. 2018).

2.4.2. Medicinal plants in Mexico

Mexico is considered the most important country after China with relevance to traditional medicinal knowledge. This is due to the fact that Mexico is a megadiverse country and is the second country in the world with the most medicinal plants recorded (Bye 1995).

Around 3000-4500 plant species with medicinal attributes exist in Mexico and they represent 15% of Mexican total flora (Lara et al. 2018).

Medicinal plants have always been a very important part of traditional Mexican medicine. Plants have been used by the indigenous populations of Mexico for thousands of years and the variety of medicinal plants in Mexico has been documented for centuries, one of the most important documents on this matter being the Cruz-Badiano manuscript

from 1552. This manuscript comprehends detailed drawing of medicinal plants used by indigenous people in that period and a description of their uses (Mendoza 2001).

Researchers have found that knowledge about medicinal plants, especially wild ones, is transmitted through family. Most of the times the knowledge is learned from mothers or other female members of the family. It has been shown that even in indigenous environments new generations possess less knowledge about medicinal plants compared with previous ones. Some of the causes to this phenomenon are urbanisation, migration, or utilisation of introduced plants (Lara et al. 2019).

2.5. Traditional markets and commerce of medicinal plants in Mexico

Traditional markets are an important area of study in ethnobotany. Mexico's most characteristic markets are called *tianguis*. They are only present in certain days of the week depending on the place where they are located and they have a long history, dating to pre-Hispanic times. They are not only a place for trade but an integral part of Mexican culture, as they have specific cultural, social, and economic value (Lira et al. 2016).

Nowadays supermarkets in Mexico are in rapid expansion thanks to their convenience but *tianguis* are still a very popular option and experts say that they will not disappear thanks to their specific cultural importance (Aguilar 2006).

A large variety of plants can be found in traditional markets, such as edibles, condiments, ornamental and medicinal. The latter hold an important place in these markets. The most common medicinal plant products present in markets are whole plants, seeds, leaves, roots. Plants can be sold as fresh or dry, usually in the form of small bundles (Villamar 2016).

It is estimated that 250 medicinal plant species are commercialised daily. Most of these are harvested from the wild without plans of sustainable management (Bye 1995).

2.6. Health status in Mexico

The three main causes of death in Mexico in 2013 were heart diseases, diabetes mellitus and malignant tumours, which together accounted for 58% of total deaths. These causes are the main ones for both women and men but from the fourth place on there are several differences when looking specifically at the two groups. The next most important causes of death for women are cerebrovascular diseases and chronic obstructive pulmonary disease. Men on the other hand die more from accidents and liver diseases.

Illness in Mexico in 2013 were mostly caused by infectious diseases such as acute respiratory tract infections, gastrointestinal infections, urinary tract infections. The past twenty years have seen a substantial increase in chronic illnesses such as diabetes and hypertension (Soto-Estrada et al. 2016).

2.6.1. Gastrointestinal disorders

Gastrointestinal disorders (GIDs) are defined as conditions that concern any part of the gastrointestinal tract, from the esophagus to the rectum, affecting its ability to digest food and liquids, absorb them, or excrete them. These disorders are caused by bacteria, viruses, fungi or parasitic organism such as protozoa and intestinal worms. GIDs can range from minor inconveniences to serious illnesses.

The main causes of illnesses in developing countries are GIDs. They affect mostly low-income and marginalized populations as well as communities with inadequate access to safe water, healthcare, and sanitation (Shawarb et al. 2021).

This is true also for Mexico, where GIDs are one of the main causes of illness. Some of the most common GIDs in Mexico are indigestion, ulcers, diarrhoea, stomach pain and dysentery. Furthermore, acute diarrheal disease affects 18% of kids younger than 5 in Mexico (Ortega-Cala et al. 2019). These data show that GIDs are a focus topic to take in consideration with relevance to Mexico's health status (Cruz-Jiménez et al. 2014).

Since many medications for treating GIDs are either expensive or unavailable in some areas, traditional medicine is the primary alternative in Mexican healthcare. Diseases of the digestive systems have been found to be the most common conditions that Mexican health practitioners treat with medicinal plants, and there is also general

agreement regarding the plants that are used to treat these affections. This could be a result of the fact that the majority of these ailments are not regarded to be very serious (Alonso-Castro et al. 2017).

Research has demonstrated that traditional medicine is widely used in many cultures worldwide to treat GIDs, especially by indigenous people. Medicinal plants are particularly significant in the treatment of GIDs (Ong and Kim, 2020). In Mexico around 50% of total medicinal plants are used for gastrointestinal disorders (Cruz-Jiménez et al. 2014).

3. Aims of the Thesis

The general objective of this thesis was to identify medicinal plant used to treat gastrointestinal disorders in the municipality of Isidro Fabela and get an insight into economic value of the plants.

The specific objectives of this thesis were to:

1. Conduct an ethnobotanical survey to find which plants are commonly used to treat gastrointestinal disorders.
2. Identify the parts of the plant utilised, their methods of preparation and what conditions they are used for.
3. Learn about commercial value of medicinal plants sold in the local market.

