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Aromatic and Medicinal Plants in Mexico

Mariana Palma-Tenango,
Ruben San Miguel-Chávez and
Ramón Marcos Soto-Hernández

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Abstract

Medicinal and aromatic plants in Mexico have been studied and explored through history. Day by day there is an increase in ethnobotanical, taxonomic, or phytochemical studies, providing an encouraging picture of research in Mexico and to support its use in traditional medicine. Chemical and biological exploration permit to provide solutions to the treatment of diseases. With this background, the objective of this chapter is to show the potential of endemic medicinal and aromatic plants in Mexico.

Keywords: endemic, medicinal herbs, Mexico

1. Introduction

Mexico is a country with a wide variety of medicinal and aromatic plants; their use is rooted in its culture, and they are employed to solve health problems in areas with little access to medicines. Although there are several introduced species, Mexico has a high number of endemic plants that are considered medicinal.

Demand for medicinal plants increases with the market, which is broad [1]. They are plants that produce secondary metabolites, each with different active ingredients and different therapeutic properties [2]. However, phytochemical information is generally focused on introduced species. Mexico has medicinal and aromatic species that require scientific research and wider dissemination. The cultivated area in the country is smaller than the demand there, and most of the plants are grown commercially. With this background, it is vital to gather information about endemic species of Mexico that are important for agriculture, pharmaceuticals, cosmetics, etc. due to their phytochemical and pharmacological properties.

Mexico has an estimated 30,000 species of plants, where approximately 3,000–to 5,000 are of medicinal use [3]. Most of the medicinal plants are gathered from the wild, and only 15% are cultivated. About 50,000 tons were exported, but there are no precise data about endemic species. The highest percentage of medicinal and aromatic plants is sold in local markets. Their commercialization is economically promising due to their widespread use in herbal medicine, and due to the biological activity, they have shown in some research.

The traditional use of medicinal plants has generated interest to start research to maintain a sustainable use of several species. At least 119 species of plants are used in the empirical treatment of diseases with symptoms similar to those of cancer [4]. Antibacterial activity of 75 species of plants has been reported, and 225 compounds and 140 species (40.57%) had been reported as toxic at least once.

2. History of Mexican medicinal plants

For several centuries, in what is now known as Mexico, medicinal plants have had an important part in the cultural baggage of indigenous pre-Columbian peoples, continuing through the independent period and reaching the ethnic groups that populate modern-day Mexico. The knowledge of this flora and its use to treat several maladies that affect the population are part of the knowledge that is empirically transmitted from generation to generation [5].

Before the arrival of Spanish conquered in the ancient Tenochtitlan, there was already knowledge of the flora, which was used to cure several illnesses, or during mystical ceremonies. Proof of that were the ancient botanical gardens located near Tenochtitlan, Chapultepec, Huastepc, Ixtapalapa, Peñón, Tetzoco, and a bit farther, in Atlixco, in the state of Puebla [6]. The deep knowledge of medicinal plants, joined to that of the human body, helped healers to use them to treat illnesses.

It is known that healers used these plants, and depending on the ailment or the patient, the treatment was carried out by a “specialist”; thus, there were physicians, surgeons, midwives, “hueseros” (bone healers), “sobadores” (masseurs), among others [7]. The way they employed the plants was through poultices, concoctions, dry powders, oils, infusions, etc. [7].

When the Spaniards arrived in the sixteenth century, they were marveled by the knowledge, and the use of medicinal plants that the indigenous peoples had to treat illnesses [8]. But it was at that moment when the European medicine had a negative influence in the continuity of the use of medicinal plants native of colonial Mexico.

As the Spanish control increased in New Spain, the influence of the Catholic Church became evident, as it forbidden the treatment of illnesses using the knowledge and traditions of the ancient Mexicans because it considered them magical and superstitious; this led to the punishment of many people, and it resulted in the practice of these traditions in secret [9].

