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Review Article

The Integration of Herbal Remedies as Green Dentistry into Contemporary Dental Practice: Comprehensive review

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Abstract

Since ancient times, herbal medicines and herbal prescriptions have been the preferred method for treating many modern diseases due to their distinct therapeutic properties, as well as their limited side effects and patients' acceptance of such types of herbal medicines. Oral and dental diseases are among the widespread modern diseases due to unhealthy lifestyle habits. This review has discussed how scientific research in the modern era has enriched the applications of medicinal plants and herbal preparations in treating diseases of the mouth and teeth, including tooth decay, mouth ulcers, oral mucosa inflammation, oral cancer, and others. This review also discussed the most important medicinal plants that have been used in treating various oral and dental diseases, their active ingredients, and methods of treating various oral diseases. This review is a comprehensive scientific guide for dental practitioners and patients to the most recent findings of modern research on the use of herbal medicines with an effective therapeutic effect while mitigating the side effects of their synthetic counterparts.

Keywords:
Peptic ulcers, green chemistry, sustainable drug development, eco-friendly extraction, phytochemicals.

Introduction

Medicinal plants with therapeutic effects have been used throughout history in various parts of the world, and even today, to prevent or alleviate many diseases. Dental health is one of the most prevalent diseases worldwide (Glick et al., 2020; Lagos et al., 2025). In 2022, the World Health Organization reported that oral and dental diseases affect approximately three billion people worldwide, including oral and gum diseases and infections, tooth decay, bad breath, tooth loss, and malignant tumors of the mouth and lips (Aljafar et al., 2021). Medicinal plants, herbal extracts, and essential oils are effective alternative treatments for alleviating the symptoms of oral and dental diseases. They are less expensive and have fewer side effects than synthetic drugs, making them in line with global trends toward the use of herbal medicines as a bioequivalent, safe, and affordable alternative with fewer side effects. This has earned them global trust over synthetic drugs. Many effective medicinal plants have been used to treat the symptoms of oral, gum, and dental health disorders (Hotwani et al., 2014).

Clove oil has been used as a local anesthetic, mouthwash, and in toothpaste as a local anesthetic for mouth and toothaches, and as an antimicrobial and antibacterial agent for gum infections. Essential oils extracted from sage, mint, rosemary, thyme, and chamomile have also been used in various pharmaceutical forms, such as oral gels, mouth and throat gargles, and toothpastes. Myrrh, frankincense, and Indian hemp have also been used as analgesics for mouth and gum pain, and as anti-inflammatory and antimicrobial agents in various pharmaceutical forms (Anwar et al., 2025;Dubey et al., 2025). Recent studies have shown that the use of silver, gold, and copper nanoparticles is more effective than the use of natural herbal extracts in treating many oral diseases,

such as malignant tumors of the oral membranes (Mazur et al., 2022; Refaey et al., 2024; Yazdanian et al., 2022). This review will discuss many of the most common oral and dental diseases in the modern era. It will also shed light on the most important medicinal plants that can be used as alternatives to treat many symptoms of oral and dental disorders, the active ingredients of these herbs, and their method of treating these disorders at the level of pre-clinical experiments on live subjects or clinical trials on patients, and the evaluation of this research and its effectiveness in achieving encouraging therapeutic results.

2.Common periodontal pathogens

2.1. Oral carcinoma

Oral carcinoma, also known as oral cancer, is a severe disease that destroys the tissues in the mouth and throat. Human papillomavirus (HPV) infections, excessive alcohol usage, chewing areca nuts and tobacco use are important risk factors for this illness. Human papillomavirus infection is the primary cause of the sharp increase in young people's oropharyngeal cancer incidence in several high-income communities (Mehanna et al., 2013). Men, the elderly, and those from low-income families are more likely to develop oral cancer, and socioeconomic differences have been documented both within and between nations (Conway et al., 2015). The Central and Eastern Europe, South Asia, the Pacific, and Latin America are the highest incidence regions (Warnakulasuriya, 2009). Effective therapy depends on early diagnosis, which also has a major impact on the prognosis and survival rates of those who are impacted (Zygogianni et al., 2011). The potential of several natural substances in the treatment of oral cancer has been brought to light by recent investigations. These substances have other advantages that could improve oral health in addition to their anticancer qualities. Essential oils obtained from a variety of Zingiberaceae plants, including *Curcuma mangga, Curcuma xanthorrhiza, Kaempferia galanga, and Curcuma aeruginosa*, have shown antibacterial action against several oral infections (Amil et al., 2024). According to research, zinc oxide has strong antioxidant and antibacterial properties and is stabilized by cinnamic acid that is used to encapsulate it. Additionally, these nanoparticles exhibit dose-dependent cytotoxicity against KB cells of human oral epidermal carcinoma via altering apoptotic pathways that involve important proteins like P53, BAX, and BCL-2(Ravikumar et al., 2024).

