Exploration of Drug Science

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Cedarwood essential oil (*Cedrus* spp.): a forgotten pharmacological resource with emerging therapeutic potential

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Academic Editor: Mozaniel Santana de Oliveira, Federal University of Pará, Brazil

Received: August 4, 2025 **Accepted:** September 18, 2025 **Published:** October 16, 2025

Cite this article: Diogo Gonçalves S. Cedarwood essential oil (*Cedrus* spp.): a forgotten pharmacological resource with emerging therapeutic potential. Explor Drug Sci. 2025;3:1008131. https://doi.org/10.37349/eds.2025.1008131

Abstract

Cedarwood essential oil (CWO), obtained from *Cedrus* and related species, has a long history in traditional medicine but remains relatively underexplored in modern pharmacology. This review consolidates current evidence on its phytochemical composition and pharmacological activities. Literature was retrieved from PubMed, Web of Science, and Scopus up to July 2025, including in vitro, in vivo, and limited clinical studies. Findings suggest antimicrobial, anti-inflammatory, sedative, and dermatological properties, primarily attributed to sesquiterpenes such as cedrol and α-cedrene. However, most data derive from small-scale or preclinical studies, with limited standardization of dosage and formulations. Safety aspects and toxicological gaps are also highlighted as essential considerations for future clinical translation. We conclude that CWO shows therapeutic potential, but rigorous clinical trials, standardized protocols, and comprehensive toxicological evaluations are essential before its safe and effective integration into evidence-based practice.

Keywords

cedarwood essential oil, anxiolytic, anti-inflammatory, antimicrobial, cedrol

Introduction

Essential oils have garnered significant attention as complex botanical mixtures with diverse therapeutic properties and growing relevance in integrative and complementary medicine [1]. Among these, cedarwood essential oil (CWO) is derived from the heartwood of various species commonly referred to as "cedars," including *Cedrus atlantica* (*C. atlantica*, Atlas cedar), *Cedrus deodara* (*C. deodara*, Himalayan cedar), *Juniperus virginiana* (*J. virginiana*, Virginian cedar), *Juniperus ashei* (*J. ashei*, Texas cedar), *Cupressus funebris* (*C. funebris*, Chinese cedar), and *Chamaecyparis lawsoniana* (*C. lawsoniana*, Port Orford cedar). These oils differ considerably in chemical composition and aroma, but all share a long history of aromatic and therapeutic use. It is important to note that oils from *Thuja plicata* (*T. plicata*, Western red cedar),

sometimes mislabeled as "cedarwood oil," contain the neurotoxin thujone and are not considered part of this group due to safety concerns [2]. Although widely recognized in perfumery and spiritual practices, CWO is now increasingly investigated for its pharmacological activities, ranging from anxiolytic and anti-inflammatory effects to dermatological and antimicrobial applications.

The bioactivity of CWO is attributed mainly to its unique composition of sesquiterpenes and alcohols, including cedrol, α-cedrene, and widdrol, whose molecular structures suggest interactions with neuronal, immunological, and microbial pathways. In vitro and in vivo studies have begun to elucidate its mechanisms of action, including modulation of oxidative stress, interaction with neurotransmitter systems, and inhibition of pro-inflammatory mediators.

Compared to widely studied essential oils such as lavender (*Lavandula angustifolia*) and tea tree (*Melaleuca alternifolia*), which are supported by extensive clinical and mechanistic evidence for anxiolytic and antimicrobial effects, respectively, CWO remains relatively underexplored unlike lavender, whose bioactivity is mainly attributed to monoterpenes such as linalool and linalyl acetate, or tea tree essential oil, dominated by terpinen-4-ol and used as a topical antimicrobial, CWO is distinguished by its sesquiterpene-rich composition (notably cedrol and α-cedrene) [3–5]. These compounds confer a unique pharmacological spectrum, including sedative, anti-inflammatory, and skin-regenerating properties. This gap in comparative evidence underscores the relevance of consolidating current knowledge on CWO and reassessing its therapeutic potential.

This review aims to consolidate current knowledge on the phytochemical composition, pharmacological activities, and potential therapeutic applications of CWO. Emphasis is placed on preclinical evidence, mechanisms of action, and emerging uses in integrative oncology, palliative symptom management, dermatology, and stress-related disorders. By critically examining both the existing data and gaps in knowledge, this article seeks to inform future research and guide the responsible incorporation of CWO into evidence-based practice.

