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The Use of Medicinal Plants in Sierra Norte de Puebla: Integrating Tradition and Science
El uso de plantas medicinales de la Sierra Norte de Puebla: Integrando tradición y ciencia

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Resumen

Las plantas medicinales son de gran utilidad para las sociedades y son resultado de la experiencia que han acumulado desde hace generaciones y han sido una valiosa fuente de compuestos terapéuticos. En México se han identificado diversas especies de plantas como alternativas naturales ofreciendo remedios para una amplia gama de enfermedades y afecciones en la medicina tradicional (dolores de cabeza, diarrea, dolor de estómago, pie de atleta, cicatrización de heridas, picaduras de insectos, resfriados, infecciones urinarias, tos, entre otras). El uso de plantas con fines medicinales es una práctica común en México; y ha resurgido el interés como remedio alternativo o medicina tradicional por sus componentes naturales fácilmente disponibles, menor incidencia de efectos secundarios, y muchas culturas las perciben como seguras y eficaces. El objetivo de este trabajo es compilar y analizar la información etnobotánica, fitoquímica y farmacológica reportada sobre seis especies vegetales de gran relevancia cultural en la Sierra Norte de Puebla*: Hamelia patens, Eryngium heterophyllum, Mimosa tenuiflora, Tradescantia spathacea, Justicia spicigera* y

Tradescantia pallida. Se llevó a cabo una revisión de la literatura científica mediante la búsqueda y selección de artículos en bases de datos indexadas. Se analizaron estudios enfocados en el uso tradicional, los perfiles fitoquímicos y las actividades biológicas de las seis especies seleccionadas. Se obtuvo información sobre las actividades terapéuticas y propiedades biológicas de las plantas mencionadas, las cuales están relacionadas con compuestos químicos sintetizados por el metabolismo de las mismas, llamados fitoquímicos. Los fitoquímicos aislados de diversas partes de la planta; como semillas, hojas, flores, frutos, tallos y raíces, se han empleado como medicina alternativa, como fuente de compuestos bioactivos que comprenden: alcaloides, esteroides, fitoesteroles, saponinas, cumarinas, aceites esenciales, terpenos y compuestos fenólicos, como flavonoides, taninos, ácidos rosmarinos y ácidos fenólicos, glucósidos, entre otros. Estos compuestos dan como resultado un amplio espectro de actividades biológicas, incluidas las antimicrobianas, antibióticas, antioxidantes, antiparasitarias, antivirales, anticancerígenas, antiinflamatorias, analgésicas, antidiabéticas, antidepresivas, neuroprotectoras, antinociceptivas y cardioprotectoras, hipoglucémicas y citotóxicas. El principal aporte de este trabajo radica en la integración y sistematización de la evidencia científica moderna que valida los usos tradicionales específicos de algunas plantas de la Sierra Norte de Puebla. Esta revisión no solo rescata el conocimiento biocultural de la región, sino que proporciona una base teórica crítica.

Palabras clave: antioxidante, compuestos bioactivos, fitoquímicos, plantas medicinales.

Abstract

Medicinal plants represent a significant asset to human societies, reflecting the knowledge accumulated over successive generations. These plants have played a crucial role in the development of therapeutic compounds, offering a valuable resource for healthcare. In Mexico, a variety of plant species have been identified as natural alternatives, offering remedies for a wide range of illnesses and conditions in traditional medicine. These remedies have been used to treat ailments such as headaches, diarrhea, stomach aches, athlete's foot, wound healing, insect bites, colds, urinary tract infections, and coughs, as well as to promote wound healing. The use of plants for medicinal purposes constitutes a prevalent practice in Mexico. The resurgence of interest in plants as alternative remedies or traditional medicine is attributable to their readily available natural components, reduced incidence of adverse effects, and the perception in numerous cultures that they are safe and efficacious in numerous cultures. The main objective of this work is to collect and analyze the ethnobotanical, phytochemical, and pharmacological information reported on six plant species of great cultural relevance in the Sierra Norte of Puebla: *Hamelia patens*, *Eryngium heterophyllum*, *Mimosa tenuiflora*, *Tradescantia spathacea*, *Justicia spicigera*, and *Tradescantia pallida*. A review of the scientific literature was conducted by searching and selecting papers from indexed databases. Studies focused on the traditional use, phytochemical profiles, and biological activities of the six selected plants were analyzed. Information was obtained on the therapeutic activities and biological properties of the plants, which are related to chemical compounds synthesized by their metabolism, called phytochemicals. Phytochemicals isolated from various parts of the plant, such as seeds, leaves, flowers, fruits, stems, and roots, have been used in