2.2. Oral candidiasis

Oral candidiasis is the most common fungal infection in humans, especially in early and later life The hallmarks of oral candidiasis, frequently referred to as "thrush," which includes tongue infections and other oral mucosal locales, include fungal overgrowth and superficial tissue penetration. The primary cause is Candida albicans, a widespread opportunistic fungal pathogen that frequently infects susceptible individuals' oral mucosal surfaces superficially(Williams et al., 2013). *Candida albicans* is a common oral pathogen that often poses no issues for healthy individuals. The manner the Candidate interacts with the epithelial surface it invades is the main determinant of the type of contact it has with its host. Unquestionably, there is a delicate balance between the host's immune response and the potentially detrimental effects of *Candida virulence* factors. Changes in host features often seem to cause *Candida* to transition from a commensal to a pathogenic life. Many older people are affected by it, particularly those who wear artificial teeth, and it is usually avoidable with good oral hygiene habits. Moreover, it is a prevalent issue among people with compromised immune systems and could be a sign of systemic diseases such as diabetes mellitus (Akpan & Morgan, 2002). Conversely, oesophagial overgrowth caused by an overabundance of *Candida* can result in dysphagia, which can lead to poor nutrition, prolonged hospitalization, and a delayed recovery. Additionally, it may alter taste perception and induce discomfort locally. In immunocompromised patients, infections can spread through the bloodstream or upper gastrointestinal tract, leading to severe infections with a high rate of morbidity and mortality (Akpan & Morgan, 2002).

2.3. Gingivitis

Gingivitis is an inflammatory condition that affects the gingival tissue and is marked by gingival erythema and irritation. Plaque deposits are the main cause of bacterial illness (Kurgan & Kantarci, 2018). The main causes are infections and biofilm formation, but other risk factors can be divided into nonmodifiable variables like genetic polymorphisms and modifiable factors like smoking, obesity, stress, diabetes mellitus, osteoporosis, and vitamin D and calcium deficiencies (Kurgan & Kantarci, 2018). Using dental floss and a tooth brush to mechanically remove plaque has been found

to be an effective way to treat gingivitis (Kurgan & Kantarci, 2018; Sowinski et al., 2008). As a result, other strategies, including mouthwashes and dentifrices that contain chemical or herbal agents are recommended. Essential oils (EO) and chlorhexidine (CHX) have been approved by the American Dental Association as antiseptics in mouthwashes (Costa, Susin, Cortelli, & Almeida Pordeus, 2012). According to (Mosaddad, Hussain, & Tebyaniyan, 2023), some plant-based components, including tea tree oil, aloe vera, lemongrass, and cloves, have antibacterial and anti-inflammatory properties that may help reducing the symptoms of gingivitis.

2.4. Periodontitis

Periodontitis is a more advanced form of periodontal disease than gingivitis. It causes inflammation around the tooth, affecting the supporting tissues such as the gums, periodontal ligament, and alveolar bone. Periodontitis, if left untreated, can lead to tooth loss and other serious health consequences (Lang, Schätzle, & Löe, 2009). It is a severe gum infection that destroys the soft tissue and bone that support the tooth. Periodontitis is linked to oral microbiota such *Aggregatibacter actinomycetemcomitans, Eikenella corrodens, Fusobacterium nucleatum, Porphyromonas gingivalis, Prevotella intermedia, Tannerella forsythia, Enterococcus faecalis and Treponema denticola , P. gingivalis, P. intermedia and A. actinomycetemcomitans* are regarded as the major pathogens in advancing periodontitis (Allaker & Douglas, 2009).

2.5. Mouth ulcers

Mouth ulcers, also known as aphthous ulcers or canker sores, are small, uncomfortable lesions that develop on the oral cavity's mucous membranes. The inner cheeks, lips, tongue, gums, and palate can all develop these ulcers (Philipone, Yoon, & Koutlas, 2023). Oral ulcers typically cause extreme pain and necessitate medical attention. Among its causes are lesions from trauma, immunological diseases, gastrointestinal problems, rheumatic diseases, blood disorders, infectious processes, and other conditions (Scully & Felix, 2005). The primary lesion is a direct ulceration brought on by epithelial necrosis that spreads into the basement membrane, exposing nerve terminals and causing pain or discomfort (Scully & Felix, 2005).

2.6. Tooth decay

Tooth decay is an infectious disease that damages the tooth's dentin and enamel (Wilson & Wilson, 2021) . The mouth's microorganisms start the decay process using the sugars to create acids that damage the teeth. According to (Yadav & Prakash, 2017), the key treatment techniques include spitting out, improving oral hygiene habits, and consuming fewer sugar-containing beverages. Numerous studies have documented the use of medicinal plants, including *Glycyrrhiza uralensis*, *Vaccinium macrocarpon, Uva-fugi* apple, *Vitis vinifera* (red grape seeds), *Myristica fragrans nutmeg, ajwain Trachyspermum ammi, Coffea arabica and Coffea robusta, Hordeum vulgare* (barley coffee), *Myrtus communis, Allium sativum* (garlic), *Theobroma cacao* (cocoa), *propolis, and Camellia sinensis* (tea) as an effective treatment for dental caries.

