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Review Article

# The impact of herbal and natural products in managing oral health: A pharmacological perspective

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## Abstract

The pharmacological efficacy, low side effects, and affordability of herbal and natural remedies have made them popular alternative therapeutic agents for treating oral health concerns. The pharmacological qualities of popular herbal and natural remedies for oral illnesses, including neem (Azadirachtaindica), clove (Syzygiumaromaticum), aloe vera (Aloe barbadensis), and green tea (Camellia sinensis), are rigorously assessed in this article. These bioactive substances are useful in the prevention and treatment of diseases such dental caries, gingivitis, periodontitis, and oral mucositis because they have antibacterial, anti-inflammatory, antioxidant, and analgesic qualities. The article also covers developments in the creation of herbal mouthwashes, toothpastes, and gels, as well as how they are incorporated into contemporary dentistry procedures. The review also stresses the necessity for thorough clinical trials to confirm the therapeutic potential of herbal preparations and points out the shortcomings of existing research, including inconsistent methodology and a lack of standardisation in these preparations. This article offers a thorough analysis of the function of herbal and natural products in advancing long-term oral healthcare solutions by fusing traditional knowledge with current pharmacological research.

**Keywords:** Herbal products, Oral health, Natural remedies, Pharmacological properties, Bioactive compounds.

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## 1. Introduction

### *1.1. Importance of oral health*

A fundamental part of overall health, dental health is crucial for maintaining physiological balance and quality of life. The oral cavity has a dynamic microbiota that, when imbalanced owing to poor hygiene, diet, or systemic disorders, can contribute to dental caries, gingivitis, periodontitis, and even oral malignancies. These problems not only disrupt fundamental activities like speech and mastication but also contribute to systemic diseases such as diabetes and cardiovascular disorders through microbial translocation and inflammation.[1,2] Untreated oral disorders constitute a huge global health burden, disproportionately impacting impoverished communities. Conventional dental care products, despite their effectiveness, have limitations such toxicity, high costs, and antibiotic resistance. This has generated interest in herbal and natural products as safer, cost-effective, and eco-friendly alternatives.[3,4]

Traditional medicine systems have long used herbal medicines for oral health, and scientific research has proven their pharmacological effects. Bioactive chemicals in herbs including neem, clove, turmeric, and green tea demonstrate antibacterial, anti-inflammatory, antioxidant, and wound-healing activities. These chemicals help limit bacterial adhesion, neutralize free radicals, and control inflammation, improving oral health.[5-7] Herbal products accord with holistic and preventative healthcare principles, offering biocompatibility and low adverse effects. Modern oral care includes natural products like essential oil rinses, propolis-

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based toothpaste, and aloevera gels, promoting safer, research-backed therapies.[8] Advancing herbal pharmacology involves rigorous clinical trials, formulation standardization, and regulatory frameworks to ensure efficacy and safety. Research into herbal oral care not only solves traditional medicine's shortcomings but also corresponds with the global shift toward integrative and sustainable healthcare.[9,10]

### *1.2. Limitations of conventional treatments*

Traditional dentistry techniques, including invasive operations, drugs, and synthetic oral care products, have efficiently controlled oral disorders such periodontitis, gingivitis, and dental caries. However, chemical-based products like fluoride, triclosan, and chlorhexidine entail concerns such as tooth discolouration, mucosal irritation, dysbiosis, and systemic toxicity. Additionally, the abuse of chemical antimicrobials has lead to antimicrobial resistance (AMR), complicating the management of persistent oral infections.[10,11]

Invasive procedures including scaling, root planing, and operations, though necessary in extreme situations, are costly, entail extensive recovery times, and may cause postoperative discomfort and infections. Synthetic materials in restorations can potentially elicit hypersensitivity and allergic reactions, further compromising treatment outcomes.[13,14]

A fundamental shortcoming of conventional approaches is their reactive character, addressing symptoms rather than root causes. Fluoride treatments, for example, help remineralize enamel but do not cure microbial imbalances or inflammatory processes. Moreover, synthetic oral care products contribute to environmental degradation, with microplastics in toothpaste and alcohol-based compounds in mouthwashes generating sustainability issues.[15]

These shortcomings underscore the need for safe, cost-effective, and eco-friendly solutions. Herbal and natural remedies offer promise advantages with low side effects, utilizing bioactive components for excellent dental care. This transition enables an integrative, patient-centered approach to sustainable dental healthcare.[16,17]

### *1.3. Role of herbal and natural products*

Because of their many pharmacological characteristics and compatibility with holistic healthcare methods, herbal and natural medicines have attracted a lot of interest in the field of managing oral health. These products, which are made from natural or plant-based ingredients, have a wide range of therapeutic advantages, such as antibacterial, anti-inflammatory, antioxidant, and wound-healing properties. Herbal and natural solutions work together to address the root causes of oral disorders while fostering the balance of the oral environment, in contrast to traditional oral care therapies that frequently target certain symptoms or pathogens. Its ability to prevent dental caries, manage gingivitis, reduce plaque formation, and alleviate halitosis is well known. Ingredients such as neem (Azadirachtaindica), clove (Syzygiumaromaticum), turmeric (Curcuma longa), green tea (Camellia sinensis), aloe vera (Aloe barbadensis), and liquorice (Glycyrrhizaglabra) support these benefits.[18,19]

Numerous studies have examined the pharmacological mechanisms underlying these benefits, identifying bioactive substances as polyphenols, tannins, alkaloids, flavonoids, and essential oils. These substances have a wide range of effects, including as scavenging free radicals, modifying inflammatory pathways, inhibiting bacterial adhesion, and interfering with the formation of biofilms. For example, eugenol from clove oil is frequently utilised for its analgesic and antibacterial qualities in dental pain management, while green tea polyphenols such as epigallocatechingallate (EGCG) have shown extraordinary efficacy in suppressing Streptococcus mutans, a critical pathogen in dental caries. These processes demonstrate how natural and herbal items can be used as both therapeutic and preventative measures in oral healthcare.[20]

Natural and herbal products are especially appealing in areas with limited access to traditional dental treatment and are consistent with the tenets of sustainable healthcare. By utilising locally accessible materials and traditional knowledge systems, these items frequently offer affordable alternatives to enhance oral health outcomes for marginalised communities. In addition to improving the accessibility of these goods, programs encouraging the production and sale of medicinal plants also support rural economic development. The market for herbal and natural oral care products faces difficulties with standardisation, quality control, and regulatory supervision despite their promising function. The consistency and effectiveness of these goods may be impacted by variations in the concentration of bioactive chemicals, a lack of thorough clinical trials, and poor labelling procedures. In order to firmly establish the place of herbal and natural medicines in mainstream oral healthcare, it will be essential to address these concerns through sophisticated extraction methods, thorough clinical research, and adherence to international regulatory requirements. Herbal and natural products have the potential to revolutionise oral health management by providing safer, more sustainable, and more effective answers to the world's oral health problems as the fusion of ancient knowledge with contemporary pharmacological insights continues to advance.[21-23]

