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**MEDICINAL PROPERTIES OF CLOVE (*SYZYGIUM AROMATICUM*) IN
DENTISTRY: A REVIEW OF EXPERIMENTAL AND CLINICAL DATA**

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ABSTRACT: This review article summarizes current experimental and clinical data on the medicinal properties of clove (*Syzygium aromaticum*) and its potential use in dentistry. The phytochemical composition of clove is examined, with an emphasis on eugenol and other biologically active compounds with antimicrobial, anti-inflammatory, antioxidant, and analgesic properties. The results of *in vitro* and *in vivo* studies demonstrating the activity of clove extracts against key periodontal pathogens and cariogenic microflora are analyzed. Particular attention is given to clinical studies confirming the efficacy of clove oil and its derivatives in the treatment of toothache, gingivitis, stomatitis, and as components of dental materials. Clove-based preparations are shown to have high preventive and therapeutic potential; however, standardization and further clinical trials are required to expand their use in evidence-based dentistry.

Keywords: clove, *Syzygium aromaticum*, dentistry, eugenol, antimicrobial activity, anti-inflammatory effect, toothache, periodontal disease, herbal medicine, medicinal plants.

**ЛЕКАРСТВЕННЫЕ СВОЙСТВА ГВОЗДИКИ (*SYZYGIUM AROMATICUM*) В
СТОМАТОЛОГИИ: ОБЗОР ЭКСПЕРИМЕНТАЛЬНЫХ И КЛИНИЧЕСКИХ
ДАНЫХ**

АННОТАЦИЯ: В обзорной статье обобщены современные экспериментальные и клинические данные о лекарственных свойствах гвоздики (*Syzygium aromaticum*) и возможностях её применения в стоматологической практике. Рассмотрен фитохимический состав гвоздики с акцентом на эвгенол и другие биологически активные соединения, обладающие антимикробным, противовоспалительным, антиоксидантным и анальгезирующим действием. Проанализированы результаты *in vitro* и *in vivo* исследований, демонстрирующие активность экстрактов гвоздики в отношении основных пародонтопатогенных микроорганизмов и кариесогенной микрофлоры. Отдельное внимание уделено клиническим исследованиям, подтверждающим эффективность гвоздичного масла и его производных при лечении зубной боли, гингивита, стоматита и в составе стоматологических материалов. Показано, что препараты на основе гвоздики обладают высоким профилактическим и терапевтическим потенциалом, однако требуют



стандартизации и дальнейших клинических исследований для расширения их применения в доказательной стоматологии.

Ключевые слова: гвоздика, *Syzygium aromaticum*, стоматология, эвгенол, антимикробная активность, противовоспалительное действие, зубная боль, заболевания пародонта, фитотерапия, лекарственные растения.

RELEVANCE

Dental diseases remain among the most prevalent health problems worldwide, with dental caries, periodontal diseases, and inflammatory conditions of the oral mucosa affecting a large proportion of both adult and pediatric populations. Despite advances in modern dentistry, increasing antimicrobial resistance, adverse effects of synthetic agents, and the need for cost-effective and biocompatible therapies have stimulated growing interest in plant-derived medicinal substances. In this context, medicinal plants with a long history of traditional use are being re-evaluated through the lens of evidence-based dentistry.

Syzygium aromaticum (clove) occupies a unique position in dental practice due to its well-known analgesic and antiseptic properties, primarily attributed to eugenol and related phenolic compounds. Clove oil has been traditionally used for relief of toothache and oral inflammation, and it continues to be incorporated into modern dental materials and formulations. However, the expanding body of experimental and clinical research suggests that the pharmacological potential of clove extends beyond symptomatic pain relief, encompassing antimicrobial, anti-inflammatory, antioxidant, and biofilm-inhibitory effects relevant to oral health.

The relevance of this review lies in the need to systematically analyze and integrate experimental and clinical evidence on the dental applications of *Syzygium aromaticum*. A comprehensive evaluation of its therapeutic effects, mechanisms of action, and clinical efficacy is essential for rational use in contemporary dentistry. Such analysis supports the development of standardized, safe, and scientifically validated phytotherapeutic approaches, contributing to preventive and therapeutic strategies in oral healthcare and aligning with the principles of evidence-based and integrative dentistry [1].

MATERIALS AND METHODS

This review was conducted using a narrative-analytical methodology to synthesize experimental and clinical evidence on the dental applications of *Syzygium aromaticum* (clove). A comprehensive literature search was performed in international scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search strategy combined keywords such as *Syzygium aromaticum*, clove, eugenol, dentistry, oral health, antimicrobial activity, anti-inflammatory effect, toothache, and periodontal diseases.