4. Methods

4.1. Study area

Isidro Fabela is a municipality located in the State of Mexico, Mexico. The area is particularly relevant for the study, as presence of Náhua and Otomí people has been registered in the municipality. These ethnic groups are characteristic to the State of Mexico and surrounding regions and are recognised for the medicinal and spiritual values they give to the plants present in their environment (Lara et al. 2021).

The State of Mexico is found in the central part of Mexico, and it partially englobes the capital of the country, Mexico City. Isidro Fabela is found in the north-western part of the region (see Figure 2). The municipality has a surface of 79 square kilometres. Its municipal capital is Tlazala de Fabela.

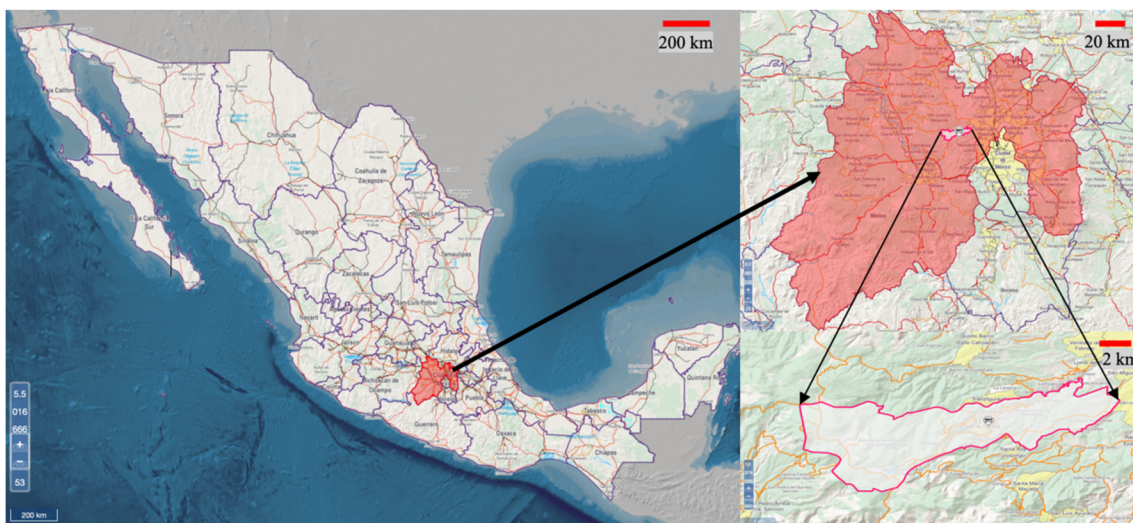


Figure 2 Location of Isidro Fabela in the State of Mexico

The altitude is between 2,300 a.s.l. to 3600 a.s.l. The climate of the region is subhumid temperate with a mean annual temperature varying from 8°C to 12°C depending on the area. The area is mountainous and uneven. Forests cover the area, and they are prevalently composed of pines (*Pinus hartwegii*), oyamels (*Abies religiosa*) and oaks (*Quercus rugosa*). These forests are part of the natural protected area Parque Otomí Mexico, with 67% of the municipality's territory being part of the protected area.

Isidro Fabela has a population of 12,669 inhabitants. The population is young with one third of it being less than 14 years old. 3.2% of inhabitants are indigenous and 6.7%

are afro Mexican. Apart from Spanish, the main other languages spoken are Náhuatl and Otomí.

60.4% of the population is economically active and the unemployment rate is 3.5%. Most people are employed in the tertiary sector. Regarding highest level of education, 36% of inhabitants have finished middle school, 24% primary school and 22% high school and 10% have a bachelor's degree. The illiteracy rate is 4.5% (Ayuntamiento de Isidro Fabela 2022).

4.2. Methodology

The study was carried out in Tlazala de Fabela, the main town of the municipality of Isidro Fabela during June 2023. Data collection was divided in two parts: ethnobotanical study and economic study.

4.2.1. Ethnobotanical study

The purpose of this study was to get information about medicinal plants used for gastrointestinal disorders. The topics of interest were local name of the plants, uses for GIDs, part of the plant used, methods of preparation. The questions were asked in form of semi-open interviews to local residents. A total of 59 responses were collected.

During this study plant material was collected and dried. The common name of the plants was then identified, and respondents were asked to provide information about their utilisations.

Taxonomic identification was done with the help of information found in the Digital Library of Mexican Traditional Medicine (www.medicinatradicionalmexicana.unam.mx/index.php). The botanical names of the species were verified with The Plant List (2013) (<http://www.theplantlist.org>).

4.2.2. Economic study

A market research was done to get information about prices of medicinal plants and provenience of the plant. Semi-open interviews were conducted with local vendors in the local market of Tlazala de Fabela. 8 total responses were collected.

5. Results and discussion

5.1. Sociodemographic aspects

59 respondents were interviewed. 39 of them were female and 20 of them were male (see Figure 3).