## 2. Pharmacological Properties of Herbal Products

### *2.1. Antimicrobial activity.*

Herbal remedies play a key role in dental health due to their robust antibacterial effects. The oral cavity supports a complex microbial ecology, and imbalances can contribute to disorders like dental caries, gingivitis, and candidiasis. Rich in bioactive components, herbal treatments efficiently battle

pathogenic microorganisms while maintaining microbiome balance.[24,] Phytochemicals such as polyphenols, alkaloids, tannins, flavonoids, and essential oils contribute to antibacterial action. Green tea polyphenols disrupt bacterial communication and biofilms, while essential oils including eugenol (clove) and thymol (thyme) permeate microbial membranes, triggering cell death. Neem inhibits Streptococcus mutans adhesion, turmeric (curcumin) decreases oxidative stress, and aloe vera combats Candida infections. Herbal rinses using liquorice or tea tree oil significantly lower bacterial burden without changing the microbiome, often complementing conventional treatments.[26-29] Unlike synthetic antimicrobials, herbal medicines have a lesser chance of resistance due to their multi-target mechanisms. Their antibacterial, anti-inflammatory, and antioxidant capabilities give holistic oral health advantages. However, issues like formulation consistency and clinical validation must be overcome to enable widespread use. Integrating ancient wisdom with current research, herbal medications offer sustainable and effective solutions for oral healthcare.[30-31]

### *2.2. Anti-inflammatory and antioxidant effects*

Herbal products have a key part in dental health by giving anti-inflammatory, antioxidant, and analgesic properties. Inflammation-driven illnesses like gingivitis, periodontitis, and mucositis can lead to tissue damage and bone loss, while oxidative stress further exacerbates oral disorders. Herbal medicines provide a dual approach by lowering inflammation and oxidative damage, encouraging tissue healing and dental health.[32]

Bioactive substances in herbal products reduce pro-inflammatory mediators such COX-2, TNF-α, and interleukins. Curcumin (Curcuma longa) inhibits NF-κB pathways, aiding in periodontitis management, whereas glycyrrhizin (Glycyrrhiza glabra) lowers gingival inflammation. Antioxidants like EGCG in green tea (Camellia sinensis) scavenge ROS and protect against oxidative stress-related diseases like leukoplakia. Aloe vera (Aloe barbadensis) improves wound healing, while eugenol (Syzygium aromaticum) provides both anti-inflammatory and analgesic properties, making herbal formulations beneficial in oral care.[33-36] Herbal analgesics work on neuronal pain pathways and inflammatory mediators. Clove oil (eugenol) inhibits COX enzymes, lowering pain, while curcumin downregulates nociceptive sensitivity, helping disorders like mucositis. Menthol in peppermint (Mentha piperita) gives cooling comfort, while aloe vera and chamomile (Matricaria chamomilla) soothe soft tissue injuries. Their complex effects make herbal analgesics safer alternatives to synthetic painkillers, decreasing negative effects like mucosal irritation and resistance development.[37-40] Herbal formulations such as gels, rinses, and lozenges are gaining popularity for their effectiveness in oral care. With increased demand for natural alternatives, continued research on formulation standardization and clinical validation will strengthen their role in evidence-based dentistry.[41-43]

### *2.3. Anticariogenic effects*

Herbal medicines' anticariogenic qualities are gaining recognized for their capacity to prevent and treat dental caries through antibacterial, remineralization, and biofilm-disrupting effects. Dental caries arises from acidogenic bacteria like Streptococcus mutans and Lactobacillus species, which demineralize enamel. Traditional therapies, such as fluoride and antibiotics, carry hazards such fluorosis and resistance, making herbal options safer and more sustainable.[44]

Herbal extracts limit bacterial growth and metabolism. Green tea (Camellia sinensis), rich in catechins like EGCG, impairs bacterial adherence, biofilm development, and acid generation. Neem (Azadirachta indica), with bioactive components such as quercetin and nimbidin, inhibits bacterial colonization and improves oral tissue healing. Clove (Syzygium aromaticum), contains eugenol, inhibits S. mutans and offers analgesic effects.[45,46] Herbal products also assist enamel remineralization. Liquorice (Glycyrrhiza glabra) components like glycyrrhizin increase calcium-phosphate deposition, while propolis, rich in flavonoids, protects against acid demineralization. Essential oils from thyme (Thymus vulgaris) and oregano (Origanum vulgare), containing thymol and carvacrol, destroy bacterial biofilms and impede quorum sensing. Herbal formulations in toothpaste, mouthwash, and chewing gum are gaining in popularity due to customer demand for natural alternatives.[47,48] Herbal anticariogenic drugs offer a holistic and sustainable approach to dental caries control. Further study is needed to standardize formulations, optimize delivery systems, and demonstrate clinical efficacy for greater incorporation into dental care.[49]

## 3. Applications in Oral Healthcare

### *3.1. Herbal formulations in dental products*

Herbal formulations in dental products provide natural, sustainable alternatives to synthetic treatments, leveraging antibacterial, anti-inflammatory, antioxidant, and anticariogenic qualities.[50] Herbal toothpaste, containing miswak (Salvadora persica), clove (Syzygium aromaticum), and neem (Azadirachta indica), efficiently prevents Streptococcus mutans growth and decreases plaque. Herbal mouth rinses with Aloe vera (Aloe barbadensis), green tea (Camellia sinensis), and tea tree oil (Melaleuca alternifolia) offer antibacterial and relaxing properties without alcohol-related adverse effects.[51] Herbal gels comprising liquorice (Glycyrrhiza glabra), chamomile (Matricaria chamomilla), and turmeric (Curcuma longa) assist in treating gingivitis, periodontal pockets, and ulcers. Turmeric gels alleviate inflammation, while chamomile and licorice give pain relief and antimicrobial properties. Herbal chewing gums and lozenges with eucalyptus (Eucalyptus globulus), peppermint

(Mentha piperita), and cinnamon (Cinnamomum verum) can minimize plaque development and freshen breath.[52,53] Advanced uses include propolis-enriched dental varnishes that stimulate remineralization and inhibit enamel demineralization. The increased demand for herbal dental products is driven by consumer awareness and regulatory backing, driving innovation in formulation technology for enhanced bioavailability and stability.[54] By blending ancient knowledge with current breakthroughs, herbal dental formulations offer safe, effective, and sustainable treatments, contributing to global efforts for eco-friendly oral healthcare. Ongoing research will further broaden their applications and influence in dentistry.

### *3.2. Mouthwashes*

Herbal mouthwashes provide a safer, effective alternative to alcohol-based formulations, addressing halitosis, plaque, gingivitis, and microbiological infections while avoiding mucosal dryness and irritation. Their bioactive phytochemicals have antibacterial, anti-inflammatory, antioxidant, and calming actions, making them increasingly attractive due to their biocompatibility and sustainability.[55] Key components include tea tree oil (Melaleuca alternifolia), which breaks bacterial biofilms, and neem (Azadirachta indica), high in nimbidin and azadirachtin, targeting cariogenic germs. Aloe vera (Aloe barbadensis) helps wound healing and decreases inflammation, helping ailments including oral lichen planus and aphthous ulcers. Green tea (Camellia sinensis), including catechins like EGCG, reduces Streptococcus mutans growth and combats halitosis.[56,57] Essential oils including peppermint (Mentha piperita), eucalyptus (Eucalyptus globulus), and thyme (Thymus vulgaris) boost antibacterial action and freshness. Chamomile (Matricaria chamomilla) and liquorice (Glycyrrhiza glabra) can treat xerostomia by relaxing and moisturizing the mucosa.[58] Driven by consumer demand, herbal mouthwashes now cater to specific demands such as cavity prevention, whitening, and sensitivity alleviation. Advancements in extraction technologies, nanoparticle incorporation, and bioavailability enhancement will further improve their efficacy. By merging ancient wisdom with modern science, these formulations offer a sustainable, side-effect-free approach to oral healthcare and preventive dentistry.[59]

