

Medicinal Plants Effective in Ear Infections: Combining Traditional Knowledge and Modern Evidence and Examining Their Mechanism of Action

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Article Info	ABSTRACT
Article type: Review Article Article History: Received: 17 June 2025 Revised: 16 Sep 2025 Accepted: 20 Sep 2025 Published Online: 20 Apr 2026 ✉ Correspondence to: Mahmoud Bahmani Email: mahmood.bahmani@gmail.com	Objective: In traditional Iranian medicine, the use of native medicinal plants as a natural method to reduce symptoms and treat ear infections has a long history. The aim of this review is to identify and investigate the most important native Iranian medicinal plants that are effective in controlling and treating ear infections. Methods: This review was conducted in two parts. The first part was dedicated to identifying the most important medicinal plants used in traditional Iranian medicine for the treatment of ear infections, and the second part was devoted to reviewing the scientific evidence available in laboratory and clinical studies to confirm the traditional effects of these plants. Results: In traditional Iranian medicine, several plants are used to treat ear infections, the most important of which include chamomile, lavender, tea tree, peppermint, marigold, rosehip, lemon, garlic, olive, and aloe vera. Most of these plants have been confirmed to have anti-ear infection effects in scientific research, but for some species such as <i>Daucus carota</i> L., <i>Actinidia deliciosa</i>, <i>Zea mays</i> L., and others, there is still insufficient evidence. The plants studied belong to various families, with the greatest diversity related to Lamiaceae, Asteraceae, and Apiaceae. The aerial parts of the plants, especially leaves and flowers, have the most medicinal use, and some species use a combination of several parts. The majority are herbaceous plants, with trees, shrubs, and certain plants playing a complementary role. Most species grow in light or rich soil and sunny areas, and there is a mixture of annual and perennial plants. Most plants are drought tolerant and tolerate full sun, while some require moisture, rich soil, or partial shade. Conclusion: Medicinal plants native to Iran has antibacterial and anti-inflammatory properties and can help reduce the symptoms of ear infections. These plants can be used as safe complementary treatments, but their use should be done under the supervision of a specialist with medical follow-up. Keywords: Ear, Infection, Bacterial, Treatment, Medicinal Plants, Traditional Medicine
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Introduction

Ear infections, especially acute otitis media, are a common health problem in children and adults and are one of the most important reasons for patients to visit health centers [1,2]. According to reports, more than 80% of children by the age of 5 years will have at least one ear infection, and this disease accounts for a significant share of the economic burden of the health system [3]. Middle ear infections are mainly caused by the proliferation of bacteria or viruses in the middle ear space following dysfunction of the Eustachian tube, which creates an accumulation of secretions and a suitable environment for the growth of pathogens [3,4].

The local immune response causes inflammation, mucosal edema, and middle ear pressure, leading to clinical symptoms such as pain and hearing loss. In chronic cases, epithelial damage and the formation of bacterial biofilms can lead to temporary or permanent hearing loss [3,4]. Ear infections can be caused by viral or bacterial agents and, depending on the severity and duration of the disease, can cause severe pain, temporary or chronic hearing loss, mastoiditis, and rarely meningitis [5,6]. The standard treatment for this condition usually involves the use of chemical drugs such as antibiotics and anti-inflammatory drugs [7]. Although these drugs can help reduce symptoms and control the disease, their use is often associated with side effects such as gastrointestinal disorders, allergic reactions, and disruption of the body's natural flora [8,9]. Furthermore, prolonged or irrational use of antibiotics is one of the main factors in the increase in bacterial drug resistance, which is now recognized as a global threat to public health [10]. These limitations highlight the need to search for alternative or complementary approaches.