2.7. Xerostomia

The clinical condition known as xerostomia, or dry mouth, is defined by a severe decrease in saliva flow, which causes discomfort and makes one more prone to oral infections, including dental caries. This problem is linked to several etiological factors, including autoimmune diseases like Sjögren's syndrome, radiation therapy that targets the head and neck, and drugs that cause xerostomia. It can cause dysphagia, or trouble swallowing (Kontogiannopoulos et al., 2023). The most researched natural products include apigenin, thyme honey, ethanolic extracts of *Ixeris dentata* (IXD), *Lycium barbarum* polysaccharides (LBP), green tea, fermented lingonberry juice, coconut oil, ginger, aloe vera, peppermint, pineapple glucosylceramide, linseed, *Malva sylvestris*, *Alcea digitata*, pilocarpine, and lycopene-enriched virgin olive oil (Ibrahim, Abou-Bakr, Ghalwash, & Hussein, 2023).

2.8. Dental plaque

It is well recognized that dental plaque removal is crucial for the health of the oral cavity, and caries is believed to be an infectious condition brought on by bacteria found in dental plaque. Dental plaques are difficult to spot with the naked eye. Therefore, plaques are typically stained using a dental-plaque detection system that consists of a dental-plaque staining agent that contains curcumin and turmeric extracts, as well as a light-emitting device that emits light with a wavelength between 250 and 500 nm to an object in the oral cavity that has the staining agent attached (Nivetha, Murthykumar, K.S, Kumar, & Priyadharshini, 2014). Pawar et al. described a dentifrice/herbal tooth

powder that contained 91% *Acacia catechu*, 2.7% Menthol, and 6.3% Camphor. The powder of *Acacia catechu* was used to remove tartar, plaque, and stains, as well as to cleanse and polish the tooth surface without causing abrasion, while menthol and camphor were used as flavouring agents. A clinical trial on this herbal dentifrice indicated 87-95%, 70-72%, and 80-95% decreases in plaque, gingivitis, and dental calculus, respectively, after approximately 15 days of treatment(Kumar, Ansari, & Ali, 2009).

2.9. Toothache

Toothache is the most common cause of mouth pain. Most of the tooth pain is unilateral, localized, and severe. It may show up as swelling and is exacerbated by biting and osmotic or thermal stimuli. Any discomfort inside or next to a tooth is called a toothache. Contrarily, pain is an unpleasant sensation brought on by actual or potential tissue injury, and it can range from mild discomfort to extreme misery (Zakrzewska, 2013).

Only in cases of systemic infection, rapid sickness spread, or immunocompromised patients are antibiotics given in addition to the last course of treatment. Odontogenic infections are treated with antibiotics such as amoxicillin or phenoxymethylpenicillin, amoxicillin with metronidazole, and amoxicillin with clavulanate or Clindamycin (Segura-Egea et al., 2018).

2.10. Oral submucous fibrosis (OSF)

Chewing areca nuts is the main cause of oral submucous fibrosis (OSF), a chronic condition that causes inflammation and fibrosis of the oral mucosa. In order to treat OSF, this study explores the use of intralesional dexamethasone, hyaluronidase, and curcumin, an anti-inflammatory polyphenol. In comparison to standard treatment, curcumin substantially boosted mouth opening and decreased symptoms in a 12-week randomized clinical trial including 34 patients. According to the results, curcumin may be a useful adjunct treatment for OSF, which calls for more investigation (Adhikari, Rimal, Maharjan, & Shrestha, 2022).

2.11. Oral submucous fibrosis (OSMF)

Fibrosis in the oral cavity causes stiffness and decreased mouth opening in oral submucous fibrosis (OSMF), a persistent and incapacitating disorder. OSMF, as defined by Pindborg and Sirsat, is frequently linked to inflammation and epithelial atrophy and can impact any area of the oral cavity, occasionally the pharynx (More, Jatti Patil, & Rao, 2020). If left untreated, this precancerous disease might develop into oral cancer. Burning sensations, trouble eating, and possible malnutrition are some of the symptoms. In order to improve patient outcomes and quality of life, effective management and treatment options require greater knowledge and research (Xu et al., 2021).

3. Materials and Methods

For this review study, keywords such as gingivitis, antiparasitic, antibacterial, antiviral, antioxidant, analgesic, anti-inflammatory, and plaque were used. The engines and databases searched for in those articles were Google Scholar, Scopus, PubMed, and Web of Science.