alternative medicine as a source of bioactive compounds, including alkaloids, steroids, phytosterols, saponins, coumarins, essential oils, terpenes, and phenolic compounds such as flavonoids, tannins, rosmarinic and phenolic acids, glycosides, and others. These compounds exhibit result in a broad spectrum of biological activities, including antimicrobial, antibiotic, antioxidant, antiparasitic, antiviral, anticancer, anti-inflammatory, analgesic, antidiabetic, antidepressant, neuroprotective, antinociceptive, cardioprotective, hypoglycemic, and cytotoxic effects. The main contribution of this work lies in the integration and systematization of modern scientific evidence that validates the specific traditional uses of some plants from the Sierra Norte de Puebla. This review not only recovers the biocultural knowledge of the region but also provides a critical scientific basis.

Keywords: antioxidant, bioactive compounds, medicinal plants, phytochemical.

Introduction

Plants have been utilized around the world for generations as therapeutic resources, offering remedies for a wide range of diseases and conditions in traditional medicine, serving as a primary source of healthcare globally, especially in developing countries [1]. There is an increasing interest in the utilization of natural sources for the treatment of diseases, due to their ready availability and natural origin, and many cultures perceive them as safe and efficacious. Nowadays, around 50,000 plant species have been reported to have some medicinal use, corresponding to approximately 10% of all those existing in the world, and 80% of the global population has used plants for their primary health care needs [2, 3]. The Sierra Norte de Puebla is located between 19° 45’ and 20° 50’ N and 97° 10’ and 98° 17’ W. It is an area that presents great environmental, biological, and cultural diversity. According Martínez, Evangelista [4], there are 758 species of plants registered in Sierra Norte de Puebla; however, most of them are used as shade trees in coffee plantations. Only 130 species are traded for their use as medicinal plants, and they are adapted to grow in specific regions depending on the climate. Women between the ages of 30 and 40 have the greatest knowledge of medicinal plants and are also the primary users of them [5].

Various plant parts, such as seeds, leaves, flowers, fruits, stems, and roots, have been employed in alternative medicine as sources of bioactive compounds including alkaloids, flavonoids, terpenoids, polyphenols, and glycosides; most of these are secondary metabolites that plants produce primarily as defense mechanisms against environmental stressors, predators, and pathogens [3, 6-8]. Over time, it has been established which plant species are most effective as treatments for specific illnesses. The standardization of medicinal plants ensures their consistency and therapeutic effectiveness [9, 10]. This review aims to provide information on some plants that have been used in the empirical treatment of pain, healing of minor wounds and burns, fever, stomach pain, and other diseases, as well as the bioactive compounds present and their biological activities (Table 1).

Methodology

This work was developed using a systematic narrative review approach to the scientific literature. The search was conducted in the indexed databases PubMed, Scopus, Web of Science, SciELO, and Google Scholar, in publications in Spanish and English, using

the following keywords: *Hamelia patens*, *Justicia spicigera*, *Mimosa tenuiflora*, *Eryngium heterophyllum*, *Tradescantia spathacea*, *Tradescantia pallida*, traditional medicine, phytochemistry, pharmacology, bioactivity, and Sierra Norte de Puebla. Original papers and systematic reviews were selected. These research works were required to provide quantitative or qualitative data on the secondary metabolite profile, validation of biological activities in vitro and in vivo, or ethnobotanical records of the six species. Additionally, papers detailing plant extraction methodologies were selected. Bibliographic references were compiled to support this review using EndNote Version 9 software.

Hamelia Patens

Hamelia patens (family Rubiaceae), is better known as "tres hojitas", "bayetilla", "trumpet grass", "coralillo", or "coral grass" (figure 1). Tres hojitas is an ornamental shrub that can grow up to 3 m in height, bearing bright reddish-orange tubular flowers that give rise to red berries [11, 12]. It is cultivated as a perennial herb that grows in tropical and subtropical regions. It does not have pest or disease problems that plague other plants, and can tolerate many types of soil. It has been considered a weed in coffee-growing areas. In Mexico, it is found in the states of Campeche, Chiapas, Jalisco, Morelos, Nayarit, Oaxaca, Querétaro, Quintana Roo, San Luis Potosí, Sinaloa, Tamaulipas, Veracruz, and Yucatán. Tres hojitas has been used in traditional medicine for many conditions such as headaches, diarrhea, stomachache, athlete’s foot, wound healing, insect bites, nervous shock, rheumatism, asthma, dysentery, and diabetes, among other applications [13-15].

