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Review Article

Essential Oils in Dermatology

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The global essential oils market was valued at 24.75 billion USD in 2024, driven by increasing consumer interest in natural healthcare alternatives. With a significant portion of the population seeking health-related information online, essential oils have gained popularity for various purposes, including skincare and alternative medicines. However, healthcare providers often lack formal training in this area, necessitating the need for evidence-based information to effectively counsel patients. This narrative review aims to fill the existing knowledge gap associated with the use of essential oils in dermatology. By summarizing available evidence, our objective is to provide healthcare professionals with a reliable resource detailing the studied uses, benefits, potential risks, and reported adverse effects of commonly used essential oils. Our narrative review combines data from extensive searches on PubMed and Science Direct. In a world where essential oils are viewed as accessible, natural remedies, it is vital for healthcare providers to have comprehensive knowledge of their dermatological implications. This concise narrative review serves as a valuable resource for clinicians, offering a balanced and accurate understanding of the use of essential oils in dermatology to facilitate informed discussions with patients.

INTRODUCTION

In 2024, the global revenue of the essential oils market was valued at 24.75 billion USD.[1] As consumer awareness surrounding the importance of health-conscious decisions continues to increase, the demand for alternative medicine and products with natural or organic origins is also increasing.[2] In the United States, it is estimated that six million individuals use the internet to retrieve information related to their health on a daily basis, with approximately 40% of these users looking to gain more information about alternative medicines.[3] The use of essential oils, especially in their pure form, is increasing rapidly.[4] A general population survey found that essential oils were used in a variety of ways including while experimenting with alternative medicine, following previous treatment failures or because it was believed that essential oils were safer than conventional treatment options.[5]

Essential oils are widely used for their aromatic and therapeutic properties however some consumers are unaware of how they differ from other products in the market such as plant extracts and cold-pressed oils. What differentiates these products are the methods of extraction used and applications of the product. Essential oils are conventionally obtained through steam distillation, producing highly concentrated, impurity-free, volatile aromatic compounds used in aromatherapy and alternative medicine. Other extraction techniques used include solvent extraction, water distillation and cold pressing. Mechanical extraction via cold pressing is also used for citrus fruit peels including oranges and lemons, maintaining heat-sensitive compounds and antioxidants.[6] In contrast, extracts are made by soaking plant material in various solvents such as water or alcohol, and producing compounds for flavoring, supplements, and herbal remedies.[7,8] Finally, cold-pressed oils can be made from plant materials including fruits, nuts, and seeds. Cold-pressed oils are mechanically pressed without heat, preserving vitamins, and antioxidants, making them suitable for culinary and skincare applications.[9] By understanding these differences, patients and providers can better assess the benefits and use cases of essential oils.

Many healthcare providers are uncomfortable with discussing the use of complementary medicine, including essentials oils, with patients as there is a lack of formal education and training on these topics. However, as patients increasingly turn to the internet for medical advice, the use of essential oils continues to grow amongst patients who view these products as easily accessible, natural, and safer than traditional medications. To effectively counsel patients, healthcare providers need to become familiar with evidence-based information on the subject.[10]

Currently, there is a gap in the literature regarding the benefits and risks of using essential oils and its impact on health.[11] This article will serve as a resource for clinicians regarding several commonly used essential oils. We emphasize their studied uses and benefits as well as their potential risks and reported adverse effects to aid providers in offering balanced and accurate information to their patients who may be using these home remedies.

For this narrative review, a list of the most used essential oils was determined via PubMed and Google searches for

"Essential Oils," "Dermatology," and "Skin." Upon finalizing a list of essential oils, databases including PubMed and Science Direct were used to identify the potential benefits, risks, and reported adverse effects of these essential oils.

LAVENDER OIL

Lavender essential oil (LEO), extracted from *Lavandula angustifolia,* is one of the most popular and commonly used essential oils.[4] The current body of literature proposes that lavender essential oil exhibits antimicrobial activity against microbes such as *Streptococcus pyogenes (S. pyogenes)*, *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) which may be useful against surface infections. LEO also lends itself to multiple dermatologic uses including the treatment of atopic dermatitis, psoriasis, and acne given its antibacterial and antifungal properties.[12-15] In treatment-resistant acne, LEO has been shown to be effective against certain antibiotic-resistant bacteria.[12] Another reported therapeutic benefit of LEO is its ability to shorten wound healing time. Data has shown that LEO can decrease wound size and shorten time to healing by supporting collagen production.[16,17] Marked concentration-dependent increases in the production of IL-6, IL-8, and VEGF, key signaling molecules important for wound healing, were observed in a human keratinocyte cell line.[18] In addition, LEO has been shown to reduce inflammation by decreasing proinflammatory cytokine production and assisting in chronic wound healing via the inhibition of macrophage pyroptosis.[19]