Literature search strategy

To compile this review, a comprehensive literature search was conducted in the databases PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Web of Science (https://webofknowledge.com), and Scopus (https://www.scopus.com/), all accessed on 31 July 2025. No restrictions on publication date or language. The following combinations of keywords were used:

- "Cedarwood essential oil" OR "Cedrus essential oil" OR "*Juniperus virginiana* essential oil" OR "*Thuja* essential oil".
- Combined with terms related to pharmacological activity: "phytochemistry", "cedrol", "α-cedrene", "antimicrobial", "anti-inflammatory", "anxiolytic", "sedative", "wound healing", "dermatology", "palliative care".

Additional sources were identified through manual searching of reference lists in relevant articles. Only full-texts were considered. Both in vitro, in vivo, and clinical studies were included, while conference abstracts, editorials, and non-peer-reviewed sources were excluded.

Phytochemical profile of cedarwood essential oil

CWO, obtained from the heartwood of several *Cedrus* species and other genera colloquially referred to as "cedar" (e.g., *J. virginiana*), contains a complex mixture of bioactive terpenoids and sesquiterpenes [2]. The oil's chemical profile varies significantly depending on the botanical source, geographical origin, and distillation technique, yet certain key compounds appear consistently across different oils. Among these, cedrol, α-cedrene, β-cedrene, thujopsene, and widdrol are frequently reported as major constituents with promising pharmacological activity.

Major constituents

Cedrol

Cedrol, a sesquiterpene alcohol, is one of the hallmarks of *Juniperus*-derived cedarwood oils, particularly abundant in *J. virginiana*, where it may represent 16–25% of the oil [6, 7]. It is associated with sedative, antiseptic, and anti-inflammatory activities. Studies suggest cedrol may exert central nervous system effects through gamma-aminobutyric acid-ergic (GABAergic) modulation, although the mechanism remains underexplored [8].

α-Cedrene and β-cedrene

These are isomeric sesquiterpenes that contribute to the essential oil's distinctive woody aroma. Found in various proportions across cedar species, α-cedrene has shown antioxidant, anti-inflammatory, and cytotoxic effects in vitro. β-Cedrene, though less studied, appears to share similar pharmacological potential. Both molecules are highly lipophilic and may interact with lipid membranes or ion channels [9, 10].

Widdrol

Widdrol is a sesquiterpene alcohol present primarily in *J. virginiana* and *Thuja* species. While not as dominant as cedrol, it contributes to the fixative and calming properties of the essential oil. Preliminary studies have indicated antibacterial and insecticidal activity, making it of interest for cosmetic and pest-control formulations [11–13].

Thujopsene

This bicyclic sesquiterpene is abundant in particular species, such as *Juniperus*, and contributes to the essential oil's antimicrobial and antifungal effects. It has shown inhibitory activity against a range of bacterial strains, although more pharmacodynamic data are needed [14].

Other minor compounds

The composition also includes various other sesquiterpenes and monoterpenes such as cuparene, himachalene, iso-cedrol, and α-himachalene, which may act synergistically. The biological activity of CWO likely results from multi-compound interactions rather than single-molecule effects alone [15].

Differences across species

CWO is derived from different botanical sources, which include (Table 1):

Table 1. Comparative phytochemical profiles of CWO from different species.

Species	Common name	Region	Dominant compounds	References
C. atlantica	Atlas cedar	North Africa	Cedrol, α-cedrene, himachalene	[2, 16]
C. deodara	Himalayan cedar	South Asia	Cedrene isomers, himachalol	[2]
J. virginiana	Eastern red cedar	North America	Cedrol, widdrol, thujopsene	[6, 10, 11, 14]
J. asheiJ. mexicana	Texas cedar	North America	Thujopsene, cedrol, α-cedrene	[5]
C. funebris	Chinese cedar	China	Cedrol, cuparene, himachalene	[5]
C. lawsoniana	Port Orford cedar	North America	Cedrol, widdrol, α-himachalene	[5]
T. plicata	Western red cedar (not recommended)	North America	Thujone (neurotoxic), thujopsene, camphene	[17]

Compound prevalence based on published GC-MS analyses; exact composition may vary due to geographical, seasonal, and methodological factors. While all listed species are sold as "cedarwood oils," their chemical profiles and biological activities vary considerably. Oils from *T. plicata* contain high levels of thujone, a neurotoxic ketone, and should not be used in cosmetics or therapeutic applications [17]. CWO: cedarwood essential oil.