4. Search strategy

The search strategy involved a systematic approach utilizing multiple databases, including PubMed, Scopus, Web of Science, and Google Scholar. Key search terms such as herbal remedies, oral health, dental health, antimicrobial properties, anti-inflammatory effects, antiplaque, analgesic and antioxidant activity were employed to maximize relevant literature retrieval.

5. The role of Medicinal Plants in dental care:

Herbal medicines are well known for their traditional uses owing to their soothing features, which have significantly advanced dental practice. Many plant-based products have been found to have strong anti-inflammatory properties. Studies in this field have been diverse, with some concentrating on formulations employing just one chemical and others investigating the effectiveness of more complex combinations. The potential of herbal medicines to improve dental treatments and patient outcomes is highlighted by this diversity of approaches (Moradpoor et al., 2021). In the following section of this review, we'll discuss some of the most significant herbs that have shown efficacy against periodontal pathogens, The efficacy of these herbs is summarized in Table 1

***5.1. Aloe barbadensis* (Aloe Vera)**

Aloe vera (L.) Burm. f. (synonym: Aloe barbadensis) or Aloe from the family Asphodelaceae (Liliaceae) ,is a perennial plant which originates from South Africa, but has also been cultivated in dry subtropical and tropical regions, such as the southern USA(López, de Tangil, Vega-Orellana,

Ramírez, & Rico, 2013). *Aloe vera* has powerful activity in treating periodontal illness, including gingivitis, periodontitis, alveolar osteitis, stomatitis, oral mucositis, oral lichen planus, and oral submucosal fibrosis; (Bhat, Kudva, & Dodwad, 2011). Furthermore, following surgical extraction, it speeds up the healing process, including for the third molar. It comes in several forms, including toothpaste, mouthwash, and gel (Al-Maweri et al., 2020).

Aloe vera gel contains a variety of bioactive substances, including polysaccharides, anthraquinones, vitamins, minerals, and enzymes(Lavu & Jeyabalan, 2023). Compounds in *Aloe vera* can also prevent the synthesis of nitric oxide and inflammatory cytokines. It may aid in tissue regeneration and repair by increasing collagen synthesis and fibroblast proliferation. *Aloe vera* mouthwash was proven to have comparable results to chlorhexidine in a number of trials concerning the plaque index without creating the taste or staining of teeth that are commonly linked to chlorhexidine (Lavu & Jeyabalan, 2023).

5.2. Camellia sinensis (Green Tea)

Green tea is made from the leaves of the *Camellia sinensis* L. plant belonging to the Theaceae family (Lavu & Jeyabalan, 2023). It was extensively cultivated in Asian, African, Latin American, and Oceanian countries, which was believed to originate from northeast India, north Myanmar, and southwest China. The main ingredient of green tea, polyphenols, particularly epigallocatechin-3-gallate (EGCG), which possesses antioxidant, antibacterial, and anti-inflammatory properties. Researchers have investigated that the green tea extracts can lessen inflammation, encourage the healing of periodontal tissue, and stop the growth of periodontal pathogens. During scaling and root planning (SRP), green tea catechins applied sub gingivally can enhance the reduction of pocket depth. Research has demonstrated that several green tea formulations, including tea sachets, strips, gel, chewing gum, and toothpaste, can decrease pocket depth , bleeding on probing, and plaque and gingival index (Godowski, 1989).

5.3. Allium sativum (Garlic)

Allium sativum L., commonly known as garlic, belongs to the genus Allium and family Alliaceae. It is mostly produced in the USA, China, India, the Mediterranean and EU countries. Many of its well-known therapeutic properties are attributed to its main constituents, S-allyl cysteine, methiin, and alliin (El-Saber Batiha et al., 2020). Garlic is a necessary part of whole foods and herbs since they are complete substances that contain a lot of sulfur-containing phytochemicals as well as other phytochemicals with potential antioxidant and bioactive properties. Aqueous extracts of *Allium sativum* have antimicrobial properties that work against both gram-positive and gram-negative bacteria, including *Salmonella, Escherichia coli, Staphylococcus, Klebsiella, Proteus, Clostridium,* and *Mycobacterium* (Lavu & Jeyabalan, 2023). Garlic is useful in dentistry because it has antibacterial properties that help treat tooth cavities and periodontitis. Recent research has also demonstrated that garlic can help treat oral cancer (Karic, Jaiswal, Abrahamse, Thakur, & Ganeshpurkar, 2020). Studies have been conducted on dental pathogens in-vitro and in-vivo as well as the antibacterial qualities of *A. sativum*. An in-vitro study showed a maximal zone of inhibition (ZOI) of 24 mm for the antibacterial activity of various garlic varieties against cariogenic bacteria (*S. mutans* and *L. acidophilus*) (Kshirsagar et al., 2018). Another investigation was carried out in-vivo to evaluate garlic's antibacterial efficacy against oral Streptococci. Using garlic as a mouthwash shows that the solution (5%) has strong antibacterial properties against oral microbes and *S. mutans*.

