Harnessing Phytotherapy in Periodontal Therapy: Clinical Efficacy, Mechanisms, and Future Directions for Herbal-Based Adjuncts in Treating Periodontitis

Running title: Phytotherapy: Herbal-Based Adjuncts for Periodontal Therapy

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ABSTRACT

Phytotherapy, or the use of medicinal plants along with herbal preparations, is a rapidly emerging, valuable tool that serves as an adjunct in the management of periodontal disease. Periodontal disease is a chronic inflammatory condition that affects the surrounding and supporting tissues of the teeth, which leads to progressive loss of attachment, ultimately resulting in tooth loss if not treated earlier. Often, microbial plaque serves as a trigger for chronic periodontitis, and this plaque shall be removed by mechanical debridement and other antimicrobial agents. However, traditional therapies impose other challenges, such as resistance to certain antibiotics, adverse effects, and compliance issues. In this review article, the context briefs you upon phytotherapy serving as a compelling, natural, and sustainable alternative and adjunct to periodontal mechanical therapy, harnessing the anti-microbial, anti-inflammatory, anti-oxidant, and wound-healing properties, which are only inherent to most of the medicinal herbs.

Keywords: Phytotherapy, Periodontitis, Herbal adjuncts, Bioactive phytochemicals, Oral health, Scaling and root planing

INTRODUCTION:

Periodontal disease is an inflammatory condition that affects the surrounding and supporting structures of the teeth, which include the gingiva, periodontal ligament, cementum, and the underlying alveolar bone. The common periodontal diseases to date are gingivitis (affecting the gingival component) and periodontitis, a progressive and destructive condition resulting in the loss of connective tissue attachment and resorption of the alveolar bone, ultimately leading to tooth loss.[1]

The pathophysiology of periodontal disease starts with plaque accumulation, a complex-structured biofilm that is composed of diverse microbial communities and pathogenic bacteria predominantly comprising Gram-negative anaerobic bacteria such as *Porphyromonas gingivalis* and *Tannerella forsythia*. These microorganisms trigger a host-immune inflammatory response, which, in the intention of fighting the pathogenic bacteria, ends up in own tissue destruction mediated by pro-inflammatory cytokines interleukin 1-beta, Tumor necrosing factor- alpha, interleukin-6 (IL-1β, TNF-α, IL-6) and

matrix metalloproteinases, leading to the destruction of collagen and alveolar bone. The course of the disease can be mapped by subclinical inflammation of the gingiva, marking the initiation of the disease. Followed by early gingivitis progressing to an established lesion of the periodontium characterized by epithelial proliferation and bleeding on probing, culminating in advanced periodontitis with very minimal chances of reversing the condition, resulting in bone loss and eventually tooth loss.[2]

The treatment and management of periodontal disease include the mechanical removal of the microbial film through conventional methods like scaling and root planing, alongside the adjunctive therapies to control the progression of the inflammation and the spread of the infection. Conventional treatments often stress the usage of systemic anti-microbial agents as an adjunct and, if needed, surgery in more complex cases.

Due to bacterial resistance to antibiotics and also the adverse effects of certain antibacterial agents, there is an increasing need for alternative preventive and therapeutic options that are safe, effective, and affordable. Therefore, the exploration of natural phytochemicals derived from medicinal plants offers a promising and viable alternative for such purposes. Newer adjuncts like phytotherapy, incorporating natural compounds and herbal formulations, are gaining attention for their anti-inflammatory, anti-microbial, anti-oxidant, and tissue-healing properties, providing a very promising complementary approach alongside the conventional periodontal care to prevent recurrence of the disease and for better oral hygiene maintenance.[3]

The Indian history of phytotherapy for treating periodontal patients dates to 3000 years, rooted in the ancient Ayurvedic system of medicine. Ayurvedic system of medicine emphasizes on holistic approach to health by utilizing various medicinal plants known for their healing properties to maintain oral hygiene. The most well-recognized herbal agents known to mankind are neem (*Azadirachta indica*), turmeric (*Curcuma longa*), tulsi (*Ocimum sanctum*), and cloves (*Syzygium aromaticum*), all of which have been traditionally and commonly used in India for their anti-microbial, anti-inflammatory, and wound-healing properties to alleviate infections and inflammation.[4]

Classic Ayurvedic texts like Charaka Samhita and Sushruta Samhita best describe the uses of these botanical herbs for oral hygiene maintenance well before the emergence of modern dental science. It recommends traditional techniques like chewing neem twigs to clean the teeth and applying turmeric paste for gingival ailments. The idea behind the balance of the body's doshas and purifying the underlying toxins through herbal formulations and

therapies align closely with each other, along with managing periodontal inflammation and infection. Post-independence, Indian researchers began scientifically looking into these traditional herbs and plants to validate their medicinal properties and efficacy in treating oral hygiene. They had successfully identified the bioactive compounds and isolated them, which gave rise to incorporating traditional phytotherapeutic agents into modern-day practice. Today, India leads its research in phytotherapy and its applications in periodontal treatment by integrating the ancient knowledge along with modern-day clinical approach, thus preserving and improving its rich heritage in natural oral health care.[4,5]

This review aims to organize and sum up the evidence about the most used medicinal plants for the treatment of periodontal diseases, which focuses on decreasing the pain and inflammatory responses.