All functional activities of *H. patens* are related to the presence of functional compounds in its leaves, stems, flowers, fruits, and roots of the plant, such as alkaloids, terpenes, and phenolic compounds, including flavonoids, tannins, rosmarinic acids, and phenolic acids [16-18]. Other functional compounds such as oxindole alkaloids and flavanone glycosides, can be extracted from the aerial parts of the plant, and ephedrine from the leaves; however, the potential functional activity of compounds extracted from *H. Patens* depends on the part of the plant used and the method of extraction [11, 13, 18]. Studies have reported the extraction of bioactive compounds using different solvents such as methanol, chloroform, and ethanol; extracts from and different parts of *H. patens* have functional activities as radical scavenging, anti-inflammatory, antibacterial, wound-healing properties, antifungal activity against *Fusarium oxysporum*, cytotoxic activity, anthelmintic, antidepressant, acetylcholinesterase inhibitory, antilithiatic, hepatoprotective, blood sugar lowering and to treat nervous shock [19-21].

Gutiérrez-Sánchez, Aguilar-Zárate [22] reported the presence of antimicrobial activity in the ethanolic extract of *Hamelia patens* on a clinical isolate of non-β-lactamase-producing *E. coli* with an MIC of 94 µg/mL. Núñez, Paz-González [23] demonstrated a similar antimicrobial effect on reference strains of *A. baumannii* ATCC BAA-747 and BAA-1605 (MIC= 250 µg/mL) using n-hexane as the extraction solvent. Both extracts were obtained by the same ultrasound-assisted extraction method.

Valle Ortiz, Aguila Muñoz [18] obtained methanolic extracts of HP using consecutive maceration, and these demonstrated significant antifungal activity against *Fusarium oxysporum* f. sp. *radicis-lycopersici*, a phytopathogenic fungus that affects economically important crops. The study demonstrated the most pronounced antifungal activity (IC_{50} 3.7% w/v), which

was concomitant with elevated levels of flavonoids (kaempferol-3-O-β-rutinoside) and tannins (rutin).

Franco-Espínola, Núñez [24] obtained methanolic extracts of a variety of medicinal plants by means of an ultrasonic bath (operating at a frequency of 35 kHz for a duration of 90 minutes at a temperature of 25 °C). The Hamelia Patens extract of the aerial parts demonstrated high antiviral activity; therefore, they can be used as a source for isolating new compounds against herpes simplex virus type 1. The effective antiviral concentrations (EC_{50}) of these extracts were determined to be 24.5 µg/mL, with a selectivity index of 14.58. The ratio of cytotoxicity to biological activity is defined as selectivity index (SI) and it is generally considered that biological efficacy is not due to the in vitro cytotoxicity when SI ≥10 [25].



Figure 1. *Hamelia patens*, better known as "tres hojitas", "bayetilla", "trumpet grass", "coralillo", or "coral grass".

Eryngium heterophyllum

The plants of *Eryngium* species are 0.3 to 1.5 m height, with one principal stem, main or several stems, and elliptic- and ovate-oval-shaped spiny fruits, and vertical roots (Figure 2). These plants are spiny, perennial, or biennial herbs. *Eryngium* species are present in dry, semi-dry, and temperate climates. One of the important plants of Eryngium species is *Eryngium heterophyllum*, which is better known as “toad grass”, “scorzonera”, “thorny grass”, “cardón” or “Frog grass” [26, 27]. Frog grass (figure 2) can grow to 0.5-1.0 m in height, it has thorns and flowers that can appear in shades of white, blue, and purple. Frog grass is a plant endemic to Mexico and Central America. In Mexico, it is commonly found in Puebla, Tlaxcala, and the Sierra Madre Occidental [26, 27]. The aerial parts of this plant are consumed as an infusion and have traditionally been used to treat diabetes, dyslipidemia, high blood pressure, and digestive problems. Species of this genus contain secondary metabolites such as flavonoids, saponins, rosmarinic acid, triterpenes, coumarins, polyacetylenes, and essential oils that give them their medicinal properties [28, 29]. Information on toad grass is scarce; some researchers report that toad grass (*Eryngium heterophyllum*) is a well-known plant empirically attributed therapeutic properties for the treatment of diabetes, arthritis, and hypercholesterolemia, among other diseases. Recent studies on the hypocholesterolemic activity of toad grass report that the aqueous extract at a dose of 100 mg/kg reduced cholesterol by 9% in male Wistar rats [30]; and that the aqueous extract from *Eryngium heterophyllum* present alkaloids, coumarins, and phenolic compounds that are related to functional activities [31, 32].