5.4. Curcuma longa (Curcumin)

Turmeric, also known as *Curcuma longa* L., belongs to the Zingiberaceae family. It is widely grown throughout Asia, primarily in China and India. Turmeric has been used in India for at least 2500 years and is most likely an Indian invention. Because of its antibacterial, anti-inflammatory, and antioxidant qualities, *C. longa* has long been used as a medicinal herb in Asian nations (Naidu & Suresh, 2018). It is used in dentistry for several conditions, such as periodontitis, gingivitis, and dental caries, oral lichen planus, as a subgingival irrigant and oral submucous fibrosis (Lavu & Jeyabalan, 2023). According to a study done to assess the antibacterial effectiveness of *C. longa* essential oil against *S. mutans*, turmeric can stop dental caries from developing by slowing the growth of *S. mutans* biofilm at high concentrations (Lee et al., 2011). In terms of lowering periodontopathic bacteria, turmeric is just as effective as or even more effective than chlorhexidine, whether applied topically, as a mouthwash, a subgingival irrigant, or a local drug delivery system to treat periodontal diseases

(Forouzanfar, Forouzanfar, Sathyapalan, Orafai, & Sahebkar, 2020).

***5.5. Ocimum sanctum* (Tulsi)**

Tulsi leaves are quite helpful against common mouth illnesses. A few raw leaves might also help you maintain good dental hygiene. Carracrol and Tetpene are antibacterial compounds discovered in this plant. Sesquiterpene b-caryophyllene also has antibacterial effects. Tulsi leaves that have been sun-dried and powdered can be used to clean your teeth. It can also be combined with mustard oil to form a paste and used as toothpaste. Tulsi has also been demonstrated to effectively treat halitosis. Its anti-inflammatory characteristics make it a good treatment for gingivitis and periodontitis, and it can be used to massage the gingiva in periodontal conditions (Lavu & Jeyabalan, 2023).

***5.6. Salvia officinalis* (Sage)**

One of the most commercially important species in the Lamiaceae family is *Salvia officinalis L*., often known as Sage. It is an evergreen, perennial subshrub that is native to the Mediterranean area. In terms of its application in dentistry, sage tea is frequently suggested as a gargle in contemporary European herbal medicine to treat gingivitis and oral irritation. *S. officinalis* herbal mouthwash's antiplaque and anti-inflammatory qualities proved effective in lowering patients' GI and PI (Sadeghi, Esfahanian, & Damavandi, 2023). Additionally, *S. officinalis* mouthwash effectively lowers the amount of *S. mutans* in school children's dental plaque, hence treating dental caries. Conversely, the essential oil of *S. officinalis* showed anticandidal activity against every strain of *Candida albicans*, with an inhibitory zone that stretched from 40.5 mm to 19.5 mm. Therefore, its volatile oil can be utilized as an antifungal denture cleaning to reduce the risk of Candida-associated denture stomatitis by preventing candidal adhesion (Sookto, Srithavaj, Thaweboon, Thaweboon, & Shrestha, 2013).

***5.7. Mangifera indica* (Mango Leaf)**

It can be present in various toothpastes and is used as a brushing substance. Mangiferin, anthocyanins, ascorbic, and phenolic acids—all of which have antibacterial qualities—are found in mango leaves. The features of mangiferin (2C, Beta D-Glucopyranosyll, 3, 6, 7 tetra hydroxylxanthone) include cardiotonic, cholerectic, diuretic, and anti-inflammatory effects. Mangiferin's antibacterial activity at different concentrations was examined by (Anarthe et al., 2017) and contrasted with that of streptomycin and penicillin G. It was discovered that mangiferin worked well against *Lactobacillus acidophilus, pneumococci, streptococci,* and *staphylococci*.

***5.8. Azadirachta indica* (Neem)**

In India and other South Asian countries, neem has long been used to clean teeth and preserve gingival health. Traditionally, neem twigs were used to wash teeth and chewed to treat periodontal disease (Lavu & Jeyabalan, 2023). Genin, sodium nimbinate, salannin, nimbin, azadirachtin, nimbidiol, quercetin, and nimbidin are the constituents of neem. Fiber, carbohydrates, proteins with at least ten amino acids, calcium, carotenoids, and fluoride are all found in neem leaves (Bhattacharyya, Hamid, & Telgi, 2017). An effective inhibitor of oral infectious disease-causing bacteria is the extract of *Azadirachta indica*. Additionally, it lowers the tooth plaque index. Neem tree leaves are said to have anti-inflammatory, astringent, antiviral, and antiseptic properties as well as the ability to eliminate toxins, cleanse the blood, and shield the body from damage caused by free radicals (Taheri, Azimi, Rafieian, & Zanjani, 2011).