Numerous clinical studies have demonstrated the effectiveness of various herbal agents, including green tea (*Camellia sinensis*), aloe vera, turmeric (*Curcuma longa*), neem (*Azadirachta indica*), clove (*Syzygium aromaticum*), tea tree oil (*Melaleuca alternifolia*), and other herbal plants. These agents not only reduce the bacterial load but also help alleviate gingival inflammation and accelerate tissue regeneration. These herbal agents are available in forms like mouth rinses, gels, oils, toothpastes, and powders with low side effects and affordability. Herbal-based mouthwashes and adjuncts have resulted in comparable and even superior outcomes compared to conventional agents like chlorhexidine. However, the clinical use of phytotherapy is limited by study designs, lack of standardization of herbal formulations, and research concerns stating that these studies might need high-quality research and even more standardized regulatory protocols for clinical testing.[6]

The global markets seem interested in phytotherapy approaches in periodontics because of clinical efficacy and a huge demand from patients who have recently shifted to natural and holistic therapies, especially in populations who have less hands-on conventional care. Modern research supports the combined and synergistic use of herbal agents with conventional scaling and root planing; therefore, positioning phytotherapy as an adjuvant therapy in treating periodontal diseases can significantly have a greater impact on the treatment outcomes and improve overall prognosis of the treatment procedure.[6]

HERBAL PLANTS AND THEIR THERAPEUTIC USES:

1.Green Tea (*Camellia sinensis*):

Green tea contains polyphenols, catechins such as epigallocatechin gallate (EGCG), that possess strong anti-oxidant, anti-inflammatory, and anti-bacterial properties. EGCG can disrupt the growth and metabolism of the periodontal pathogens like *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans*, further reducing their adhesions to teeth and the surrounding structures. The anti-oxidant effects of green tea help in neutralizing free radicals during the inflammation process, protecting the periodontal tissues. The Green Tea mouthwashes, when clinically used, provide notable improvements in plaque control, decreased gingival bleeding, and a low number of inflammatory markers in the oral cavity. These properties make green tea a safe adjunct in the non-surgical phase of periodontal therapy.[6,7]

2. Turmeric (*Curcuma longa*):

The active ingredient found in turmeric is Curcumin. It has broad anti-inflammatory properties and anti-microbial effects. Curcumin targets many number of signalling pathways, e.g., nuclear factor kappa-activated B cells (NF-κB), that serve a major role in the inflammatory processes. It further suppresses the pro-inflammatory cytokines and enzymes, reducing the destruction of connective tissue and alveolar bone. In randomized clinical trials, it was found that topical application of curcumin gels and use of mouthwashes significantly reduced gingival inflammation, bleeding on probing, and pocket depth compared to the control group. The turmeric also supports wound healing and proliferation of fibroblasts, which further promotes tissue repair after conventional scaling and root planing procedures carried out in the non-surgical phase of periodontal therapy.[6,8]

3. Neem (*Azadirachta indica*):

Neem extracts are found to be rich in azadirachtin, nimbidin, and nimbolide, which are potent anti-bacterial, anti-fungal, anti-inflammatory, and healing agents. Mouthwashes and toothpastes containing neem have shown properties that reduce the number and virulence of plaque-forming bacteria and have improved the overall oral hygiene index scores. It was also found to be a rival to chlorhexidine in controlling the periodontal disease from causing further destruction. Its anti-inflammatory agents help in alleviating gingival swelling and redness, and the antioxidant properties govern the protection of the gums from cellular

damage. The astringent properties of neem have been shown to improve keratinization, along with restoring the health of the gingival tissues.[6,9]

4.Aloe Vera (*Aloe barbadensis miller*):

Aloe vera gel contains polysaccharides (acemannan), vitamins, amino acids, and enzymes that contribute to its soothing properties and regeneration of gingival tissues. Its anti-bacterial effects make it effective and powerful against common periodontal pathogens. Aloe vera also enhances the synthesis of collagens, epithelial cell growth, and decreases the number of migratory inflammatory cells during the phase of inflammation. Randomized studies reveal that aloe vera, both on topical application and as mouthwash, accelerates wound healing, reduces gingival bleeding, and improves clinical attachment levels. Therefore, aloe vera can be used as an adjunct during post-scaling or surgical interventions.[6,10]