Castañeda-Espinoza, Alvarez Soto [33] obtained a methanolic extract of *Eryngium heterophyllum* that exhibited cytotoxic activity in cervical cancer cell lines, with IC_{50} values of 24.5 ± 3.6 µg/mL (HeLa cells) and 27.45 ± 3.7 µg/mL (SiHa cells). This resulted in evident morphological alterations,

including cell rounding, loss of adherence, and reduced cell density compared to untreated controls. In order to assess selectivity, non-cancerous cell models were analyzed, thus enabling a biologically relevant comparison to be made. It is noteworthy that all non-cancerous cell lines exhibited higher median inhibitory concentrations (IC_{50}) in comparison to their cancerous counterparts. This observation signifies that the non-cancerous cell lines demonstrated reduced sensitivity to the examined extracts.

The study by Villa-Santiago, Camacho-Díaz [34] evaluated the phytochemical profile, as well as the antioxidant and hypoglycemic activities, of the leaf extract of *Eryngium heterophyllum*. The study demonstrated inhibition rates of 64.4% and 64.9% in the ABTS•+ and DPPH• assays, respectively, with IC50 values of 21.8 µg/mL and 20.72 µg/mL, respectively. The presence of β-sitosterol, rutin, catechin, ferulic acid, gallic acid, and caffeic acid was noted at concentrations of 315.9 µg/mL, 189.1 µg/mL, 88.3 ± 2.2 µg/mL, 105.5 ± 1.3 µg/mL, 31.6 ± 1.0 µg/mL, and 37.6 ± 1.3 µg/mL, respectively. The enzyme α-glucosidase has been shown to catalyze the release of glucose from complex carbohydrates, thereby contributing to postprandial blood glucose levels. Dysregulation of this enzyme activity has been demonstrated to promote the development of type 2 diabetes; therefore, its inhibition is an effective strategy for attenuating postprandial glucose spikes [26]. In this context, the *E. heterophyllum* extract demonstrated effective inhibition of α-glucosidase (26.8 ± 2.9%, IC_{50} = 9.6 µg/mL), suggesting a hypoglycemic potential associated with its metabolites. These findings are consistent with previous reports indicating that phenolic acids and flavonoids inhibit α-glucosidase [35].



Figure 2. *Eryngium heterophyllum*, better known as “toad grass”, “scorzonera”, “thorny grass”, “cardón” or “Frog grass”

Mimosa tenuiflora

Mimosa tenuiflora belongs to the Fabaceae family. It is well known as “tepezcohuite”, “cabrera”, “carbon colorado”, “carbona”, “jurema”, “jurema preta”, and “yurema” (Figure 3). Tepezcohuite is a shrub or medium-sized tree 5 to 7 m tall; it can grow in several environments, including forests, savanna areas, and fields, across Mexico and South America (mostly Brazil and Venezuela). It is also an important forage plant used to feed small ruminants during the dry season [36-39]. Tepezcohuite is widely used as an effective remedy to treat skin burns and wounds in traditional Mexican and Brazilian medicine. Compounds such as tannins, flavones, catechins, leukoanthocyanidins, saponins, anthocyanidins, flavonols, flavonones, flavononones, xanthones, diterpenes, triterpenes, alkaloids, polyphenols, phenolic compounds, steroids, flavonoids, pentacyclic triterpenoids, and triterpene saponins have been found in Tepezcohuite [36, 40]. Bioactive compounds from Tepezcohuite can be obtained not only from the leaves but also from the stem bark and heartwood. These compounds have been reported to present antimicrobial activity against *Staphylococcus aureus*, *Micrococcus luteus*, *Bacillus subtilis*, *Candida albicans* yeasts, and dermatophytes. This capacity of

Tepezcohuite extracts is due to their ability to cause the rupture of the bacterial wall and/or cell membrane, because the bioactive compounds from Tepezcohuite can form complexes with the proteins present in these structures. Furthermore, compounds such as flavonoids can cause an alteration in the permeability of the bacterial membrane, causing the extravasation of its intracellular components and thus leading to the rupture of the cytoplasmic membrane [36, 41]. Additionally, Tepezcohuite extracts present antioxidant activity linked to aflatoxin synthesis, as well as anti-inflammatory, cardioprotective, hypoglycemic, antidiarrheal, antiulcerogenic, antidiabetic, antinociceptive, and cytotoxic effects [40, 42-44].

