

THERAPEUTIC EVALUATION OF GERANIUM AND LAVENDER ESSENTIAL OILS IN ORAL CAVITY DISORDERS

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Abstract

The increasing interest in plant-based therapies has highlighted the therapeutic potential of essential oils in oral health. This review evaluates the effectiveness of *Pelargonium graveolens* (Geranium) and *Lavandula angustifolia* (Lavender) essential oils in the prevention and management of oral cavity disorders. These oils exhibit broad antimicrobial, anti-inflammatory, antioxidant, analgesic, and wound-healing properties, making them suitable for treating gingivitis, aphthous ulcers, oral candidiasis, and halitosis. In vitro and in vivo studies support their activity against common oral pathogens such as *Streptococcus mutans* and *Candida albicans*, as well as their modulatory effects on pro-inflammatory cytokines. Clinical data, though limited, suggest promising results in reducing plaque, inflammation, and discomfort. Their pleasant aroma and low toxicity also support patient acceptability and compliance. However, the lack of standardized formulations and long-term clinical trials presents challenges. Further research is necessary to establish evidence-based guidelines and integrate these essential oils effectively into dental care. This review highlights their potential as natural, complementary agents in modern oral therapeutics.

Keywords: Essential oils, geranium, lavender, oral health, antimicrobial therapy

Introduction

The rising interest in natural and plant-based therapeutics has driven significant attention toward essential oils, particularly for their antimicrobial, anti-inflammatory, and wound-healing properties. In dentistry, where microbial control and soft tissue healing are critical, the use of essential oils has emerged as a promising adjunct to conventional therapies. Among the numerous essential oils investigated, *Pelargonium graveolens* (Geranium) and *Lavandula angustifolia* (Lavender) have gained recognition due to their broad spectrum of biological activities and long-standing use in traditional medicine [1-3].

Oral cavity disorders, ranging from gingivitis and aphthous ulcers to candidiasis and halitosis, often involve chronic inflammation, microbial imbalance, and

mucosal sensitivity. Conventional management typically relies on chemical antiseptics, antifungals, and corticosteroids, which, although effective, may lead to side effects such as mucosal irritation, altered taste, or microbial resistance. In this context, essential oils represent a viable alternative or complementary solution that can modulate inflammation, control microbial growth, and promote mucosal regeneration with a potentially lower risk profile [2-4].

Geranium essential oil is derived from the leaves and stems of *Pelargonium graveolens* and is rich in active compounds, including citronellol, geraniol, and linalool, which are known for their antimicrobial and anti-inflammatory properties. Lavender oil, extracted from *Lavandula angustifolia*, contains linalool and linalyl acetate as

major constituents, offering sedative, analgesic, and antifungal effects. Both oils have been widely investigated in dermatology and aromatherapy, but their roles in oral healthcare are still emerging [1-4].

This review aims to evaluate the therapeutic potential of these two essential oils in the context of oral cavity disorders. It will focus on their phytochemical composition, mechanisms of action relevant to oral pathology, in vitro and in vivo evidence, and available clinical data. Particular attention will be given to their antimicrobial properties against oral pathogens such as *Candida albicans*, *Streptococcus mutans*, and *Porphyromonas gingivalis*, as well as their anti-inflammatory and wound-healing capacities on oral mucosa.

Moreover, the increasing demand for non-toxic, biocompatible, and natural alternatives in dentistry underscores the importance of validating essential oils through rigorous scientific research. While many commercial products incorporate essential oils as flavoring agents or antiseptics, their therapeutic concentrations, formulation stability, and efficacy in oral disease management remain insufficiently standardized [4-8].

The integration of *Pelargonium graveolens* and *Lavandula angustifolia* into evidence-based dental practice requires a thorough understanding of their biological effects, safety profile, and therapeutic limitations. This review, therefore, provides a comprehensive analysis of the current literature, identifies knowledge gaps, and explores the feasibility of incorporating these natural agents into routine oral care protocols, particularly for inflammatory and infectious conditions of the oral cavity.