Peer-reviewed experimental studies (*in vitro* and *in vivo*), randomized and non-randomized clinical trials, systematic reviews, and relevant pharmacological reports published predominantly over the last 20–25 years were considered for inclusion. Priority was given to studies evaluating antimicrobial efficacy against oral pathogens, anti-inflammatory and analgesic effects, biofilm inhibition, and clinical outcomes in dental conditions. Publications lacking methodological clarity or unrelated to dental applications were excluded.

The selection process involved initial screening of titles and abstracts, followed by full-text assessment for relevance and scientific rigor. Data extraction focused on study design, type of clove preparation (essential oil, extracts, isolated compounds), dosage, target oral conditions, and reported outcomes. Qualitative thematic analysis was applied to compare experimental findings



with clinical evidence, identify consistent effects, and assess translational relevance for evidence-based dentistry.

RESULTS AND DISCUSSION

The analysis of experimental and clinical literature demonstrates that *Syzygium aromaticum* possesses a wide range of pharmacological properties relevant to dental practice. These effects are primarily attributed to its rich phytochemical composition, with eugenol identified as the major biologically active compound, comprising up to 70–85% of clove essential oil [1]. Additional constituents, including β -caryophyllene, eugenyl acetate, flavonoids, and tannins, contribute to the overall biological activity and synergistic effects observed in dental applications [2].

Experimental in vitro studies consistently confirm the pronounced antimicrobial activity of clove extracts and essential oil against oral pathogens. Significant inhibitory effects have been reported against *Streptococcus mutans*, *Streptococcus sobrinus*, *Lactobacillus spp.*, *Porphyromonas gingivalis*, and *Aggregatibacter actinomycetemcomitans*, which are key microorganisms involved in the development of dental caries and periodontal diseases [3]. Minimum inhibitory concentration values for eugenol against cariogenic streptococci range from 0.05 to 0.2 mg/mL, demonstrating comparable or superior activity to some conventional antiseptics used in dentistry [4].

Biofilm-related studies further indicate that clove-derived compounds not only inhibit bacterial growth but also disrupt biofilm formation and maturation. Experimental models show a reduction in biofilm biomass by 40–70% following exposure to clove oil or eugenol, suggesting potential utility in preventing plaque accumulation and biofilm-associated resistance [5]. These findings are particularly relevant given the central role of biofilms in the persistence and progression of oral diseases.

Anti-inflammatory properties of *Syzygium aromaticum* have been extensively investigated in experimental models. Eugenol has been shown to suppress the production of pro-inflammatory mediators, including prostaglandins, nitric oxide, and cytokines such as TNF- α and IL-6, through inhibition of cyclooxygenase and lipoxygenase pathways [6]. In animal models of oral inflammation, topical application of clove-derived preparations resulted in significant reductions in gingival edema and inflammatory cell infiltration [7]. These mechanisms provide a scientific basis for the traditional use of clove in the management of gingivitis and oral mucosal inflammation.

Analgesic activity represents one of the most recognized dental applications of clove. Experimental studies indicate that eugenol exerts local anesthetic effects by blocking voltage-gated sodium channels and modulating nociceptive signaling pathways [8]. This pharmacological action explains its long-standing use for temporary relief of toothache and pulpitis-related pain. Comparative studies suggest that clove oil provides rapid onset of analgesia, with pain reduction observed within minutes of application in experimental pain models [9].

Collectively, the experimental evidence confirms that *Syzygium aromaticum* exhibits antimicrobial, anti-inflammatory, and analgesic properties that directly address key pathogenic mechanisms underlying common dental diseases. These findings support its relevance as a natural therapeutic agent and provide a foundation for its clinical evaluation. Clinical studies and practical observations confirm that the pharmacological properties of *Syzygium aromaticum* identified in experimental models translate into tangible therapeutic effects in dental practice. One of the most widely documented clinical applications of clove is the management of odontogenic pain. Clinical trials and observational studies report that topical application of clove



oil or eugenol-containing formulations leads to a significant reduction in toothache intensity, particularly in cases of reversible pulpitis and dentin hypersensitivity [10]. Pain relief is typically observed within 5–10 minutes after application and may persist for several hours, making clove-based agents useful for temporary symptomatic management.

In the context of periodontal diseases, clinical evidence suggests that clove-derived preparations exert beneficial effects on gingival inflammation. Controlled clinical studies evaluating herbal mouth rinses containing clove extract demonstrate reductions in gingival index and bleeding on probing comparable to those achieved with chlorhexidine-based formulations [2]. Importantly, clove-containing products are associated with fewer adverse effects, such as tooth staining or taste disturbances, which often limit long-term use of synthetic antiseptics. These findings highlight the potential role of clove as a safer alternative or adjunct in periodontal therapy.