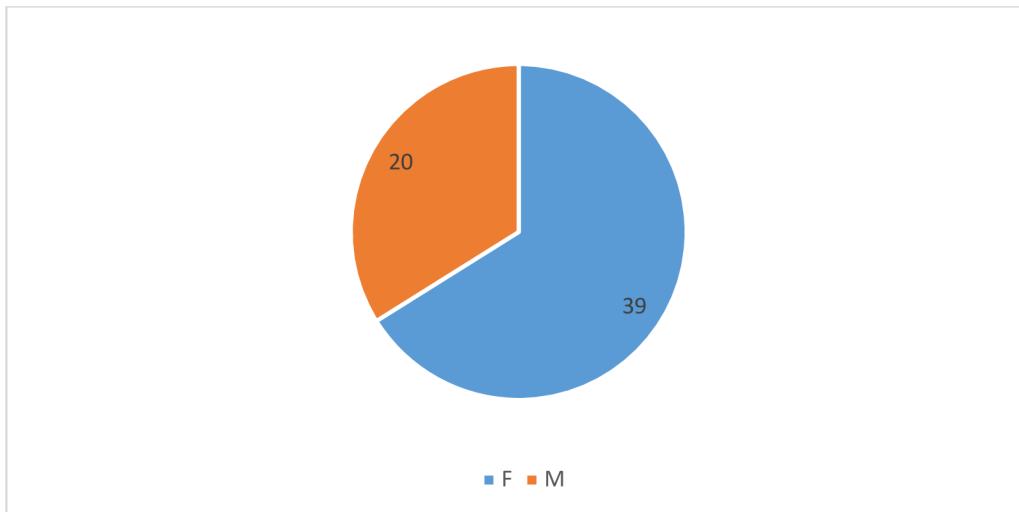


Figure 3 Number of respondents by gender

The age of the respondents was divided into four groups: 15-30 years old (n=24), 31-45 years old (n=21), 46-60 years old (n=8), 61-75 years old (n=6) (see Figure 4).

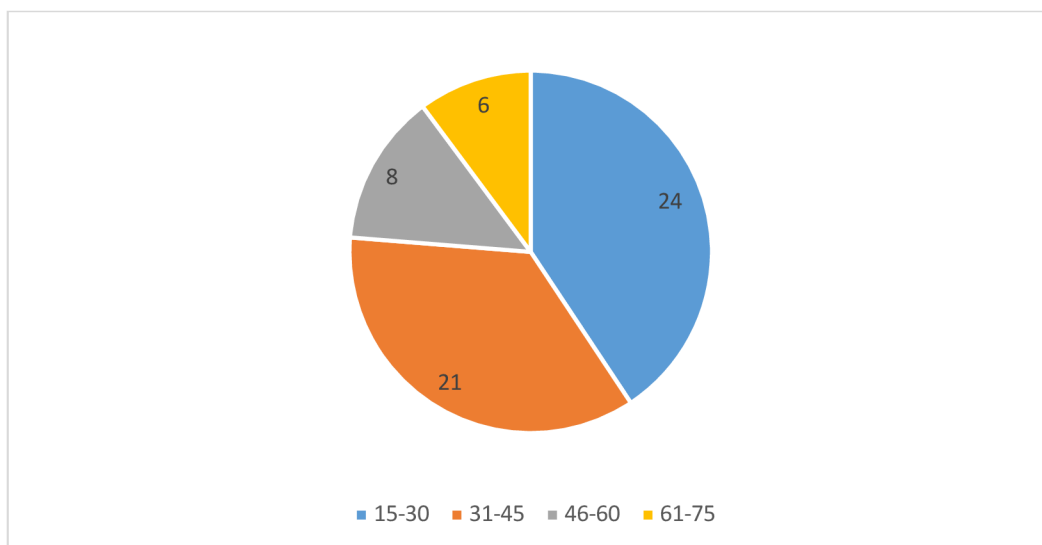


Figure 4 Number of respondents by age group

5.2. Ethnobotanical study

28 species of plants were mentioned to treat GIDs. These were distributed in 24 genera and 17 botanical families. The uses for GIDs were identified, together with common name, parts used, whether the plant is used in fresh or dry form, methods of preparation and origin of the plant (see Table 1).

5.2.1. Plant families

The plant families with the most numbers of plants were Asteraceae (n=4), subsequently Lamiaceae (n= 3), Malvaceae (n=2), Amaranthaceae (n=2), Apiaceae (n=2), Rutaceae (n=2). Other plant families mentioned were Anacardiaceae (n=1), Myrtaceae (n=1), Asphodelaceae (n=1), Rosaceae (n=1), Polygonaceae (n=1), Solanaceae (n=1), Amaryllidaceae (n=1), Geraniaceae (n=1), Verbenaceae (n=1), Acanthaceae (n=1), Lauraceae (n=1) (see Figure 5.)