Botanical and chemical profile

Pelargonium graveolens, commonly known as rose-scented geranium, is a perennial plant native to southern Africa, cultivated extensively for its aromatic

properties. The essential oil is typically obtained by steam distillation of its leaves and stems and is widely used in aromatherapy, dermatology, and now increasingly in oral health applications. *Lavandula angustifolia*, commonly referred to as true lavender, is a Mediterranean species known for its soothing fragrance and therapeutic qualities. Its essential oil is extracted from the flowering tops and is well-recognized for its antimicrobial and anti-inflammatory potential [5-9].

Geranium essential oil (GEO) is composed primarily of monoterpenoids and sesquiterpenes. The major bioactive components include citronellol, geraniol, linalool, and isomenthone, which contribute to its broad-spectrum antimicrobial activity. Citronellol and geraniol are particularly effective against Gram-positive and Gram-negative bacteria, as well as various fungi. These constituents exhibit membrane-disruptive properties, increasing permeability and leading to microbial cell death. In addition to their antimicrobial effects, they also display anti-inflammatory actions by modulating pro-inflammatory mediators such as prostaglandins and cytokines [4,6-9].

Lavender essential oil (LEO) contains two dominant components: linalool and linalyl acetate, both of which have been shown to possess sedative, antinociceptive, and antimicrobial effects. Linalool is known for its ability to disrupt microbial cell membranes, similar to GEO compounds, and for its inhibitory effects on the synthesis of nitric oxide and inflammatory cytokines. Linalyl acetate, while less potent antimicrobially, contributes to the oil's calming and healing effects, which can aid in reducing discomfort in patients with painful oral lesions or mucosal inflammation [5,9-11].

Both GEO and LEO are characterized by low molecular weight, lipophilic nature, and high volatility, allowing for effective penetration of biological membranes, including the oral

mucosa. This property makes them particularly useful for topical applications in the oral cavity, whether in mouth rinses, gels, or lozenges. Moreover, their pleasant aroma contributes to patient compliance and may reduce anxiety during treatment [8-11].

Studies using gas chromatography-mass-mass spectrometry (GC-MS) have

confirmed the presence and concentration of these key compounds in high-quality essential oils. This analytical method is essential for identifying adulterations or variability in commercial preparations, a critical step when translating laboratory evidence to clinical use [9-12].

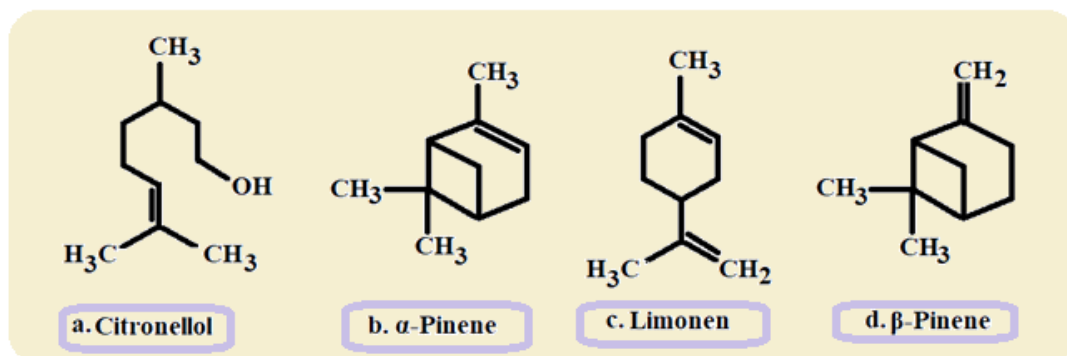


Figure 1. The most important phytonutrients found after the GC-MS exam (a.Citronellol, b.α-Pinene, c. Limonene, d.β-Pinene)

Table 1 summarizes the main bioactive compounds in *Pelargonium graveolens* and *Lavandula angustifolia* essential oils, including their chemical class, biological effects, and target actions

relevant to oral pathology. It highlights their antimicrobial, anti-inflammatory, and healing roles in dental applications based on existing phytochemical evidence [4,6-12].