The use of eugenol in dental materials represents another clinically relevant application. Eugenol has long been incorporated into zinc oxide–eugenol (ZOE) cements, widely used as temporary restorative materials, liners, and endodontic sealers. Clinical evaluations indicate that ZOE-based materials provide effective sealing properties, antibacterial activity, and soothing effects on the dental pulp [3]. The sedative action of eugenol on pulp tissue contributes to reduced postoperative sensitivity and improved patient comfort. However, studies also note that prolonged exposure to eugenol may interfere with resin polymerization, necessitating careful material selection in restorative procedures [4].

Clove-based formulations have also been explored in the management of oral mucosal conditions, including aphthous stomatitis and denture-related stomatitis. Clinical observations report reductions in pain, erythema, and lesion duration following topical application of clove extracts, likely due to combined antimicrobial and anti-inflammatory effects [5]. Although large-scale randomized trials remain limited, available data support the adjunctive use of clove in managing inflammatory conditions of the oral mucosa.

Comparative clinical studies further suggest that clove-derived agents may enhance oral hygiene outcomes when incorporated into toothpastes and mouthwashes. Regular use of such products has been associated with decreased plaque accumulation and reduced counts of cariogenic bacteria in saliva [6]. These effects reinforce the preventive potential of clove in maintaining oral health and reducing the risk of caries and periodontal disease.

Overall, the clinical evidence indicates that *Syzygium aromaticum* possesses measurable therapeutic benefits in dentistry, particularly for pain management, inflammation control, and antimicrobial support. While many applications are currently adjunctive rather than primary treatments, the consistency of clinical findings supports further integration of clove-based agents into evidence-informed dental care [7].

The preventive potential of *Syzygium aromaticum* in dentistry has received increasing attention in recent years, particularly in the context of long-term oral health maintenance. Experimental and clinical findings suggest that regular exposure to clove-derived compounds may contribute to the prevention of dental caries and periodontal diseases by suppressing pathogenic microflora and modulating inflammatory responses [8]. The incorporation of clove extracts into oral hygiene products such as toothpastes, gels, and mouth rinses has been associated with reduced plaque indices and improved gingival health, supporting its role in preventive dentistry [8, 9].

In preventive applications, the antimicrobial spectrum of clove is particularly relevant. Studies indicate that clove oil effectively inhibits acidogenic and aciduric bacteria responsible for enamel demineralization, thereby reducing cariogenic potential [3]. Additionally, anti-



inflammatory and antioxidant effects may help maintain periodontal tissue integrity and slow disease progression in individuals at risk of gingivitis and periodontitis [6]. These properties align with modern preventive dentistry strategies aimed at controlling biofilm-related diseases through minimally invasive and biocompatible interventions.

Safety considerations remain an essential aspect of clove application in dental practice. Although generally regarded as safe at low concentrations, eugenol exhibits cytotoxic and irritant effects at higher doses or with prolonged exposure [10]. In vitro studies demonstrate dose-dependent cytotoxicity toward fibroblasts and pulp cells, emphasizing the importance of appropriate formulation and controlled dosage [1]. Clinical reports of adverse reactions, including mucosal irritation and allergic responses, are relatively rare but underscore the need for caution, particularly in pediatric and hypersensitive patients.

Standardization and quality control represent significant challenges in the broader use of clove-based products. Variability in phytochemical composition due to differences in plant origin, extraction methods, and storage conditions can lead to inconsistent therapeutic effects [2]. The lack of standardized dosing guidelines and regulatory frameworks further limits widespread clinical adoption. Current evidence supports the necessity of establishing standardized preparations with defined concentrations of active constituents to ensure reproducibility and safety [2].

Despite these limitations, the convergence of experimental and clinical data highlights promising directions for future research. Well-designed randomized controlled trials are needed to clarify optimal dosages, delivery systems, and long-term outcomes associated with clove use in dentistry. Additionally, investigations into synergistic effects between clove-derived compounds and conventional dental agents may enhance therapeutic efficacy while reducing reliance on synthetic antimicrobials [3].

In summary, the reviewed evidence demonstrates that *Syzygium aromaticum* holds considerable therapeutic and preventive potential in dentistry. Its antimicrobial, anti-inflammatory, and analgesic properties support both symptomatic management and preventive strategies. However, further standardization, safety evaluation, and high-quality clinical research are required to fully integrate clove-based preparations into evidence-based dental practice and preventive oral healthcare [4].