### *3.3. Toothpastes*

Herbal toothpastes integrate natural components with sophisticated formulation techniques, delivering safe, biocompatible, and effective oral hygiene treatments. They address gum disease, plaque, poor breath, and dental cavities while matching with sustainable oral healthcare trends.[60] Key components include neem (Azadirachta indica), which combats Streptococcus mutans, decreasing plaque and gingival irritation. Clove oil (Syzygium aromaticum), high in eugenol, provides antibacterial, analgesic, and anti-inflammatory properties. Miswak (Salvadora persica) increases gum health, reduces plaque, and lowers microbial burden. Turmeric (Curcuma longa), containing curcumin, offers antibacterial, anti-inflammatory, and whitening effects. Liquorice (Glycyrrhiza glabra) prevents bacterial adhesion and decreases plaque, while aloe vera (Aloe barbadensis) soothes and improves post-surgical healing. Essential oils like peppermint (Mentha piperita) and spearmint (Mentha spicata) give breath freshness and antibacterial action.[61,62] Multi-herb preparations including neem, clove, and turmeric have synergistic effects, improving gum repair and bacterial control. Growing worries over synthetic chemicals like sodium lauryl sulfate and triclosan have fuelled the emergence of herbal alternatives, which are safer for delicate oral tissues. Innovations like nano-herbal compositions boost bioavailability and efficacy, while eco-friendly packaging matches with sustainability aims. As research improves, herbal toothpastes will continue improving, giving tailored, effective, and natural oral healthcare solutions.[8,38,60]

### *3.4. Gels*

Herbal gels provide an efficient, focused strategy for treating oral diseases by combining plant extracts with easy-to-apply formulations. Their semi-solid structure ensures extended contact and continuous release of bioactive components, making them appropriate for disorders like oral ulcers, periodontitis, and post-surgical wound care.[63] Key constituents include aloe vera (Aloe barbadensis), which relieves inflammation and promotes tissue regeneration, and turmeric (Curcuma longa), whose curcumin content decreases oxidative stress and gingival inflammation. Liquorice (Glycyrrhiza glabra) suppresses bacterial development and promotes ulcer healing, while neem (Azadirachta indica) decreases plaque formation and supports gum health. Clove oil (Syzygium aromaticum), high in eugenol, gives pain relief and antimicrobial action. Honey contains antibacterial and wound-healing qualities, notably good for mucositis. Essential oils like peppermint (Mentha piperita) and tea tree oil (Melaleuca alternifolia) aid in breath freshness and fungal infection control.[64,65] Natural polymers such as pectin and xanthan gum promote gel adhesion and controlled release. With increased demand for chemical-free oral care, herbal gels accord with holistic and sustainable healthcare. Continued research will broaden their function in addressing complex oral health conditions.[66]

### *3.5. Herbal chewing gums*

Herbal chewing gums have both mechanical and therapeutic benefits, aiding in the prevention of tooth cavities, periodontal disorders, and halitosis. By boosting salivary flow, they help neutralize acids, wash away microorganisms, and enhance oral defense mechanisms.[67] Key ingredients include neem (Azadirachta indica), which inhibits Streptococcus mutans and prevents plaque formation, clove (Syzygium aromaticum), rich in eugenol for pain relief and antimicrobial action, and licorice (Glycyrrhiza glabra), which

combats cariogenic bacteria and supports gum health. Herbal chewing gums give a handy, everyday oral care solution while supporting natural and sustainable dental health.

Herbal chewing gums combine therapeutic benefits with sensory appeal, aiding in dental hygiene and disease prevention. Licorice (Glycyrrhiza glabra) gives a slight sweetness, while cinnamon (Cinnamomum verum) combats oral malodor by lowering volatile sulfur compounds (VSCs). Tea tree oil (Melaleuca alternifolia) provides antifungal and antibacterial protection, making it excellent for dental infections and orthodontic care. Green tea (Camellia sinensis), rich in catechins, offers antioxidant and antibacterial effects, decreasing gum inflammation.[68] Natural sweeteners like xylitol further boost tooth health by blocking bacterial metabolism and biofilm formation. With increasing customer preference for natural mouth care, the global market for herbal gums is expanding. These formulations correspond with sustainable healthcare trends and continue to evolve with research advancements. **Table 1** enlists marketed formulations.[43,69]

## 4. Clinical Applications

### *4.1. Dental caries*

Dental caries develops from enamel demineralization due to acidic metabolites of Streptococcus mutans and Lactobacillus metabolism. While fluoride therapies remain key treatments, herbal alternatives offer antibacterial, remineralizing, and protective effects.[70] Neem (Azadirachta indica) reduces bacterial adhesion and biofilm development, lowering plaque and caries risk. Clove (Syzygium aromaticum), rich in eugenol, exerts antibacterial and analgesic properties, breaking bacterial cell walls and alleviating pain.[28,71] Propolis, including flavonoids and phenolic acids, reduces bacterial growth and enamel demineralization, while its antioxidants minimize oral oxidative stress. Green tea (Camellia sinensis), particularly EGCG, inhibits S. mutans growth and acid generation, increasing remineralization due to its fluoride concentration.[73]

**Table 1:** Applications of herbal formulations in oral healthcare with marketed formulations

| Product Type with Herbal Ingredients | Key Benefits | Marketed Formulations |
|---|---|---|
| **Toothpastes**<br>Neem (Azadirachtaindica), Clove (Syzygiumaromaticum), Miswak (Salvadorapersica), Turmeric (Curcuma longa), Licorice (Glycyrrhizaglabra), Aloe Vera (Aloe barbadensis) | Antibacterial, anti-inflammatory, antimicrobial, plaque control, gingivitis prevention, and gum health support. | - **Dabur Red Toothpaste** (Neem, Clove, and Mint) |
| | | - **Patanjali Dant Kanti** (Neem, Clove, and Mint) |
| | | - **Vicco Vajradanti** (Basil, Turmeric, and Clove) |
| | | - **Himalaya Complete Care Toothpaste** (Neem, Pomegranate) |
| **Mouthwashes**<br>Tea Tree Oil (Melaleucaalternifolia), Aloe Vera (Aloe barbadensis), Green Tea (Camellia sinensis), Eucalyptus (Eucalyptus globulus), Peppermint (Menthapiperita), Thyme (Thymus vulgaris) | Antimicrobial, anti-inflammatory, breath freshening, soothing, and plaque reduction. | - **Himalaya Herbal Mouthwash** (Aloe Vera, Neem, and Clove) |
| | | - **The Natural Dentist Healthy Gums Mouthwash** (Aloe Vera, Echinacea) |
| | | - **Listerine Natural Green Tea Mouthwash** (Green Tea) |
| **Herbal Gels**<br>Turmeric (Curcuma longa), Aloe Vera (Aloe barbadensis), Licorice (Glycyrrhizaglabra), Chamomile (Matricariachamomilla) | Soothing, anti-inflammatory, wound healing, analgesic, antimicrobial, and tissue repair. | - **Dabur Red Tooth Gel** (Clove, Aloe Vera) |
| | | - **Himalaya Gingel** (Turmeric, Aloe Vera) |
| | | - **Burt's Bees Toothpaste with Fluoride** (Chamomile, Peppermint) |
| | | - **Amway Glister Herbal Gel** |
| **Chewing Gums**<br>Eucalyptus (Eucalyptus globulus), Peppermint (Menthapiperita), Cinnamon (Cinnamomumverum), Licorice (Glycyrrhizaglabra) | Breathe freshening, antimicrobial, plaque reduction, and gum health. | - **Colgate Max Fresh Herbal** (Peppermint, Eucalyptus) |
| | | - **Orbit Sugar-Free Chewing Gum** (Spearmint, Peppermint) |
| | | - **Spry Xylitol Chewing Gum** (Licorice, Peppermint) |
| **Varnishes and Coatings**<br>Propolis, Aloe Vera, Green Tea Extract, Neem | Enamel remineralization, plaque reduction, antimicrobial protection, and caries prevention. | - **GC Tooth Mousse** (Milk Protein, Fluoride) |
| | | - **Colgate ProRelief** (Fluoride, Calcium) |
| | | - **MI Paste** (Recaldent™ with Propolis and Aloe Vera) |