Table 1. Key compounds in geranium and lavender essential oils

Essential oil	Major compound	Chemical class	Biological effects	Target pathogens/effects
Geranium (<i>Pelargonium graveolens</i>)	Citronellol	Monoterpenoid	Antimicrobial, anti-inflammatory, and membrane disruption	Gram-positive / Gram-negative bacteria, fungi
Geranium (<i>Pelargonium graveolens</i>)	Geraniol	Monoterpenoid	Antimicrobial, anti-inflammatory, and membrane disruption	Gram-positive / Gram-negative bacteria, fungi
Geranium (<i>Pelargonium graveolens</i>)	Linalool	Monoterpenoid	Antimicrobial, anti-inflammatory, anxiolytic	Inhibits NO and cytokines, microbial membranes
Lavender (<i>Lavandula angustifolia</i>)	Linalool	Monoterpenoid	Antimicrobial, anti-inflammatory, analgesic	Inhibits NO and cytokines, microbial membranes
Lavender (<i>Lavandula angustifolia</i>)	Linalyl acetate	Ester	Calming, wound healing	Reduces discomfort, enhances healing in oral lesions

Lavender (<i>Lavandula angustifolia</i>)	α -Pinene	Monoterpene	Antimicrobial, bronchodilator, antioxidant	Inhibits oral bacteria and biofilm formation
Lavender (<i>Lavandula angustifolia</i>)	β -Pinene	Monoterpene	Antimicrobial, anti- inflammatory, antibacterial	Targets bacterial inflammation and oxidative stress

The composition of these essential oils can vary depending on multiple factors such as plant chemotype, geographical origin, cultivation conditions, harvest timing, and extraction methods. Standardization of oil composition is crucial when used in clinical settings to ensure reproducibility and efficacy. For example, citronellol-rich chemotypes of geranium may have stronger antimicrobial properties, while lavender oils with high linalool content may be more effective in modulating inflammation [10-13].

Understanding the botanical origin and chemical profile of *Pelargonium graveolens* and *Lavandula angustifolia* is fundamental to assessing their therapeutic value. Their bioactive constituents offer a multifaceted approach to managing oral cavity disorders, providing antimicrobial, anti-inflammatory, analgesic, and healing effects. As natural products, their appeal is enhanced by a generally favorable safety profile and low incidence of side effects when used appropriately [10-14].

Mechanisms of action in oral pathology

The therapeutic effectiveness of *Pelargonium graveolens* (Geranium) and *Lavandula angustifolia* (Lavender) essential oils in oral cavity disorders is primarily attributed to their complex phytochemical composition and multiple biological activities. Their mechanisms of action involve antimicrobial, anti-inflammatory, antioxidant, analgesic, and wound-healing effects that target key pathological processes commonly seen in oral diseases such as gingivitis, stomatitis, oral candidiasis, halitosis, and aphthous ulcers [13-16].

Table 2 outlines the primary mechanisms by which geranium and lavender essential oils exert therapeutic effects in oral cavity disorders. It highlights key bioactive compounds, their biological targets, and specific clinical benefits, including antimicrobial, anti-inflammatory, antioxidant, analgesic, and wound-healing actions relevant to oral health. [8,10-16].

Table 2. Mechanisms of action of geranium and lavender essential oils in oral pathology

Mechanism of action	Key compounds	Biological target	Therapeutic relevance in oral pathology
Antimicrobial	Citronellol, Geraniol, Linalool	Microbial membranes	Disrupts <i>S. mutans</i> , <i>P. gingivalis</i> , and <i>C. albicans</i> biofilm
Anti-inflammatory	Linalool, Citronellol	NF- κ B, IL-1 β , TNF- α , IL-6	Reduces gingival inflammation, mucosal swelling, and pain
Antioxidant	Geraniol, Linalool	Reactive oxygen species (ROS)	Prevents oxidative damage in chronic inflammation
Analgesic	Linalool	NMDA/glutamate receptors	Reduces nociception in aphthous ulcers, surgical wounds
Wound healing	Citronellol, Geraniol	Fibroblasts, epithelial regeneration	Accelerates healing of oral ulcers, post-extraction sites

One of the most significant properties of both essential oils is their broad-spectrum antimicrobial activity. The key compounds—citronellol, geraniol, and linalool—exert bactericidal and fungicidal effects by disrupting the integrity of microbial cell membranes. These lipophilic molecules insert into the phospholipid bilayer, increasing membrane permeability and leading to leakage of intracellular contents. This mechanism has been confirmed in vitro against common oral pathogens including *Streptococcus mutans*, *Porphyromonas gingivalis*, *Actinomyces spp.*, and *Candida albicans*. Notably, geranium and lavender oils have demonstrated synergistic effects when used in combination with conventional antimicrobials, reducing the required dose and potentially minimizing microbial resistance [12-16].

