

Evergreen Plants in Medicine: A Narrative Review of Their Therapeutic Potential and Pharmacological Applications

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Abstract

Evergreen plants, known for retaining their foliage throughout the year, play an essential ecological and medicinal role across diverse environments. Traditionally valued in various healing systems, these plants offer year-round accessibility and are rich in pharmacologically active compounds. This review aims to provide a comprehensive overview of the botanical characteristics, phytochemical profiles, ethnobotanical uses, and pharmacological mechanisms of evergreen plants, while highlighting their clinical applications and research limitations. Evergreen species such as *Taxus brevifolia*, *Camellia sinensis*, and *Ilex paraguariensis* have demonstrated significant therapeutic benefits, including anti-inflammatory, anticancer, antimicrobial, and antioxidant activities. These properties are largely attributed to bioactive compounds like terpenoids, flavonoids, and polyphenols, which interact with molecular pathways relevant to chronic and infectious diseases. Despite these promising attributes, current research is hindered by challenges such as inconsistent extraction methods, limited clinical trials, and threats to biodiversity due to overharvesting. This review highlights the need for standardized, interdisciplinary research approaches and sustainable practices to fully realize the medicinal potential of evergreen plants. It is recommended that future studies prioritize clinical validation, conservation, and integration of traditional knowledge into evidence-based frameworks.

Keywords Evergreen Plants · Phytotherapy · Medicinal Plants · Traditional Medicine · Pharmacological

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Introduction

Evergreen plants, known for retaining foliage throughout the year, have long captivated scientific and medicinal interest due to their wide distribution and unique phytochemical profiles (Rathore et al., 2022). These plants encompass a variety of species including pines, firs, cedars, and hollies, many of which possess potent bioactive compounds. Globally, medicinal plants contribute to the primary healthcare needs of approximately 80% of the population, particularly in developing countries (Beyene et al., 2016). Evergreen species stand out for their resilience and year-round availability, making them attractive candidates for pharmacological exploitation. Several studies have demonstrated that compounds derived from these plants exhibit antimicrobial, anti-inflammatory, anticancer, and antioxidant properties (Bourais et al., 2023, Cuevas-Cianca et al., 2023). Despite their historical use in traditional medicine, modern pharmacological research on evergreen plants remains limited compared to deciduous species. As chronic diseases continue to burden global health systems, the search for novel therapeutic agents from natural sources has intensified. This increasing demand underscores the importance of reviewing and synthesizing existing knowledge on the medicinal applications of evergreen plants to guide future research and drug development.

The therapeutic significance of evergreen plants is largely attributed to their secondary metabolites, including alkaloids, terpenoids, flavonoids, and phenolic acids. These bioactive constituents are synthesized as part of the plants' natural defense mechanisms against environmental stressors, pests, and pathogens. For example, compounds such as taxol (from the Pacific yew, *Taxus brevifolia*) have demonstrated significant anticancer efficacy and have been successfully incorporated into clinical treatment protocols (YADAV et al., 2023). Similarly, essential oils from conifers have shown antimicrobial and anti-inflammatory activity, which has spurred interest in their use in aromatherapy and topical formulations (Bhardwaj et al., 2020). The stability and sustainability of evergreen plants make them a reliable source of phytochemicals year-round, unlike seasonal herbs. This characteristic provides an advantage in pharmaceutical industries where consistency of supply is critical. Moreover, evergreen plants tend to accumulate compounds in leaves and bark, which are accessible without destroying the plant. These advantages collectively contribute to their growing appeal in ethnomedicine and integrative healthcare systems.

Research into the pharmacological potential of evergreen

plants has revealed a multitude of therapeutic pathways. Several studies have reported their capacity to modulate inflammatory cytokines, inhibit tumor cell proliferation, and protect against oxidative stress-induced cellular damage (Ashraf et al., 2024). For instance, polyphenols from holly species (*Ilex spp.*) have shown cardiovascular benefits due to their antioxidant effects (Cheng et al., 2024). Furthermore, the adaptogenic properties of plants like *Rhododendron* and *Juniperus* have been linked to improved stress response and immune function (Esmaealzadeh et al., 2022). These findings suggest that evergreen plants could serve as templates for novel drugs targeting complex chronic diseases such as cancer, diabetes, and neurodegenerative disorders. Additionally, their broad spectrum of biological activities positions them as potential candidates for antimicrobial resistance mitigation, a growing public health concern. However, the complexity of plant extracts and variability in phytochemical content demand robust and standardized analytical methods for accurate pharmacological assessment. Interdisciplinary approaches combining ethnobotany, pharmacognosy, and molecular biology are essential for unlocking the full medicinal potential of evergreen species.