*4.2. Periodontal diseases*

Periodontal illnesses like gingivitis and periodontitis originate from microbial plaque biofilms, causing gum inflammation, tissue damage, and tooth loss. While standard therapies like scaling and antimicrobial drugs are helpful, herbal options offer anti-inflammatory, antibacterial, and wound-healing properties.[74] Neem (Azadirachta indica) in toothpaste and mouthwash decreases gum irritation and plaque via azadirachtin and nimbidin, which prevent bacterial adhesion and biofilms. Tea tree oil (Melaleuca alternifolia), rich in terpinen-4-ol, displays high antibacterial activity against periodontal infections. Further research is needed for standardization and optimum distribution, although herbal formulations present a promising, sustainable approach to periodontal health **Table 2** offers a summary of herbal items used in clinical settings for oral health.[75,76]

*4.3. Oral mucositis*

Oral mucositis, a painful illness connected to cancer therapy, hinders nutrition and communication while raising infection risk. Conventional treatments provide minimal alleviation, prompting curiosity in herbal alternatives. Coconut and sesame oil, used in oil pulling, establish a protective barrier, minimizing irritation and bacterial colonization. While promising, further clinical research are needed to standardize doses and delivery. Integrating herbal treatments into treatment strategies may boost patient outcomes and quality of life.[78,79]

**Table 2:** Overview of herbal products in clinical oral health applications[54-76]

| Condition | Herbal Product | Active Compounds | Mechanism of Action | Clinical Applications |
|---|---|---|---|---|
| **Dental Caries** | Neem (Azadirachtaindica) | Nimbidin, Azadirachtin | Antimicrobial inhibits bacterial adhesion and biofilm formation. | Reduces plaque and caries risk in toothpaste and mouthwash. |
| | Clove (Syzygiumaromaticum) | Eugenol | Antimicrobial, analgesic, and disrupts bacterial cell walls. | Used in clove oil and dental formulations for plaque control. |
| | Propolis | Flavonoids, Phenolic acids | Antimicrobial, inhibits demineralization, and offers antioxidant properties. | Gels and varnishes reduce bacterial load and protect enamel. |
| **Periodontal Diseases** | Tea Tree Oil (Melaleucaalternifolia) | Terpinen-4-ol | Antimicrobial, reduces inflammation, and inhibits pocket depth. | Used in gels and mouthwashes to improve gum health. |
| | Turmeric (Curcuma longa) | Curcumin | Anti-inflammatory, inhibits pro-inflammatory cytokines (IL-6, IL-8, TNF-α). | Reduces bleeding, pocket depth, and plaque index with turmeric-based gels. |
| | Aloe Vera (Aloe barbadensis miller) | Anthraquinones, Acemannan | Promotes wound healing, collagen synthesis, and reduces inflammation. | Adjunct to scaling and root planing to enhance tissue healing. |
| **Oral Mucositis** | Honey | Flavonoids, Phenolic acids, Hydrogen peroxide | Forms a protective barrier, prevents microbial invasion, and promotes epithelial regeneration. | Manuka honey alleviates ulceration and severity in cancer patients. |
| | Chamomile (Matricariachamomilla) | Chamazulene, Apigenin, Bisabolol | Anti-inflammatory and soothing effects, inhibits pro-inflammatory mediators. | Mouth rinses reduce erythema, pain, and ulceration in mucositis. |
| | Green Tea (Camellia sinensis) | Epigallocatechingallate (EGCG) | Antioxidant, reduces oxidative stress, and inhibits S. mutans growth. | Mouthwashes alleviate symptoms and accelerate healing. |

### *4.4. Tooth sensitivity*

Tooth sensitivity, induced by exposed dentinal tubules, leads to intense discomfort from diverse stimuli. Conventional therapies offer short relief, whilst herbal options provide long-term benefits with minimal adverse effects. Arginine creates calcium-arginine complexes to block tubules, while curcumin in turmeric has anti-inflammatory and tubule-occluding effects. These natural remedies not only alleviate discomfort but also address underlying reasons including gingival irritation and enamel loss. Further study is needed to standardize formulations and increase administration for optimal inclusion into mainstream dental treatment.[80,81]

### *4.5. Bad breath (halitosis)*

Bad breath, or halitosis, is a common ailment that can have a major impact on a person's social interactions and general quality of life. Poor oral hygiene, systemic disorders, and microbial imbalances in the oral ecosystem are some of the etiological causes that can lead to this condition, which is mostly characterised by an unpleasant odour coming from the mouth cavity. Pharmacologically, antimicrobials, mouthwashes, and toothpaste that contain chemicals like zinc compounds, essential oils, and chlorhexidine have long been used to treat halitosis. Recent clinical research, however, has shown more and more how successful herbal and natural remedies are in treating the underlying causes of halitosis, providing a more comprehensive, possibly safer, and frequently more affordable option than synthetic therapies.[82]

Clinical success frequently depends on the concentration, formulation, and frequency of use, even though the pharmacological characteristics of these natural medicines are encouraging. When used in well planned therapeutic settings, herbal therapies can offer a safer substitute for synthetic medications, particularly for those who are chemically sensitive or are looking for long-term preventive measures. It is important to remember, though, that herbal and natural remedies shouldn't take the place of conventional medical and dental examinations, particularly when halitosis is a sign of more serious underlying illnesses like diabetes, liver disease, or gastrointestinal issues. A comprehensive strategy for treating halitosis is provided by the pharmacological use of herbal and natural medicines, with an emphasis on deodorisation, inflammatory reduction, and antibacterial action. These natural alternatives may be successfully included into oral health care routines, either as stand-alone treatments or as adjuncts, according to the growing corpus of clinical evidence in favour of them. Herbal treatments will be a useful tool in the comprehensive management of foul breath once future clinical trials and systematic reviews clarify the best formulations, doses, and application schedules.[9,83]

## 5. Limitations and Challenges

Although herbal and natural treatments have great potential for controlling oral health, there are many obstacles and restrictions to their broad use. For them to be successfully incorporated into general dental care, these problems need to be resolved.