CWO is not a uniform product but rather a group of essential oils obtained from different botanical sources that are often marketed under the same name "cedarwood oil." Their chemical compositions and biological activities vary significantly according to species, region, and extraction methods. The main cedarwood oils include:

- *C. atlantica* (Atlas cedar): characterized by high levels of α-cedrene, himachalene, and related sesquiterpenes. Recent analyses suggest that cedrol is present but not a dominant constituent, contradicting earlier assumptions of its abundance [16, 18]. Recent studies of *C. atlantica* cones identified α-pinene as the major constituent, highlighting variability in chemical composition depending on plant part and extraction conditions [18].
- *C. deodara* (Himalayan cedar): contains a mixture of cedrene isomers and himachalol, with notable antioxidant and antimicrobial activity [2].
- *J. virginiana* (Virginian/Eastern red cedar): rich in cedrol, widdrol, and thujopsene, which are associated with sedative, antimicrobial, and insect-repellent effects [6, 10, 11, 14].
- *J. ashei/J. mexicana* (Texas cedar): typically dominated by thujopsene and α-cedrene, with minor amounts of cedrol. Its profile supports insecticidal and preservative applications [5].
- *C. funebris* (Chinese cedar): contains sesquiterpenes such as cedrol, cuparene, and himachalene. Used in perfumery, though pharmacological studies remain limited [5].
- *C. lawsoniana* (Port Orford cedar): produces an oil with cedrol, widdrol, and α-himachalene, mainly employed for fragrance purposes [5].

Impact of distillation methods

Steam distillation is the most common method for extracting CWO, but hydrodistillation and CO_2 supercritical extraction are also employed. Each method influences the volatility, polarity, and yield of specific constituents:

- Steam distillation: produces a broader spectrum of sesquiterpenes but may degrade heat-sensitive compounds like cedrol or result in variable cedrene/cedrol ratios [19, 20].
- Hydrodistillation: often yields slightly higher levels of oxygenated terpenoids such as widdrol and cedrol, but can produce higher water content [21].
- Supercritical CO_2 extraction: preserves delicate constituents and may enhance yields of non-volatile or thermolabile molecules. However, it is less widely used due to cost and equipment requirements [22].

Additionally, the distillation time and temperature significantly impact the profile. Longer distillations tend to increase sesquiterpenoid content (e.g., cedrol), while shorter runs yield higher monoterpenes. Aging and storage conditions also influence the chemical stability and transformation of components over time.

Pharmacological activities of cedarwood essential oil

CWO has been historically valued for its therapeutic properties in traditional medicine systems. Despite its relatively underexplored status in contemporary pharmacology, emerging research suggests that CWO exhibits a wide range of bioactivities, including antimicrobial, anxiolytic/sedative, anti-inflammatory, skin-healing, and insect-repellent effects. These pharmacological actions are primarily attributed to its abundant sesquiterpenes and oxygenated derivatives, notably cedrol, α-cedrene, thujopsene, and widdrol.

The pharmacological activities of CWOs should be interpreted in a species-specific context, as their chemical composition varies considerably. For example, sedative and anxiolytic effects have been primarily demonstrated for *J. virginiana* oil, where cedrol is abundant, whereas antibacterial and cytotoxic effects have been reported mainly for *C. atlantica* oil, rich in himachalenes and atlantones [15, 17]. Therefore, conclusions about therapeutic potential cannot be generalized across all cedarwood oils, but must be linked to the specific species and chemotype studied.

It is important to note that pharmacological conclusions should not be extrapolated across all CWOs, but must instead be interpreted in light of their botanical origin and chemical composition, since oils from *Cedrus*, *Juniperus*, *Cupressus*, and *Chamaecyparis* differ markedly in their dominant constituents and biological activities.

Antimicrobial activity (*C. atlantica*, *J. virginiana*)

CWO demonstrates broad-spectrum antimicrobial effects against both Gram-positive and Gram-negative bacteria, as well as fungi and yeasts. The antimicrobial activity is primarily attributed to sesquiterpenes, such as cedrol, thujopsene, and α-cedrene, which can disrupt microbial cell membranes, increase permeability, and interfere with metabolic functions [16]. In addition to previously reported effects, *C. atlantica* essential oil exhibited marked antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, with the latter appearing to be the most susceptible strain [18].