Existing literature has primarily focused on isolated examples or specific genera, often neglecting a comprehensive review of evergreen plants as a unified botanical group. This fragmentation limits our understanding of common mechanisms and patterns of bioactivity across species. Additionally, much of the pharmacological research has been conducted in vitro or in animal models, with insufficient clinical trials to support therapeutic claims. There is also a geographic bias in research, with certain regions underrepresented despite their rich evergreen flora. The complexity of plant matrices and lack of standardized extraction and testing protocols further hinder reproducibility and cross-study comparisons. These gaps not only restrict evidence-based integration into modern medicine but also overlook the potential economic and ecological benefits of sustainable harvesting practices. Therefore, in this study we aim to narratively review the therapeutic potential and pharmacological applications of evergreen plants, highlighting their significance, challenges, and future directions in medicinal research.

Botanical and Phytochemical Characteristics of Evergreen Plants

Evergreen plants are defined by their ability to retain functional foliage throughout the year, distinguishing them ecologically and physiologically from their deciduous counterparts (Givnish, 2002). They are found across a wide range of climatic zones, from boreal forests dominated by

coniferous evergreens to tropical rainforests rich in broad-leaved evergreen species. Botanically, evergreen plants exhibit diverse morphological traits, including thick, waxy leaves with sunken stomata, adaptations that reduce water loss and confer resilience to environmental stressors such as drought, cold, or nutrient-poor soils (Pires, 2019). Their slow growth and extended leaf lifespan often correlate with long-term energy conservation strategies, which are particularly important in nutrient-deficient habitats. Taxonomically, evergreens are widely distributed across multiple plant families, such as Pinaceae, Cupressaceae, Lauraceae, and Ericaceae, encompassing both gymnosperms and angiosperms (Dreiss and Volin, 2020). The perennial foliage of these plants allows for continuous photosynthesis, which contributes to their role as stabilizers of ecosystems and consistent sources of medicinally relevant biomass. In traditional medicine systems such as Ayurveda, Traditional Chinese Medicine, and Native American healing practices, evergreen plants have long held therapeutic relevance due to their year-round accessibility and perceived vitality.

Phytochemically, evergreen plants are rich in a diverse array of bioactive compounds, many of which are integral to their survival and protective mechanisms. These include terpenoids, alkaloids, flavonoids, tannins, lignans, and essential oils—substances known for their therapeutic potential in treating infections, inflammation, cancer, and oxidative stress-related disorders (Alamgir and Alamgir, 2018). For instance, monoterpenes such as α -pinene and limonene, common in coniferous evergreens, possess anti-inflammatory, bronchodilatory, and antimicrobial properties (Bhardwaj et al., 2020). Similarly, evergreen shrubs like *Ilex paraguariensis* (yerba mate) and *Camellia sinensis* (tea plant) are noted for their high polyphenol content, which has been linked to cardiovascular and metabolic health benefits. The phytochemical composition of evergreen species is often influenced by environmental factors such as altitude, climate, and soil conditions, contributing to inter- and intra-species variability. Moreover, the concentration of active compounds in evergreen leaves and bark tends to be stable across seasons, enhancing their pharmacological consistency (Zidorn, 2018). These rich and stable phytochemical profiles position evergreen plants as valuable candidates for both traditional remedies and modern drug discovery initiatives.

Traditional and Ethnobotanical Uses

Evergreen plants have played a foundational role in traditional medicine systems across diverse cultures for centuries (Balick and Cox, 2020). Their year-round availability, symbolic association with vitality, and rich phytochemical content have made them reliable components of ethnobotanical practices (Luo et al., 2024).

In Traditional Chinese Medicine (TCM), for instance, species like *Podocarpus macrophyllus* and *Pinus massoniana* are used for their warming and detoxifying properties, often prescribed for respiratory ailments, joint pain, and skin disorders (Ye et al., 2021). Similarly, Ayurveda utilizes evergreens such as *Cedrus deodara* and *Cinnamomum camphora* to balance doshas and treat conditions ranging from inflammation to parasitic infections (Anand et al., 2022). Indigenous North American tribes have long relied on conifers like *Thuja occidentalis* (white cedar) and *Picea glauca* (white spruce) for treating coughs, fevers, wounds, and spiritual purification rituals (Turner, 2014, Anand et al., 2022). These cultural traditions are often rooted in a deep ecological understanding, with knowledge passed orally through generations and integrated into holistic health systems.

