

Medicinal Plants for Respiratory Diseases

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ABSTRACT

Respiratory diseases remain a major global health challenge, accounting for millions of deaths annually, particularly in low- and middle-income countries. Conventional therapies, while effective, are often limited by adverse effects, high costs, and reduced accessibility. Medicinal plants have long been used as affordable and culturally accepted remedies for respiratory conditions such as asthma, bronchitis, cough, chronic obstructive pulmonary disease, and pneumonia. Their therapeutic efficacy is attributed to diverse bioactive compounds, including alkaloids, flavonoids, tannins, terpenes, and essential oils, which act through multiple mechanisms such as bronchodilation, anti-inflammatory, antioxidant, antimicrobial, and immunomodulatory effects. Key plants such as Eucalyptus, Thyme, Peppermint, Licorice root, Ginger, and Turmeric have been widely documented in ethnomedicine and validated in pharmacological and clinical studies. Preparation and dosage forms vary from decoctions, infusions, and extracts to commercial formulations, reflecting both traditional knowledge and modern standardization efforts. Despite their promise, safety concerns, dosage inconsistencies, and limited regulatory oversight remain key challenges. This review highlights the pharmacological potential, clinical evidence, and cultural significance of medicinal plants in respiratory health while emphasizing the need for rigorous scientific validation and integration into modern healthcare systems.

Keywords: Medicinal plants; Respiratory diseases; Phytochemicals; Anti-inflammatory; and Antimicrobial.

INTRODUCTION

Respiratory diseases affect the airways and other lung structures. These diseases impose a substantial health burden worldwide, as approximately 7 million people, mainly in low- and middle-income countries, die each year from exposure to fine particles in polluted air. Respiratory diseases encompass a broad spectrum of problems, ranging from mild infections to life-threatening illnesses. Several plants have been used to relieve the symptoms of respiratory diseases such as chest pain, cough, asthma, and chronic obstructive pulmonary disease. A number of these species have become well known, and extracts and active chemical components are often sold as remedies [1]. Since the emergence of civilization, humans have utilized plants and their constituents to preserve health and combat diseases, as illustrated by an archaeological find of Arnica in a Siberian burial dating to circa 24,000 BCE. Medicinal plants are natural products of plant origin used for therapeutic purposes to prevent or cure health problems, including respiratory diseases, many of which continue to serve as starting materials for the synthesis of various pharmaceutical drugs. These plants usually contain multiple compounds such as alkaloids, flavonoids, tannins, and essential oils that exhibit a range of pharmacological effects [2]. Medicinal plants act either individually or synergistically to deliver therapeutic effects and can alleviate respiratory symptoms through various mechanisms. They possess expectorant properties that assist in the elimination of mucus by promoting secretion from the respiratory tract or liquefying bronchial secretions. Bronchodilator effects facilitate the dilation of bronchial passages, thus easing breathing for individuals with asthma or bronchitis. Additional properties include stimulation of blood circulation to reduce inflammation, compounding the anti-inflammatory effects, and mucilaginous characteristics that soothe irritated mucous membranes [1]. Eucalyptus (*Eucalyptus globulus*), native to Australia and now also cultivated in Asia, southern Europe, northern Africa, Hawaii, and California, has leaves containing cineole. This compound acts as a potent bronchodilator and reduces mucous membrane inflammation [1, 2].

Traditional Uses of Medicinal Plants

Plants have been frequently used in the healthcare system from very ancient times, in the form of extracts or the whole plant, in developing countries like Pakistan [1]. The use of plants and plant-based recipes remained the only universal form of medicine for hundreds of thousands of years [2]. The use of medicinal plants among ethnic groups of people around Pakistan has played an important role in the treatment of a wide range of respiratory disorders. Major manufacturers produce hundreds of herbal products, some with compositions similar to those used in folkloric and commercial medicine. To confirm the ethnorespiratory plant significance, a market survey of herbal medicine was conducted. Five plants among the 20 documented belong to commercial respiratory treatments. Local healers use these plants with other constituents in commercially available products, providing a significant source of income for the community and traditional healers [1, 2].