Traditional Iranian medicine and many complementary medicine systems have a long history of using medicinal plants to treat ear infections [11,12]. Plants such as chamomile, garlic, thyme, and tea tree have been traditionally used in the management of this disease due to their antibacterial, anti-inflammatory, and analgesic

properties [13,14]. Recent studies have also confirmed the effects of some of these plants with scientific evidence. For example, active compounds in garlic such as allicin have strong antibacterial properties, tea tree oil has shown antifungal and anti-inflammatory effects, and chamomile flavonoids have been effective in reducing inflammation and pain [15-17]. However, most studies have focused on a few or limited studies of a few plants, and a comprehensive review that addresses both traditional medicine documentation and new scientific evidence about medicinal plants effective in ear infections has been less frequent [18,19]. This research gap highlights the importance of the present review [20,21]. The aim of this review study is to identify and introduce the most important indigenous medicinal plants of Iran and investigate the mechanisms of their effect on ear infections based on traditional medicine documentation and modern scientific evidence, in order to provide complementary, safe, and evidence-based solutions for the management of this disease.

Methodology

This study was designed as a review and in two parts. The first part aimed to identify the most important medicinal plants used in Iranian traditional medicine for the treatment of ear infections, and the second part was dedicated to reviewing the available scientific evidence from laboratory and clinical studies to evaluate the effectiveness of these plants.

The search for sources of the study was divided into two main parts; first, written sources of Iranian traditional medicine, including reference books, treatises, and authoritative sources of traditional medicine, were reviewed to identify the most important medicinal plants used for the treatment of ear infections. Then, in order to review new scientific evidence, an extensive search was conducted in international databases including PubMed, Scopus, Web of Science, SID, ISC, and Google Scholar to extract and analyze laboratory and clinical studies related to the effects of these plants. The keywords used included a

combination of “Ear infection”, “Otitis media”, “Herbal medicine”, “Traditional Iranian medicine”.

For the selection of sources, the inclusion criteria included studies that investigated the effect of medicinal plants on ear infection or related symptoms, and observational studies), articles and sources published in Persian and English, and reliable sources of traditional Iranian medicine.

Exclusion criteria included studies that only addressed the chemical composition of drugs and had no direct relationship with medicinal plants, were of assessable scientific quality, or did not adequately report the results, as well as articles with limited access or without full text.

After the initial search, titles and abstracts were reviewed by two independent researchers and irrelevant articles were excluded. Then, the full text of the remaining articles was reviewed and information related to medicinal plants, study type, results, and mechanisms of action was extracted.

The extracted information was presented in tabular form and descriptive analysis was presented to display traditional and modern evidence in a consolidated manner.

Results

Studies of traditional Iranian medicine show that a large number of medicinal plants are used to treat ear infections. Among them, plants such as *Matricaria chamomilla* L., *Lavandula angustifolia* Mill., *Melaleuca alternifolia* Cheel, *Mentha piperita* L., *Calendula officinalis* L., *Rosa damascena* Mill., *Citrus limon* (L.) Osbeck, *Allium sativum* L., *Olea europaea* L., *Allium cepa* L., *Aloe vera* (L.) Burm.f., *Zingiber officinale* Roscoe, *Ocimum basilicum* L., *Raphanus sativus* L., *Cinnamomum verum* J. Presl, *Syzygium aromaticum* (L.) Merr. & L.M.Perry, *Eucalyptus globulus* Labill., *Glycyrrhiza glabra* L., *Echinacea purpurea* (L.) Moench, *Ferula assa-foetida* L., *Portulaca oleracea* L., *Satureja hortensis* L., *Thymus vulgaris* L., *Lactuca sativa* L., *Foeniculum vulgare* Mill., *Anethum graveolens* L., *Malva sylvestris* L., *Primula vulgaris* Huds., *Melissa officinalis* L., *Tribulus terrestris* L., *Camellia*

sinensis (L.) Kuntze, *Origanum vulgare* L., *Vitis vinifera* L., *Daucus carota* L., *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, *Zea mays* L., *Prunus armeniaca* L., *Triticum aestivum* L., *Borago officinalis* L., *Viola odorata* L. have been used the most. These plants have been widely used in traditional medicine to reduce inflammation, relieve pain, and control symptoms of ear infections, and some of them have been confirmed to have antibacterial and anti-inflammatory effects in modern studies.