One study also discussed the benefits of LEO on hair growth. Of 86 study patients with alopecia areata, approximately half of the study population showed an improvement in hair growth after 7 weeks of treatment with essential oils containing lavender.[20] Small animal studies have also shown increased hair growth with LEO as compared to placebo.[21]

One of the most widely acclaimed properties of LEO is its ability to induce relaxation.[22] After cutaneous application or inhalation of LEO or its main constituent, linalool, three studies reported a decrease in autonomic stimulation as evidenced by decreased heart rate, blood pressure, or skin temperature; indicating that lavender oil does affect the parasympathetic nervous system.[22-25]

While LEO is known for its therapeutic benefits, recent studies have expressed concerns regarding its potential endocrine disrupting effects.[26,27] Within the literature, LEO has been linked to premature thelarche and prepubertal gynecomastia due to its estrogenic and antiandrogenic properties.[28] Case reports show that continuous exposure to lavender-containing fragrance products were associated with breast growth in children, which dissipated in all patients upon discontinuation/removal of the products.[28,29] In vitro studies also confirmed that components of LEO exhibit endocrine-disrupting activities, suggesting it may be a potential source of idiopathic prepubertal breast development.[26]

Despite being derived from natural sources, LEO's use has been reported to cause adverse effects including contact dermatitis and photoallergic reactions, which have become more recognizable with the increased popularity of essential oils for aromatherapy.[4,30-36] Lavender oil in its pure form has been demonstrated to be a weak sensitizer; however, its oxidized counterpart was identified to be a moderate allergen causing one of the highest positive patch test rates when tested among other compounds such as oxidized linalyl acetate and linool, major components found in other essential oils.[37,38]

When advising patients on the utilization of lavender essential oil (LEO), the most robust evidence supports its efficacy in promoting relaxation.[22] Due to the potential risk of contact dermatitis associated with topical application, it is recommended to employ LEO as an aromatherapy agent via inhalation.[37,38] Additionally, a small study indicates potential benefits of LEO in the management of alopecia areata.[20] For patients inclined towards "natural" remedies, topical application to the scalp could be considered as an adjunct to standard treatments for alopecia areata, provided that the patient does not exhibit contact dermatitis upon application.

FRANKINCENSE OIL

Frankincense essential oil (FREO), derived from the oleogum resins of the *Boswellia* species, has been used for multiple centuries for both its aromatic and medicinal benefits.[39,40] Due to a push towards natural remedies, studies exploring the anti-inflammatory, antimicrobial, and antitumoral properties of FREO and its therapeutic uses have increased.[40]

FREO as a microemulsion (oil content of 7.8%) displayed higher anti-inflammatory effects when compared to the common synthetic anti-inflammatory medication piroxicam in non-steroidal anti-inflammatory drug (NSAID) gel upon transdermal application. This was evidenced by the FREO microemulsion having an increased percentage of inhibition of inflammation within an in vivo mouse model.[41] Studies completed on human cell lines showed that treatment with FREO decreased proliferation of fibroblasts and the production of tissue remodeling molecules, such as collagen III, in vitro, elucidating potential benefits in wound healing and the prevention of scar formation.[42,43]

FREO has also been shown to have antimicrobial properties, demonstrating activity against common skin pathogens including *Propionibacterium acnes (P. acnes)*, *Malassezia* spp*. and *Candida albicans (C. albicans)*, with maximum antimicrobial activity against *Trichophyton* spp. When used alongside azoles in the treatment of skin and nail infections, it has been shown to have synergistic antifungal effects.[44,45]

Regarding its anti-tumoral properties, high concentrations of boswellic acid, FREO's active molecule, have shown in-vitro cytotoxic and cytostatic effects on certain malignant cell lines, including melanoma.[46,47] It has also demonstrated antitumoral activity in mouse models.[48] However, there are limited in vivo studies assessing FREO's effect on cutaneous malignancies.[3]

Additional reported properties of FREO include its potential to increase the transdermal uptake of drugs via increased skin perfusion and permeability and decrease erythema in patients with atopic dermatitis and psoriasis.[49-51]

Adverse reactions to FREO are limited and therefore may allow for daily use, however there are reports of FREO causing harm due to online misinformation.[3,52] One paper reported a blistering reaction to topical FREO when a patient attempted to use it for mole removal. The "mole" was eventually biopsied and found to be a nodular basal cell carcinoma.[3] This once again emphasizes the importance of educating patients on best practices for the use of alternative medications and when medical care should be sought.