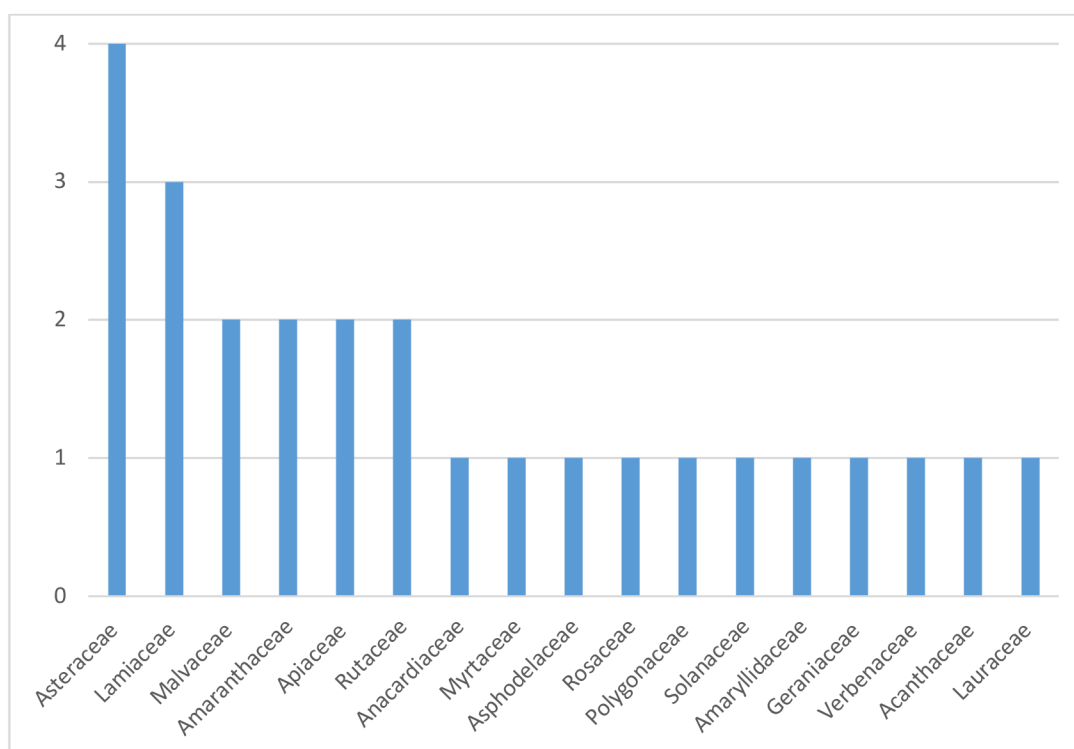


Figure 5 Dominant plant families

Table 1 List of medicinal plants mentioned

Family	Scientific name	Common name	Use	Part used	Fresh or dry	Method of preparation	Native or introduced plant	N° of times mentioned for use
Acanthaceae	<i>Justicia spicigera</i> Schltld.	Muicle	Constipation	Leaves	f	Infusion	N	3
Amaranthaceae	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants	Epazote	Intestinal parasites	Leaves	f	Infusion	N	3
	<i>Dysphania graveolens</i> (W.A.Weber) Mosyakin & Clemants	Epazote de Zorrillo	Diarrhea	Whole plant	f	Infusion	N	1
Amaryllidaceae	<i>Allium glandulosum</i> Link & Otto	Barbas de Cebolla	Indigestion	Root	f	Infusion	N	1
Anacardiaceae	<i>Amphipterygium adstringens</i> (Schltld.) Schiede ex Standl.	Cuachalalate	Bile	Bark	d	Infusion	N	1
Apiaceae	<i>Coriandrum sativum</i> L.	Cilantro	Stomach pain	Whole plant	f	Infusion	I	1
	<i>Apium graveolens</i> L.	Apio	Constipation	Whole plant	f	Infusion	I	1
Asphodelaceae	<i>Aloe vera</i> (L.) Burm.f.	Sabila	Gastritis	Leaves	f	Liquefied	I	3
			Weight loss	Leaves	f	Liquefied		2
Asteraceae	<i>Matricaria chamomilla</i> L.	Manzanilla	Stomach pain	Whole plant	f/d	Infusion	N	15
	<i>Artemisia ludoviciana</i> Nutt.	Estafiate	Diarrhea	Whole plant	f	Infusion	N	6
	<i>Ageratina oligocephala</i> (DC.) R.M.King & H.Rob.	Peshto	Liver problems	Whole plant	f	Infusion	N	2
	<i>Laennecia filaginoides</i> (DC.)	Simonillo	Stomach pain	Whole plant	f	Infusion	N	1
Geraniaceae	<i>Pelargonium zonale</i> (L.) L'Hér.	Malvon	Constipation	Whole plant	f	Infusion	I	1