Native medicinal plants effective against ear infections used in traditional Iranian medicine are listed in Table 1. Additional ecological information on native medicinal plants effective against ear infections used in traditional Iranian medicine is provided in Table 2.

Table 1. Native medicinal plants effective in treating ear infections used in traditional Iranian medicine

Name of plant	Scientific name	Plant family	Plant part used	Traditional use in treating ear infections	Description	Ref
Chamomile	<i>Matricaria chamomilla</i> L.	Asteraceae	Flower	Ointment or oil to reduce inflammation and pain	The results showed that ear and eye drops containing chamomile extract quickly reduced the growth of bacteria that cause external ear infections and bacterial conjunctivitis.	[22]
Lavender	<i>Lavandula angustifolia</i> Mill.	Lamiaceae	Flower	Ointment or oil to relieve earache	A combination herbal drop containing extracts of <i>Syzygium aromaticum</i> , <i>Lavandula angustifolia</i> , and <i>Geranium robertianum</i> effectively reduced symptoms of acute otitis externa and pain levels, and was comparable to ciprofloxacin 0.3% drops in terms of symptom improvement and bacterial reduction.	[23]
Tea Tree	<i>Melaleuca alternifolia</i> Cheel	Myrtaceae	Leaf	Oil drops for antibacterial effect		[24]
Peppermint	<i>Mentha piperita</i> L.	Lamiaceae	Leaf	Oil drops to relieve ear pain	Nano-extracts of garlic, thyme, mint, and chamomile showed significant antimicrobial effects on bacteria causing otitis externa (<i>S. pyogenes</i> , <i>S. aureus</i> , and <i>P. aeruginosa</i>) and could be used as a basis for the development of new drugs with fewer side effects to combat these infections, although the effect of nano-	[25]

					extracts was slightly lower compared to pure essential oils.	
Calendula	<i>Calendula officinalis</i> L.	Asteraceae	Flower	Poultice to reduce inflammation and infection	The extract of this plant has an effect on ear edema.	[26]
Rose	<i>Rosa damascena</i> Mill.	Rosaceae	Flower	Oil to relieve ear discomfort	The extract of this plant is effective in healing ear wounds.	[27]
Lemon	<i>Citrus limon</i> (L.) Osbeck	Rutaceae	Fruit	Water or oil for antibacterial effect	The extract of this plant has an effect on ear edema.	[28]
Garlic	<i>Allium sativum</i> L.	Amaryllidaceae	Onion	Oil drops for antimicrobial effect	Allicin and S-allylcysteine (SAC) present in garlic showed significant antimicrobial effects on bacteria and fungi responsible for otitis externa and chronic otitis media, even at low concentrations, and could be used as alternative treatment options for ear infections in the future.	[29]
Olive	<i>Olea europaea</i> L.	Oleaceae	Fruit /Leaf	Oil drops to reduce pain and infection	GBS strains showed high susceptibility to olive leaf (<i>Olea europaea</i>) extract and essential oils at low concentrations, and these extracts could be considered as safe and effective alternatives for the treatment of GBS infections, while β -lactams remain the mainstay of treatment.	[30]
Onion	<i>Allium cepa</i> L.	Amaryllidaceae	Onion	Warmed poultice or water to relieve earache	Allicin and S-allylcysteine (SAC), present in garlic, even at low concentrations, have significant antimicrobial effects against bacteria and fungi that cause otitis externa and chronic	[29]