Currently there are multiple in vitro benefits reported for FREO.[42-47,49] With regards to its use in a clinical setting, FREO may be used in cases of atopic dermatitis and psoriasis to decrease erythema.[51]

GERANIUM OIL

Geranium essential oil (GEO), extracted from the leaves of *Pelargonium graveolens* and belonging to the Geraniaceae family, is popularly used for its fragrant properties within the cosmetics industries as well as medicinally.[53]

GEO has demonstrated dose-dependent anti-inflammatory properties in rodent models by reducing edema and peritoneal inflammation.[54,55] In one study, GEO was found to have significant antiproliferative activity against human dermal fibroblasts which may play a role in wound healing.[42]

Research shows that GEO may also have anti-aging and photo-protective effects.[56,57] GEO demonstrates an ability to reduce and prevent oxidative stress. When introduced into a skincare routine, GEO can leverage its antioxidant properties to aid in slowing down the process of skin aging. When combined with calendula essential oil, the antioxidant and SPF properties of both oils can provide increased photoprotective effects and may enhance cosmeceutical formulations.[57]

GEO also has antimicrobial and antiparasitic properties, and can be a useful adjunct to antibiotics in treatment-resistant infections.[58,59] Out of 14 essential oils, GEO was amongst the top five most active against test fungi including *Microsporum gypseum (M. gypseum), Microsporum canis (M. canis),* and *Trichophyton mentagrophytes (T. mentagrophytes)*.[60]

GEO has been shown to promote hair growth in vitro and in vivo through regulation of the involved cellular response.[61] It also serves as an effective component of bug repellent mixtures; however, all the essential oil mixtures tested were significantly shorter acting than DEET 19%.[62-64]

Current data on the adverse effects of GEO is limited, requiring further research to clearly define its usage risks. Given the lack of data on adverse effects, there is insufficient evidence to recommend GEO's use in a clinical setting.

MYRRH OIL

Myrrh essential oil (MEO) is derived from the resins of the *Commiphora myrrh* plant.[65] It is widely used as a natural remedy in Asia and Africa and traditionally revered for its medicinal properties.[66]

Although MEO has not been extensively studied, there are animal studies that support MEO as an effective agent in wound healing.[67,68] Mice treated with myrrh had higher leukocyte counts both prior to and after skin injury.[67] Additionally, mice with skin wounds treated topically with myrrh had an increased rate of wound contraction, shorter re-epithelialization times and increased wound tensile strength. MEO was also found to inhibit elastase, a biomarker of inflammation produced by neutrophils.[68]

In addition to this, MEO also demonstrated significant activity against a wide variety of pathogens thus showcasing its antimicrobial properties. Its antimicrobial effects measured by zone of inhibition were shown to be similar to that of the broad-spectrum antibiotic ciprofloxacin. Gram negative bacteria including *E. coli, Vibrio cholerae (V. cholerae)* and *Salmonella typhi Ty2* (*S. typhi*) were the most inhibited by MEO. Similarly, MEO was shown to be ~78.9% as active as the antifungal medication griseofulvin against test fungi which included *C. albicans, Aspergillus niger (A. niger), Penicillium funiculosum (P. funiculosum),* and *Penicillium notatum (P. notatum)*.[68]

MEO has been described as non-irritating when administered in low concentrations (ointment 4%).[68] However there are multiple case reports in the literature of MEO-induced allergic contact dermatitis with subsequent positive patch tests to myrrh.[69-71] Similar contact reactions to those induced by MEO have been seen after topically applying traditional Chinese medicine pain relievers.[71]

At this time, there is insufficient evidence to recommend MEO's use in a clinical setting.

NEROLI OIL

Neroli essential oil (NEO), extracted from *Citrus aurantium* flowers, is known for its widespread use in floral perfumery. In addition to its use in fragrances, it is also thought to possess antimicrobial, antifungal, and antioxidant properties.[72]

NEO's antimicrobial activity is most pronounced against gram negative bacteria, with increased activity seen against *Pseudomonas aeruginosa (P. aeruginosa)*. NEO also demonstrated strong anti-fungal activity against *Saccharomyces cerevisiae* (*S. cerevisiae)* and *C. albicans*, evidenced by inhibition zones comparable to the antifungal medication nystatin which was used as a positive reference. The antioxidant properties of NEO are dependent on its chemical composition. Despite γ-terpine, a minor component of NEO, being shown to have high antioxidant activity, limonene, a major component of NEO, was shown to have low antioxidant properties as evidenced by low free radical scavenging activity.[72] Regarding its anti-inflammatory properties, NEO has been shown to block signaling pathways activated during the acute and chronic inflammatory

response, including the mitogen-activated protein kinase pathway.[72,73]

Adverse effects of NEO have been documented in the literature. Exposure to neroli oil in the context of perfume factory workers resulted in multiple cases of contact dermatitis.[74,75] There are reports of Belgian patients using ketoprofen, a topical NSAID cream, combined with fragrance components from NEO who subsequently developed photoallergic dermatitis.[75]

Given numerous reported adverse effects, currently we do not recommend use of NEO in a clinical setting.