Family	Scientific name	Common name	Use	Part used	Fresh or dry	Method of preparation	Native or introduced plant	N° of times mentioned for use
Lamiaceae	<i>Mentha spicata</i> L.	Hierbabuena	Stomach pain	Leaves	f	Infusion	I	12
	<i>Salvia rosmarinus</i> Spenn.	Romero	Condiment	Whole plant	f	Infusion	I	1
			Stomach pain	Whole plant	f	Infusion		1
	<i>Thymus vulgaris</i> L.	Tomillo	Condiment	Whole plant	f	Infusion	I	1
Lauraceae	<i>Laurus nobilis</i> L.	Laurel	Hemorrhoids	Leaves	f	Infusion	I	1
			Indigestion	Leaves	f	Infusion		2
Malvaceae	<i>Malva sylvestris</i> L.	Malva	Indigestion	Leaves	f	Infusion	I	1
	<i>Malva parviflora</i> L.	Quesillos de Malva	Indigestion	Whole plant	f	Infusion	I	1
Myrtaceae	<i>Psidium guajava</i> L.	Hoja de Guayaba	Diarrhea	Leaves	f	Infusion	I	2
Polygonaceae	<i>Rumex mexicanus</i> Meisn.	Hiscuas	Indigestion	Leaves	f	Cataplasm	N	1
Rosaceae	<i>Rosa centifolia</i> L.	Rosa de Castilla	Indigestion	Whole plant	f	Infusion	I	2
Rutaceae	<i>Ruta graveolens</i> L.	Ruda	Stomach pain	Whole plant	f	Infusion	I	10
	<i>Citrus limon</i> L.	Limón	Condiment	Fruit	f	Infusion	I	3
Solanaceae	<i>Solanum tuberosum</i> L.	Papa	Gastritis	Root	f	Liquefied	I	2
Verbenaceae	<i>Aloysia citrodora</i> Paláu	Cedron	Stomach pain	Whole plant	f	Infusion	I	2

Discussion: People in Isidro Fabela use 28 species of plants to treat GIDs. Out of these species the study shows that Asteraceae is the main plant family observed. Another study conducted in the area had similar results (López-Mathamba et al. 2020). The study was conducted in the Guadalupe dam watershed, State of Mexico and indicated that the botanical family most represented in the area was Asteraceae. Rivera et al. in 2020 stated that Asteraceae is the largest plant family in Mexico as it comprehends around 417 genera and 3,113 species. In fact Mexico is considered to be the biggest centre of diversity for Asteraceae. Asteraceae plants are found on all the territory of Mexico throughout several different climates. The states with higher number of species from Asteraceae are Oaxaca, Jalisco, Durango, Guerrero and Michoacán (Villaseñor 2018). The high number of Asteraceae plants found could also be due to the fact that Asteraceae and Lamiaceae are amongst the most common medicinal plant families in the world (Gras et al. 2021).

5.2.2. Species

The species mentioned in the study were *Matricaria chamomilla* L. (n=15), *Mentha spicata* L. (n=12), *Ruta graveolens* L. (n=10), *Artemisia ludoviciana* Nutt. (n=6), *Justicia spicigera* Schltld. (n=3), *Dysphania ambrosioides* (L.) Mosyakin & Clemants (n=3), *Aloe vera* (L.) Burm.f. (n=3), *Citrus limon* L. (n=3), *Ageratina oligocephala* (DC.) R.M.King & H.Rob. (n=2), *Psidium guajava* L. (n=2), *Rosa centifolia* L. (n=2), *Solanum tuberosum* L. (n=2), *Aloysia citrodora* Paláu (n=2), *Dysphania graveolens* (W.A.Weber) Mosyakin & Clemants (n=1), *Allium glandulosum* Link & Otto (n=1), *Amphipterygium adstringens* (Schltld.) Schiede ex Standl. (n=1), *Coriandrum sativum* L. (n=1), *Apium graveolens* L. (n=1), *Laennecia filaginoides* (DC.) (n=1), *Pelargonium zonale* (L.) L'Hér. (n=1), *Salvia rosmarinus* Spenn. (n=1), *Thymus vulgaris* L. (n=1), *Laurus nobilis* L. (n=1), *Malva sylvestris* L. (n=1), *Malva parviflora* L. (n=1), *Rumex mexicanus* Meisn (n=1) (see Figure 6).