### *5.1. Standardization issues*

The lack of uniformity in the composition, potency, and dose of herbal medications is one of the biggest obstacles to their use. Numerous bioactive chemicals are frequently found in herbal formulations, and their amounts can differ greatly based on a variety of factors, including plant species, growth circumstances, and extraction techniques. The constant therapeutic efficacy of these items is hampered by the lack of regular standards for production, quality control, and storage, which also makes results more difficult to repeat. The synergistic effects of several components further complicate standardisation, making it challenging to identify and measure the active compounds.[9]

### *5.2. Variability in methodologies*

There is frequently a lack of consistency in the methods used to investigate and produce herbal products, which results in inconsistent findings in different clinical and research contexts. Variability in the products' bioactivity and effectiveness may arise from variations in the extraction processes, solvents employed, and analytical methodologies. Furthermore, it can be difficult to compare results or reach firm conclusions because in vitro and in vivo research usually employ different techniques. The scientific and medical societies' acceptance and confidence in herbal products are weakened by this heterogeneity.[84]

### *5.3. Lack of large-scale clinical trials*

The lack of extensive, high-caliber clinical research assessing the effectiveness and safety of herbal medications in oral healthcare is another major drawback. Although numerous exploratory or small-scale studies have shown encouraging outcomes, their conclusions are sometimes constrained by insufficient controls, brief study periods, or small sample sizes. It is challenging to develop evidence-based recommendations for the use of herbal products in dental practice due to the lack of solid clinical data. This difficulty is made worse by the lack of resources and enthusiasm for carrying out extensive trials for herbal medicines in comparison to synthetic medications.[85]

### *5.4. Regulatory challenges*

Since they are not technically categorised as either medications or dietary supplements in many places, herbal products frequently fall into a regulatory grey area. Standards for quality, safety, and labelling are inconsistent as a result of unclear legislative frameworks. Many nations lack proper testing and approval procedures for herbal items, which permits inferior or tainted goods to be sold. Furthermore, the worldwide trade and adoption of these items are hampered by the diversity of regulatory requirements around the globe. It

is still difficult to create comprehensive laws that strike a balance between accessibility, efficacy, and safety.[86]

### *5.5. Consumer misconceptions*

Another obstacle is consumer attitudes and misunderstandings regarding herbal products. Many people assume that "natural" means "safe," which can result in the overuse or abuse of herbal therapies without the right supervision. Negative side effects, drug interactions, or decreased efficacy may arise from this. However, a wider audience cannot adopt herbal products because of scepticism regarding their effectiveness brought either by ignorance or false information. To successfully include these devices into oral healthcare, customers must be informed about their limitations and proper usage.[87] Unlocking the full potential of herbal and natural products in the management of oral health requires addressing these restrictions and difficulties. Their scientific credibility must be established by rigorous clinical validation, standardisation, and methodological consistency. At the same time, consumer education and legislative changes can increase accessibility and trust, opening the door for these biocompatible and sustainable dental care options to become a standard component of contemporary dental treatment.[86]

## 6. Future Directions

The growing interest in natural and herbal products as oral health treatments emphasises the necessity of strategic developments to address current issues and maximise their potential. For these items to become dependable and efficient dental care solutions, future research and development must prioritise sustainability, technological integration, and scientific rigour.[22]

### *6.1. Standardized protocols for herbal formulations*

Establishing standardised procedures for the creation, manufacturing, and quality assurance of herbal products is essential to guaranteeing their effectiveness and security. This entails defining consistent standards for the production, harvesting, and extraction of plants as well as figuring out constant levels of bioactive substances. To guarantee reproducibility and preserve product quality, sophisticated analytical methods like mass spectrometry and high-performance liquid chromatography (HPLC) can be used. Standardised procedures will increase the legitimacy of herbal products, make regulatory clearance easier, and encourage consumer and dental professional adoption.[9]

### *6.2. Multi-center randomized clinical trials*

To confirm the medicinal advantages of herbal products in oral healthcare, extensive, multi-center randomised clinical studies (RCTs) are necessary. To give thorough information on safety and efficacy, such studies should concentrate on a range of populations, dosages, and long-term results. The constraints of small-scale studies can be addressed and strong evidence for therapeutic applicability can be provided by carrying out well-designed RCTs using standardised protocols. In order to facilitate these trials and put research findings into practice, cooperation between academic institutions, industry stakeholders, and regulatory bodies will be essential.[88]

### *6.3. Integration with modern technologies*

Combining contemporary technologies, especially nanotechnology, with herbal medicines presents intriguing prospects for improving their accuracy and efficacy. By improving the solubility, stability, and bioavailability of bioactive substances, nanoencapsulation allows for tailored administration to particular oral tissues. Novelties like herbal gels, mouthwashes, and toothpaste based on nanoparticles can offer prolonged release and enhanced medicinal benefits. Furthermore, by reducing problems associated with the deterioration of herbal compounds, nanotechnology might increase the usefulness and shelf life of these substances.[89]

### *6.4. Personalized oral care*

The idea of customised dental treatment, which is fuelled by developments in precision medicine, has enormous potential to maximise the use of herbal products. Customised herbal formulations that target each person's unique oral health needs can be created by combining genetic, microbiome, and lifestyle data. This method guarantees the efficient use of specialised herbal treatments to treat certain illnesses like dental caries, periodontal disorders, or tooth sensitivity. Personalised oral care can be further improved by integrating biosensors and AI-driven diagnostic tools, which allow for real-time monitoring and flexible treatment plans.[90]

### *6.5. Sustainable sourcing and production*

In order to preserve ecological balance and conserve biodiversity, it is crucial to ensure sustainable sourcing and production practices as the demand for herbal products rises. Fair trade and organic farming are two examples of ethical plant production methods that can lessen their negative effects on the environment and encourage sustainability. Additionally, using green chemistry techniques throughout the formulation and extraction operations minimises waste and the usage of hazardous solvents. In addition to guaranteeing the long-term availability of medicinal plants, sustainable practices also satisfy customer demands for goods that respect the environment. The combination of sustainability, innovation, and standardisation will determine the future of herbal and natural products used to manage oral health. Their scientific basis will be established by standardised procedures and stringent clinical trials, and their therapeutic potential will be enhanced by integration with contemporary technologies and individualised techniques. Adopting sustainable practices also guarantees these solutions' morality and environmental sustainability. When taken as a whole, these developments will make herbal

products a vital component of comprehensive and successful oral healthcare in the years to come.[91]

## 7. Discussion

The trend towards safer, more sustainable, and biocompatible treatment choices is reflected in the increased interest in herbal and natural solutions for oral health management. The important pharmacological characteristics of herbal products—such as their antibacterial, anti-inflammatory, antioxidant, analgesic, and anticariogenic effects—are highlighted in this study. Because of these qualities, herbal formulations are positioned as potential supplements or substitutes for traditional oral healthcare procedures. Dental caries, periodontal disorders, oral mucositis, and tooth sensitivity are just a few of the oral health issues that herbal products including mouthwashes, toothpastes, gels, and chewing gums have shown promise in treating. However, restrictions include lack of standardisation, inconsistent approaches, a dearth of large-scale clinical trials, and regulatory barriers impede their therapeutic uses. The bioactive substances found in herbal products, such as flavonoids, alkaloids, terpenoids, and polyphenols, are intimately related to their pharmacological potential. By interacting with biological mechanisms, these substances minimise side effects while producing therapeutic results. Nevertheless, there are still a lot of obstacles to overcome before these benefits may be applied in clinical settings. The incorporation of plant-derived bioactive substances into mainstream dentistry is complicated by their inconsistent formulation and fluctuating concentrations. Campaigns for education and awareness are also necessary to dispel consumer myths regarding the effectiveness and safety of herbal remedies. Precision medicine and nanotechnology are two examples of emerging technologies that provide creative answers to these problems. Herbal compounds' stability, bioavailability, and targeted distribution can all be improved via nanoencapsulation, which raises the medicinal effectiveness of these substances. Furthermore, herbal therapies can be customised to meet the needs of each individual through personalised dental care that is backed by genetic and microbiome data, improving results. As demand for herbal products grows worldwide, ethical production methods and sustainable sourcing are essential to ensuring their environmental sustainability.[92-94]