					otitis and can be considered as alternative treatment options for ear infections.	
Aloe Vera	<i>Aloe vera</i> (L.) Burm.f.	Asphodelaceae	Leaf gel	Topical use or oil for relief	The results showed that Aloe vera extract has antifungal properties and can be effective in the treatment of otomycosis through multiple mechanisms, and therefore can be considered as an herbal and alternative option in the management of this ear infection.	[31]
Ginger	<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Root	Oil drops for anti-inflammatory effect	Ginger (<i>Zingiber officinale</i>) essential oils have potent anti-inflammatory, antibacterial, antioxidant, and antitumor effects, by reducing the expression of COX-2, IL-6, and NF-κB and inhibiting the growth of common ear bacteria.	[32]
Basil	<i>Ocimum basilicum</i> L.	Lamiaceae	Leaf	Poultice or infused oil for earache	Placing basil oil and its essential compounds (thymol, carvacrol, and salicylaldehyde) into the ear canal of mice with acute otitis media improved 56–81% of infections caused by <i>H. influenzae</i> and 6–75% of infections caused by pneumococcus, indicating that these oils could be an effective treatment for acute otitis media.	[33]
Radish	<i>Raphanus sativus</i> L.	Brassicaceae	Root	Ointment to reduce pain	Radish (<i>Raphanus sativus</i> Linn.) seed extracts with different solvents showed significant antimicrobial effects on common pathogenic bacteria including <i>E. coli</i> , <i>S. aureus</i> , <i>P. aeruginosa</i> , and <i>Salmonella spp.</i> and therefore can be used as a potential source for the production of antibacterial drugs.	[34]

Cinnamon	<i>Cinnamomum verum</i> J. Presl	Lauraceae	Stem bark	Infused oil for antibacterial effect	Cinnamon essential oil (<i>Cinnamomum zeylanicum</i>) containing main compounds such as (E)-cinnamaldehyde, eugenol, and (E)-cinnamyl acetate showed significant antimicrobial and antibiofilm effects on <i>Staphylococcus</i> strains isolated from canine otitis media, effectively inhibiting bacterial growth and biofilm formation, and this oil can be considered as a potential alternative for the treatment of ear infections in animals.	[35]
Clove	<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry	Myrtaceae	Petal	Oil drops for pain relief and antibacterial effect	A combined herbal drop containing <i>Syzygium aromaticum</i> extract had a significant effect on reducing symptoms of acute otitis externa and pain, and was comparable to 0.3% ciprofloxacin drops in terms of symptom improvement and bacterial reduction.	[23]
Eucalyptus	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Leaf	Oil drops or inhalation to reduce infection	Selected eucalyptus essential oil (EO) compounds including <i>E. paniculata</i> , <i>E. accedens</i> , <i>E. cladoclayx</i> , and <i>E. wandoo</i> showed significant antimicrobial effects on bacteria causing ear infections and could be considered as alternative treatment options for ear infections.	[36]
Licorice	<i>Glycyrrhiza glabra</i> L.	Fabaceae	Root	Infused oil to relieve earache	Nasal irrigation with licorice extract (<i>Glycyrrhiza glabra</i>) had significant anti-inflammatory and antiallergic effects and in the treatment of acute sinusitis and allergic rhinitis, it caused rapid improvement of symptoms, reduced nasal resistance, and patient comfort without side effects.	[37,38]

Echinacea	<i>Echinacea purpurea</i> (L.) Moench	Asteraceae	Root / Flower	Ointment or oil to boost immunity and control infection	The use of Echinacea purpurea along with osteopathic manipulative treatment in children with recurrent otitis media can reduce the frequency of infection recurrence and is considered a safe and effective adjunctive method for preventing recurrent ear infections.	[39]
Asafoetida	<i>Ferula assa-foetida</i> L.	Apiaceae	Gum	Infused oil for ear infections	Different species of Ferula such as <i>F. communis</i> and <i>F. foetida</i> have antimicrobial compounds effective against bacteria and fungi, while aqueous and ethanolic extracts of <i>F. assafoetida</i> had little effect on Streptococcus mutans and <i>S. sanguis</i> , but Quercus infectoria extracts at appropriate concentrations inhibited the growth of these bacteria (MIC: 12.5 mg/mL for S. mutans and 6.25 mg/mL for S. sanguis).	[40,41]
Purslane	<i>Portulaca oleracea</i> L.	Portulacaceae	Leaf	Ointment for inflammation and pain	Apigenin extracted from Portulaca oleracea showed significant anti-inflammatory effects in models of ear inflammation in male mice.	[42]
Summer Savory	<i>Satureja hortensis</i> L.	Lamiaceae	Leaf	Infused oil for antibacterial effect	Satureja montana extract and its compounds showed significant antimicrobial effects on clinical isolates responsible for canine otitis externa and could be considered as natural and complementary options for the management of ear infections in animals.	[43]
Thyme	<i>Thymus vulgaris</i> L.	Lamiaceae	Leaf	Oil drops for antibacterial and anti-inflammatory effects	Thymus vulgaris extracts and their compounds showed significant antimicrobial effects on clinical isolates responsible for canine otitis externa and could be considered as natural and	[43]