Also, the European culture, represented by the Spaniards, brought new ways of healing and it introduced plants such as chamomile, rosemary, basil, thyme, marjoram, wormwood, English marigold, fennel, mint, peppermint, among others [4]. As a result of this interbreeding, the

“botica” was introduced; this was the place where remedies containing plant extracts, oils, essences, powders, etc., were prepared. The botica was overseen by a physician who had to take a quite rigorous test to be able to treat patients. He diagnosed, wrote prescriptions, and prepared the “medicines” for the patient [10].

Despite the prohibitions that the Spaniards had established at the beginning, the interest to commercialize the native plants of New Spain in Europe continued, and thus, in the sixteenth century, the codex de la Cruz Badiano appeared; this codex had been created for the most part for the purpose of this trade [11]. This compendium documented the vast medicinal flora of the century, with at least 41 illustrations of plants, and which practically constituted the first document and list of medicinal plants of Mexico.

The Spanish government promoted the Royal Botanic Expedition, which was carried out towards the end of the eighteenth century in New Spain. This expedition was an extremely important contribution to the knowledge of the botany in Mexico. José Mariano Mociño, who is considered the first Mexican botanist, took part in this expedition and in the creation of the manuscripts of the great Flora Mexicana [12].

Through the years, the pharmaceutical industry appeared, and the traditional medicine and the use of medicinal plants diminished, and they were relegated, and even considered illegal.

Nowadays, the use of medicinal plants still persists in the Mexican traditional medicine, especially in rural zones, where it may be the only available resource to treat illnesses and diseases. Unfortunately, there is too an inappropriate use of the technique, lack of asepsis, or the prescription of ingredients by people without proper training; this contributes to the discredit of this resource.

In spite of all the negative publicity that this technique attracted for many years, nowadays researchers of several institutions, including universities, health institutes, and the pharmaceutical industry have started paying attention to studies with scientific evidence that show that it is a useful alternative to solve health problems.

3. Endemic medicinal and aromatic plants of Mexico

Mexico is a country with the fourth largest floristic richness in the world; there are reported 23,314 native vascular plants, of which 11,600 are endemic; although it is reported that the percentage of endemism is actually 50% [3]. The family Lamiaceae is one of the most diverse in the country.

There is no exact number of endemic species with medicinal and aromatic uses, but 3,000 species are reported with medicinal uses in Mexican traditional medicine. It is mentioned that 1,549 are used in the Mayan culture, 816 in the Nahuas, and 3,059 in the Zapotecs. [13].

In Mexican culture, plants are used with different medicinal objectives. Every day, new phytochemical, ethnobotanical, or biodiversity reports arise. This has allowed exploring their potential and supporting their traditional use.

Scientific name*	Family	Composition	Activity	Reference
<i>Agastache mexicana</i> subsp. <i>xolocotziana</i> Bye, E.L. Linares and Ramamoorthy	Lamiaceae	Essential oils – methyl eugenol – Estragole – Limonene – Estragole – Menthone – Pulegone	Antifungal	[14, 15]
<i>Agastache mexicana</i> subsp. <i>mexicana</i>	Lamiaceae	Essential oils – Limonene – Linalool – Methyl Clavicol	Antifungal	[15]
<i>Montanoa tomentosa</i> Cerv.	Asteraceae	Volatile compounds – Sabinene – α -pinene – α -tujene Diterpenes Sesquiterpene lactones	Uterotonic, antibacterial, and antifungal	[16, 17]
<i>Lippia graveolens</i> Kunth	Verbenaceae	Essential oils – α -Pinene – α -Thujene – Camphene– -3-Carene – α -Terpinene– Limonene – p-Cymene– Thymol – Carvacrol	Acaricidal, antibacterial	[18, 19]
<i>Erythrina americana</i> Mill. <i>Erythrina coralloides</i> DC. <i>Erythrina lepthoriza</i> A. DC. <i>Erythrina mexicana</i> Krukoff <i>Erythrina oaxacana</i> Krukoff <i>Erythrina sousae</i> Krukoff	Fabaceae	Alkaloids	Sedative, antifungal	[20, 21]
<i>Hintonia latiflora</i> (Sessé and Moc. ex DC.) Bullock	Rubiaceae	Alkaloids, flavonoids, phenylcoumarin and glucocucurbitacins	Malaria, gastroprotector	[22]
<i>Salvia hispanica</i> L.	Lamiaceae	Fatty acids, phenolic compounds	Antioxidant activity	[23, 24]
<i>Bursera fagaroides</i> var. <i>fagaroides</i>	Burceraceae	Flavonoids, lignanans	Citotoxy activity, antitumoral	[25]
<i>Jatropha neopauciflora</i> Pax	Euphorbiaceae	Uncommon Sesquiterpenoids and New Triterpenoids	Antimicrobial and insecticide, antibacterial activities, Cytotoxic	[26, 27]
<i>Eysenhardtia platycarpa</i> Pennell and Saff.	Fabaceae	Flavones, oleanolic acid, lupeol, betulinic acid, β -sitosterol, β -sitosteryl β -D-glucopyranoside, β -sitosteryl palmitate, and 3-O-methyl-myo-inositol	Antihyperglycemic	[28]