Aquino, Gomes [45] evaluated the antimicrobial activity of *Mimosa tenuiflora* extract (100 mg/mL) and found it to be effective against a mixed culture composed of coccobacilli and streptobacilli, both of which are Gram-negative. This effect may be attributed to the presence of condensed tannins, which have been shown to possess antimicrobial specificity, targeting the bacterial cell membrane and inducing cell death. In a separate study by Crepaldi, Da Rocha Bispo [46], the antimicrobial activity of the methanolic extract of *Mimosa tenuiflora* (40 μg/mL) was examined against *Aeromonas* strains. The study by Silva, de Oliveira [47] demonstrated the antimicrobial efficacy of the ethanolic extract derived from the bark of *M. tenuiflora* against *Staphylococcus aureus* strains, using the disk diffusion method, which produced a halo with a radius of 9.85 mm.

Luyen, Hao [48] conducted a phytochemical study of the alcoholic extract of green propolis from *Mimosa tenuiflora*, which resulted in the separation of six flavonoids, including the flavonols quercetin 3-methyl ether and 3,3′-O-dimethylquercetin, and four flavanones. The flavonols demonstrated considerable antioxidant activity against DPPH radicals, with IC_{50} values of 12.40 and 16.23 μg/mL, respectively. All six flavonoids exhibited anti-inflammatory properties in the context of nitric oxide (NO) production in lipopolysaccharide-stimulated RAW 264.7 cells (inflammatory activation), with quercetin 3-methyl ether demonstrating superior activity in comparison to the standard dexamethasone reference (IC_{50} 13.35 μg/mL). Furthermore, the investigation revealed that flavanols were able to inhibit the growth of Gram-positive bacteria, namely *Bacillus subtilis* ATCC 6051 and *Staphylococcus aureus* ATCC 29213, with minimum inhibitory concentrations (MICs) ranging from 32 to 64 μg/mL. The six isolated flavonoids demonstrated potent or moderate larvicidal activity against fourth-stage larvae of *Aedes aegypti* and *Ae. albopictus*, with LC_{50} values at 24 hours ranging from 29.62 to 55.89 μg/mL.



Figure 3. *Mimosa tenuiflora*, also known as "tepezcohuite", "cabrera", "carbon colorado", "carbona", "jurema", "jurema preta", and "yurema".

Tradescantia spathacea

Tradescantia spathacea, also known as "barquilla", "purple maguey", "oyster plant", or "boat lily", is a perennial herbaceous plant belonging to the Commelinaceae family (Figure 4). It is native to southern Mexico and has been identified in the states of Chiapas, Tabasco, and the Yucatan Peninsula; it is also present in Sierra Norte de Puebla [49]. The

aesthetic appeal of its foliage has contributed to its extensive cultivation in tropical regions. The plant is moderately erect, with a height ranging from 0.3 m to 0.6 m. It is distinguished by its propensity to thrive in dense clusters and by its broad and linear leaves, which exhibit a remarkable color change from green to purple, with the green color predominant on the upper surface and the purple on the lower surface [50].

This plant has a history of use in traditional medicine for a wide range of remedies, including colds, dysentery, asthma, venereal diseases, urinary tract infections, coughs, and as a healing agent [51]. Barquilla is characterized by the presence of bioactive compounds, including phenolic acids, coumarins, tannins, phytosterols, terpenes, alkaloids, flavonoids, glycosides, quinones, and fatty acid derivatives [52]. Consequently, these compounds exhibit a wide range of biological activities, including antiviral, antimicrobial, anticancer, anti-inflammatory, analgesic, antidiabetic, antioxidant, antidepressant, and neuroprotective properties [53].