- Bacterial activity: In vitro studies have reported moderate to strong inhibitory effects of *J. virginiana* and *C. atlantica* essential oils against pathogens such as *S. aureus*, *E. coli*, *Bacillus subtilis*, and *Pseudomonas aeruginosa* [16, 23].
- Antifungal activity: CWO has shown activity against dermatophytes (e.g., *Trichophyton* spp.), molds (*Aspergillus niger*), and yeasts (*Candida albicans*), supporting its potential use in topical antifungal formulations [24].
- Synergism: Combinations of CWO with other essential oils or antibiotics have demonstrated synergistic antimicrobial effects, which could be useful for reducing antibiotic resistance or enhancing preservation in food and cosmetics [25].

However, most antimicrobial data are based on in vitro assays using variable extraction methods and poorly standardized concentrations. Few studies employ clinically relevant models, and the lack of dose-response analyses or toxicity comparisons limits translational value. Larger, standardized studies—including in vivo or clinical trials—are needed to validate these effects.

Anxiolytic and sedative effects (*J. virginiana*)

CWO is widely used in aromatherapy for its calming, grounding properties. The sedative and anxiolytic effects have been primarily attributed to cedrol, a major constituent in *J. virginiana* essential oil [26].

Preclinical studies in rodents have shown that inhalation of cedrol leads to reduced locomotor activity, prolonged sleep time, and lower stress-induced corticosterone levels [27]. Cedrol is hypothesized to act via GABAergic pathways, similar to benzodiazepines, though direct receptor binding studies are limited [28].

While human trials are scarce, anecdotal reports and pilot aromatherapy studies suggest benefits for anxiety, insomnia, and agitation, especially in palliative care or dementia settings [29].

Despite promising rodent findings, these studies are generally limited by small sample sizes and a lack of standardized inhalation protocols. Human data are anecdotal or derived from small pilot studies without rigorous controls. Without defined dosage parameters or placebo-controlled trials, it doesn't remain easy to assess reproducibility or clinical relevance.

Anti-inflammatory properties (*C. deodara*, *C. atlantica*)

Inflammation underlies a wide spectrum of chronic diseases, and CWO may offer mild to moderate anti-inflammatory effects.

In vitro studies show inhibition of pro-inflammatory mediators such as nitric oxide (NO), prostaglandins (PGE2), and tumor necrosis factor-α (TNF-α) in macrophage and keratinocyte models [30]. Topical applications in animal models have demonstrated reduced edema and erythema, suggesting potential for use in inflammatory skin conditions, such as eczema or contact dermatitis [31, 32].

Although promising, the data remain preliminary and warrant more controlled, dose-dependent studies.

Current evidence is limited to cell-based and small animal models, often with uncharacterized or non-standardized essential oil preparations. The variability in chemical composition across species and extraction methods further complicates interpretation. Robust dose-ranging studies and clinical validation are required before therapeutic claims can be substantiated.

Skin healing and dermatological applications (*J. virginiana*, *C. atlantica*)

CWO is traditionally used in cosmetics, scalp care, and wound treatment, supported by its antimicrobial, anti-inflammatory, and astringent properties.

- Acne and oily skin: Its astringent and antibacterial effects may help regulate sebum production and reduce microbial colonization (*Propionibacterium acnes*) [33, 34].
- Wound healing: Preliminary in vitro data suggest increased fibroblast activity and collagen synthesis when exposed to specific oil fractions [35].
- Dermatitis and irritation: Its soothing and anti-pruritic qualities are valuable in calming irritated skin—aligning with your work on essential oils for pruritus [36, 37].

The essential oil's low dermal toxicity at appropriate dilutions supports its inclusion in creams, balms, and hydrolates for cosmetic and therapeutic use. Although topical benefits are frequently reported, supporting studies often rely on preliminary in vitro assays or non-randomized animal models. Clinical trials are scarce, and the lack of standardized formulations (e.g., concentration, vehicle, duration of application) weakens the evidence base. This raises concerns about reproducibility and comparability across studies.

Insecticidal and repellent properties (*J. ashei*, *J. virginiana*)

One of the best-documented uses of CWO is as a natural insect repellent, particularly against mosquitoes, fleas, moths, and ticks.

- Insecticidal action: Cedrol and thujopsene disrupt neural signaling in insects and interfere with respiration through spiracle blockage [9].
- Applications: CWO is commonly used in pet shampoos, wood treatments, and closet fresheners. In humans, it may be used as a safer alternative to synthetic repellents like DEET, though with a shorter duration of efficacy [38].
- Regulatory status: The U.S. EPA classifies CWO as a minimum risk pesticide, increasing its appeal in natural product formulations [39].

Despite this, more standardized field trials are needed to compare its repellent efficacy across species and concentrations.