PATCHOULI OIL

Patchouli essential oil (PEO), an essential oil derived from the *Pogostemon cablin* plant, rich in sesquiterpenes, has widespread use in both Indian and Chinese traditional medicine.[76,77] PEO has been used in the treatment of various dermatologic conditions including in the treatment of acne and eczema.[78] PEO has also demonstrated pharmacological benefits including antioxidant, antimicrobial, and sedative properties.[79-81]

There is some preliminary evidence to support PEO's use in anti-aging, specifically protection against photo-aging. Animal studies showed that application of an isolated component of PEO, pogostone, prior to UV sun exposure resulted in decreased wrinkles, improved maintenance of skin elasticity, and decreased epidermal thickening on histology in mouse models. The proposed mechanism of protection against photoaging is via antioxidant free radical scavenging and subsequent decreased inflammation.[82,83]

PEO has also shown benefit in wound healing and prevention of scarring. PEO demonstrated significant antiproliferative effects against dermal fibroblasts in vitro, and inhibitory effects towards a tissue remodeling biomarker (PAI-1).[42]

PEO may also be used against two of the main organisms implicated in acne, *P. acnes* and *Staphylococcus epidermidis (S. epidermidis)*.[80] Although no synergistic effects amongst combinations of PEO with 69 other essential oils were observed, additive effects were noted.[80] Finally, PEO has insecticidal properties. Among 38 different oils, PEO ranked within the top four repellants against three different species of mosquito.[84]

Current data on the adverse effects of PEO is limited, requiring further research to clearly define its usage risks. At this time, there is insufficient evidence to recommend PEO's use in a clinical setting.

ROSE OIL

Rose essential oil (REO) is derived from the petals of the Rosa species. REO is most commonly extracted from the *Rosa x damascena* Mill. due to the superior quality of oil that can be procured from it.[85] It is popularly used for its fragrance in both the cosmetic and food industries.[86] REO is known to be expensive due to the low oil content in the plant itself and the lack of available synthetic substitutes.[87]

There is some evidence emerging in the literature that rose oil may have anti-aging benefits. REO was found to be hydrating to dry skin, with one study finding that it improved skin barrier function when used in combination with tea tree extract within a topical gel formulation, thereby demonstrating its potential uses in cosmetic anti-aging formulations.[88,89] Rose oil was also found to have additive antioxidant properties when mixed with clove oil.[90]

REO may be used as an adjunct to wound healing. An animal study showed that the topical application of REO accelerated the recovery of the barrier function in mouse skin.[91] In one study, REO extracted from the *Rosa rugosa* 'Plena' flower, significantly reduced both oxidative and inflammatory biomarkers such as nitric oxide, superoxide dismutase, and monodialdehyde.[92] Additionally, REO has been shown to have antibacterial activity against bacteria including *P. aeruginosa, E. coli, Chromobacterium violaceum (C. violaceum),* and *S. aureus*.[93,94] REO has also been shown to have antifungal properties against *P. notatum*, *A. niger*, and *C. albicans*.[95]

The relaxation properties of REO have also been studied. Human studies demonstrated that inhaling rose essential oil inhibited the typical effects of chronic stress, including increased salivary cortisol levels and transepidermal water loss, as observed during and after students completed a scheduled academic exam. Whether this effect is clinically significant remains to be seen.[96] Another study demonstrated a decrease in several autonomic parameters in those who massaged REO topically on the skin for five minutes.[97] Additionally, a study demonstrated that REO was an agonist of transient receptor potential vanillioid subtype 1 (TRPV1), receptors activated by capsaicin, with activity equivalent to 45% that of capsaicin; identifying rose oil as a potential agent in treating pain. In addition to being involved in peripheral nociception, TRPV1 has also been shown to be expressed in the keratinocytes of the human epidermis and hair follicles. One study showed that TRPV1 activation was involved in inhibiting hair matrix keratinocyte proliferation and the induction of apoptosis, thereby elucidating a role for REO in skin disorders.[98] However further research is needed to understand REO's therapeutic potential in the latter context.

A study on the pharmacokinetics of phenylethyl alcohol, one of the main constituents of rose oil, indicated that it is safe for use. Both human and rat studies determined that REO is safe up to 2600 mg/kg applied topically and is likely safe in pregnancy as well.[99] However, there may be some variations in this maximum level of REO that should be incorporated in formulations as rose oil has been shown to be absorbed very differently depending on which area of the body it is applied to.[100] There are several case reports highlighting allergic contact dermatitis to rose oil found in cosmetic products or applied to skin in its pure form.[101-103] A study investigating the effects of rose oil on workers in a perfume factory also demonstrated the effects of sensitization and indicates that more cases of allergy to rose oil and other essential oils may occur as the use of essential oils increases.[104]

The relaxation properties of REO have been well-documented.[96,97,99] Currently, REO could be considered for use as a relaxation agent for aromatherapy, administered via inhalation.