The ethnobotanical relevance of evergreen plants extends beyond physical healing into spiritual and ceremonial practices. Many evergreen species are burned as incense, used in purification rites, or incorporated into protective amulets due to their perceived ability to ward off evil spirits or promote longevity. For example, in Japanese Shinto practices, the evergreen Sakaki tree (Swan, 2011) is considered sacred and is used in temple rituals (Yadav et al., 2020). In Latin American traditions, plants such as *Eucalyptus globulus* and *Cupressus sempervirens* are employed in herbal baths and steam therapies for cleansing and respiratory relief. The multifunctional applications of these plants—ranging from teas and poultices to oils and resins—reflect both their pharmacological efficacy and symbolic importance. Additionally, the use of evergreens in ethnoveterinary medicine among rural communities highlights their value in treating livestock diseases and promoting agricultural sustainability (Mandal and Rahaman, 2022). Despite modernization and the decline of oral traditions, many evergreen-based remedies continue to influence contemporary alternative medicine and integrative healthcare.

Pharmacological Properties and Mechanisms of Action

Evergreen plants exhibit a broad spectrum of pharmacological properties owing to their rich phytochemical content, which includes terpenoids, alkaloids, phenolics, and flavonoids (Nwozo et al., 2023). These compounds contribute to diverse therapeutic effects such as antioxidant, anti-inflammatory, antimicrobial, anticancer, and cardioprotective activities (Saleem et al., 2022). For instance, *taxanes* derived from *Taxus* species have shown potent antimitotic activity by stabilizing microtubules, thereby inhibiting cell division in cancer

therapy (Sinha, 2020). Similarly, essential oils from conifers like *Pinus sylvestris* and *Abies alba* demonstrate antimicrobial effects through membrane disruption and inhibition of microbial enzyme systems (Visan et al., 2021). The anti-inflammatory properties of compounds like α -pinene and eugenol are mediated by suppression of pro-inflammatory cytokines such as TNF- α and IL-6, often through inhibition of the NF- κ B signaling pathway (Neamah et al., 2024). These multifaceted bioactivities suggest that evergreen-derived compounds target various molecular pathways, making them promising for multitarget drug development.

The mechanisms of action underlying these pharmacological effects are increasingly being elucidated through modern biochemical and molecular studies. Antioxidant activity, commonly attributed to phenolic compounds in species like *Camellia sinensis*, involves free radical scavenging and upregulation of endogenous antioxidant enzymes such as SOD and catalase (Vishnoi et al., 2018). In cardiovascular contexts, polyphenols from evergreen leaves improve endothelial function and modulate lipid metabolism, partly by enhancing nitric oxide availability and reducing LDL oxidation (Iqbal et al., 2023). Some evergreen-derived alkaloids and lignans act on central nervous system receptors, offering potential for neuroprotective and anxiolytic effects. Importantly, the bioavailability and synergistic interactions among compounds in whole plant extracts often enhance pharmacological efficacy compared to isolated constituents

Clinical Applications and Therapeutic Potential

The therapeutic potential of evergreen plants is being increasingly recognized in clinical settings, particularly for chronic and degenerative diseases (Sun and Shahrajabian, 2023). Extracts and bioactive compounds from species such as *Taxus brevifolia* (taxol), *Camellia sinensis* (green tea), and *Ilex paraguariensis* (yerba mate) have shown clinical efficacy in oncology, cardiovascular health, and metabolic disorders (Gerber et al., 2023). Taxol, a landmark chemotherapy drug, is widely used in the treatment of breast, ovarian, and lung cancers due to its antimitotic activity (van Vuuren et al., 2015). Green tea catechins have demonstrated lipid-lowering and glucose-regulating effects in human trials, supporting their use in managing obesity and type 2 diabetes (Alasvand Zarasvand et al., 2025). Moreover, essential oils from coniferous evergreens are applied in aromatherapy for respiratory relief and stress reduction (Sadowski, 2020). While these applications highlight promising outcomes, standardized clinical trials remain limited. Thus, further evidence-based studies are

essential to validate the safety, efficacy, and dosage of evergreen-derived therapeutics for broader medical integration.