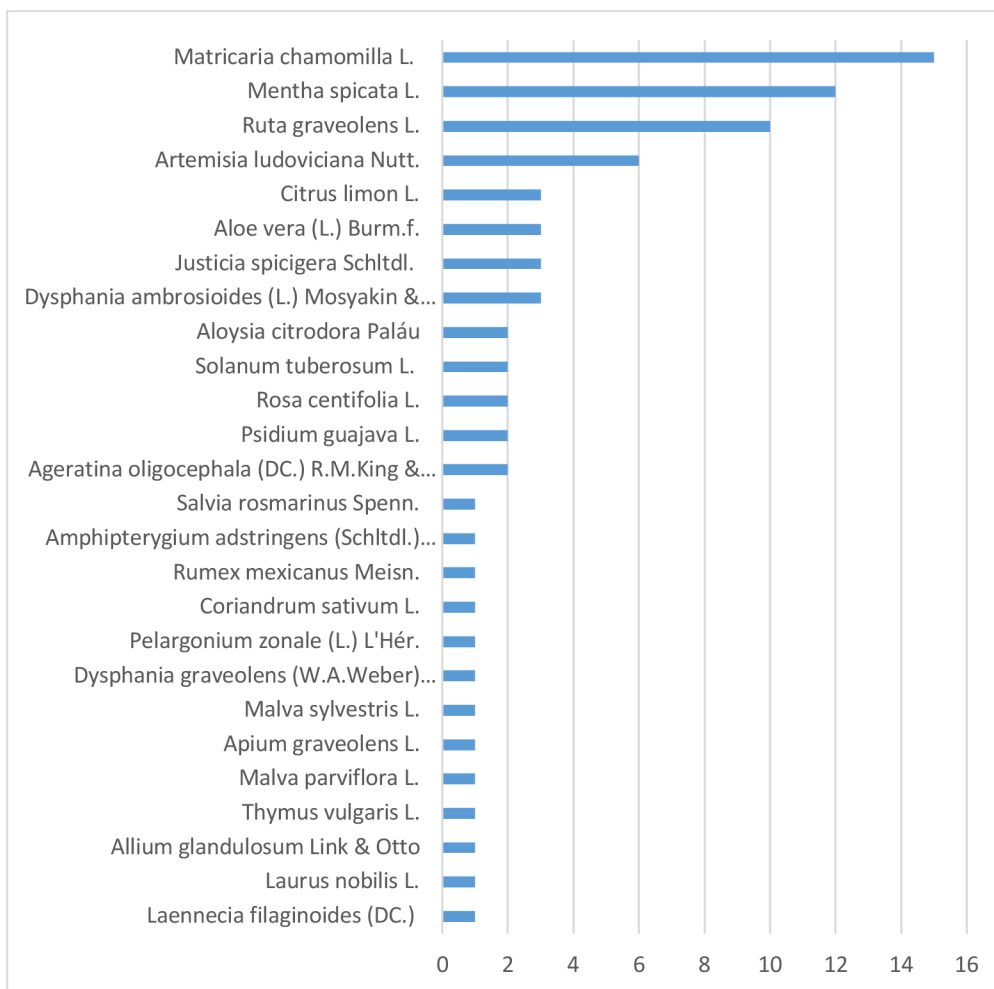


Figure 6 Mentioned species

Discussion: *Matricaria chamomilla* L. and *Mentha spicata* L. were the species most often used to treat gastrointestinal illnesses. This was in conformity with other a study about medicinal plants used for digestive system in Mexico conducted by Gutiérrez et al. (2023).

-*Matricaria chamomilla* L. has been found to be the most used medicinal plant in Zacatecas state. This plant is a staple of medicinal plants in Mexico and is used for numerous illnesses varying from digestive to respiratory to colic pain and even for fever (Lara et al. 2018). The effects of the plant on GIDs have been studied by Al-Snafi & Hasham (2023). The plant has antidiarrheal, antispasmodic, antidiabetic and antiparasitic effects which makes it a powerful remedy for digestive issues.

-*Mentha spicata* L. is one of the most consumed plants in Mexico (Castellano-Jimenez et al. 2021). It is grown commercially worldwide, and it is used for the treatment

of diarrhoea, stomach ache, dysentery and indigestion (Mahendran et al. 2021). While Mahendram et al. (2021) stated that one of the most common ways of using *Mentha spicata* L. is in the form of oil and essential oil, the study in Isidro Fabela only mentioned infusion.

5.2.3. Part of the plant used

As can be seen in figure 7, the part of the plants used the most where whole plant (52%), followed by leaves (35%), root (7%), bark (3%) and fruit (3%) .

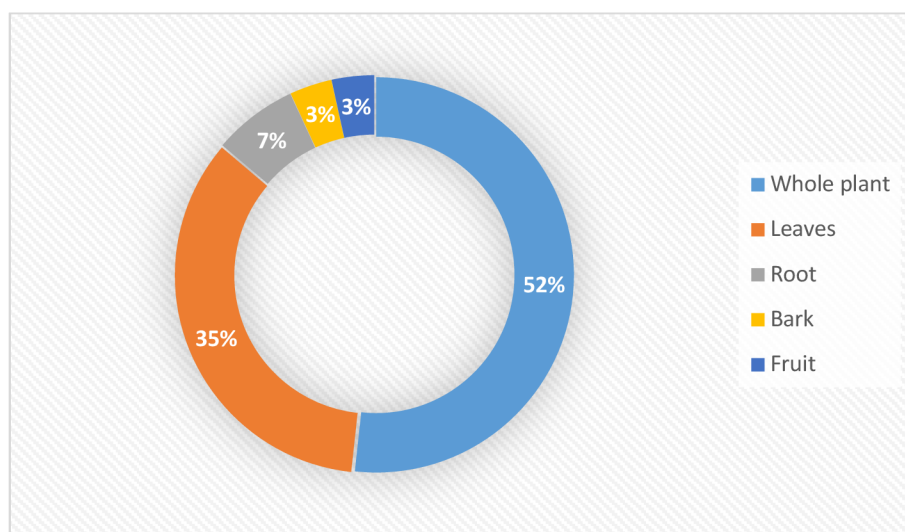


Figure 7 Part of plant used

Discussion: Principal used parts of the plants were whole plant and leaves. A study conducted by Gutiérrez et al. (2023) regarding several regions of Mexico found leaves to be more used than the whole plant. Another study from Chiapas (Cruz-Jiménez et al. 2014) identified leaves and stems to be the most used. The differences in these data are also caused by disparities in differentiation of part used, for instance the study conducted by Cruz-Jiménez et al. (2014) did not include whole plant as an option.