Quantitative data from independent experimental studies further substantiate the antimicrobial and dental relevance of *Syzygium aromaticum*, particularly in relation to cariogenic and periodontal-associated microorganisms. Multiple in vitro investigations have demonstrated pronounced antibacterial activity of clove essential oil against *Streptococcus mutans*, one of the primary etiological agents of dental caries. Reported minimum inhibitory concentrations for clove oil against this microorganism range between 125 and 1000 µg/mL, depending on extraction method and testing protocol. At concentrations of 1000, 500, 250, and 125 µg/mL, bacterial growth was markedly suppressed, with colony counts remaining below 10⁵ CFU, whereas lower concentrations resulted in a significant loss of inhibitory effect.

Diffusion-based antimicrobial assays have also revealed large zones of inhibition produced by clove oil against cariogenic bacteria. In several studies, inhibition zones exceeding 30 mm were observed for *S. mutans*, indicating strong antibacterial potency compared with many other plant-derived agents. Such findings highlight the ability of clove-derived compounds to interfere with bacterial proliferation and adhesion processes relevant to plaque formation.

Quantitative antimicrobial effects of clove preparations have additionally been reported against a broader range of microorganisms, including *Staphylococcus aureus*, methicillin-resistant *S. aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella pneumoniae*.



Inhibition zone diameters for these organisms typically ranged from 27 to 33 mm, suggesting broad-spectrum activity. Although these bacteria are not exclusively oral pathogens, their suppression is relevant to oral wound healing, denture-related infections, and mixed-species biofilms commonly encountered in the oral cavity.

Experimental data related to dental biomaterials further support the quantitative relevance of clove-derived compounds. Studies investigating zinc oxide–eugenol–based materials demonstrated sustained antibacterial activity associated with eugenol release. Antimicrobial effects were observed across concentration ranges from 0 to 1250 µg/mL and persisted even after prolonged water storage, indicating long-term biological activity relevant to temporary restorations and endodontic applications.

Collectively, these quantitative findings confirm that clove-derived preparations exert measurable antibacterial effects at defined concentration ranges, with consistent suppression of cariogenic bacteria and biofilm-forming microorganisms. The variability in reported effective doses underscores the influence of formulation, extraction technique, and testing methodology, emphasizing the importance of standardization. Nevertheless, the convergence of numeric data from multiple studies reinforces the experimental rationale for the use of *Syzygium aromaticum* in dental prevention, adjunctive antimicrobial control, and the development of phytotherapeutic dental products.

CONCLUSIONS

The analysis of experimental and clinical data confirms that *Syzygium aromaticum* possesses significant pharmacological properties relevant to modern dentistry. Its biological activity is primarily associated with eugenol and other phenolic compounds that exhibit antimicrobial, anti-inflammatory, analgesic, and antioxidant effects. These properties directly address key pathogenic mechanisms involved in the development and progression of common oral diseases, including dental caries, periodontal inflammation, and mucosal lesions.

Experimental studies consistently demonstrate that clove-derived preparations inhibit the growth of cariogenic and periodontal-associated microorganisms at defined concentration ranges and interfere with biofilm formation, which is central to oral disease persistence. Quantitative data from in vitro investigations indicate that clove essential oil can suppress bacterial growth at microgram-per-milliliter levels, while diffusion assays reveal large inhibition zones against relevant oral pathogens. These findings provide a strong scientific basis for the antimicrobial potential of clove in dental applications.

Clinical evidence supports the traditional and contemporary use of clove-based agents for the management of dental pain and inflammatory conditions. Topical application of clove oil and eugenol-containing formulations has been shown to provide rapid analgesic effects and reduce gingival inflammation, while incorporation of eugenol into dental materials contributes to antibacterial activity and pulp-sedative properties. Additionally, preventive applications in oral hygiene products suggest a role for clove in reducing plaque accumulation and maintaining periodontal health.

Despite its promising therapeutic and preventive potential, several limitations remain. Variability in phytochemical composition, lack of standardized formulations, and dose-dependent cytotoxic effects highlight the necessity of controlled dosing and rigorous quality assurance. Moreover, the current body of clinical evidence, while supportive, remains limited by small sample sizes and heterogeneity in study design.

In conclusion, *Syzygium aromaticum* represents a valuable phytotherapeutic resource in dentistry with both therapeutic and preventive applications. Its integration into evidence-based



dental practice requires further standardized experimental studies and well-designed clinical trials to establish optimal formulations, safety profiles, and long-term efficacy. Continued research in this field may facilitate the development of safe, effective, and biocompatible plant-based alternatives and adjuncts to conventional dental treatments.

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