Anti-inflammatory activity is another vital mechanism, especially relevant in conditions such as gingivitis and mucositis. Linalool and citronellol have been shown to inhibit the release of pro-inflammatory cytokines such as IL-1 β , TNF- α , and IL-6 by modulating NF- κ B signaling pathways. These compounds also reduce the production of prostaglandins and nitric oxide, mediators known to exacerbate inflammation and pain in oral tissues. Such

activity helps decrease edema, erythema, and discomfort associated with soft tissue lesions [12-16].

Antioxidant effects further support tissue protection and regeneration. The reactive oxygen species (ROS)-scavenging ability of lavender and geranium oils reduces oxidative stress in inflamed mucosal tissues, aiding in cellular repair. This mechanism is essential in chronic inflammatory conditions, where oxidative damage contributes to delayed healing and epithelial degeneration [14-16].

Analgesic effects, although less extensively studied, have been observed in both animal and human models. Linalool, in particular, interacts with glutamate and NMDA receptors, reducing neuronal excitability and nociception. This can be beneficial in painful oral lesions such as aphthae or post-extraction wounds, where topical application of essential oils may offer symptomatic relief [14-17].

Additionally, wound-healing properties of these oils have been linked to enhanced fibroblast proliferation, improved collagen synthesis, and increased re-epithelialization. Studies indicate that low concentrations of geranium oil accelerate the closure of epithelial defects, suggesting potential applications in post-surgical oral care or in treating traumatic ulcers [15-17].

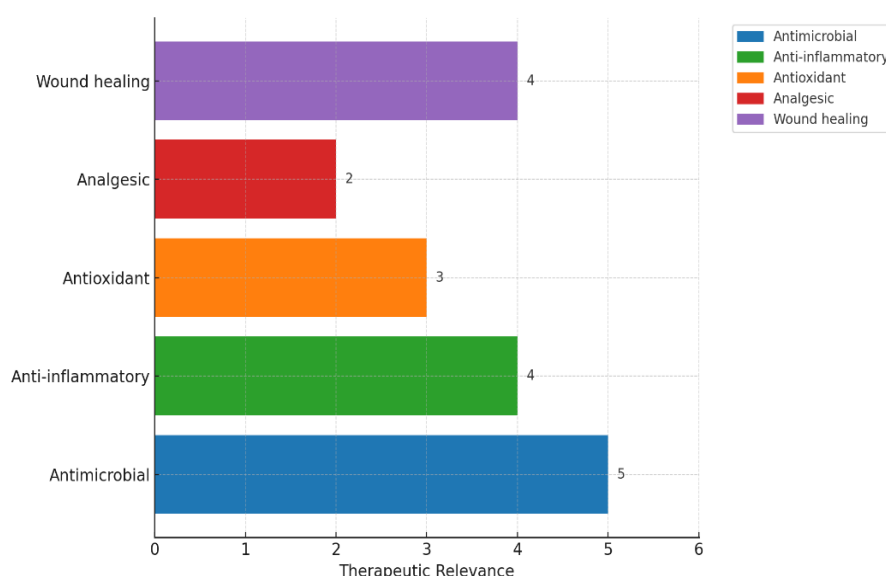


Figure 2. The graph illustrates the relative therapeutic relevance of key mechanisms by which geranium and lavender essential oils act in oral care, emphasizing antimicrobial and anti-inflammatory properties as confirmed by GC-MS [11,14-17].

These combined mechanisms allow geranium and lavender essential oils to modulate multiple aspects of oral pathology simultaneously. Their actions not only suppress pathogenic microbial load but also create a favorable environment for tissue recovery. The multifactorial effects are especially valuable in patients seeking natural alternatives to synthetic medications or in those with hypersensitivity to standard antiseptics [14-17].

In vitro and in vivo evidence

Several in vitro and in vivo studies have investigated the therapeutic potential of *Pelargonium graveolens* and *Lavandula angustifolia* essential oils in the context of oral health. The majority of this evidence supports their antimicrobial, anti-inflammatory, and healing effects, with promising implications for clinical application in oral cavity disorders [6,14-17].