5.2.4. Methods of preparation

As shown in Figure 8, the methods of preparation of the plants were infusion which was used in 86% of cases, liquefied (10%) and lastly cataplasm (4%).

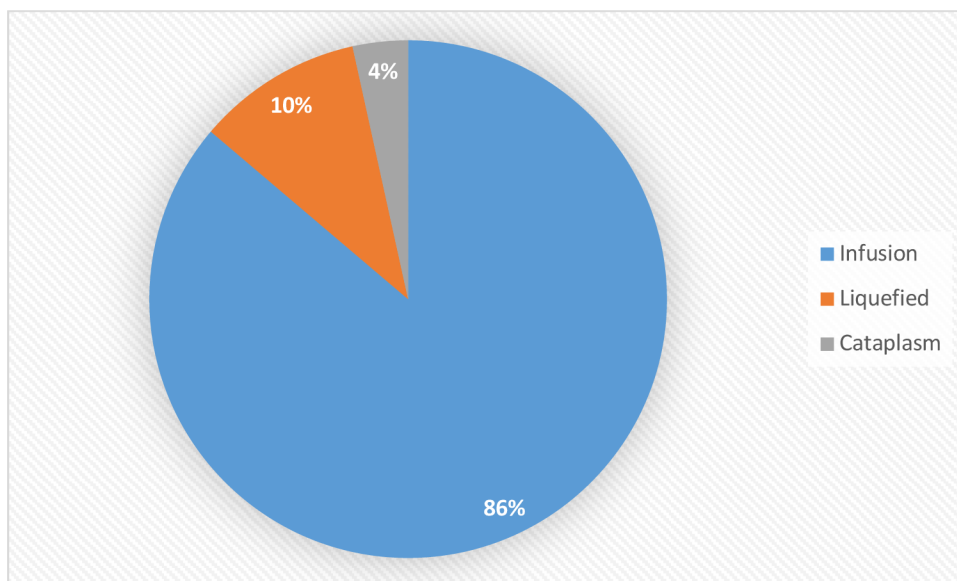


Figure 8 Method of preparation

Discussion: The preferred method of preparation of the plants was infusion. Infusion is a method that involves using hot water as a solvent. Another study conducted by Torres-León et al. (2023) found that in areas of northern Mexico the most common preparation method was decoction. This method implies boiling of the plants.

5.2.5. Origin of the plant

62% of the plant species mentioned were introduced while 38% were native to Mexico (see Figure 9).

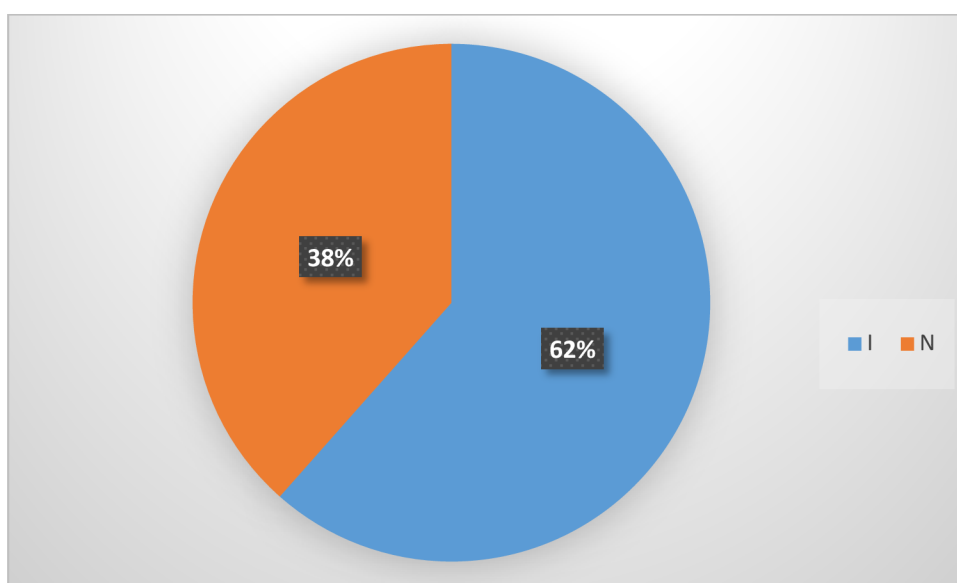


Figure 9 Origin of plant species

Discussion: In a study conducted in Morelos 62% of the plants studied were native to Mexico (Ortega-Cala et al. 2019). Furthermore Vizuet et al. (2022) identified that more than half of the medicinal plants used in the region of Teziutlán, Puebla are native to Mexico.