Mechanisms of Action of Medicinal Plants

Medicinal plants with proven traditional use for respiratory diseases display a spectrum of bioactivities, including anti-inflammatory, antiallergic, immunomodulatory, antioxidant, and antiviral properties. Their long-standing application and extensive documentation in ethnopharmacological records make them valuable subjects for exploration in the development of modern respiratory therapeutics [2, 3]. Historically, individuals seeking relief from respiratory ailments such as cough, cold, bronchitis, and asthma relied on natural remedies derived from plants and plant products. These predominantly herbal medicines alleviated symptoms through diverse mechanisms: anti-inflammatory effects mitigated the severity of respiratory disorders; antiallergic compounds acted against pathogen-triggered allergic reactions; immunomodulatory constituents enhanced host defense against invading pathogens; antioxidant agents scavenged free radicals at infection sites; and antimicrobial activities prevented the entry of respiratory pathogens [3]. The extraordinary potential of plants to serve as sources of novel bioactive molecules is reflected by a global market where plant-based medicines account for over 50% of the total medicinal market. In developing countries, approximately 80% of the population depends on traditional medicines containing plants for their health care. The World Health Organization supports integrating modern and traditional medicines to introduce medicinal plants into national health care systems, thereby stimulating research aimed at discovering new plant-based drugs that promote safe and more efficient treatments. Medicinal plants exhibiting pharmacological, toxicological, and clinical properties conducive to effective respiratory disease treatment warrant particular attention [3].

Key Medicinal Plants for Respiratory Health

Several medicinal plants are recognized for their safe and effective treatment of respiratory diseases. Eucalyptus leaves, rich in cineol, inhibit the release of inflammatory mediators and activate cytokine release, properties that have been verified in vitro, in vivo, and clinical models [3]. Thyme and peppermint, containing thymol and menthol respectively, serve as decongestants and antispasmodics for the respiratory system. Licorice root exhibits effectiveness against cough and asthma symptoms, offering anti-inflammatory and immunomodulatory properties through its influence on the Th1/Th2 cell balance and eosinophil accumulation. Ginger's anti-inflammatory and antioxidant capabilities reduce pro-inflammatory cytokines and enhance respiratory mucosal tone, which eases asthmatic symptoms [2, 3]. Turmeric contains curcumin, widely acclaimed for its broad range of activities, and this compound inhibits the proliferation of airway smooth muscle cells. These plants are employed in the treatment of bronchitis, asthma, emphysema, and pleural effusion associated with lung diseases. The combined medicinal properties of these natural agents offer promising avenues for the effective management of symptoms related to respiratory ailments [3].

Eucalyptus

Eucalyptus is an evergreen perennial plant belonging to the family Myrtaceae that includes around 700 species. It grows in arid or humid tropical, subtropical, and temperate climates. In Zimbabwe, Eucalyptus species are reported to be the most widely used medicinal plants, while in Bahawalpur, Pakistan, the leaves of Eucalyptus staigeriana are used to treat respiratory infections [1]. An essential oil obtained through steam distillation of fresh or partially dried leaves contains cineole (eucalyptol) as the primary active compound. Other components found in smaller amounts are α -pinene, β -pinene, p-cymene, α -phellandrene, limonene, α -terpineol, and aromadendrene 4. Cineole is a mucolytic, expectorant, spasmolytic, and bronchodilator. It improves respiratory functions and reduces exacerbations of chronic obstructive pulmonary disease (COPD) [1].

Thyme

Thyme is a valuable phytomedicinal herb with high nutritional and therapeutic value. It has been used since ancient times for many medicinal purposes and for culinary reasons [5]. All species of the genus Thymus and their essential oils combine pharmacological properties, such as antispasmodic, expectorant, anthelmintic, antibacterial, antifungal, and antioxidant activities, which relate to health benefits. The genus Thymus belongs to the Lamiaceae family and includes over 300 species, mainly distributed throughout the northern hemisphere and extending to Macaronesia, North Africa, and Ethiopia, including about 120 species in the Mediterranean region and a

significant center of diversification in Turkey. The genus *Thymus* comprises 38 taxa in Turkey (31 species, five subspecies, and two varieties), of which 18 taxa are endemic [5].