In vitro studies demonstrate strong antibacterial and antifungal activity of both oils against common oral pathogens. Geranium oil exhibits inhibitory effects against *Streptococcus mutans*, *Porphyromonas gingivalis*, *Fusobacterium*

nucleatum, and *Candida albicans*, often at relatively low concentrations. These effects are attributed primarily to citronellol and geraniol, which disrupt bacterial cell membranes and interfere with biofilm formation. Lavender oil has shown comparable effects, particularly against *C. albicans* and *Staphylococcus aureus*, due to the action of linalool and linalyl acetate. Notably, both oils impair microbial adhesion and reduce biofilm viability, which is crucial in the prevention of dental plaque and mucosal infections [15-17].

In vitro anti-inflammatory assays have revealed reduced levels of TNF- α , IL-1 β , and IL-6 in human gingival fibroblasts and epithelial cells exposed to essential oil components. This supports their role in managing inflammatory oral conditions such as gingivitis, stomatitis, and lichen planus [9,14-17].

Animal studies further validate the wound-healing and antimicrobial effects of these oils. In rodent models with induced oral ulcers or gingival inflammation, topical application of geranium or lavender oil led to accelerated healing, reduced ulcer size, and decreased inflammatory cell infiltration. Histological analysis revealed

improved epithelial regeneration and collagen organization. Some studies also reported analgesic responses in treated groups, consistent with the oils' known action on sensory pathways [15-18].

Despite encouraging data, clinical trials in human subjects are limited. Preliminary pilot studies using lavender oil-containing mouthwashes or gels have shown reductions in plaque index, gingival inflammation, and oral pain. However, more randomized controlled trials with standardized formulations and dosages are needed to confirm efficacy and establish safety profiles for routine dental use [16-18].

Clinical applications in oral disorders

The therapeutic use of *Pelargonium graveolens* and *Lavandula angustifolia* essential oils in dentistry has gained attention due to their antimicrobial, anti-inflammatory, and healing properties. While clinical data remain limited, emerging evidence supports their adjunctive role in managing various oral cavity disorders, particularly in patients seeking natural, well-tolerated alternatives [16-19].

In gingivitis and periodontitis, lavender and geranium oils have demonstrated potential as active ingredients in mouthwashes and gels. Their ability to reduce microbial load and modulate inflammation contributes to improved gingival health. Preliminary studies have reported significant decreases in plaque index, gingival bleeding, and subjective symptoms such as pain and swelling after using lavender-based rinses. Geranium oil, applied topically in gels, has shown similar effects by decreasing pro-inflammatory cytokines and promoting epithelial healing [14,16-19].

For oral candidiasis, especially in immunocompromised or denture-wearing individuals, both oils offer antifungal effects against *Candida albicans*. In vitro data support their fungistatic and fungicidal

activity, and topical formulations such as sprays or rinses may reduce fungal colonization and mucosal inflammation. Clinical application remains experimental, though some case reports describe symptomatic relief and improved mucosal appearance [16-20].

In recurrent aphthous stomatitis and traumatic ulcers, essential oils can reduce discomfort and accelerate healing. Lavender oil's analgesic and calming effects, along with geranium's regenerative properties, make them suitable for inclusion in mucoadhesive gels or patches. Their local anti-inflammatory action helps limit ulcer size and duration, and their pleasant aroma can increase patient compliance. For halitosis, essential oils offer dual action by targeting anaerobic bacteria and neutralizing malodor compounds. Lavender, in particular, is effective in masking unpleasant odors, while geranium has shown antibacterial activity against *Fusobacterium nucleatum*, a key producer of volatile sulfur compounds [17-20].

Safety profile and contraindications

The use of *Pelargonium graveolens* and *Lavandula angustifolia* essential oils in oral care is generally regarded as safe when properly formulated and applied in appropriate concentrations. However, as with all bioactive natural products, safety considerations are essential to minimize adverse effects and ensure clinical efficacy [18-21].

Both geranium and lavender oils have a long history of use in traditional medicine, aromatherapy, and topical applications, with low toxicity reported in the majority of cases. When applied topically in diluted form, they are usually well tolerated by the oral mucosa. Mild adverse effects, such as transient burning sensations, dryness, or irritation, may occur, particularly in formulations with high concentrations or in individuals with sensitive mucosa. Proper dilution, usually

within 0.5% to 2% in oral products, is crucial to avoid mucosal damage [19-22].