While insect-repellent effects are among the best documented, most data come from short-term laboratory bioassays rather than large-scale field trials. Duration of efficacy is inconsistent, and comparisons with standard repellents (e.g., DEET) are limited. Lack of standardized testing protocols restricts clear assessment of practical utility.

Mechanisms of action

The pharmacological effects of CWO are attributed to its complex chemical composition, which is rich in sesquiterpenes, including cedrol, α-cedrene, widdrol, and thujopsene. While pharmacodynamic studies on CWO remain limited, emerging preclinical data and phytochemical analyses suggest that its therapeutic actions are mediated through several overlapping biological pathways, notably involving the central nervous system, oxidative stress modulation, and genomic stability.

One proposed mechanism involves interaction with the GABA system, the primary inhibitory neurotransmitter pathway in the central nervous system. Cedrol, a predominant constituent in *J. virginiana* and *C. atlantica* essential oils, has been shown in rodent studies to exert sedative and anxiolytic effects [26]. Inhalation of cedrol resulted in significant reductions in locomotor activity and prolonged sleep duration in mice, indicating a depressant effect on the central nervous system [27]. While direct binding assays have not yet conclusively demonstrated interaction with $GABA_A$ receptors, the pharmacological profile of cedrol resembles that of GABAergic modulators, supporting the hypothesis that CWO may influence inhibitory neurotransmission [8, 28]. This mechanism could underlie its traditional use in aromatherapy for anxiety, stress, and sleep disorders.

In addition to its neuroactive properties, CWO exhibits antioxidant activity, likely contributing to its anti-inflammatory and tissue-protective effects [40]. The sesquiterpenes present in the essential oil, including α-cedrene and widdrol, have been reported to scavenge reactive oxygen species (ROS) and inhibit lipid peroxidation in cell-based models [41, 42]. By attenuating oxidative stress, these compounds may downregulate redox-sensitive inflammatory pathways such as NF-κB and inducible nitric oxide synthase (iNOS), both of which are implicated in chronic inflammation and cellular damage. Although the precise antioxidant capacity of CWO varies according to its botanical source and extraction method, its potential to modulate oxidative homeostasis is increasingly recognized as a key mechanism in its pharmacological action.

Another emerging area of interest is the potential DNA-protective effect of CWO constituents [7]. While direct studies on CWO and genotoxicity are limited, sesquiterpene-rich essential oils from related species have demonstrated antigenotoxic properties in assays such as the comet assay and micronucleus test [43]. The ability of these compounds to reduce DNA strand breaks and chromosomal aberrations may be linked to their antioxidant activity, as oxidative stress is a known inducer of genomic instability. Furthermore, the anti-inflammatory effects of CWO may indirectly support DNA integrity by limiting the production of mutagenic byproducts associated with chronic inflammation, such as peroxynitrite and hydroxyl radicals [44, 45].

Taken together, the therapeutic actions of CWO are likely mediated through a combination of central nervous system modulation, oxidative stress reduction, and potentially genome-protective mechanisms. Further investigation using receptor-binding studies, transcriptomic analysis, and in vivo genotoxicity models is warranted to fully elucidate these pathways and validate the oil's bioactivity in clinical settings. Table 2 summarizes key pharmacological findings associated with CWO, highlighting the target organisms or systems, experimental models employed, and proposed mechanisms of action. These data offer preliminary but promising insights into the therapeutic potential of CWO and underscore the need for further mechanistic and clinical investigations.

Table 2. Pharmacological activities of CWOs by species.

Species/Source	Pharmacological activity	Key compounds	Proposed mechanisms	References
J. virginiana (Virginian/Eastern red cedar)	Anxiolytic, sedative	Cedrol, widdrol	GABAergic modulation; reduced corticosterone levels	[25, 26, 28]
J. virginiana	Antimicrobial (fungal and bacterial)	Cedrol, thujopsene	Membrane disruption, metabolic inhibition	[9, 10, 13, 22, 23]
C. atlantica (Atlas cedar)	Antimicrobial, cytotoxic	α-Cedrene, β-himachalene, atlantones	Cell membrane disruption; induction of oxidative stress in cancer cell lines	[15, 17]
C. deodara (Himalayan cedar)	Anti-inflammatory, antioxidant	Cedrene isomers, himachalol	Inhibition of NO and pro-inflammatory cytokines	[2, 29]
C. funebris (Chinese cedar)	Antioxidant, limited antimicrobial reports	Cedrol, cuparene, himachalene	ROS scavenging; preliminary antimicrobial activity	[5]
C. lawsoniana (Port Orford cedar)	Fragrance/aromatic use (limited pharmacological data)	Cedrol, widdrol, α-himachalene	Fixative properties in perfumery	[5]