***5.9. Matricaria recutita* (German Chamomile)**

German Chamomile, or *Matricaria chamomilla*, is a well-known medicinal herb of Asteraceae family. It is native to northern and western Asia, as well as southern and eastern Europe. Several phytochemicals have been detected in *M. chamomilla*; its main classes include flavonoids, coumarins, sesquiterpenes, volatile terpenoids, and phenolic acids (Sharifi-Rad et al., 2018). Chamomile is commonly used to treat periodontal diseases. Its flowers have 1-2% volatile oils that contain alpha-bisabolol, alpha-bisabolol oxides A and B, and matricin. It also contains bioflavonoids such as apigenin, luteolin, and quercetin. These ingredients have anti-inflammatory properties. According to the study findings, Chamomile has potential benefits as a mouthwash for the treatment and prevention of periodontitis (Groppo et al., 2008).

5.10. Calendula officinalis

Calendula officinalis L., a plant belonging to the Asteraceae family, is found throughout southern Europe and the Mediterranean region. *C. officinalis* is used in dentistry to treat plaque and gingivitis.

The effectiveness of calendula mouthwash as a scaling supplement in lowering tooth plaque and gingivitis is substantiated by the randomized trial assessing *C. officinalis* as an anti-plaque and anti-gingivitis agent (Khairnar, Pawar, Marawar, & Mani, 2013). Furthermore, a study examining the antimicrobial activity of various calendula extract concentrations on periodontal pathogens showed that employing varying concentrations of *C. officinalis* mouthwash can successfully lower the total microbial count in patients with gingivitis and periodontitis (Jamwal & Kanade, 2020). In cases of oral candidiasis, calendula helps treat oral candidiasis and has antifungal qualities similar to nystatin, according to a study done to evaluate the antifungal activity of *C. officinalis* volatile oil (Jamwal & Kanade, 2020).

***5.11. Zingiber officinale* (Ginger).**

Zingiber officinale Roscoe, frequently referred to as Ginger, is a member of the Zingiberaceae family and genus. Ginger has been used for therapeutic purposes for 2,500 years. Ginger and other Zingiberaceae plants contain strong antioxidant and anti-inflammatory properties, and some of its strong ingredients have been shown to prevent cancer in experimental carcinogenesis. It can be used as an intracanal dressing in the dental field and patients with recurring denture stomatitis and aphthous infections (Al-Shibani, Al-Kattan, Alssum, & Allam, 2022). A natural gel containing honey and *Z. officinale* can be used to successfully control plaque during the periodontal maintenance phase (Al-Shibani et al., 2022). Although ginger has less side effects than ibuprofen, it is still better when used as an analgesic to control pain during periodontal flap surgery since it lowers pain almost as efficiently.

***5.12. Glycyrrhiza glabra (*Licorice)**

Glycyrrhiza glabra L., a member of the Leguminosae family, has been extensively utilized for more than 4000 years in Ayurvedic and traditional medicine. Dental caries, gingival and periodontal diseases, oral cancer, endodontic problems, and oral candidiasis are among the conditions it is used to treat in dentistry (Hambire & Hambire, 2020). In human subjects, licorice extracts significantly reduce the development of dental caries, particularly when produced as candies, lollipops, or other such products. In order to improve dental health and avoid gingival problems, these extracts can be used to oral hygiene products (Hambire & Hambire, 2020). Both planktonic and biofilm cells were used in a study to test the antibacterial and anti-proteolytic qualities of licorice root extract against *P. gingivalis*. MIC and MBC values of 62.5 µg/ml and 25 µg/ml, respectively, demonstrated the extract's antibacterial efficacy against *P. gingivalis* (Suwannakul & Chaibenjawong, 2017) .

Table 1 Efficacy of Herbal medicine against dental diseases:

NO	Plant name	Part of the plant used	Therapeutic effect	Formulations used	References
1	Aloe vera barbadensis L.	Leaf	Anti-gingivitis and plaque, antiulcer, and antibacterial	-Mouthwash -toothpaste.	(Chandrahas et al., 2012)
2	Curcuma longa	Rhizome	-Anti-gingivitis, -Anti-inflammatory -Antioxidant, antiseptic -Antimicrobial	- topical application. - mouthwash. - subgingival irrigate.	(Mali, Behal, & Gilda, 2012)
3	Matricaria chamomilla	Leaf and essential oil	-Antibacterial -Antifungal, antiviral - Anti-inflammatory	------	(Adwan, Salameh, Adwan, & Barakat, 2012)
4	Rosmarinus officinalis	Leaf	- Gingival diseases. - Halitosis, dental caries. periodontitis.	toothpaste.	(Sener, 2019)