*The botanical names were corroborated at Missouri Botanical Garden (2016)-TROPICOS.

Table 1. Plants aromatic and medicinal endemic reported in Mexico, with economic potentiall.

Several authors have reported studies about endemic plants that are considered medicinal or aromatic (**Table 1**). They show a promising future due to their compounds or biological activities. These species are sold all over the country, and some compounds are already being semi-synthesized, as is the case of taxol, to be commercialized and to be used in cancer treatments all over the world.

4. Secondary metabolites in Mexican plants

Research about natural products from endemic, native, and introduced medicinal plants is based on phytochemical studies. It is important to discover new molecules and evaluate their biological activity. Worldwide, 70% of anti-cancer compounds [29] and 75% of drugs destined to treat infectious diseases come from natural products [30]. Secondary metabolites are used as pigments, fibers, glue, oils, waxes, scent agents, perfumes, and drugs.

The acknowledgment of the biological properties of natural products has raised interest not only in their therapeutic activities, but also in their possible uses as antibiotics, to control pests and diseases, and as cosmetics [30].

A clear example is *Taxus*: there have been several phytochemical studies about this genus and one of its species is endemic to Mexico. In Mexican yew (*Taxus globosa* Schltdl.), the presence of taxol as the main component was documented [31]. Taxol was approved in 1992 to be commercialized as a therapeutic agent used in chemotherapy against a type of cancer.

Secondary metabolites are classified by their chemical structure, biosynthetic approach, or chemosystematic composition. The basic classification includes flavonoids, phenylpropanoids, phenolic compounds, tannins, saponins, essential oils, alkaloids, terpenoids, and glucosinolates [32].

The main secondary metabolites in endemic medicinal and aromatic plants of Mexico that have been investigated are phenolic compounds, flavonoids, terpenoids, and essential oils. Every day the list of groups of compounds or specific molecules and their biological evaluation grows. Studies about medicinal plants report several properties and the presence of secondary metabolites in several plant parts such as barks, leaves, fruits, flowers, roots, stems, wood, and whole plants.

5. Extraction methods and analyses

Phytochemical studies of Mexican medicinal and aromatic plants have been carried out using traditional extraction methods (**Figure 1**). They are used because they are simple, low cost, and easy to obtain. However, these processes can be slow, and there is a constant search to find techniques that can optimize extractions, that are cheap, fast, and that extract contains the highest number of compounds.

The techniques that have been reported to analyze and characterize chemical compounds from Mexican plants have been (LC), (GC-MS), (NMR), (IR), (UV), and (MS).