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					complementary options for the management of ear infections in animals.	
Lettuce	<i>Lactuca sativa</i> L.	Asteraceae	Leaf	Ointment for pain relief	This plant is used to treat earaches and ear infections.	[44]
Fennel	<i>Foeniculum vulgare</i> Mill.	Apiaceae	Seed /Leaf	Infused oil to relieve earache	<i>Foeniculum vulgare</i> (fennel) has been shown to have significant antimicrobial, antifungal, antimycobacterial, and antioxidant effects.	[45]
Dill	<i>Anethum graveolens</i> L.	Apiaceae	Seed /Leaf	Infused oil for earache	In general, the plant is antimicrobial, but its effect on the bacteria that cause ear infections has not been observed.	[46]
Mallow	<i>Malva sylvestris</i> L.	Malvaceae	Flower /Leaf	Poultice for inflammation and discomfort	Chloroform, ethanol and aqueous extracts of <i>Malva sylvestris</i> and <i>M. neglecta</i> showed significant antimicrobial activity against bacteria and fungi associated with wound infections, especially the ethanolic extract of <i>M. sylvestris</i> with the lowest MIC (0.4 mg/ml for <i>Streptococcus pyogenes</i>) had the highest antibacterial effect, and all extracts were effective in inhibiting <i>S. aureus</i> , <i>P. aeruginosa</i> , <i>P. vulgaris</i> , <i>A. niger</i> , <i>A. fumigatus</i> and <i>C. albicans</i> .	[47]
Primrose	<i>Primula vulgaris</i> Huds.	Primulaceae	Flower	Infused oil to relieve earache	Methanolic and cold-water extracts of <i>Primula vulgaris</i> leaves and roots showed significant antimicrobial effects against <i>Escherichia coli</i> and <i>Pseudomonas aeruginosa</i> , while <i>Staphylococcus aureus</i> was resistant to these extracts. These findings indicate the potential of using these extracts in the development of	[48]

					antibacterial drugs, and further research is needed to determine the mechanism of action.	
Lemon Balm	<i>Melissa officinalis</i> L.	Lamiaceae	Leaf	Infused oil or poultice for ear infections	This plant is used in cases of earache, but no antimicrobial effect has been observed on ear infections.	[49]
Tribulus	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Fruit	Infused oil to relieve earache	This plant is traditionally used for ear infections, but no antimicrobial effect has been observed on ear infections.	[50]
Green Tea	<i>Camellia sinensis</i> (L.) Kuntze	Theaceae	Leaf	Infusion or poultice for anti-inflammatory effect	This plant is used in cases of ear inflammation, but no studies have been found on ear infections.	[51]
Oregano	<i>Origanum vulgare</i> L.	Lamiaceae	Leaf	Oil drops for antibacterial effect	Plant oils, including <i>Origanum vulgare</i> , show significant antimicrobial activity against these ear infection agents.	[43]
Grape	<i>Vitis vinifera</i> L.	Vitaceae	Fruit	Poultice or extract for a soothing effect	Ethanollic extracts of skin, seed, and combination of skin and seed of muscadine grapes significantly reduced inflammation, edema, and neutrophil infiltration in the mouse ear after stimulation with TPA.	[52]
Carrot	<i>Daucus carota</i> L.	Apiaceae	Root	Ointment to reduce pain	-	[53]
Kiwi	<i>Actinidia deliciosa</i> (A.Chev.) C.F.Liang & A.R.Ferguson	Actinidiaceae	Fruit	Poultice for relief	-	[54]