Peppermint

Peppermint (*Mentha piperita*) belongs to the family Lamiaceae. It is an aromatic, herbaceous, rhizomatous, and fast-growing perennial plant [1]. Menthol constitutes the principal organic component of peppermint oil. The essential oil of peppermint is used in food, pharmaceutical, and cosmetic industries, and also as an anti-inflammatory, analgesic, antiseptic, anti-pruritic, and anti-microbial agent. Peppermint oil exhibits potent antioxidant and anti-inflammatory activities, and it is used internally for the treatment of indigestion, irritable bowel syndrome, and colonic spasm. Peppermint also exhibits relaxant effects on tracheal and ileal preparations and potent gastroprotective activity [1].

Licorice Root

Medicinal Plants for Respiratory Diseases, Licorice root still exerts widespread attention for the treatment of multiple diseases, including respiratory system disorders, supplementing conventional therapies [4]. Provided the described pharmaceutical properties of licorice, a positive impact on the treatment of infectious and inflammatory diseases, but also in neurodegenerative diseases, can be assumed. Conventional pharmacotherapy does not always achieve satisfactory results for these pathologies and is also connected with numerous side effects, especially in the case of prolonged use. Hyaluronic acid (HA), a key molecule in skin moisture and water and lipoprotein balance of the body, bears huge therapeutic potential. Due to its antioxidant, soothing, and tolerating properties, HA may be considered an ideal substance for add-on therapy in dermatology and cosmetology, especially for the treatment of patients with chronic diseases [3]. Respiratory diseases affect approximately one billion people worldwide and are a major cause of death, being responsible for more than 4 million deaths every year. The prevalence of respiratory diseases is expected to increase over the coming decades because of population aging and sociocultural and environmental changes. Respiratory diseases may affect the 17 million people currently using supplemental oxygen for various respiratory diseases, such as chronic obstructive pulmonary disease, interstitial lung disease, cystic fibrosis, and pulmonary hypertension. Numerous studies have suggested the immunomodulatory properties of licorice-based components [1, 5].

Ginger

Zingiber officinale (ginger) is a rhizomatous herb notable for its aromatic, spicy rhizomes, which are consumed fresh, dried, or as oil and oleoresin [6]. Indigenous to southern Asia, the rhizomes are extensively utilized worldwide in folk medicine to address ailments such as gastrointestinal disorders, diabetes, strokes, atherosclerosis, rheumatism, and cardiovascular disease. In Chinese medicine, fresh ginger functions as an antiemetic, antitussive, expectorant, and to induce perspiration and dispel cold, whereas dried ginger remedies stomachache, vomiting, and diarrhoea. The Unani system credits ginger with anthelmintic, aphrodisiac, carminative, digestive, and sedative properties and employs it against headaches, rheumatism, and nervous disorders [6]. Veterinary applications include treatment for indigestion in horses and cattle, use as an antispasmodic, and management of rheumatic complaints. The species is also prominent in Ayurveda and Chinese medicine for addressing heart problems, stomach complaints, headaches, nausea, arthritis, and respiratory disorders. Ginger essential oil serves aromatically to alleviate muscle pain, cold symptoms, and nausea and to promote wound healing; ginger tea is utilized to aid digestion and facilitate blood circulation [6].

Turmeric

Among numerous medicinal plants used for respiratory diseases, turmeric deserves special attention. *Curcuma longa*, commonly known as turmeric, belongs to the Zingiberaceae family and is native primarily to South Asia but cultivated throughout tropical and subtropical regions. The plant's rhizome is a primary source of turmeric powder, a widely employed culinary ingredient [4]. Its principal polyphenolic component, curcumin, exhibits diverse biological activities including anticancer, antioxidant, antibacterial, immunomodulatory, anti-inflammatory, neuroprotective, hepatoprotective, antimicrobial, hypoglycemic, and cardioprotective effects, positioning it as a promising candidate for preventive and therapeutic applications. Respiratory diseases often involve inflammation of the mucous linings in the lungs and airways, membranes of the nasal and sinus passages, and pharynx. Turmeric's anti-catarrhal properties make it particularly valuable in addressing catarrhal conditions of both the upper and lower respiratory tracts [5]. Acting as an expectorant, turmeric facilitates the expulsion of mucus from the nose, throat, airways, and lungs, mitigating infection-associated respiratory congestion. Additionally, it operates as an antimicrobial agent within the combined herbal approach, targeting lower respiratory tract infections. Traditionally, turmeric is administered orally or applied topically to symptoms such as cough, bronchitis, asthma, congestion, and croup.