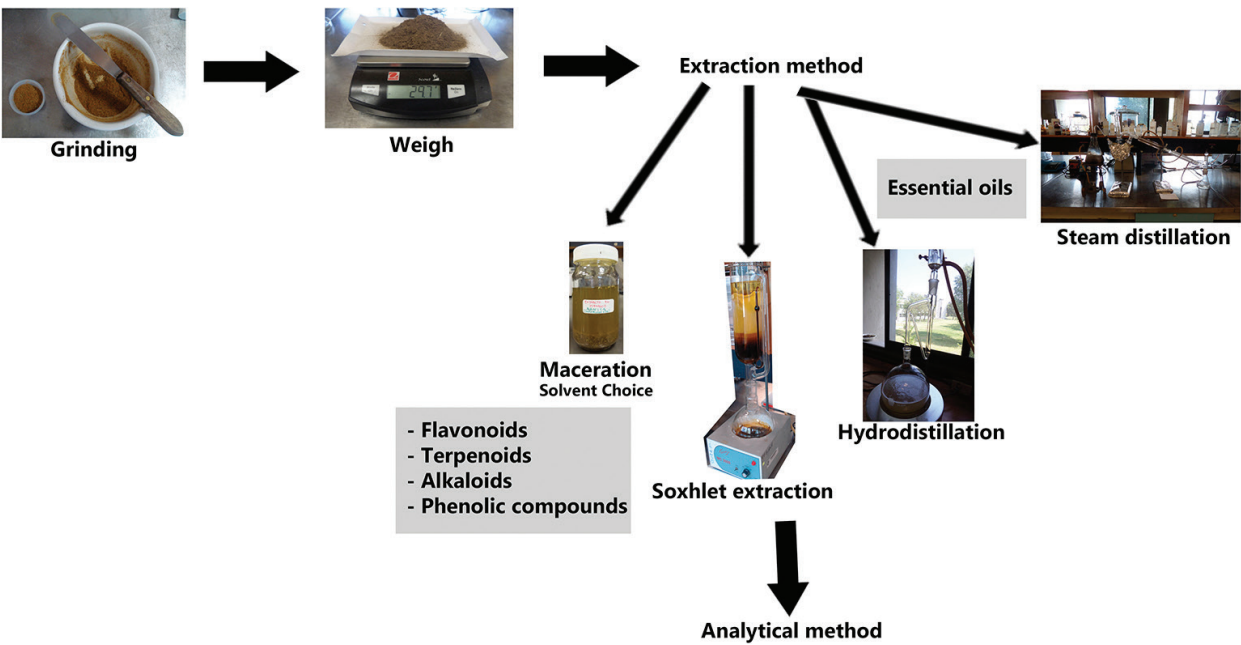


Figure 1. Main extraction methods of secondary metabolites in Mexican plants.

Scientific name*	Family	Plant parts use	Method extraction	Compounds	Analysis	Ref.
<i>Agastache mexicana</i> subsp. <i>xolocoziana</i> Bye, E.L. Linares and Ramamoorthy	Lamiaceae	Inflorescence, leaves and stems	Hydrodistillation Maceration	Essential oils Flavonoids	GC-MS HPLC-MS	[14, 33]
<i>Montanoa tomentosa</i> Cerv.	Asteraceae	Leaves	Maceration with sonicated	Terpenoids	HPLC, GC-MS	[16]
<i>Salvia hispanica</i> L.	Lamiaceae	Seeds	Soxhlet	Fatty acids composition, Total phenolic compounds	GC-MS Spectrophotometry maceration	[23, 24]
<i>Heterotheca inuloides</i> Cass.	Asteraceae	Inflorescence	SC-CO2	Volatile Fatty acids	GC-MS	[34]
<i>Tagetes lucida</i> Cav.	Asteraceae	Inflorescence	Maceration	Coumarinic constituents	UHPLC	[35, 36]
<i>Bursera fagaroides</i> var. <i>Fagaroides</i> <i>Bursera fagaroides</i> var. <i>elongata</i> McVaugh and Rzed <i>Bursera fagaroides</i> var. <i>purpusii</i> (Brandegee) McVaugh and Rzed.	Burseraceae	Leaves	Chromatographic fractionation	Flavonoids, lignans, volatile compounds	HPLC, 1H-NMR	[25, 37]
<i>Jatropha neopauciflora</i> Pax	Euphorbiaceae	Bark	Maceration	Sesquiterpenoids	CC, HPLC, 1H-NMR	[27]