Table 2. Pharmacological activities of CWOs by species. (*continued*)

Species/Source	Pharmacological activity	Key compounds	Proposed mechanisms	References
J. ashei (Texas cedar)	Insecticidal, preservative	Thujopsene, α-cedrene	Neural disruption in insects; repellency	[5, 36]
T. plicata (Western red cedar)	Not recommended (toxic)	Thujone, thujopsene	Neurotoxic; convulsant risk	[16, 46]

The pharmacological activities of CWOs vary by species and chemotype. Conclusions should not be generalized across all CWOs but must be interpreted in light of their botanical origin and chemical composition. Oils from *T. plicata* contain thujone and are not suitable for therapeutic or cosmetic use. CWOs: cedarwood essential oils; GABAergic:gamma-aminobutyric acid-ergic; NO: nitric oxide; ROS: reactive oxygen species.

Potential applications

The diverse pharmacological properties of CWO, including its antimicrobial, anti-inflammatory, sedative, antioxidant, and dermatological effects, suggest possible applications across clinical and wellness contexts. However, current evidence is preliminary, with most data derived from preclinical or small-scale studies. Translation into practice requires careful consideration of methodological limitations, variability in chemical composition, and a lack of standardized dosing.

Integrative oncology

In the context of integrative oncology, CWO has been proposed as a supportive agent for managing symptoms commonly associated with cancer and its treatment, such as anxiety, insomnia, fatigue, and systemic inflammation [27, 47]. Notably, *C. atlantica* essential oil demonstrated potent cytotoxic effects against the human breast cancer cell line MCF-7, suggesting potential anticancer applications that merit further investigation [18]. It also has antioxidant effects that may counteract oxidative stress associated with chemotherapy. These findings suggest potential adjunctive roles for CWO, either as a direct anticancer agent or as a complementary therapy to alleviate treatment-related side effects [48, 49].

In addition to laboratory data, CWO's anxiolytic and sedative properties—primarily attributed to cedrol—may have relevance for cancer patients who frequently experience distress and sleep disruption [26, 27]. Aromatherapy interventions using cedarwood-based blends have been reported anecdotally in oncology and palliative settings to improve relaxation and emotional well-being [29, 50]. These observations align with the broader use of essential oils in integrative oncology as non-pharmacological tools to enhance quality of life.

Despite these promising avenues, the evidence remains highly preliminary. Cytotoxic effects reported in vitro cannot be directly extrapolated to clinical efficacy, and there are no robust in vivo tumor studies or human trials that confirm anticancer activity. Similarly, reports of improved sleep and anxiety reduction are mainly drawn from small, uncontrolled aromatherapy interventions, with variable oil composition and poorly defined dosages. The lack of standardized inhalation or topical protocols makes reproducibility difficult, while inter-individual variability in response further complicates interpretation.

Therefore, while CWO may hold promise as a supportive tool in integrative oncology—particularly for symptom management rather than direct anticancer action—its clinical role remains speculative. Future research should prioritize controlled trials assessing standardized preparations of CWO for defined indications, such as sleep quality or anxiety reduction in oncology patients. Rigorous safety monitoring will also be required, given the vulnerability of this patient population and the potential for herb-drug interactions.

Palliative symptom management

Palliative care emphasizes the relief of symptoms, psychosocial support, and enhancement of quality of life in patients facing advanced illness. CWO, with its calming aroma, mild sedative effects, and reported anti-inflammatory and skin-soothing properties, has been explored as a potential adjunct in this context. Anecdotal accounts and small-scale aromatherapy interventions suggest that CWO may help ease insomnia, agitation, pruritus, and low-level discomfort, offering a non-invasive means of enhancing patient comfort.

Its grounding and stabilizing aromatic profile may also contribute to creating a calming environment for both patients and caregivers, aligning with holistic palliative care goals [36, 51].

Topical applications, such as diluted massage oils, balms, or compresses, have been reported to improve skin comfort, particularly in cases of dryness, irritation, or fragile skin often seen in terminal illness. Inhalation through diffusion or personal inhalers has been used informally to reduce anxiety and restlessness, while integration into massage therapy may additionally support caregiver-patient bonding. These multimodal applications highlight the versatility of CWO as a complementary tool within individualized care plans [52].