TEA TREE OIL

Tea tree oil (TTO) is a monoterpene-rich essential oil derived from the *Melaleuca alternifolia* plant.[105] TTO has been cited in the literature for its antimicrobial and anti-inflammatory properties which provides the foundation for its use in treating acne.[106]

As TTO treatments are available without a prescription, it has been difficult to gauge its use and feedback. However, among online patients it was identified as the second most used topical product for treating acne secondary to benzoyl peroxide (2.5%).[107] Tea tree oil gels are effective for acne treatment due to their sustained release, enhanced penetration, and anti-inflammatory properties, allowing prolonged contact with the skin while minimizing irritation. They are non-greasy, easily absorbed, and demonstrate a low incidence of adverse events across studies, making them ideal for topical use in acne-prone and sensitive skin.[108] A double-blind RCT reported that the use of TTO 5% gel for 45 days resulted in a significant decrease in total lesion count, acne severity index, comedones, papules, and pustules among patients with mild-moderate acne vulgaris.[109] An uncontrolled open-label multicentric phase III RCT reported that the use of TTO 5% gel for 4 weeks resulted in a significant decrease in blackheads, papules, and pustules among patients with mild-moderate acne vulgaris.[110] A comparative investigator-blind study reported that in comparison to a 2% erythromycin gel, a 5% topical TTO gel was found to be more effective in reducing acne lesion count and acne severity index.[111] Despite its proven benefits, tea tree oil (5% water based gel) was found to be less effective than benzoyl peroxide (5% water based lotion) in reducing inflammatory lesions and skin oiliness. However, benzoyl peroxide was found to have more adverse effects such as skin irritation, erythema, and itching.[112] Many previous studies investigated products with up to 5% TTO in the treatment of acne; however, these products are not readily commercially available. A dual center-open label phase II pilot study was thus undertaken and reported that the use of tea tree medicated gel (200 mg/g) resulted in a significant decrease in total lesion count, investigator global assessment mean, and facial oiliness among patients with mild-moderate acne vulgaris. This efficacy was hypothesized to be due to the antibacterial activity of TTO against *P. acnes* and supports its potential as a treatment option for mild to moderate acne. However, the effectiveness of TTO in treating acne depends on the concentration, treatment frequency, and formulation.[113]

TTO's demonstrated fungicidal properties have resulted in its use as a treatment of onychomyosis.[114] A double blind, single-arm clinical trial showed that the use of 100% tea tree oil twice daily for 6 months resulted in 89% of patients achieving mycological cure and 27% patients being clinically cured.[115] A double-blind RCT showed that the use of 100% tea tree oil twice daily for 6 months resulted in 82% of the patients achieving a mycological cure.[116] An in- vitro study demonstrated that TTO (at concentrations < 0.5%) inhibited the growth of *Trichophyton schoenleinii, Trichophyton tonsurans*, and *Trichophyton rubrum*, three common causative agents of nail infections, suggesting TTO's potential as an alternative treatment for onychomycosis.[117]

Over the last few decades, TTO has become an increasingly popular essential oil which continues to be incorporated into skin care and alternative medicine formulations.[118] This may explain why TTO has the most documented allergic reactions when compared to all other essential oils within the published literature; with most reactions induced by the pure form of the essential oil.[119] Adverse reactions to TTO (5%) include burning, erythema, and pruritus. However, significantly fewer adverse events were recorded in patients given TTO when directly compared with patients given 5% benzoyl peroxide.[112]

While TTO is widely praised for its antimicrobial and anti-inflammatory properties, similar to LEO, recent studies have expressed concerns regarding TTO's potential endocrine disrupting effects.[26,27] Case reports show that repeated topical application of products containing TTO were associated with prepubertal gynecomastia with symptoms resolving after discontinuation.[26] In-vitro studies also indicated that components of TTO exhibits estrogenic and antiandrogenic activity, potentially disrupting the hormonal balance necessary for normal puberty.[26]

Although tea tree oil (TTO) has the highest incidence of documented allergic reactions among essential oils, it also possesses the most robust evidence for treating acne.[106, 111,113,119] Currently, TTO gel formulations could be considered for use as an adjunct to conventional acne treatments in appropriate candidates and 100% TTO could be considered for use in cases of onychomycosis.