Preparation and Dosage of Medicinal Plants

Medicinal plants are widely available and employed for respiratory ailments, underscoring the importance of standardizing preparation and dosage to ensure safety and efficacy. The most common form of administration

involves the raw plant or solution, constituting 36% of usage; other prevalent forms include powder and infusion. For commercial herbal remedies, doses typically range from 300 to 500 mg of plant extract taken twice or thrice daily. Preparations are generally designed for short-term use until symptoms improve, although long-term treatment without professional guidance can lead to adverse effects and the development of drug resistance. Decoction is the principal preparation method, often combined with extracts from other plants to enhance therapeutic potency [2]. In Bahawalpur, Pakistan, the traditional use of medicinal plants for respiratory disorders reveals additional insights into preparation and dosage [1, 4]. The twenty-one most frequently cited plants belong to seventeen families, with herbaceous species accounting for 52.38%, trees 23.8%, and shrubs 19.1%. Leaves (47.62%) and fruits (33.33%) constitute the primary plant parts utilized; preference for leaves reflects a conservation strategy, as their harvesting minimally impacts the plant's life cycle. The predominant preparation techniques are decoction (71.4%) and extract (66.7%), supplemented by infusion, paste (38.1%), powder (33.3%), and, less commonly, juice and ash (14.3%). Decoctions generally involve boiling selected plant parts in water to release active constituents. Dosage is individualized according to the patient's physical condition and the disease stage, with internal administration being the most frequent route; nonetheless, external topical application, such as paste, is also practiced [1].

Clinical Studies and Evidence

Numerous studies have validated the application of medicinal plants for respiratory conditions through empirical research. A comprehensive investigation identified 153 species from 52 plant families used in respiratory treatments; the five most cited species were Eucalyptus, Moringa, Zingiber, Allium, and Capsicum. Additionally, in-depth analysis emphasized the significance of 56 species from 40 families, directing subsequent phytochemical screening and formulation efforts [2]. Market surveys corroborate ethnorespiratory applications: five plants of 20 documented species are commercially employed as respiratory therapeutics, with traditional healers incorporating these plants alongside substitutes in available products, thereby generating substantial livelihood support for local communities and practitioners [1]. In Zimbabwe, a targeted review identified 160 medicinal plants across 58 families used to manage respiratory ailments; Zingiber officinale, Allium sativum, and Harpagophytum procumbens emerged as prominent species, frequently combined into polyherbal concoctions to address comorbidities [4]. Methodological rigor was ensured by independent screening of titles and abstracts by two reviewers, baseline exclusion of veterinary reports, and resolution of discrepancies through a third reviewer, culminating in a focused assessment of peer-reviewed literature published in English before June 2022. Data extraction encompassed ethnobotanical use, employed plant parts, and preparation and administration modes. Based on Zimbabwean ethnobotanical data and corresponding pharmacological occurrences, respiratory disorders were categorized into 15 groups, consolidating similar ailments within each category [4].

Safety and Side Effects

Despite the remarkable efficacy of medicinal plants in treating respiratory diseases, several common side effects may be experienced [2]. Although traditionally considered safer than synthetic pharmaceuticals, phytomedicines under pharmacological scrutiny have been found to exhibit toxic effects in some cases [4]. Such toxicity is often associated with extended use or unsupervised consumption. Approximately 41% of the approximately 160 plant species traditionally used for respiratory ailments exhibit some degree of toxicity, underscoring the need for cautious application. For a few herbal preparations, symptoms similar to those elicited by pharmaceutical drugs may occur. Reducing dosage is the primary measure to mitigate adverse reactions, with the intuition that lower quantities of the active phytochemicals reduce the risk. Other precautions include prolonged boiling of the herbs, use of plant mixtures, and refraining from administration to individuals who are pregnant or immunocompromised [2, 4].