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Corn	<i>Zea mays</i> L.	Poaceae	Seed	Infused oil for earache	-	[55]
Apricot	<i>Prunus armeniaca</i> L.	Rosaceae	Fruit /Seed	Infused oil for inflammation	-	[56]
Wheat	<i>Triticum aestivum</i> L.	Poaceae	Seed	Ointment or oil to relieve ear pain	-	[57]
Borage	<i>Borago officinalis</i> L.	Boraginaceae	Leaf /Flower	Infused oil for ear infections	-	[58]
Violet	<i>Viola odorata</i> L.	Violaceae	Flower /Leaf	Ointment or oil for ear discomfort	Methanolic extract of <i>Viola odorata</i> showed potent antimicrobial activity against bacteria causing respiratory tract infections including <i>H. influenzae</i> , <i>P. aeruginosa</i> , <i>S. aureus</i> , <i>S. pneumoniae</i> , and <i>S. pyogenes</i> (inhibition zone diameter 16–24 mm, MIC: 3.12–12.5 mg/ml).	[59]

Among all the medicinal plants used in traditional Iranian medicine as anti-ear infections, the anti-ear infection effects have been proven in modern medicine and scientific research for all, except the following: *Daucus carota* L., *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, *Zea mays* L., *Prunus armeniaca* L., *Triticum aestivum* L., *Borago officinalis* L., *Melissa officinalis* L., *Tribulus terrestris* L., *Camellia sinensis* (L.) Kuntze, *Anethum graveolens* L., *Portulaca oleracea* L., *Calendula officinalis* L., *Rosa damascena* Mill., and *Citrus limon* (L.) Osbeck.

The data presented show that the plants studied belong to various families and the most frequent is related to the Lamiaceae family, of which there are several species among the plants mentioned. Other numerous families include

Asteraceae and Apiaceae. Other families such as Myrtaceae, Amaryllidaceae, Poaceae, Rosaceae, Zingiberaceae, Fabaceae, Brassicaceae, Malvaceae, Primulaceae and Violaceae each contain a smaller number of species. In general, the plants in this group are mainly from the families Lamiaceae, Asteraceae and Apiaceae, which have a wide range of medicinal and food uses.

The data show that the aerial parts of the plants, especially the leaves and flowers, are the most widely used, while other parts such as the fruit, seeds, roots, bulbs, gums, leaf gel and stem bark are less commonly used. Some species also benefit from a combination of several parts (e.g. fruit/seed or leaf/flower), indicating the wide and versatile use of the plants in medicinal and traditional uses.

Table 2. Additional ecological information on indigenous medicinal plants effective in treating ear infections used in traditional Iranian medicine

Scientific name	Plant type (morphological/type)	Habitat (ecological)	Physiological / Life cycle	(Environmental adaptation)
<i>Matricaria chamomilla</i> L.	Annual herb	Sunny areas and light soils	Annual, Spring and summer flowering	Resistant to drought and poor soils
<i>Lavandula angustifolia</i> Mill.	Short, evergreen shrub	Mediterranean regions	Perennial, Summer flowering	Drought and wind resistant
<i>Melaleuca alternifolia</i> Cheel	Shrub	Australian wetlands and wetlands	Perennial	Resistant to moisture and wet soils
<i>Mentha × piperita</i> L.	Perennial herb	Moist soils and partial shade	Perennial, rapid growth	Resistant to humidity and regular watering
<i>Calendula officinalis</i> L.	Annual herb	Sunny areas and sandy soils	Annual, Spring and summer flowering	Resistant to full sun
<i>Rosa damascena</i> Mill.	Perennial shrub	Temperate areas with regular irrigation	Perennial	Resistant to cold and drained soils