YLANG-YLANG OIL

Ylang-ylang essential oil (YEO) is procured from the flower of the *Cananga odorata* plant and is widely used for its fragrant properties within the cosmetics, culinary, and aromatherapy industries.[120] YEO is also reported to have medicinal properties demonstrating antimicrobial, antioxidant, wound healing, anti-aging, and mood regulating effects.[42, 80,120-124]

YEO shows strong synergistic activity against two of the main bacteria implicated in the development of acne, *P. acnes*, and *S. epidermidis* when used alongside myrrh and petit grain oil.[80] At high doses, YEO also showed activity against scabies mites due to its main chemical constituent isoeugenol.[121]

Additionally, in vitro YEO was shown to decrease proliferation of human fibroblasts and inhibit tissue remodeling biomarkers, with potential to be useful in wound healing and scar prevention.[42]

During transdermal application on human subjects, YEO was found to decrease blood pressure, increase skin temperature, and increase subjective calmness and relax-

ation.[122] Similar effects were observed when inhaled, but attentiveness and alertness were also increased.[123]

YEO was found to be safe when consumed as a food additive and posed virtually no risk to human health when consumed at levels of 0.0001 mg/kg/day.[125] The National Toxicology program found that isoeugenol, the main component of YEO, was non-mutagenic in two bacterial assays (*Salmonella typhimurium* and *E. coli*). However, in male rats there was evidence of a significant increase in carcinogenic activity when isoeugenol was ingested at large doses (75, 150, 300 mg/kg). Specifically, these mice developed hepatocellular adenoma and or carcinoma.[126] There are multiple cases of YEO induced contact dermatitis and resultant hyperpigmentation.[127-129] Sensitivity to YEO determined via patch testing was also shown to be the highest in comparison to all other essential oils tested.[130-137] The Scientific Community on Consumer Safety found ylang-ylang oil to be a contact allergen with an "alarming" prevalence of sensitization defined by 100-1000 reported cases.[138] When applied to the skin, ylang-ylang oil also has the potential to alter the absorption of other substances.[138] YEO has also been shown to cause heat sensitization reactions in both humans and animals.[124]

Given numerous reported adverse effects when used topically, YEO could be considered for use for relaxation via inhalation aromatherapy.

LEMONGRASS OIL

Lemongrass essential oil (LGEO) comes from the tropical plant *Cymbopogon citratus* and is cultivated in Asia, Africa, and South America where it is widely used.[139] In addition to its aromatic properties, published literature supports its medicinal value attributed to its antifungal, antitumoral, antioxidant, anti-aging properties.[140-142]

Both in silico and in vitro studies among fungi, parasites, and humans provide evidence of its specific inhibitory action against ATP catalyzing enzymes thus highlighting its usability as an antifungal and antitumoral drugs. With regards to its antitumoral properties in specific, the effect is maximally seen when LGEO is combined with Geraniol and Citral oil.[141] LGEO also demonstrated its capacity to serve as an antifungal agent against all *Candida tropicalis* (*C. tropicalis)* strains by significantly reducing growth and biofilm formation when applied to silicone rubber prostheses and medical devices. This was in comparison to lemon and cumin essential oil which showed limited antifungal effects.[143]

LGEO has been shown to reduce the expression of inflammatory cytokines, oxidative stress, and hydrocarbon induced DNA damage in human cell lines.[144] Additionally, LGEO has also demonstrated high antioxidant activity indicating its potential use in anti-aging spa and cosmetic formulations.[145]

Current data on the adverse effects of LGEO is limited, requiring further research to clearly define its usage risks. At this time, there is insufficient evidence to recommend LGEO's use in a clinical setting.

SANDALWOOD OIL

The use of sandalwood essential oil (SEO) derived from the *Santalum album* tree can be traced back multiple centuries in both Ayurvedic and Chinese medicine. It continues to be used to date for its anti-inflammatory, antimicrobial, and anti-proliferative properties.[146]

Studies have shown that SEO interacts with transcription factors and decreases pro-inflammatory enzymes.[147] SEO has thus been used in the treatment of skin conditions including atopic dermatitis and psoriasis because of its anti-inflammatory properties.[147]

SEO demonstrates antimicrobial properties that have been leveraged against antibiotic-resistant bacteria such as methicillin resistant *S. aureus* (MRSA) and vancomycin resistant *S. aureus* (VRSA), with its mechanism of action hypothesized to be via the disruption of the cell membrane.[146] SEO has also shown activity against herpes simplex virus, human papillomavirus, and molluscum contagiosum virus. When used transdermally on warts, 80% of patients experienced a resolution of warts upon 12 weeks of daily treatment with no associated irritation, pain, or discomfort.[148]

The anti-proliferative effects of SEO have been studied in mice and human cancer cell lines.[146,149-153] In relation to skin cancer, sandalwood oil has been seen to induce autophagy and cell cycle death in actively proliferating keratinocytes, showing evidence for possible integration into the treatment of skin cancer.[149] In addition to possessing chemo-preventive benefits and inducing apoptosis in cancer cells as seen within all 60 of the tumor cell lines within the National Cancer Institute's NCI-60 panel, this cytotoxicity is not observed in non-cancerous cells.[146]