Despite these potential benefits, the scientific evidence supporting the use of CWO in palliative settings is limited. Most reports are descriptive, lacking standardized outcome measures, randomized controls, or large sample sizes. Aromatherapy interventions often combine multiple oils, making it difficult to isolate the specific effects of CWO. Furthermore, the vulnerability of palliative patients raises safety concerns, particularly regarding dermal sensitization, possible respiratory irritation with prolonged inhalation, and unknown herb-drug interactions in individuals receiving complex pharmacotherapy.

Consequently, while CWO may offer supportive benefits in symptom management and emotional well-being, its clinical application in palliative care remains largely speculative. More rigorous studies are needed to establish efficacy, optimize delivery methods, and assess safety in this sensitive population. Until such data are available, CWO should be considered an adjunctive, exploratory intervention rather than a validated therapeutic option in palliative care.

Dermatology and cosmetic formulations

CWO has a longstanding presence in dermatological and cosmetic products, where it is valued for its woody aroma, astringent qualities, and antimicrobial activity. Traditionally, it has been incorporated into preparations for acne-prone and oily skin, scalp conditions such as dandruff, and wound healing. In vitro studies support these uses, showing antibacterial activity against *Propionibacterium acnes* and antifungal effects against dermatophytes, as well as stimulation of fibroblast activity and collagen synthesis. Such findings suggest a potential role for CWO in formulations aimed at managing acne, enhancing skin repair, and improving scalp health [52, 53].

In cosmetic contexts, CWO is also popular in hair and beard care products, where it is claimed to reduce irritation, strengthen hair follicles, and improve overall scalp condition [53]. Its sesquiterpene-rich composition may contribute to skin barrier function and resilience against oxidative stress, properties that could be beneficial for both therapeutic and preventive skincare [54]. Moreover, the oil's fixative qualities help stabilize aromatic blends, increasing its appeal for fragrance formulations.

Nevertheless, the clinical evidence supporting these dermatological applications is sparse. Most studies remain limited to laboratory assays or preliminary animal models, without robust randomized clinical trials to confirm efficacy in human populations. Additionally, essential oil composition varies considerably by species, geographic origin, and extraction method, which complicates reproducibility and standardization in commercial formulations. Safety is another concern: While generally regarded as low in dermal toxicity at recommended dilutions, CWO has been associated with skin sensitization, particularly if oxidized or used inappropriately concentrated. Regulatory frameworks provide only limited guidance on maximum dermal concentrations, leaving formulation safety to individual manufacturers.

Taken together, while CWO shows promise as a multifunctional ingredient in dermatology and cosmetics, its role is best regarded as preliminary. Without controlled clinical validation and stricter standardization of oil quality, claims of therapeutic benefit should be interpreted cautiously. Future work should focus on dermatological trials that establish both efficacy and safety across specific skin conditions, as well as efforts to define optimal concentrations, vehicles, and formulation practices for consumer use.

Stress-related disorders

Stress-related disorders, including generalized anxiety, insomnia, and psychosomatic complaints, represent one of the most common contexts in which CWO is used, particularly in aromatherapy practice. Its

grounding aroma and reported sedative effects, largely attributed to cedrol, have made it a popular choice in blends aimed at promoting relaxation, reducing autonomic arousal, and supporting sleep quality. Preclinical studies in rodents provide some mechanistic insights, suggesting modulation of GABAergic neurotransmission and reductions in stress-induced corticosterone levels, thereby supporting a neurobiological rationale for its traditional use [55].

In human contexts, anecdotal evidence and small pilot studies have reported improvements in sleep onset, reduced agitation, and greater subjective calm when CWO is inhaled or diffused [46, 56]. These findings resonate with broader clinical interest in essential oils as low-cost, non-invasive adjuncts for stress management. Given the increasing prevalence of sleep disturbances and anxiety in modern healthcare, CWO has been positioned as a potentially attractive complementary intervention.

However, the limitations of the evidence base are significant. Human studies to date are scarce, typically underpowered, and often lack placebo controls, blinding, or standardized dosing protocols. Many interventions involve complex essential oil blends, making it difficult to attribute observed effects specifically to CWO. Moreover, response to aromatherapy can be highly subjective and influenced by individual olfactory preference, cultural context, and expectancy effects. Without larger, well-designed trials, it is difficult to determine whether CWO offers reproducible benefits beyond placebo.