Scientific name*	Family	Plant parts use	Method extraction	Compounds	Analysis	Ref.
<i>Lippia graveolens</i> Kunth	Verbenaceae	Leaves and stems	Hydrodistillation Maceration	Essential oils Phenolic compounds	GC-MS UHLPC-MS	[38, 39]
<i>Amphipterygium adstringens</i> (Schltdl.) Standl.	Anacardiaceae	Bark	Maceration	Terpenoids and maticadienoic acid	Spectroscopic and RNM methods	[40, 41]
*The botanical names were corroborated at Missouri Botanical Garden (2016)-TROPICOS.						

Table 2. Methods of extraction and analysis of secondary metabolites in Mexican endemic plants.

Several phytochemical methods describe details to extract and analyze compounds from Mexican plants, but the most used in endemic plants (**Table 2**) are maceration and hydrodistillation, and the most used solvents are hexane, methanol, dichloromethane, acetone, petroleum ether, ethanol, and water.

6. Commercialization of Mexican medicinal plants

6.1. National market

The sale of the plants in Mexico occurs mainly in regional markets. These plants are concentrated in specific locations, from where they are distributed to several parts of the country. Important zones of trade of medicinal plants and aromatic herbs are the market of Ozumba, in the state of Mexico, and Atlixco and San Martín Texmelucan, in the state of Puebla.

The plants that are mostly gathered from the wild are sold in large quantities in the “Mercado de Sonora” (market of Sonora). This market, located in Mexico City, is the most famous market due to the trade of dry and fresh plants [42]; approximately 15 tons of each medicinal plant is sold every year in this market.

The “Mercado de Ozumba” (market of Ozumba) is another place where one can get plants (**Figure 2**) that is closest to the market of Sonora. Here, local useful and medicinal plants, which have an important role for the economic and ceremonial life of the inhabitants of this region, are sold [42].

There are no precise reports about the species that are sold in regional markets, or about the total amount of income that is generated. Prices can vary depending on the species, part of the plant, or the location. The lack of information is related to illegal collection of plants. Plants collected from the wild are an important source of income for the inhabitants of the zones where they grow.

The species that are known in the country as having medicinal properties, and that have been collected for years (endangering their presence or distribution) are peyote (*Lophophora williamsii* (Lem. Ex Salm-Dyck) J.M Coult.), Mexican valerian (*Valeriana edulis subsp. procera* (Kunth)



Figure 2. Trade of medicinal plants in Ozumba, state of Mexico.

F.G. Mey.), cuachalalate (*Amphipterygium adstringens* (Schltdl.) Standl.), tepezcohuite (*Mimosa tenuiflora* Benth), and probably other species for which reports are lacking.

Plants sold in markets can be endemic or introduced. Trade conditions vary depending on the state of the plant: when dry, they are sold by weight, and when fresh, they are sold in bundles. They can be sold wholesale or retail, depending on the location, season of the year, and plant availability.

Some plants have the same common name and the same use all over the country. For example, Mexican arnica (*Heterotheca inuloides* Cass.) is sold dry or fresh (**Figure 3**), and also as part of different types of products including ointments, gels, shampoo, soap, etc.

6.2. International market

The international markets demand Mexican medicinal plants [43]. For example, damiana (*Chrysactinia mexicana* A. Gray), sarsaparilla (*Smilax aristolochiifolia* Mill.), Mexican arnica (*H. inuloides*), Mexican oregano (*Lippia graveolens* Kunth), cuachalalate (*A. adstringens* (Schltdl.) Standl.), mexican valerian (*Valeriana edulis* subsp. *procera* (Kunth) F.G. Mey.) are exported to the United States, Japan, and Germany.