With regards to its safety, like YEO, the Scientific Community on Consumer Safety found SEO to be a contact allergen with an "alarming" prevalence of sensitization defined by 100-1000 reported cases.[138] Despite this, sandalwood oil is reported to have low oral and dermal toxicity in laboratory animals and is also demonstrated to be non-mutagenic.[146,154]

Clinically, SEO could be utilized in patients seeking alternative treatments for warts, particularly given that the primary objective of wart treatment is to induce an irritant reaction.[148]

CARROT SEED OIL

Carrot seed essential oil (CSEO) is derived from the seeds of the *Daucus carota* plant.[155] Of all the essential oils reviewed, CSEO is the least studied. It has been proposed CSEO possesses anti-inflammatory properties by minimizing the production of nitric oxide and strong antimicrobial activity against gram positive bacteria including *Bacillus subtilis* (*B. subtilis*), *S. aureus*, *Cryptococcus neoformans* (*C. neoformans*), and dermatophytes.[156] CSEO also has the potential to be a skin rejuvenating agent based on several properties including its stability and free radical scavenging ability. Animal studies demonstrated that the application of CSEO prior to UV radiation decreased collagen bundle

disorganization to a higher degree than the current commercially available anti-aging formulations.[157] Furthermore, all CSEO emulsions studied produced no more than slight irritation when applied to rat skin, with many of the mixtures producing none.[158]

Although CSEO is one of the most recommended oils for sun protection, a study found the SPF of CSEO to be 2.5. Thus, claims of its ability to protect humans from UVB radiation can thus be misleading and dangerous.[159] In addition to this, in terms of safety, a primary constituent of CSEO, carotol, exhibited moderate non-selective cytotoxic effects on a human pharyngeal squamous cell carcinoma cell line and on green monkey kidney.[158]

At this time, there is insufficient evidence to recommend CSEO's use in a clinical setting.

CONCLUSION

Essential oils in dermatology have a variety of benefits. Yet, supporting scientific evidence is currently limited and continues to grow as the use of these products increases. This narrative review is primarily rooted in basic science data with extrapolation into clinical utility. While there are documented advantages, it is crucial to acknowledge the associated risks of using these products. Contact dermatitis and photoallergic dermatitis were cited as two of the most common concerns with the use of popular essential oils. Clinicians are recommended to exercise caution and ensure patients are well-informed about the potential risks involved when incorporating essential oils into their healthcare regimens. It is imperative to address misleading claims made about essential oils on the internet that may lead to a delay or lack of proper treatment. Thus, a balanced and informed approach to the use of essential oils is needed to maximize the potential benefits and reduce any risks associated with its use. The use of many of these oils in insecticidal and cosmeceutical formulations represents a promising area for future research.

Manuscript Legend

Lavender essential oil: LEO
Frankincense essential oil: FREO
Geranium essential oil; GEO
Myrrh essential oil: MEO
Neroli essential oil: NEO
Patchouli essential oil: PEO
Rose essential oil: REO
Tea tree essential oil: TTEO
Ylang-ylang essential oil: YEO
Lemongrass essential oil: LMEO
Sandalwood essential oil: SEO
Carrot seed essential oil: CSEO

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CONFLICTS OF INTEREST

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Table 1. Reported Benefits and Risks of Common Essential Oils in Dermatology