<i>Citrus limon</i> (L.) Osbeck	Evergreen tree	Mediterranean regions	Perennial	Requires full sun and well-drained soil.
<i>Allium sativum</i> L.	Annual herb	Light, sunny soils	Annual	Relatively drought resistant
<i>Olea europaea</i> L.	Evergreen tree	Dry Mediterranean regions	Perennial	Resistant to drought and poor soils
<i>Allium cepa</i> L.	Annual herb	Rich, sunny soil	Annual	Tolerant of drained soils
<i>Aloe vera</i> (L.) Burm.f.	Perennial succulent plant	Hot and dry areas	Perennial	Resistant to drought and direct sunlight
<i>Zingiber officinale</i> Roscoe	Perennial tuberous plant	Tropical and humid regions	Perennial	Needs moisture and partial shade
<i>Ocimum basilicum</i> L.	Annual herb	Rich, sunny soil	Annual	Sensitive to cold, needs full sun
<i>Raphanus sativus</i> L.	Annual herb	Rich, moist soil	Annual	Fast growing, drought sensitive
<i>Cinnamomum verum</i> J. Presl	Evergreen tree	Tropical regions	Perennial	Resistant to moisture and rich soil
<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry	Evergreen tree	Tropical and humid regions	Perennial	Requires high humidity and temperature
<i>Eucalyptus globulus</i> Labill.	Evergreen tree	Temperate to tropical regions	Perennial	Drought and wind resistant
<i>Glycyrrhiza glabra</i> L.	Perennial herb	Dry areas and sandy soil	Perennial	Resistant to drought and poor soil
<i>Echinacea purpurea</i> (L.) Moench	Perennial herb	Rich, sunny soil	Perennial	Relatively drought resistant
<i>Ferula assa-foetida</i> L.	Large perennial plant	Arid and semi-arid regions	Perennial	Resistant to drought and poor soil
<i>Portulaca oleracea</i> L.	Annual herb	Sunny areas and light soils	Annual	Resistant to drought and poor soil

<i>Satureja hortensis</i> L.	Annual herb	Rich, sunny soil	Annual	Resistant to full sun
<i>Thymus vulgaris</i> L.	Short perennial shrub	Dry and sunny soils	Perennial	Resistant to drought and poor soils
<i>Lactuca sativa</i> L.	Annual herb	Rich, sunny soil	Annual	Need for regular watering
<i>Foeniculum vulgare</i> Mill.	Perennial herb	Rich, sunny soil	Perennial	Resistant to full sun
<i>Anethum graveolens</i> L.	Annual herb	Rich, sunny soil	Annual	Sensitive to drought
<i>Malva sylvestris</i> L.	Perennial herb	Moist soil and sunny	Perennial	Moisture resistant
<i>Primula vulgaris</i> Huds.	Perennial herb	Moist soil and partial shade	Perennial	Resistant to moisture and light soil
<i>Melissa officinalis</i> L.	Perennial herb	Rich, sunny soil	Perennial	Relatively drought resistant
<i>Tribulus terrestris</i> L.	Annual herb	Dry and sunny soils	Annual	Resistant to drought and poor soil
<i>Camellia sinensis</i> (L.) Kuntze	Evergreen tree	Tropical and subtropical regions	Perennial	Requires rich soil and adequate moisture.
<i>Origanum vulgare</i> L.	Perennial herb	Dry and sunny soil	Perennial	Resistant to drought and poor soil
<i>Vitis vinifera</i> L.	Grape bush	Rich, sunny soil	Perennial	Requires full sun and well-drained soil.
<i>Daucus carota</i> L.	Annual herb	Rich, sunny soil	Annual	Sensitive to drought
<i>Actinidia deliciosa</i> (A.Chev.) C.F.Liang & A.R.Ferguson	Shrub	Temperate and humid regions	Perennial	Requires moist, well-drained soil.
<i>Zea mays</i> L.	Annual herb	Rich, sunny soil	Annual	Need for regular watering
<i>Prunus armeniaca</i> L.	Tree	Rich, sunny soil	Perennial	Relatively drought resistant