Barquilla hydro-ethanolic extract has demonstrated notable anti-inflammatory properties at doses of 75, 150, and 300 mg/kg in isolated strips of urinary bladder. The observed anti-inflammatory properties could prove particularly beneficial in mitigating chronic inflammation, a common factor in the progression of kidney diseases such as chronic kidney disease and glomerulonephritis [54]. An HPLC chromatogram of *Tradescantia spathacea* confirmed the presence of vanillic acid, gallic acid, and p-coumaric acid [54]. Gallic acid has been employed in the treatment of gastrointestinal disorders, including diarrhea and dysentery [55]. In addition, vanillic acid has been reported to possess spasmolytic, antimotility, and antidiarrheal properties in isolated intestinal tissues [56].

In another study, the antidiabetic potential of Barquilla extract was examined using the oral glucose tolerance test with streptozotocin and an alloxan diabetes rat model [57]. This investigation revealed that treatment with the extract led to a significant reduction in blood glucose levels in experimental animals. The data demonstrate that *T. spathacea* extract at a dose of 400 mg/kg has a significant effect on blood glucose levels, equivalent to glibenclamide. Consequently, this study examined the antiulcer activities in rats with gastric ulcers. The ulcer index demonstrated a considerable dose-dependent decrease at 200 mg/kg (IU; 5.33 ± 0.494) and 400 mg/kg (IU: 2.55 ± 0.199) in animals pretreated with test extracts [57].

Barquilla extract also presents antioxidant activity the DPPH radical and in the FRAP assay, with a CE50 of 288 ± 36 μg/mL and 12.18 ± 0.12 mmol Fe2+/g DW. The extract also showed inhibition of bacterial growth, such as *Staphylococcus aureus*. Hexane has been used for the extraction of low-polarity bioactive compounds in *Tradescantia spathacea*, including terpenoids, steroids, oils, and specific phenolic terpenes. Ethyl acetate has been employed in the extraction of slightly more polar chemical constituents, such as polyphenols, carbohydrates, amino acids, and chlorophylls [53, 54, 57].

Furthermore, according to Lim, Keng [58], *T. spathacea* extracts exhibit antibacterial properties against a variety of bacteria. In this study, the hexane and ethyl acetate extracts of the roots showed weak inhibition against *S. aureus*, giving a maximum inhibition zone of 10 mm and 8 mm, respectively.



Figure 4. *Tradescantia spathacea,* also known as “barquilla”, “purple maguey”, “oyster plant”, or “boat lily”.

Justicia spicigera

Justicia spicigera, is commonly known as “muicle”, “muitle”, or “mohuitli”, it is native to Latin America (El Salvador, Belize, Costa Rica, Nicaragua, Honduras, and Mexico). In Mexico, this plant is primarily found in the states of Chiapas, Nayarit, San Luis Potosí, Mexico City, Veracruz, Morelos, Tlaxcala, Yucatán, Hidalgo and Puebla. This plant can be cultivated in warm, semi-warm, semi-dry, dry, and temperate climates from sea level up to 3,000 meters above sea level. Muicle is a dense shrub, reaching 1-1.5 m in height. Its leaves are elongated, with a rough texture and prominent veins. The flowers are clustered at both the base of the stem and the top of the plant and are a characteristic orange color with a tubular shape (Figure 5) [59]. This plant has a coloration that varies from red to dark blue and has been used to dye textiles and crafts, and recently it has been incorporated as a natural colorant in various food products [60].

Traditionally, the leaves, flowers, and stems of muicle are used in decoctions, infusions, and tinctures to treat stomach aches, coughs, respiratory problems, anemia, fever, diarrhea, hemorrhoids, skin and kidney infections, nervous disorders, circulatory and dermal conditions, and as an aid in women's health issues such as cramps or menstrual pain [61].

These uses of this plant are associated with the presence of bioactive compounds in its structure, derived from adaptation processes, abiotic stress, animal attractants or repellents, and color pigments. Therefore, muicle contains compounds such as simple carbohydrates, mucilage, pectins, glycosides, pigments, resins, essential oils, and minerals. Flavonoids (kaempferol and its derivatives), carotenoids, some aliphatic compounds, eucalyptol, fatty acid derivatives, and cinnamic acid esters have been isolated from the leaves of this species. In addition, anthocyanins, such as cyanidin 3-O-glucoside and cyanidin 3,5-diglucoside, have been identified [62].

Furthermore, from a pharmacological perspective, muicle exhibits various biological activities: immunomodulatory, antiprotozoal, anthelmintic, antibacterial and antifungal, anti-inflammatory, antiobesogenic, antidiabetic, antihypertensive, antinociceptive, and anxiolytic [63-65].