## 8. Conclusion

Herbal and natural products have emerged as viable solutions for controlling common oral health disorders such as dental caries, periodontal diseases, oral mucositis, and tooth sensitivity due to their antibacterial, anti-inflammatory, antioxidant, and analgesic qualities. Their biocompatibility and increased consumer enthusiasm for alternative therapies further boost their medicinal potential. However, various barriers, including limited large-scale clinical research, regulatory limits, standardization issues, and consumer misconceptions, must be overcome for their widespread implementation in dental treatment. Future research should focus on producing standardized formulations, optimizing delivery systems, and conducting rigorous clinical studies to verify their efficacy and safety. Advances in nanotechnology can enhance the stability, bioavailability, and targeted administration of herbal ingredients, increasing therapy outcomes. Additionally, incorporating individualized oral care treatments based on microbiome and genetic data could further optimize medication efficacy. Ethical and sustainable sourcing of herbal raw materials is also vital to address environmental concerns connected with increasing demand. A multidisciplinary approach combining scientific validation, regulatory developments, technology innovations, and public education will be vital to successfully incorporating herbal products into mainstream oral healthcare. By overcoming these issues, herbal and natural products can emerge into dependable, safe, and effective alternatives, complementing conventional dentistry treatments and contributing to worldwide oral health advancements.

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None.

## References

1. Sedghi L, DiMassa V, Harrington A, Lynch SV, Kapila YL. The oral microbiome: Role of key organisms and complex networks in oral health and disease. *Periodontol 2000*. 2021;87(1):107–31.
2. Giordano-Kelhoffer B, Lorca C, Llanes JM, Rábano A, Del Ser T, Serra A, et al. Oral Microbiota, Its Equilibrium and Implications in the Pathophysiology of Human Diseases: A Systematic Review. *Biomedicines*. 2022;10(8):1803.
3. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. *Lancet*. 2019;394(10194):249–60.
4. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. *Bull World Health Organ*. 2005;83(9):661–9.
5. Guo J, Low KS, Mei L, Li JH, Qu W, Guan G. Use of traditional medicine for dental care by different ethnic groups in New Zealand. *BMC Oral Health*. 2020;20(1):280
6. Kumar S, Verma M, Hajam YA, Kumar R. Honey infused with herbs: A boon to cure pathological diseases. *Heliyon*. 2024;10(1):e23302
7. Wu L, Chen W, Wang Z. Traditional Indian medicine in China: The status quo of recognition, development and research. *J Ethnopharmacol*. 2021;279:114317.
8. Pradeep P, Thomas AR, Kaur K, Samson RS, Mayya A, Adiga S, et al. Herbal medicines to prevent dental caries. *Cochrane Database Syst Rev*. 2024;2024(5):CD015832.
9. Wang H, Chen Y, Wang L, Liu Q, Yang S, Wang C. Advancing herbal medicine: enhancing product quality and safety through robust quality control practices. *Front Pharmacol*. 2023;14:1265178.
10. Khuspe P, Mane D, Hole A, Raskar A, Vyavahare R, Ban A, Kharmate P. Ayurvedic Dosage Forms: An Updated Overview. *Int J Pharm Drug Des*. 2024;6(1).