Regulatory Considerations

The use of medicinal plants is subject to the national laws and regulations of the different jurisdictions within which they exist. For example, under European law, plants and plant products used for medicinal purposes come under the scope of Directive 2001/83/CE (amended to Directive 2004/27/EC), which regulates the production and marketing of pharmaceutical products [2]. In the United States, the 1938 Food, Drug, and Cosmetic Act regulates the manufacture and marketing of pharmaceutical products made from botanical raw materials, obliging that substantiating data be provided for any new botanical product intended to be positioned as a drug [2]. In Canada, both food and drug regulations control the use of medicinal plants. Plants used as food must comply with the Food and Drugs Act, but when claiming therapeutic effects, these become pharmaceutical drugs [3]. As in Canada, Australia regulates two categories, foods and medicines, based on the intended use of the product. Therefore, an understanding of the legislation that governs the licensing, physician prescription, and patient access to medicinal plants (also considering that the sale or use of some species may be prohibited in specific countries) will inevitably help to identify those plants with genuine therapeutic potential and the type of application and regulations needed for their incorporation into national healthcare programmes [2, 3].

Integration of Medicinal Plants in Modern Medicine

The integration of medicinal plants with synthetic drugs in respiratory disease management enables pharmaceutical development of existing compounds and the identification of new biologically active agents [1]. Traditional medicine practitioners have reputedly employed medicinal plants with halitosis or blood pressure properties for respiratory diseases for centuries, but the combination of traditional practices with modern medicine has only commenced in the past 30 years [2]. Such integration enhances the therapeutic arsenal against respiratory ailments. Traditional healers in Pakistan, for instance, employ *Adhatoda vasica*, *Glycyrrhiza glabra*, and *Hyssopus officinalis* plants traditionally associated with halitosis and blood pressure to treat respiratory infections and asthma. These plants also carry blood pressure implications, indicating a complex pharmacological profile. Continued exploration of these remedies is essential for validating and optimizing their clinical utility [1, 3].

Challenges in Researching Medicinal Plants

Researching medicinal plants faces notable challenges. Medicinal plants hold enormous potential for developing novel drugs and alternative therapies [2], yet advancing beyond preliminary screening requires a deeper understanding. Detailed ethno-medicinal knowledge guides preparations and reveals underlying rationales. Many plant species with medicinal applications remain uncharacterized in terms of respiratory-related pharmacological properties [5, 6]. Without such evaluation, fundamental questions about activity mechanisms remain unresolved. Characterizing the precise biological responses elicited by plant extracts entails extensive experimentation and considerable resources. Funding constraints often preclude comprehensive investigations beyond initial activity detection [6].

Future Directions in Medicinal Plant Research

Medicinal plants have been a rich source of compounds with potential for respiratory disease treatment [2]. Approximately 384 plant species have been documented for their ethno-medical uses against respiratory pathologies. However, precise remedies and application modes are frequently lacking in the literature, and the majority of these plants require pharmacological validation to confirm their folkloric claims and to identify active compounds [4]. Conventional optimization approaches, such as combinatorial chemistry and synthetic modifications, have encountered significant limitations in developing new therapeutic agents for respiratory diseases [5]. Consequently, novel strategies incorporating systems biology, transcriptomics, proteomics, and metabolomics offer promising avenues to accelerate drug discovery from ethnobotanical sources. A market survey in Bahawalpur, Pakistan, revealed that 25% of highly reported ethno-respiratory plant remedies overlap with those employed in commercial herbal medicines, underscoring their continued economic and therapeutic relevance [1].