5	Mangifera indica L	Fruit	- periodontitis, inhibition of oral streptococcus, and reduction of plaque and oral inflammation	alternatives to CHX in mouthwashes for children.	(Adwan et al., 2012)
6	Ocimum basilicum	Leaf and seed	Antimicrobial, antifungal	------	(Naiktari, Gaonkar, Gurav, & Khiste, 2014)
7	Calendula officinalis	Flowers	- anti-plaque, gingivitis. -oral candidiasis -oropharyngeal mucositis in patients undergoing radiotherapy	Mouthwash	(Saini et al., 2012)
8	Acacia arabica	bark	-Mild to moderate chronic periodontitis. -controlling plaque. -gingivitis, oral hygiene. -enamel hardness	-chewing stick.	(Ramalingam & Amaechi, 2020)
9	Acasia senegal	essential oil	-Antibacterial, anti-protease anti-inflammatory, anti-plaque	------	(Makkar, Tewari, Kishor, & Kataria, 2013)
10	Glycyrrhiza glabra	Root	Antibacterial and antifungal	------	(Jafari Sales & Bolouri, 2018)
11	Vaccinium macrocarpon	Fruits	Antioxidant Used to treat tooth decay, gum diseases.	------	(Bhattacharyya et al., 2017)
12	Syzgium aromaticum	Flower buds	-Antiseptic, Analgesic. -Used to treat toothache, bleeding gums.	------	(Bhattacharyya et al., 2017)
13	Thymus vulgaris -	essential oil	-dental caries. -oral herpes, halitosis. -chronic candidiasis.	gingival mucoadhesive patch from the essential oil.	(Botelho et al., 2007)
14	Cimmiphoramolol .	Stem	Antibacterial, analgesic. -gingivitis, oral ulcers, stomatitis	-----	(Bhattacharyya et al., 2017)
15	Sanguinaria canadensis .	Root	Used to treat swollen gums, remineralization of enamel lesions	-----	(Poureslami, 2012)
16	Trigonella foenum-graecum	seeds	-An alternative periodontal dressing to reduce postoperative	bucco-adhesive paste.	(Sundaram, Gd, Ramakrishnan, & Kanimozhi, 2022)

			inflammation -recurrent aphthous, stomatitis -gingivitis, -Anti-inflammatory.		
17	Propolis	resin-like material	Stomatitis, Periodontitis, halitosis, dental caries, traumatic ulcers.	toothpastes	(Sardana, Indushekar, Manchanda, Saraf, & Sheoran, 2013)
18	Mentha piperita .	leaf	reduce gingival inflammation, stop toothache, a cooling effect that serves as an analgesic and lessens discomfort	toothpaste. mouthwash.	(Sener, 2019)
19	Nigella sativa	seed	toothache. Periodontitis, gingivitis, antioxidant. anti-inflammatory	------	(Tembhurne, S, B, & D, 2014)
20	Salvia officinalis	leaf	mouth inflammation, gingivitis, dental caries halitosis.	mouthwash	(Kharaeva et al., 2020)

6. Herbal Formulations in Dental Therapy

Herbal extracts are concentrated substances made from plants that contain active compounds that may have therapeutic uses (Ashfaq et al., 2023). However, solubility and absorption issues restrict the effectiveness of many herbal extracts in treating a variety of oral and dental conditions. Several techniques were used to improve these qualities, including formulations based on nanotechnology. Herbal extracts' solubility, stability, and release duration can be greatly increased by nanotechnology-based delivery systems, such as lipid nanoparticles, polymeric nanoparticles, and hybrid nanoparticles, which facilitate efficient absorption via biological membranes (Wassif et al., 2024). The effectiveness of several dental care products, including mouthwash, polishing pastes, and toothpastes, can be improved by nanomaterials. With a size range of 1 to 100 nm, they are highly bioavailable to cells and tissues due to their exceptional surface-to-volume ratio(Carrouel, Viennot, Ottolenghi, Gaillard, & Bourgeois, 2020). To improve the mechanical, antibacterial, and regenerative qualities of dental materials, metal nanoparticles have been added. Zinc, silver, gold, copper, and titanium, for instance, exhibit antibacterial properties(Agnihotri, Gaur, & Albin, 2020). In addition, photodynamic therapy employs a combination of a certain wavelength of light and a photosensitizer medication in the presence of oxygen to create harmful oxygen species that disrupt and harm the cellular components of pathogens (Konopka & Goslinski, 2007). Furthermore, dentistry has made extensive use of nanocomposites. By increasing the consistency between the tooth's structure and these effective regenerative materials, they may be able to establish a more durable and organic interaction between the tooth's hard mineralized tissues and the tiny filler particles used. Flexural strength, exceptional hardness, translucency, elasticity, excellent handling qualities, and a 50% decrease in filling shrinkage are all potential benefits of these nanofillers (Aktas et al., 2024). Fortunately, in addition to its therapeutic benefits, nanotechnology was predicted to play a major role in the development of digital dental imaging techniques. Digital radiography using nanophosphor scintillators could produce high-quality images with a lower radiation exposure. Zinc-containing medications, such as zinc citrate, zinc oxide, zinc chloride, and zinc gluconate, have become more