Mexico exports essential oils and resinoids to several countries, especially the United States (**Figure 4**). There are no specific records on exports of essential oils of endemic plants in the

country. But it is known that the most popular essential oils are Mexican oregano, sweet lime, and Mexican lime. [44].



Figure 3. Trade of Mexican arnica in the market of Ozumba, state of Mexico. (Photography: Mariana Palma Tenango).

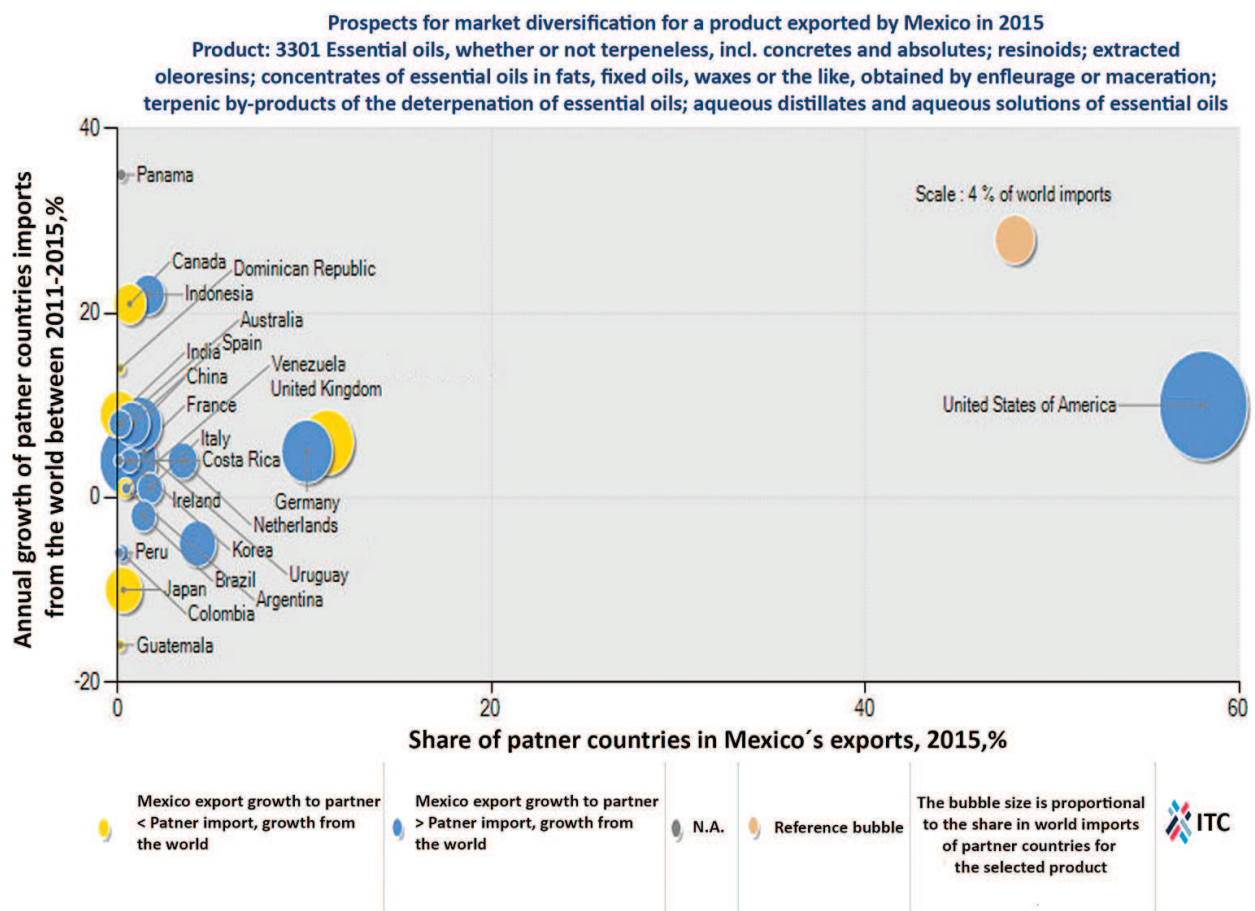


Figure 4. Prospect for market diversification for product exported by Mexico in 2015. Product 3301. Essential oils (terpenes or not), resinoids, and extracted oleoresins [44].