Allergic reactions, although rare, have been documented. Linalool, geraniol, and citronellol—major components of these oils—are recognized as potential allergens under the EU Cosmetics Regulation. Patch testing may be advisable in patients with a history of atopy or known sensitivities to fragrances or botanicals. Ingestion of essential oils is generally not recommended unless under strict professional supervision, as concentrated doses can lead to toxicity, including gastrointestinal or neurological symptoms [20-23].

Caution is advised when using essential oils in children under six years, pregnant or breastfeeding women, and immunocompromised patients, due to limited safety data in these groups. Although topical use in adults is considered safe, systemic absorption through oral mucosa, especially with repeated applications, warrants further study. In pediatric populations, the use of lavender oil has been associated in rare cases with hormonal disruption, although causality remains unconfirmed [19,21-23].

Research gaps and future perspectives

Despite encouraging preliminary evidence regarding the therapeutic use of *Pelargonium graveolens* and *Lavandula angustifolia* essential oils in oral care, several research gaps must be addressed to enable broader clinical adoption. Existing studies are predominantly in vitro or based on small-scale animal models, with a limited number of well-designed clinical trials evaluating efficacy, safety, and long-term outcomes in human populations [23-25].

One major limitation is the lack of standardized formulations. Variability in plant chemotype, extraction method, and oil composition can significantly affect biological activity. Establishing validated chemical profiles and defining therapeutic concentrations are critical for ensuring

reproducibility and consistency across studies and clinical applications. Moreover, commercial products often include essential oils in undefined concentrations, limiting the ability to draw comparisons between research findings and real-world use [25-27].

Despite the growing body of evidence supporting the therapeutic use of essential oils in oral medicine, several critical areas remain underexplored. The translational pathway from laboratory results to clinical practice is hindered by the lack of robust, large-scale studies, particularly those focusing on long-term efficacy, safety, and optimal dosing. The variability in plant sources and extraction techniques further complicates the standardization of essential oil-based products. Moreover, integrating natural compounds into biomedical applications requires interdisciplinary collaboration, drawing insights from fields such as regenerative medicine, polymer science, diagnostic imaging, and biomaterials research. Investigations into advanced delivery systems, such as bioadhesive formulations, hydrogels, or 3D-printed scaffolds, may open new therapeutic avenues. Additionally, the incorporation of artificial intelligence in diagnosis and treatment planning, as well as the use of imaging technologies for outcome evaluation, could significantly enhance the precision and applicability of these therapies [28-38].

There is also insufficient data on optimal delivery systems in the oral cavity. While mouthwashes, gels, sprays, and lozenges are suggested vehicles, few studies have assessed their pharmacokinetics, mucosal penetration, or interaction with saliva and oral microbiota. Research on nanocarrier-based or mucoadhesive systems may enhance bioavailability and patient adherence, particularly for lesions located in hard-to-reach oral sites [39-41].

Long-term safety studies are lacking, particularly regarding chronic

exposure and systemic absorption through the oral mucosa. While essential oils are generally recognized as safe, their cumulative effects, especially in vulnerable groups such as children, the elderly, or immunocompromised patients, remain unclear. Future research should prioritize dose-response analyses and explore any potential endocrine, cytotoxic, or microbiome-disruptive consequences [40-44].

Conclusion

Pelargonium graveolens and *Lavandula angustifolia* essential oils demonstrate promising therapeutic potential in managing various oral cavity disorders due to their antimicrobial, anti-inflammatory, analgesic, and wound-healing properties. In vitro and in vivo

studies support their effectiveness against key oral pathogens and inflammatory mediators, while early clinical applications show encouraging results in conditions such as gingivitis, candidiasis, and aphthous ulcers. Their favorable safety profile, pleasant aroma, and patient acceptability make them attractive as adjunctive agents in oral care. However, the lack of standardized formulations, limited human trials, and insufficient long-term safety data highlight the need for further research. Future efforts should focus on formulation development, controlled clinical trials, and integration with existing dental protocols. Overall, these essential oils represent a valuable natural alternative with the potential to enhance current approaches in oral medicine.

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