Challenges and Limitations in Research and Use

Despite the growing interest in evergreen plants for medicinal purposes, several challenges hinder their comprehensive utilization in modern pharmacology. One major limitation is the insufficient standardization of extraction methods, which leads to variability in phytochemical content and inconsistent therapeutic outcomes. Additionally, much of the existing data is derived from in vitro or animal studies, with limited human clinical trials to confirm efficacy and safety. The complexity of plant matrices also makes it difficult to isolate and understand specific active compounds and their mechanisms of action. Furthermore, ecological and conservation concerns arise from the overharvesting of wild evergreen species, particularly those with slow growth rates or restricted habitats. Regulatory barriers and lack of integration into conventional healthcare systems also limit their widespread adoption. Lastly, the decline in traditional knowledge transmission poses a risk to ethnobotanical insights. Addressing these issues requires multidisciplinary collaboration and investment in rigorous, standardized research protocols. For a detailed overview of the medicinally relevant evergreen plants and their uses, refer to Table 1.

Table 1. Medicinally Relevant Evergreen Plants: Traditional Uses, Bioactive Compounds, and Pharmacological Activities

Botanical Name	Common Name	Traditional Uses	Key Bioactive Compounds	Pharmacological Activities	Geographic/ Ethnomedical Context
<i>Taxus brevifolia</i>	Pacific Yew	Decoctions for fever, pain, and respiratory issues	Paclitaxel (Taxol)	Anticancer (mitotic inhibition), anti-inflammatory	Native American medicine (Pacific Northwest, USA)
<i>Camellia sinensis</i>	Tea Plant	Infusions for digestion, mental alertness, and cardiovascular health	Catechins (EGCG), theanine, caffeine	Antioxidant, anti-obesity, antidiabetic, cardioprotective	Traditional Chinese and Japanese medicine
<i>Ilex paraguariensis</i>	Yerba Mate	Tonic for fatigue, weight loss, and metabolic stimulation	Caffeoyl derivatives, polyphenols, saponins	Antioxidant, anti-obesity, hypolipidemic, neuroprotective	South American (Guaraní tribes, Brazil, Argentina)
<i>Thuja occidentalis</i>	White Cedar	Treatment of colds, arthritis, and skin conditions	Thujone, flavonoids, polysaccharides	Immunomodulatory, antimicrobial, anti-inflammatory	Indigenous North American medicine
<i>Cinnamomum camphora</i>	Camphor Tree	Muscle pain, respiratory congestion, antiseptic applications	Camphor, cineole, saffrole	Analgesic, anti-inflammatory, antispasmodic, antimicrobial	Ayurveda, Unani, East Asian traditional medicine
<i>Juniperus communis</i>	Common Juniper	Diuretic, digestive tonic, antiseptic	Monoterpenes (α -pinene, myrcene), flavonoids	Antimicrobial, anti-inflammatory, diuretic	European folk medicine and Native American traditions
<i>Rhododendron arboreum</i>	Tree Rhododendron	Anti-diarrheal, anti-inflammatory, and mood-stabilizing uses	Flavonoids, saponins, anthocyanins	Antioxidant, anti-inflammatory, hepatoprotective	Himalayan traditional medicine (India, Nepal)
<i>Pinus sylvestris</i>	Scots Pine	Used for bronchitis, colds, and muscular pain	α -pinene, β -pinene, limonene	Expectorant, bronchodilator, antimicrobial	European and Russian traditional medicine
<i>Eucalyptus globulus</i>	Blue Gum Tree	Inhalations for respiratory infections and wound antiseptics	Eucalyptol (1,8-cineole), tannins, flavonoids	Mucolytic, antibacterial, anti-inflammatory	Aboriginal Australian and global herbal medicine
<i>Podocarpus macrophyllus</i>	Buddhist Pine	Used to relieve fevers and headaches; sacred ritual plant	Podolide, biflavonoids	Antioxidant, anti-tumor, antibacterial	East Asian traditional medicine (China, Japan)

Conclusion

Evergreen plants represent a rich and underexplored reservoir of therapeutic agents with significant pharmacological potential. Their longstanding role in traditional medicine, coupled with emerging scientific validation, highlights their relevance in addressing modern health challenges. However, realizing their full clinical value requires overcoming current limitations in research standardization, ecological sustainability, and regulatory integration. Continued interdisciplinary studies are essential to bridge traditional knowledge with evidence-based applications and promote the safe, effective use of evergreen-derived therapeutics.

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