11. Bessa LJ, Botelho J, Machado V, Alves R, Mendes JJ. Managing Oral Health in the Context of Antimicrobial Resistance. *Int J Environ Res Public Health*. 2022;19(24):16448.
12. National Institute of Dental and Craniofacial Research (US). Oral health in America: advances and challenges [Internet]. Bethesda (MD): National Institute of Dental and Craniofacial Research (US); 2021 Dec. Section 3A, Oral health across the lifespan: working-age adults. Available from: https://www.ncbi.nlm.nih.gov/books/NBK578294/.
13. Lamont T, Worthington HV, Clarkson JE, Beirne PV. Routine scale and polish for periodontal health in adults. *Cochrane Database Syst Rev*. 2018;12(12):CD004625.
14. Van der Weijden GA, Dekkers GJ, Slot DE. Success of non-surgical periodontal therapy in adult periodontitis patients: A retrospective analysis. *Int J Dent Hyg*. 2019;17(4):309–17.
15. Tungare S, Paranjpe AG. Diet and nutrition to prevent dental problems [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 Jan- [updated 2023 Jul 10]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK534248/.
16. Ekins P, Zenghelis D. The costs and benefits of environmental sustainability. *Sustain Sci*. 2021;16(3):949–65.
17. Moshood TD, Nawanir G, Mahmud F, Mohamad F, Ahmad MH, Abdul Ghani A. Sustainability of biodegradable plastics: New problem or solution to solve the global plastic pollution? *Curr Res Gree Sustain Chem*. 2022;5:100273.
18. Yuan H, Ma Q, Ye L, Piao G. The Traditional Medicine and Modern Medicine from Natural Products. *Molecules*. 2016;21(5):559.
19. Martínez CC, Gómez MD, Oh MS. Use of traditional herbal medicine as an alternative in dental treatment in Mexican dentistry: a review. *Pharm Biol*. 2017;55(1):1992–8.
20. Sorrenti V, Burò I, Consoli V, Vanella L. Recent Advances in Health Benefits of Bioactive Compounds from Food Wastes and By-Products: Biochemical Aspects. *Int J Mol Sci*. 2023;24(3):2019.
21. Palombo EA. Traditional Medicinal Plant Extracts and Natural Products with Activity against Oral Bacteria: Potential Application in the Prevention and Treatment of Oral Diseases. *Evid Based Complement Alternat Med*. 2011;2011:680354
22. Budala DG, Martu M-A, Maftei G-A, Diaconu-Popa DA, Danila V, Luchian I. The Role of Natural Compounds in Optimizing Contemporary Dental Treatment-Current Status and Future Trends. *J Funct Biomater*. 2023;14(5):273.
23. Arif A, Khar MS, Shahid N, Aman W, Javed J, Rubab A, et al. Progression in nano-botanical oral hygiene solutions: The Dawn of biomimetic nanomaterials. *Eur J Med Chem Rep*. 2024;12:100219.
24. Milho C, Silva J, Guimarães R, Ferreira ICF, Barros L, Alves MJ. Antimicrobials from Medicinal Plants: An Emergent Strategy to Control Oral Biofilms. *Appl Sci*. 2021;11(9):4020.
25. Parham S, Kharazi AZ, Bakhsheshi-Rad HR, Nur H, Ismail AF, Sharif S, et al. Antioxidant, Antimicrobial and Antiviral Properties of Herbal Materials. *Antioxidants (Basel)*. 2020;9(12):1309.
26. Al AlSheikh HM, Sultan I, Kumar V, Rather IA, Al-Sheikh H, Jan AT, Haq QMR. Plant-Based Phytochemicals as Possible Alternative to Antibiotics in Combating Bacterial Drug Resistance. *Antibiotics[1] (Basel)*. 2020;9(8):480.
27. Cowan MM. Plant products as antimicrobial agents. *Clin Microbiol Rev*. 1999;12(4):564–82.
28. Wylie MR, Merrell DS. The Antimicrobial Potential of the Neem Tree *Azadirachta indica*. *Front Pharmacol*. 2022;13:891535.
29. Lakshmi T, Krishnan V, Rajendran R, Madhusudhanan N. *Azadirachta indica*: A herbal panacea in dentistry - An update. *Pharmacogn Rev*. 2015;9(17):41–4.
30. Vaou N, Stavropoulou E, Voidarou C, Tsigalou C, Bezirtzoglou E. Towards Advances in Medicinal Plant Antimicrobial Activity: A Review Study on Challenges and Future Perspectives. *Microorganisms*. 2021;9(10):2041.
31. Gupta R, Sharma S. Role of alternatives to antibiotics in mitigating the antimicrobial resistance crisis. *Indian J Med Res*. 2022;156(3):464–77.
32. López-Valverde N, López-Valverde A, Montero J, Rodríguez C, Macedo de Sousa B, Aragoneses JM. Antioxidant, anti-inflammatory and antimicrobial activity of natural products in periodontal disease: a comprehensive review. *Front Bioeng Biotechnol*. 2023;11:1226907.
33. Desai SJ, Prickril B, Rasooly A. Mechanisms of Phytonutrient Modulation of Cyclooxygenase-2 (COX-2) and Inflammation Related to Cancer. *Nutr Cancer*. 2018;70(3):350–75.
34. Nisar A, Jagtap S, Vyavahare S, Deshpande M, Harsulkar A, Ranjekar P, et al. Phytochemicals in the treatment of inflammation-associated diseases: the journey from preclinical trials to clinical practice. *Front Pharmacol*. 2023;14:1177050.
35. Gonfa YH, Tessema FB, Bachheti A, Rai N, Tadesse MG, Singab AN. Anti-inflammatory activity of phytochemicals from medicinal plants and their nanoparticles: A review. *Curr Res Biotechnol*. 2023;6:100152.
36. Nisar MF, Khadim M, Rafiq M, Chen J, Yang Y, Wan CC. Pharmacological Properties and Health Benefits of Eugenol: A Comprehensive Review. *Oxid Med Cell Longev*. 2021;2021:2497354.
37. Rizvi SAA, Einstein GP, Tulp OL, Sainvil F, Branly R. Introduction to Traditional Medicine and Their Role in Prevention and Treatment of Emerging and Re-Emerging Diseases. *Biomolecules*. 2022;12(10):1442.
38. Refaey MS, Abosalem EF, El-Basyouni RY, Elsheriri SE, Elbehary SH, Fayed MAA. Exploring the therapeutic potential of medicinal plants and their active principles in dental care: A comprehensive review. *Heliyon*. 2024;10(18):e37641.
39. Ulanowska M, Olas B. Biological Properties and Prospects for the Application of Eugenol-A Review. *Int J Mol Sci*. 2021;22(7):3671.
40. Basu P, Maier C, Basu A. Effects of Curcumin and Its Different Formulations in Preclinical and Clinical Studies of Peripheral Neuropathic and Postoperative Pain: A Comprehensive Review. *Int J Mol Sci*. 2021;22(9):4666.
41. Sánchez M, González-Burgos E, Iglesias I, Gómez-Serranillos MP. Pharmacological Update Properties of *Aloe Vera* and its Major Active Constituents. *Molecules*. 2020;25(6):1324.
42. Barrera SD, Cepeda LJB, Díaz Báez DA, Kwon J, Siddiq A, Parra JEC, et al. Herbal extracts in orofacial pain: a systematic review and direct and indirect meta-analysis. *Sci Rep*. 2024;14:29656.
43. Chatzopoulos GS, Karakostas P, Kavakloglou S, Assimopoulou A, Barmpalexis P, Tsalikis L. Clinical Effectiveness of Herbal Oral Care Products in Periodontitis Patients: A Systematic Review. *Int J Environ Res Public Health*. 2022;19(16):10061.
44. Tzimas K, Antoniadou M, Varzakas T, Voidarou CC. Plant-Derived Compounds: A Promising Tool for Dental Caries Prevention. *Curr Issues Mol Biol*. 2024;46(6):5257–90.
45. Xu X, Zhou XD, Wu CD. The tea catechin epigallocatechin gallate suppresses cariogenic virulence factors of *Streptococcus mutans*. *Antimicrob Agents Chemother*. 2011;55(3):1229–36.
46. Araghizadeh A, Kohanteb J, Fani MM. Inhibitory activity of green tea (*Camellia sinensis*) extract on some clinically isolated cariogenic and periodontopathic bacteria. *Med Princ Pract*. 2013;22(4):368–72.
47. Xu J, Shi H, Luo J, Yao H, Wang P, Li Z, Wei J. Advanced materials for enamel remineralization. *Front Bioeng Biotechnol*. 2022;10:985881.
48. Cochrane NJ, Cai F, Huq NL, Burrow MF, Reynolds EC. New approaches to enhanced remineralization of tooth enamel. *J Dent Res*. 2010;89(11):1187–97.
49. Ferrazzano GF, Amato I, Ingenito A, Zarrelli A, Pinto G, Pollio A. Plant polyphenols and their anti-cariogenic properties: a review. *Molecules*. 2011;16(2):1486–507.
50. Duggal S, Chandrika PS, Nasyam FA, Singh DK, Devraj IM, Anand C. Herbal Dentistry: Nurturing Oral Health with Natural Remedies. *J Pharm Bioallied Sci*. 2024;16(Suppl 3):S1932–S1934.
51. Shaheen SS, Reddy P, Hemalatha, Reddy S, Doshi D, Kulkarni S, Kumar M. Antimicrobial Efficacy of Ten Commercially Available Herbal Dentifrices against Specific Oral Microflora – In Vitro Study. *J Clin Diagn Res*. 2015;9(4):ZC42–ZC46.