Safety considerations also remain underexplored. While short-term inhalation at low concentrations appears well tolerated, there is little data on the long-term effects of repeated exposure, especially in populations with respiratory or neurological vulnerabilities. Variability in oil composition across species and preparations adds further uncertainty regarding both efficacy and tolerability.

In summary, while preliminary evidence and traditional practice suggest that CWO may support stress reduction and sleep quality, its current use should be regarded as exploratory. Future research should focus on randomized controlled trials employing standardized inhalation or topical protocols, alongside safety assessments that address long-term use. Only with such data can the role of CWO in stress-related disorders be adequately defined.

Safety and toxicity considerations

While CWO has a long history of use in traditional medicine and aromatherapy, systematic toxicological evaluations remain scarce. Available data highlight several safety considerations that warrant closer attention for responsible therapeutic use.

Species-specific risks

The chemical composition of CWO varies markedly by botanical source. *T. plicata* oil, for example, contains thujone, a monoterpene ketone with well-documented neurotoxic and convulsant effects at high doses [57]. This limits its suitability for therapeutic use compared to *C. atlantica* or *J. virginiana* oils, which are generally considered safer [7, 58]. Accurate botanical identification and compositional analysis are therefore critical to minimize toxicological risk.

Dermal safety and sensitization

Topical use of CWO is common in cosmetics and dermatological formulations. While generally well tolerated at appropriate dilutions, reports of skin sensitization and irritation have been documented, particularly with oxidized or poor-quality oils [32, 59]. The high lipophilicity of sesquiterpenes may enhance dermal penetration, raising the risk of allergic reactions in sensitive individuals. Patch testing and adherence to established dermal limits (e.g., ≤ 2% dilution for leave-on products) are advisable [60, 61].

Inhalation and respiratory safety

CWO is frequently administered via inhalation in aromatherapy. Preclinical studies suggest sedative benefits, but long-term inhalation safety remains insufficiently studied [27]. Concerns include potential respiratory irritation, cumulative effects of prolonged exposure, and variability in individual tolerance.

Controlled human trials with standardized exposure parameters are needed to assess both efficacy and safety in clinical settings.

Systemic toxicity and metabolic interactions

Data on systemic toxicity are limited. Rodent studies of Virginia cedarwood oil (CASRN 8000-27-9) suggest low acute toxicity with no significant carcinogenicity; however, chronic exposure studies are lacking [7]. Additionally, in vitro assays indicate that sesquiterpenes such as cedrol and thujopsene may inhibit cytochrome P450 enzymes, raising the possibility of herb-drug interactions [9, 62]. Clinical investigations are required to determine whether such interactions are relevant at therapeutic doses.

Regulatory status and knowledge gaps

CWO is classified as "Generally Recognized as Safe" (GRAS) by the U.S. FDA for limited use as a flavoring agent, and the U.S. [63]. EPA lists it as a minimum-risk pesticide [64]. Nonetheless, these approvals are based on restricted applications rather than therapeutic dosing. Major gaps persist regarding long-term safety, reproductive and developmental toxicity, and species-specific differences. Standardization of essential oil chemotypes, along with rigorous toxicological and clinical evaluation, will be essential for advancing CWO into evidence-based practice.

Conclusions

CWO demonstrates a broad spectrum of pharmacological activities, yet the supporting evidence is largely confined to in vitro and animal models, with limited clinical validation. Significant gaps remain in the standardization of chemical composition, determination of safe and effective dosages, and evaluation of long-term safety, particularly regarding dermal sensitization, inhalation exposure, and potential metabolic interactions. Future research should therefore focus on rigorous clinical trials, comprehensive toxicological assessments, and standardized methodologies to clarify its therapeutic potential and ensure responsible integration into evidence-based practice.

Abbreviations

C. atlantica: *Cedrus atlantica*

C. deodara: *Cedrus deodara*

C. funebris: *Cupressus funebris*

C. lawsoniana: *Chamaecyparis lawsoniana*

CWO: cedarwood essential oil

GABAergic: gamma-aminobutyric acid-ergic

J. ashei: *Juniperus ashei*

J. virginiana: *Juniperus virginiana*

T. plicata: *Thuja plicata*

Declarations

Author contributions

SDG: Conceptualization, Investigation, Writing—original draft, Writing—review & editing, Validation, Data curation, Formal analysis, Resources, Project administration, Methodology, Supervision. The author read and approved the submitted version.

Conflicts of interest

The author declares that there are no conflicts of interest.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

Not applicable.

Funding

Not applicable.

Publisher's note

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