5.2.6. Gastrointestinal disorders treated

The uses of the plants for GIDs were stomach pain (n=7), indigestion (n=5), constipation (n=3), diarrhoea (n=3), gastritis (n=2), intestinal parasites (n=1), bile (n=1), liver problems (n=1), weight loss (n=1), haemorrhoids (n=1) (see Figure 10).

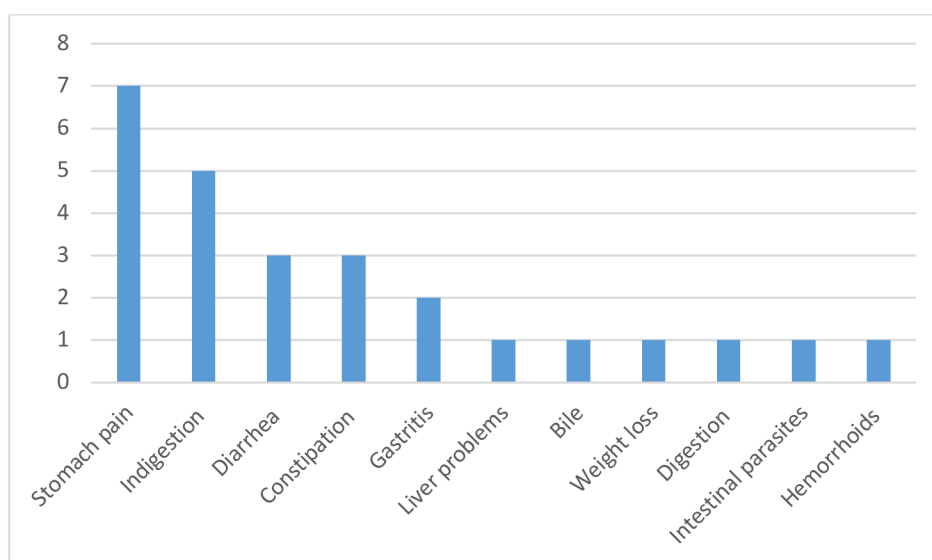


Figure 10 Gastrointestinal disorders cured

Discussion: In other studies conducted in Mexico (Lara et al. 2018; Torres-León et al. 2023), gastrointestinal have been found to be the illnesses treated the most with medicinal plants. Furthermore, they were also the ones treated with the highest number of species. The most common gastrointestinal issues mentioned in the study were stomach pain, indigestion, constipation, and diarrhoea. A study conducted in the state of Morelos also identified diarrhoea and stomach pain to be the main gastrointestinal illnesses (Ortega et al. 2019). Another study conducted in Chiapas by Cruz-Jiménez et al. (2014) found diarrhoea, gastroenteritis, stomach pain and abdominal pain to be the principal gastrointestinal diseases. As can be noticed, some of the names of GIDs vary across studies, making it more complicated to have a general overview of the most common illnesses.

5.3. Economic study

Plants were sold in the form of small bundles weighting around 100 grams. However, the weight of the bundle varied depending on the plant. Some plants were sold in fresh, dry, or both forms. The cost of a bundle varied between 7 to 40 Mexican pesos (approximately €0.40 to €2.20) depending on the plant.

Information gathered from sellers in the local market led to the conclusion that the most common method of obtaining the plants is collection from the wild, followed by cultivation and lastly purchase from retailers.

Discussion: Most of the medicinal plants sold in the market were harvested from the wild. This is in line with studies done by Lira et al. (2016) which stated that around 90% of plants used in Mexico by traditional people are obtained through harvesting.

Harvest of plants from the wild poses risks such as overexploitation. A study done in West Africa by Van Andel et al. (2015) stresses that little is known about the effects of commercial extraction on wild plant populations. In order to assure their survival it is necessary to implement sustainable management practices. One of the main steps for doing this is to document effects of commercialisation on wild plant populations (Van Andel et al. 2015).

Multiple factors need to be analysed to determine management of plant resources. To identify the best conservation strategies of botanical richness it is necessary to first understand and analyse the uses of the plants sold in markets (Arellanes et al. 2013).

Although the research in the market of Isidro Fabela was not extensive and only few responses were collected, the results suggest that further investigation about effects of harvesting wild plants are needed.

6. Conclusions

This thesis consolidates the critical role of ethnobotanical knowledge in managing gastrointestinal disorders through the use of medicinal plants in Isidro Fabela, State of Mexico. It catalogues 28 plant species in 17 botanical families, with a focus on the most frequently used species like *Matricaria chamomilla* L. and *Mentha spicata* L., which are pivotal in local healthcare practices. The study highlights the traditional methods of preparation and the economic aspects of these plants in local markets, emphasizing the need for sustainable practices to prevent overexploitation.

The findings reveal a deep connection with traditional medicine in the region, reflecting broader themes of cultural identity and biodiversity conservation. Future research is recommended to further document the medicinal uses of plants for a variety of ailments and to assess the sustainability of commercial practices. This would not only aid in the conservation of local plant species but also in the preservation of cultural heritage and the enhancement of community health outcomes in Isidro Fabela.

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