The hydroalcoholic extract of muicle showed a clear dose-dependent antiproliferative effect on LNCaP prostate cancer cells, characterized by cell cycle arrest in the G0/G1 phase at 250 µg/mL and induction of apoptosis as early as 24 h at concentrations ≥500 µg/mL, including cell shrinkage, rounding, and partial detachment from the substrate. These changes intensified at 48 h, marked by pronounced membrane blebbing and disruption of the monolayer [66]. *In vitro* studies have demonstrated that muicle ethanolic extract stimulates the immune activity of macrophages and NK cells and increases the proliferation of murine splenocytes (immunological response) [67]. Research on muicle hydroalcoholic extracts showed their antiproliferative and cytotoxic effects in the androgen-dependent stage of prostate cancer, concluding that the extract affects the proliferation of LNCaP cells, preventing progression to mitosis in the cell cycle [68].

The 70% aqueous ethanol ultrasound-assisted extract exhibited the highest levels of phenolic compounds and *in vitro* antidiabetic activity among the extracts evaluated against α-amylase and α-glucosidase [69]. Similarly, the relationship between flavonoid content and the inhibition of α-amylase and α-glucosidase in *J. spicigera* extracts is consistent with the study reported by Parveen, Shehzadi [70], who found, in an *in silico* study, that kaempferols are potent inhibitors of α-amylase.



Figure 5. *Justicia spicigera*, commonly known as “muicle”, “muitle”, or “mohuitli”.

Tradescantia pallida

Tradescantia pallida belongs to the Commelinaceae family. It is traditionally known as “purpurina”, “purple queen”, and “purple heart”. It is a perennial plant widely distributed in tropical and subtropical regions, including Pakistan, India, the West Indies, Africa, the United States, and Mexico. This hardy herb has a history of application in the food sector, where it has been used as an additive for its preservative and coloring properties [16, 71]. It is an ornamental plant with important traditional medicinal properties. Purpurina has been used for its high efficacy in antitoxic activities (improving blood circulation), antioxidant, antibacterial, anti-inflammatory, antitumor, cytotoxic, analgesic, antidiabetic, antiobesogenic, thrombolytic, and membrane-stabilizing activities [72].

Phytochemical studies of purpurina extracts attribute biological activities to various compounds, such as phenols, flavonoids, tannins, alkaloids, and saponins. It is also a rich source of natural coloring compounds, especially anthocyanins [71, 72].

Parab and Vootla [73] extracted and characterized the anthocyanin cyanidin-3-glucoside from *Tradescantia pallida* (TP)

using a 1:1 water/ethanol solvent system. Further, the antimicrobial activity of the extracted TP anthocyanin showed noticeable inhibition zones against *E. coli* (~18.00 mm) and *B. cereus* (~19.00 mm) and excellent antioxidant activity against DPPH free radicals, along with strong ferric reducing power as revealed by the FRAP assay. TP anthocyanins demonstrated promising anticancer activity against the MDA-MB-231 triple-negative breast cancer cell line, with cell viability reduced to 27.307%. Previous studies reported that the crude anthocyanins from pomegranate had greater antibacterial efficiency than that of purified anthocyanin extract due to the hydroxyl components lost during the removal of impurities, which have a synergistic effect on the bacteriostatic action [74].

In vitro studies of purpurina extracts revealed that the polyphenols morin and catechin exhibited >72% inhibition of α-amylase and >67% inhibition of hemoglobin glycosylation, findings corroborate the antidiabetic potential [75]. The ethanolic extract of purpurina showed hepatoprotective effects through the analysis of functional and biochemical indicators. These results imply that the hepatoprotective action is equivalent to that of silymarin, a widely used hepatoprotective drug [72, 76].

In another study, purpurina aqueous infusion extract is proposed as an alternative bioextract for organic producers. It affects all developmental stages of the insects, especially the adult stage, reducing the number of individuals in the next generation and resulting in lower pupal weight, fecundity, fertility, and longevity in females [76]. They observed that a 10% concentration of plant extract affected the biology and development of the diamondback moth through lethal and sublethal effects, ranging from larvicidal effects to reductions in pupal weight and reproduction at the adult stage.



Figure 6. *Tradescantia pallida* belong to the Commelinaceae family, traditionally known as “purpurina”.

Table 1. Medicinal plants, bioactive compounds, traditional uses, and biological activities.