Some of the plants with medicinal and gastronomic importance are cacao (*Theobroma cacao* L.) and vanilla (*Vanilla planifolia* Jacks.), and the countries with the highest percentage of their consumption are the United States, France, and Germany. However, vanilla from Madagascar competes against Mexican vanilla, which has diminished the market for the latter.

6.3. Future prospects

Currently, there are several challenges; the most important is the sustainable use of plants with medicinal, cosmetologic, culinary or ritual applications, and their preservation through germoplasm banks. The domestic and international demand for medicinal plants is growing. About 90% of the plants are collected from the wild, and the remaining 10% is cultivated. Due to this, overexploitation is a real danger, because the species are collected without thinking about their recovery or the environmental damage. In Mexico, 83 species are considered endangered, 206 threatened, and 175 vulnerable [3]. One example of this is cuachalalate (*A. adstringens*), which is exploited in the state of Guerrero; when too much of its bark is removed, the tree is unable to recover and dies. Something similar occurs with mexican valerian (*V. edulis* subsp. *procera*), whose roots were collected relatively easily in the past in the wooded area of the boroughs of Milpa Alta and Xochimilco in Mexico City; nowadays it is almost impossible to find the plant. To avoid these situations, it is desirable that secretariats and institutes in charge of the care and promotion of the diversity of Mexican plant species enforce the laws and regulations that are already in place, to preserve these natural resources.

Another important aspect to take into account is the necessity to encourage the culture of plants that are collected from the wild, and to create technology packages to improve culturing, harvesting, and drying of the plants to monitor the quality of the secondary metabolites that are being produced, because in these plants what is sought is precisely this mixture of secondary metabolites that give, in the end, the beneficial effect to health and/or cosmetology that is desired by people.

The pharmaceutical industry, which in the beginning turned its back on the traditional medicine, is starting to see medicinal plants and their uses and the traditions of the indigenous peoples that know and use them on a daily basis, as a source of active ingredients to be incorporated into its drugs. Today it is not surprising anymore to see vitamin supplements with Ginseng extracts, cough syrups with propolis or great mullein, or pills with cuachalalate extracts to cure gastritis, etc.

Medicinal plants used in traditional medicine may represent alternative sources for new compounds to treat various diseases. For example, plants used for gastrointestinal disorders [35], used by antibacterial activities [45], anxiolytic or antidepressant activity [46], or for the treatment of colorectal cancer [4]. In Mexican arnica flowers (*H. inuloides*) were actives as antidiarrhoeals or antiparasitics [47].

The list increases, providing important data of compounds and biological activities. But it is necessary to increase developing phytochemical studies associated to the agricultural sector to produce medicinal plants, natural products, extracts, and other subproducts in a sustainable way.

Aromatherapy is another source of demand for aromatic plants. In Mexico, the demand of essential oils is higher than their production, which has led to the import of these substances.

The diversity in Mexico is large, and despite the scientific technological developments, there remains a lot to be researched about all the species with medicinal potential. We can say that the table is set and waiting for people to research, rationally exploit, and care for all this exquisite variety of medicinal and aromatic plants.

7. Conclusions

Endemic plants are known and commercialized in Mexico, but there are no precise numbers about their cultured surface. Phytochemical and biological activity research requires a previous botanical and taxonomical classification, and thus, their research is slow, but necessary to get scientific bases about their use.

Author details

Mariana Palma-Tenango, Ruben San Miguel-Chávez and Ramón Marcos Soto-Hernández*

*Address all correspondence to: msoto@colpos.mx

Colegio de Postgraduados, Campus Montecillo, Texcoco, Estado de México, México

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