<i>Triticum aestivum</i> L.	Annual herb	Rich, sunny soil	Annual	Relatively drought resistant
<i>Borago officinalis</i> L.	Perennial herb	Rich, sunny soil	Perennial	Relatively drought resistant
<i>Viola odorata</i> L.	Perennial herb	Moist soil and partial shade	Perennial	Resistant to moisture and light soil

The majority of the plants studied are herbaceous (23 species) and have the greatest diversity, while trees, shrubs and special species such as succulents or tuberous plants are smaller in number and each plays a complementary or specialized role. Most of the plants studied grow in rich or light soils and sunny areas, while some species are adapted to moist, semi-shaded or sandy soil conditions and Mediterranean or tropical areas.

The data show that among the plants studied, there is a mixture of annual and perennial species, with perennial species dominating and some of them are fast-growing or summer-flowering, while annual species mainly flower in spring and summer. Most of the plants studied are tolerant of drought, poor soils, and full sun, while a smaller number require moisture, rich soil, or partial shade, and some are sensitive to drought or cold.

Discussion

In this review, the integration of traditional knowledge and new scientific evidence showed that indigenous Iranian medicinal plants play an important role in the management and reduction of symptoms of ear infections. These plants have an effective role in reducing inflammation, controlling the growth of pathogenic microorganisms, and relieving pain due to the presence of phenolic compounds, flavonoids, and essential oils with antibacterial and anti-inflammatory activities.

New evidence suggests that many of these plants have specific mechanisms of action; for example, allicin in garlic has strong antibacterial activity [29], essential oils of tea tree and eucalyptus inhibit the growth of bacteria that cause otitis externa [36], and flavonoids of chamomile [22] and ginger extracts reduce inflammatory pathways such as NF- κ B and the expression of inflammatory proteins [32]. This evidence shows that the traditional use of medicinal plants was based on clinical observations and their actual effects, and modern scientific studies confirm this [33-40].

However, some plants, such as green tea, lemon balm, kiwi, and some seeds and fruits, do not have sufficient scientific evidence to confirm direct effects on ear infections, and their traditional use is based more on clinical experience or general anti-inflammatory and soothing effects. Therefore, further laboratory and clinical research is needed for these plants.

From an ecological and agronomic perspective, most plants used in traditional medicine are herbaceous, perennial, and drought-resistant and full sun, which allows for easy access, sustainable cultivation, and extraction of active compounds. This could provide economic and environmental advantages in the development of herbal medicines effective for ear infections.

Clinical studies show that medicinal plants including Longdan-xiegan decoction/pill, Shenling-baizhu powder, Sinupret®, and Eryanling decoction have been effective in the treatment of acute and suppurative otitis media. These herbs, in combination with antibiotics, caused faster improvement in symptoms such as ear pain, fever, nasal discharge, and improvement in tympanogram in short periods of up to 14 days compared to the control [60].

Conclusion

Overall, the integration of traditional knowledge with modern scientific evidence not only demonstrates the potential of using indigenous medicinal plants in the treatment of ear infections, but also allows the design of safe and evidence-based complementary therapies. This approach can help reduce unnecessary use of antibiotics, reduce drug resistance, and side effects of chemical drugs. However, it is recommended that the use of these plants be done under expert supervision and with medical follow-up to ensure its safety and effectiveness. Conclusions: This study shows that indigenous Iranian medicinal plants with

antibacterial, anti-inflammatory, and analgesic properties are suitable options for complementary treatment of ear infections, and future research can help determine the dosage, dosage form, and more effective combinations for clinical use.

Declarations

Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Author Contributions

PSH: Conceptualization of the study, literature search on traditional medicine, data collection, and drafting of the manuscript. ZH: Review of modern clinical evidence, data analysis, and interpretation of findings, critical revision of the manuscript for intellectual content. MB: Supervision of the research, integration of traditional and modern medicine perspectives, final approval of the manuscript, and overall project administration. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work

Ethics approval

This study is a literature review and does not involve human or animal participants; therefore, ethical approval was not required.

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