Essential Oil	Reported In-Vitro Benefits	Reported In-Vivo Benefits	Risks
Lavender Essential Oil (LEO)	- Antibacterial against surface infections by *S. pyogenes*, *S. Aureus* and *E. coli*[15] - Increased concentration-dependent production of key signaling molecules involved in wound healing[18]	- Promotes hair growth in patients with alopecia areata[20] - Reduces inflammation by decreasing cytokine production and assists in chronic wound healing by inhibiting macrophage pyroptosis[19] - Induces relaxation via decreases in autonomic stimulation[22–25] - May be effective in treatment-resistant acne[12,15]	- Endocrine disrupting effects including premature thelarche and prepubertal gynecomastia[26–29] - Contact dermatitis[30–35] - Photoallergic reactions[31]
Frankincense Essential Oil (FREO)	- Anti-inflammatory via production of tissue remodeling molecules and decreased proliferation of fibroblasts[42,43] - Antimicrobial against *P. acnes*, *Malassezia* spp. *C. albicans*, *Trichophyton* spp.[44,45] - Anti-tumoral properties via cytotoxic and cytostatic effects[46, 47] - Enhances skin permeability of other transdermal drugs[49]	- FREO microemulsion (oil content 7.8%) displayed higher anti-inflammatory effects when compared to piroxicam in NSAID gel upon transdermal application[41] - Decreases erythema in skin conditions such as atopic dermatitis and psoriasis[51] - Enhances skin perfusion[50]	- Blistering reactions when misused ex. for mole removal[3]
Geranium Essential Oil (GEO)	- Anti-inflammatory via antiproliferative activity against dermal fibroblasts[42] - Reduces and prevents oxidative stress[57] - Antimicrobial and antiparasitic effects, with antifungal effects against *M. gypseum*, *M. canis*, and *T. mentagrophytes*[58–60] - Photoprotective effects when combined with calendula essential oil[57]	- Dose-dependent anti-inflammatory properties in rodent models[54,55] - Promotes hair growth through regulation of growth factors and the involved cellular response[61] - Can be effective when used as a component of bug repellant[62–64]	Limited data on adverse effects, further research needed
Myrrh Essential Oil (MEO)	- Antibacterial against *E. coli*, *V. cholerae*, and *S. typhi Ty2*[68] - Antifungal against *C. albicans*, *A. niger*, *P. funiculosum*, and *P. notatum*[68]	- Promotes wound healing via increased wound contraction, shorter re-epithelialization times and increased wound tensile strength[68]	- Allergic contact dermatitis[69–71]
Neroli Essential Oil (NEO)	- Antibacterial against *P. aeruginosa*[72] - Antifungal against *S. cerevisiae* and *C. albicans*[72] - Anti-inflammatory by blocking mitogen-activated protein kinase pathway[72,73]		- Contact dermatitis[74,75] - Photoallergic reactions[75]
Patchouli Essential Oil (PEO)	- Antibacterial against *P. acnes* and *S. epidermidis*[80] - Promotes wound healing[42]	- Sedative properties when inhaled[81] - Anti-aging via antioxidant free radical scavenging[82,83] - Anti-insecticidal properties against mosquitos[84]	Limited data on adverse effects, further research needed
Rose Essential Oil (REO)	- Antibacterial activity against *P. aeruginosa*, *E. coli*, *C. violaceum*, and *S. Aureus*[93,94] - Antifungal against *P. notatum*, *A. niger*, and *C. albicans*[95] - Antioxidant properties when mixed with clove oil[90] - Promotes wound healing by reducing both oxidative and inflammatory biomarkers[92] - Pain relief via TRPV1 receptor activation[98]	- Hydrating and improved skin barrier function when coupled with tea tree essential oil[88] - Induces relaxation[96,97]	- Allergic contact dermatitis[101–103] - Potential sensitization in cosmetic workers[104]
Tea Tree Essential Oil	- Antibacterial against *P. acnes*[113] - Anti-inflammatory	- Effective in treatment of mild to moderate acne by reducing acne lesion	- Endocrine disrupting effects including

Essential Oil	Reported In-Vitro Benefits	Reported In-Vivo Benefits	Risks
(TTEO)	properties[106]	count and acne severity index[108–110,113] - Effective in the treatment of onychomycosis[114–117]	prepubertal gynecomastia[26,27] - Documented allergic reactions[106,111,113,119] - Potential irritation, burning, erythema[112]
Ylang-Ylang Essential Oil (YEO)	- Synergistic antibacterial activity *P. acnes* and *S. epidermidis* when combined with myrrh and petit grain oil[80] - Antioxidant properties[124] - Promotes wound healing and scar prevention by decreasing proliferation of human fibroblasts and inhibiting tissue remodeling biomarkers[42]	- Induces relaxation and mood regulation by increasing parasympathetic activity[122,123]	- Contact dermatitis and resultant hyperpigmentation[127–129] - High sensitization potential[138]
Lemongrass Essential Oil (LMEO)	- Antifungal activity against *C. tropicalis* strains[143] - Antioxidant by reducing expression of inflammatory cytokines, oxidative stress, and hydrocarbon induced DNA damage[144] - Anti-aging via high antioxidant activity[145] - Antitumoral effects when combined with Geraniol and Citral oil[141]		Limited data on adverse effects, further research needed
Sandalwood Essential Oil (SEO)	- Antibacterial activity against antibiotic resistant bacteria such as MRSA and VRSA[146] - Anti-inflammatory by decreasing pro-inflammatory enzymes[147] - Anti-proliferative properties including inducing autophagy and cell cycle death in actively proliferating keratinocytes[148,149]	- Antiviral properties against herpes simplex virus, human papillomavirus, and molluscum contagiosum virus[148]	- Contact allergen with high sensitization prevalence[138]
Carrot Seed Essential Oil (CSEO)	- Antimicrobial properties[156] - Antioxidant properties[156] - Anti-inflammatory properties - Skin rejuvenation based on its stability and free radical scavenging ability[157] - Protection against UV radiation by decreasing collagen bundle disorganization[157]		- Moderate cytotoxic effects on certain cell lines[158] - SPF claims may be misleading[159]

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