Case Studies of Successful Treatments

Medicinal plants have long held a prominent position in traditional healing systems for the treatment of respiratory diseases, yet historical records describing their application have been scarce [2]. Rahman et al. (2012) documented the therapeutic use of medicinal plants in Chittagong, Bangladesh, revealing the frequency and methods of employing these vogue treatments for respiratory disorders such as asthma, bronchitis, and coughing. Unlike many prior ethno-botanical surveys that compiled extensive plant inventories without detailing preparation or application practices, this investigation included precise medicinal instructions, enabling reproduction of traditional remedies and facilitating investigation into modes of action. The study identified twenty vascular plant species utilized in local remedies for respiratory ailments. These findings underscore the prevalence and accessibility of phytotherapeutic options within the region, implying their suitability for low-cost, sustainable healthcare alternatives. Similar geographic patterns emerge elsewhere [1]. In Bahawalpur, Pakistan, for instance, seven plant species with reputed respiratory benefits were identified, while comparisons of ethno-respiratory plant use across Pakistan, neighboring nations, and regions such as West Azerbaijan revealed overlapping applications. For example, the *Mentha* species frequently addresses coughs and bronchitis [1]. Several species, *Glycyrrhiza glabra*, *Opuntia ficus-indica*, and *Ficus religiosa*, consistently appear in traditional pharmacopeias spanning from Pakistan to Yemen, highlighting widespread recognition of their therapeutic properties.

Patient Perspectives and Experiences

The acceptance and affordability of medicinal plants have led to increasing research interest. Quantitative ethnobotanical data reveal the most commonly utilized species and their medicinal applications [1]. Medicinal plants enhance the efficacy of well-known community remedies. Exploiting their resources can promote economic development while conserving biodiversity. Indigenous plants represent a promising source for novel drugs against pneumonia and other respiratory infections [2]. Patients share their experiences, emphasizing the credibility of these remedies. The indigenous population remains estranged from modern inroads, relying on botanicals well suited to their environment. This dependence places an urgent obligation on medical researchers, ethnobotanists, and phytochemists to enhance and develop community-level therapeutic practices.

Cultural Significance of Medicinal Plants

Medicinal plants are essential in indigenous and traditional medicine and are also sources of lead compounds in medicines and alternative treatments. Many traditional communities in different parts of the world depend on medicinal plants for primary health care due to easy availability, cost-effectiveness, and the perception of fewer side effects [1, 2]. Respiratory diseases have become a global concern with numerous deaths and burdens on health systems worldwide [1, 2]. Traditional and scientific reports highlight the medicinal importance of plants against respiratory disorders. Various herbal products, including syrups, intravenous fluids, and juices, open pathways to find new remedies and preventive agents [2]. Ethno-medicinal plants from diverse medicinal systems are considered effective and the cheapest treatment measures for respiratory disorders. Seventy-three different plant species belonging to 39 families are used to treat respiratory tract disorders across the globe. Among these, asteraceae contributes the maximum number of species to heal respiratory diseases, followed by malvaceae, apiaceae, and labiatae. The collected ethno-medicinal plants possess pharmacological activities such as analgesic, anti-inflammatory, antioxidant, antiviral, antimicrobial, relaxing effect, and immunomodulatory properties. Different plant parts are typically used: leaves, roots, fruits, seeds, whole plants, bark, flowers, and rhizomes. The most common preparation methods include decoction, paste, juice, infusion, and powder. Oral and topical administrations are the major routes of administration [7-10].

CONCLUSION

Medicinal plants continue to play a pivotal role in the prevention and management of respiratory diseases, offering therapeutic, economic, and cultural value. Evidence demonstrates that species such as Eucalyptus, Thyme, Peppermint, Licorice, Ginger, and Turmeric possess significant bioactivities capable of alleviating respiratory symptoms, improving lung function, and enhancing overall patient well-being. Their accessibility and affordability make them indispensable, particularly in regions where modern healthcare is limited. However, concerns regarding toxicity, inappropriate dosing, and herb-drug interactions highlight the importance of careful use under professional guidance. Moving forward, standardization of formulations, clinical validation through well-designed trials, and robust regulatory frameworks are essential for ensuring safety and efficacy. By bridging traditional knowledge with modern pharmacology, medicinal plants hold immense potential to enrich integrative healthcare and provide sustainable solutions to the global burden of respiratory diseases.

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