Plant	Common Names	Bioactive compunds	Traditional Uses	Biological Activities	References
Hamelia patens	Tres hojitas, bayetilla, trumpet grass, coralillo, coral grass.	Alkaloids, terpenes, and flavonoids such as kaempferol-3-O-β-rutinoside, tannins such as rutin, rosmarinic acid, and flavanone glycosides.	Headache, diarrhea, stomachache, athlete's foot, wound healing, insect bites, nervous shock, rheumatism, asthma, dysentery, and diabetes.	Antimicrobial, antifungal, antiviral, antioxidant, anti-inflammatory, cytotoxic, hypoglycemic, and hepatoprotective.	[11-25]
Eryngium heterophyllum	Hierba del sapo, toad grass, scorzonera, thorny grass, cardón, frog grass.	Flavonoids (rutin, catechin), saponins, rosmarinic acid, triterpenes, coumarins, essential oils, phytosterols (β-sitosterol), and phenolic acids (ferulic, gallic, caffeic acid).	Diabetes, dyslipidemia, hypertension, digestive problems, arthritis, and hypercholesterolemia.	Antidiabetic, hypocholesterolemic, antioxidant, and selective cytotoxicity in cervical cancer cells.	[26-35]
Mimosa tenuiflora	Tepezcohuite, cabrera, carbón colorado, carbona, jurema, jurema preta, yurema.	Condensed tannins, flavonoids (quercetin 3-methyl ether, 3,3′-O-dimethylquercetin, flavanones), triterpene saponins, alkaloids, steroids, and polyphenols.	Effective remedy for skin burns, wound healing, and as a forage plant.	Antimicrobial, anti-inflammatory, antioxidant, larvicidal, cardioprotective, and cytotoxic.	[36-48]
Tradescantia spathacea	Barquilla, purple maguey, oyster plant, boat lily.	Phenolic acids (gallic, vanillic, p-coumaric acid), coumarins, tannins, phytosterols, terpenes, alkaloids, flavonoids, glycosides, and quinones.	Colds, dysentery, asthma, venereal diseases, urinary tract infections, coughs, and as a healing agent.	Anti-inflammatory, antidiabetic, antiulcer, antioxidant, and antibacterial.	[49-58]
Justicia spicigera	Muicle, muitle, mohuitli.	Flavonoids (kaempferol and derivatives), anthocyanins (cyanidin 3-O-glucoside and cyanidin 3,5-diglucoside), carotenoids, eucalyptol, pectins, mucilage, and essential oils.	Stomach pain, cough, respiratory problems, anemia, fever, diarrhea, hemorrhoids, skin and kidney infections, nervous disorders, menstrual cramps.	Antiproliferative and cytotoxic, immunomodulatory, antidiabetic, and antinociceptive.	[59-70]
Tradescantia pallida	Purpurina, purple queen, purple heart.	Anthocyanins (cyanidin-3-glucoside), phenols, flavonoids (morin, catechin), tannins, alkaloids, and saponins.	Used as a preservative and natural food colorant.	Antioxidant, antibacterial, anticancer, antidiabetic and hepatoprotective.	[16,71-76]

Conclusions

This review highlights the rich herbal resources of the Sierra Norte de Puebla, represented by *Hamelia patens, Eryngium heterophyllum, Mimosa tenuiflora, Tradescantia spathacea, Justicia spicigera,* and *Tradescantia pallida*. These plants have been used in infusions to treat stomach aches, coughs, respiratory problems, anemia, fever, diarrhea, hemorrhoids, skin and kidney infections, nervous disorders, circulatory and dermal conditions, and as an aid in women's health issues such as cramps or menstrual pain, constituting an invaluable biocultural tradition. Furthermore, this comparative analysis of scientific evidence demonstrates the bioactive effects of Tres hojitas, Hierba del sapo, tepezcohuite, Barquilla, Muicle, and Purpurina, such as the control of blood glucose levels, tissue regeneration, antiulcer activity, antimicrobial, and antioxidant properties, among other effects. The bioactive activities are related to phytochemical profiles featuring key compounds such as kaempferitrin, oxindole alkaloids, triterpene saponins, and condensed tannins. For future research, it is imperative to prioritize chronic toxicity assays to determine long-term biosafety, standardize extraction methodologies to ensure homogeneity in the concentration of active metabolites, and evaluate the pharmacological synergies of herbal mixtures as used in traditional community practice. In this way, the scientific validation of these species will not only drive innovation in medical therapeutics but also promote biodiversity conservation and respect for the intellectual property rights of the indigenous communities of the Sierra Norte de Puebla.

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