52. Rani N, Singla RK, Narwal S, Tanushree, Kumar N, Rahman MM. Medicinal Plants Used as an Alternative to Treat Gingivitis and Periodontitis. *Evid Based Complement Alternat Med*. 2022;2022:2327641.
53. Safiaghdam H, Oveissi V, Bahramsoltani R, Farzaei MH, Rahimi R. Medicinal plants for gingivitis: a review of clinical trials. *Iran J Basic Med Sci*. 2018;21(10):978–91.
54. Ancuceanu R, Anghel AI, Ionescu C, Hovaneț MV, Cojocaru-Toma M, Dinu M. Clinical Trials with Herbal Products for the Prevention of Dental Caries and Their Quality: A Scoping Study. *Biomolecules*. 2019;9(12):884.
55. Cai H, Chen J, Perera NKP, Liang X. Effects of Herbal Mouthwashes on Plaque and Inflammation Control for Patients with Gingivitis: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *Evid Based Complement Alternat Med*. 2020;2020:2829854
56. Surjushe A, Vasani R, Saple DG. Aloe vera: a short review. *Indian J Dermatol*. 2008;53(4):163–6.
57. Chelu M, Musuc AM, Popa M, Moreno JC. Aloe vera-Based Hydrogels for Wound Healing: Properties and Therapeutic Effects. *Gels*. 2023;9(7):539.
58. Elangovan S, Mudgil P. Antibacterial Properties of *Eucalyptus globulus* Essential Oil against MRSA: A Systematic Review. *Antibiotics (Basel)*. 2023;12(3):474.
59. Yazicioglu O, Ucuncu MK, Guven K. Ingredients in Commercially Available Mouthwashes. *Int Dent J*. 2024;74(2):223–41.
60. Karadağlıoğlu Öİ, Ulusoy N, Başer KHC, Hanoğlu A, Şık İ. Herbal Toothpastes Combined with Essential Oils Against *Streptococcus mutans*'ın Antibakteriyel Aktiviteleri. *Pathogens*. 2019;8(1):20.
61. Shaalan O, El-Rashidy A. Antibacterial Effect of Miswak herbal toothpaste Compared to Fluoride Toothpaste in High Caries Risk Patients: Randomized Clinical Trial. *J Clin Exp Dent*. 2023;15(7):e526–34
62. Khan SF, Shetty B, Fazal I, Khan AM, Mir FM, Moothedath M, et al. Licorice as a herbal extract in periodontal therapy. *Drug Target Insights*. 2023;17:70–7.
63. Shekar BRC, Nagarajappa R, Suma S, Thakur R. Herbal extracts in oral health care - A review of the current scenario and its future needs. *Pharmacogn Rev*. 2015;9(18):87–92.
64. Fuloria S, Mehta J, Chandel A, Sekar M, Rani NNI, Begum MY, et al. A Comprehensive Review on the Therapeutic Potential of *Curcuma longa* Linn. in Relation to its Major Active Constituent Curcumin. *Front Pharmacol*. 2022;13:820806
65. Haro-González JN, Castillo-Herrera GA, Martínez-Velázquez M, Espinosa-Andrews H. Clove Essential Oil (*Syzygium aromaticum* L. Myrtaceae): Extraction, Chemical Composition, Food Applications, and Essential Bioactivity [1] for Human Health. *Molecules*. 2021;26(21):6387.
66. Maurya R, Misro L, Boini T, Radhakrishnan T, Nair PG, Gaidhani SN, Jain A. Transforming Medicinal Oil into Advanced Gel: An Update on Advancements. *Gels*. 2024;10(5):342.
67. Thivya P, Durgadevi M, Sinija VRN. Biodegradable medicated chewing gum: A modernized system for delivering bioactive compounds. *Future Foods*. 2021;4:100054.
68. Kannan N, S G, Ramani P, Shanmugam R, Ramalingam K. A Novel Gum Paint Formulation Derived From Licorice and Triphala: Characteristics and Clinical Significance for Improved Oral Health. *Cureus*. 2024;16(7):e63940.
69. Chavan S, Lakashminarayan N, Kemparaj U. Effect of Chewing Xylitol Containing and Herbal Chewing Gums on Salivary *Mutans Streptococcus* Count among School Children. *Int J Prev Med*. 2015;6:44.
70. Spatafora G, Li Y, He X, Cowan A, Tanner ACR. The Evolving Microbiome of Dental Caries. *Microorganisms*. 2024;12(1):121.
71. Baby AR, Freire TB, Marques GA, Rijo P, Lima FV, Carvalho JCM, et al. Azadirachta indica (Neem) as a Potential Natural Active for Dermocosmetic and Topical Products: A Narrative Review. *Cosmetics*. 2022;9(3):58.
72. Wagh VD. Propolis: a wonder bees product and its pharmacological potentials. *Adv Pharmacol Sci*. 2013;2013:308249.
73. Almuhayawi MS. Propolis as a novel antibacterial agent. *Saudi J Biol Sci*. 2020;27(11):3079–3086.
74. Rathee M, Jain P. Gingivitis [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 Jan- [updated 2023 Mar 27]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557422/.
75. Rani N, Singla RK, Narwal S, Tanushree, Kumar N, Rahman MM. Medicinal Plants Used as an Alternative to Treat Gingivitis and Periodontitis. *Evid Based Complement Alternat Med*. 2022;2022:2327641.
76. Carrol DH, Chassagne F, Dettweiler M, Quave CL. Antibacterial activity of plant species used for oral health against *Porphyromonas gingivalis*. *PLoS One*. 2020;15(10):e0239316.
77. Reuss JM, Alonso-Gamo L, Garcia-Aranda M, Reuss D, Albi M, Albi B, et al. Oral Mucosa in Cancer Patients-Putting the Pieces Together: A Narrative Review and New Perspectives. *Cancers (Basel)*. 2023;15(13):3295.
78. Ferreira AS, Macedo C, Silva AM, Delerue-Matos C, Costa P, Rodrigues F. Natural Products for the Prevention and Treatment of Oral Mucositis-A Review. *Int J Mol Sci*. 2022;23(8):4385.
79. Colella G, Boschetti CE, Vitagliano R, Colella C, Jiao L, King-Smith N, et al. Interventions for the Prevention of Oral Mucositis in Patients Receiving Cancer Treatment: Evidence from Randomised Controlled Trials. *Curr Oncol*. 2023;30(1):967–80.
80. Langenbach F, Naujoks C, Smeets R, Berr K, Depprich R, Kübler N, Handschel J. Scaffold-free microtissues: differences from monolayer cultures and their potential in bone tissue engineering. *Clin Oral Investig*. 2013;17(1):9-17.
81. Sharifi-Rad J, Rayess YE, Rizk AA, Sadaka C, Zgheib R, Zam W, et al. Turmeric and Its Major Compound Curcumin on Health: Bioactive Effects and Safety Profiles for Food, Pharmaceutical, Biotechnological and Medicinal Applications. *Front Pharmacol*. 2020;11:01021.
82. Briceag R, Caraiane A, Raftu G, Horhat RM, Bogdan I, Fericean RM, et al. Emotional and Social Impact of Halitosis on Adolescents and Young Adults: A Systematic Review. *Medicina (Kaunas)*. 2023;59(3):64.
83. Hussain MS. Patient counseling about herbal-drug interactions. *Afr J Tradit Complement Altern Med*. 2011;8(5 Suppl):152–63.
84. Osman A, Chittiboyina AG, Avula B, Ali Z, Adams SJ, Khan IA. Quality Consistency of Herbal Products: Chemical Evaluation. *Prog Chem Org Nat Prod*. 2023;122:163–219.
85. Parveen A, Parveen B, Parveen R, Ahmad S. Challenges and guidelines for clinical trial of herbal drugs. *J Pharm Bioallied Sci*. 2015;7(4):329–33.
86. Ng JY, Kim M, Suri A. Exploration of facilitators and barriers to the regulatory frameworks of dietary and herbal supplements: a scoping review. *J Pharm Policy Pract*. 2022;15(1):55.
87. Okaiyeto K, Oguntibeju OO. African Herbal Medicines: Adverse Effects and Cytotoxic Potentials with Different Therapeutic Applications. *Int J Environ Res Public Health*. 2021;18(11):5988.
88. Barnes J. Quality, efficacy and safety of complementary medicines: fashions, facts and the future. Part II: Efficacy and safety. *Br J Clin Pharmacol*. 2003;55(4):331–40.
89. Bonifácio BV, Silva PB, Ramos MADS, Negri KMS, Bauab TM, Chorilli M. Nanotechnology-based drug delivery systems and herbal medicines: a review. *Int J Nanomedicine*. 2014;9:1-15.
90. Amato A. Personalized Oral and Dental Care. *J Pers Med*. 2023;13(1):110
91. Marcelino S, Hamdane S, Gaspar PD, Paço, A. Sustainable Agricultural Practices for the Production of Medicinal and Aromatic Plants: Evidence and Recommendations. *Sustainability*. 2023,15(19),14095.
92. Karobari MI, Adil AH, Assiry AA, Basheer SN, Noorani TY, Pawar AM, et al. Herbal Medications in Endodontics and Its Application-A Review of Literature. *Materials (Basel)*. 2022;15(9):3111.
93. Martínez CC, Gómez MD, Oh MS. Use of traditional herbal medicine as an alternative in dental treatment in Mexican dentistry: a review. *Pharm Biol*. 2017;55(1):1992–8.

94. Kumar M, Prakash S, Radha, Kumari N, Pundir A, Punia S, et al. Beneficial Role of Antioxidant Secondary Metabolites from Medicinal Plants in Maintaining Oral Health. *Antioxidants (Basel)*. 2021;10(7):1061.

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