and more popular in dental treatments because of their strong antibacterial properties and ability to promote mucosal healing (Uwitonze, Ojeh, Murererehe, Atfi, & Razzaque, 2020). Because it prevents bacteria from growing, zinc citrate, which is frequently present in mouthwashes and toothpaste, helps to reduce the incidence of gingivitis and plaque. Zinc oxide has remineralizing and antimicrobial qualities and is widely used in dental cements and fillings (Moradpoor et al., 2021). Mouthwashes and topical gels containing zinc chloride aid in the treatment of oral infections and hasten the healing of wounds following dental procedures. Zinc gluconate also helps to prevent bacteria from growing and lessen bad breath(Pushpalatha et al., 2022). Additionally, research on the incorporation of zinc oxide nanoparticles showed that they could prevent dental caries and treat oral infections by preventing Streptococcus mutans and Lactobacillus from producing acid in dental plaque(El Shahawi, 2023). The utilization of zinc oxide nanoparticles in endodontics, restoratives, periodontics, implantology, orthodontics, and prosthodontics was the subject of another study. Dental materials could benefit from these nanoparticles' enhanced cytotoxicity, high selectivity, biocompatibility, and ease of manufacture (Zeidan, Enany, Mohamed, & Marzouk, 2022). Nanotechnology has been found to enhance the stability of plant extracts against hydrolysis, oxidation, photo or thermal degradation, and to reduce volatility(Antunes Filho et al., 2023) .Curcumin was shown to be photoreactive, lowering activity by 70%. As a result, (Onoue et al., 2013), developed curcumin-loaded solid dispersions with improved physical stability, with just 17% degradation identified, enhancing their efficacy in treating gingivitis and mucositis. Furthermore, (Tonglairoum, Ngawhirunpat, Rojanarata, Kaomongkolgit, & Opanasopit, 2016)found that complexing betel and clove oils with cyclodextrins enhanced their solubility. They were subsequently incorporated into nanofibers, which produced quick oil release and increased antifungal activity against oral Candida species, suggesting their potential to cure denture stomatitis. To treat periodontitis, a range of herbal extracts have been added to nanosystems. Recently developed kaempferol nanoparticles loaded with calcium sulphate composite beads have been demonstrated to exhibit antibacterial activity against Staphylococcus aureus and Escherichia coli, suggesting their potential utility in periodontal treatment to reduce bacterial levels at the site of infection (Narang & Narang, 2015).

Additionally, herbal extracts from *Trypterygium wilfordii*, despite their low intestinal absorption and water insoluble nature, shown encouraging outcomes as oral chemotherapy therapies. According to a study, lipid-based nanocarriers containing Trypterygium wilfordii, such as lipid nanospheres and lipid nanoparticles,were created to increase the solubility and diffusivity of the bacteria into tumor cells(Guo, Zhang, & Al-Jamal, 2021) .

Conversely, compared to free curcumin dispersion, silica nanoparticles loaded with curcumin demonstrated increased cellular absorption and cytotoxicity in oral squamous cell carcinoma cells. When compared to free curcumin forms, curcumin-loaded nanoparticles demonstrated more cytotoxicity, encouraging cancer cells to undergo apoptosis (Pecorini, Ferraro, & Puppi, 2023). Fortunately, in addition to its therapeutic benefits, nanotechnology was predicted to play a major role in the development of digital dental imaging techniques. Digital radiography using nanophosphor scintillators could produce high-quality images with a lower radiation exposure.

Numerous formulations of plant-based treatments have been researched for the treatment of periodontal disease, including:

1.**Mouthwashes:** To provide antimicrobial and anti-inflammatory effects, natural oral rinses can be formulated with herbs, essential oils or extracts.

2.**Toothpaste:** Herbal toothpaste can be made with a variety of herbal ingredients such as aloe vera, curcumin, neem, myrrh, or clove.

3.**Gels and irrigation solutions:** Plant-based gels or solutions containing herbal extracts or ingredients such as aloe vera and curcumin can be applied to periodontal pockets. They may promote healing, reduce inflammation, relieve pain and reduce bacterial load.

4.**Chewing sticks:** Chewing sticks made from the branches of certain plants, such as Salvadora persica (Miswak) or Neem (Azadirachta indica), have traditionally been used for oral hygiene, particularly in certain parts of Africa, Asia and in Middle East countries which contains antimicrobial properties.

Conclusion

We are moving away from nature as our way of life becomes more and more reliant on technology, but since we are a part of nature, we cannot escape it. Because they are natural products, herbs are available locally, relatively safe, and environmentally friendly. Promoting them is crucial in order to save lives. A variety of plants have antibacterial properties that can stop the growth of periodontal pathogens, including strains that are resistant to antibiotics, hence avoiding gum infections and plaque buildup. Gum health is also improved by the antioxidant activity of certain plants, which fights oxidative stress in oral tissues. In comparison to traditional therapies, herbal remedies have several noteworthy benefits, such as affordability, accessibility, long-lasting effects, and reduced toxicity.

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