5.Clove (*Syzygium aromaticum*):

The main ingredient in clove is eugenol, which provides strong analgesic, anti-inflammatory, and anti-microbial effects. Eugenol causes a break in the membrane of pathogenic bacteria, inhibits the biofilm formation, and suppresses the synthesis of prostaglandins, resulting in the reduction of pain and swelling. Clinically used mouthwashes and gels containing clove extract have demonstrated greater reduction in gingival index scores and gingival bleeding, with additional benefits of pain relief and clean breath due to its aromatic qualities [6,11]

6.Tea Tree Oil (*Melaleuca alternifolia*):

Tea tree oil contains terpinene-4-ol and γ-terpinene, which are intended to directly kill the Gram-negative anaerobes like *Porphyromonas gingivalis*. Its anti-inflammatory properties reduce the release of cytokines as a part of the inflammatory process and reduce the oedema formation in the gingival tissues. It is designed for a period of short-term use due to its potent flavour, but has also shown a reduction in plaque index after usage. It shows further added benefits, including reduction in the probing depths, and alleviation of the symptoms in patients with moderate to severe periodontitis.[6,12]

7. Sage (*Salvia officinalis*):

Essential oils found in sage include thujone, cineole, phenolic acids, and flavonoids showcase great anti-bacterial and anti-inflammatory properties. The extracts inhibit

bacterial growth, act on free radicals produced during the inflammation, and reduce further progression of inflammation by suppressing the formation of prostaglandins. It can be applied intraorally as a gel or a rinse after scaling and root planing procedure, resulting in reduced plaque formation and improved gingival health, along with good compliance from the patient.[6,13]

8. Pomegranate (*Punica granatum*):

The pomegranate plant contains phytochemicals like punicic acid, ellagic acid, phenols, and flavonoids. It possesses anti-gingivitis properties due to the antioxidant capabilities of the flavonoids. It enhances the action on free radicals of hepatic enzymes such as catalase and peroxidase. When used as a rinse, pomegranate inhibits alpha-glucuronidase, an enzyme that disassembles the sucrose. Randomized clinical trials on adult patients with periodontitis have found that using pomegranate extracts in the form of gels and chips, along with scaling and root planing, could alleviate the symptoms of periodontal disease and reduce the pocket depth.[6,14]

9.Tulsi (*Ocimum Sanctum*):

Tulsi leaves are primarily composed of eugenol and methyl eugenol. The anti-inflammatory effects fight against oedema, which is induced by the prostaglandins E2, leukotriene, and arachidonic acid. Tulsi leaves are found to be effective against various pathogens, including *Streptococcus mutans*, *Streptococcus aureus*, and *Escherichia coli*. It further shows anti-viral, anti-fungal, and anti-cariogenic properties. The anti-bacterial properties of *O. sanctum* could break the cytoplasmic membranes of microbial pathogens, resulting in their destruction. Along with the above-mentioned pathogens, *A. actinomycetemcomitans* was also found to be affected by the usage of Tulsi as a rinse and mouthwash. Tulsi extracts could act as rivals against the conventional chlorhexidine mouthwashes. Furthermore, after several clinical studies, it was found that the extracts of Tulsi have an immunomodulatory effect, increasing the interferon, T-helper cells, and interleukin-4 levels in the host.[6,15]

10. Guava (*Psidium guajava*):

It contains essential oils, flavonoids, triterpenoid acids, sesquiterpene alcohols, and certain vitamins, of which all the agents contain anti-oxidant, anti-inflammatory, anti-microbial, anti-hyperglycaemic, and analgesic properties. In previous years, people used to use the guava extract as a paste to maintain their oral hygiene. This paste was found to be destructive against Gram-positive and Gram-negative bacteria. Studies show that

suppression of gingivitis is closely related to vitamin C and other vitamins in minor amounts. Quercetin, a substance found in Guava, has extraordinary anti-bacterial properties, which result in suppression of prostaglandins and histamines, which are found in the process of gingival inflammation. [6,16]

11. Amla (*Emblica officinalis*):

Amla is found to play a major role in traditional medicine and has several beneficial properties. It contains flavonoids, phenols, and tannins. Tannins tend to produce anti-bacterial properties along with their phenolic components, resulting in the reduction of inflammatory processes. It also has anti-inflammatory, anti-oxidant, and cyto-protective properties that are much better when compared with the cytotoxic and genotoxic properties of chlorhexidine. Studies revealed that, when amla extracts were used along with routine mechanical therapy in patients with chronic periodontitis, the condition significantly improved clinically.[6,17]

12. Garlic (*Allium sativum*):

Garlic, specifically aged garlic extract (AGE), has given notable benefits in the prevention and post-treatment phase of periodontal diseases due to its anti-oxidant, anti-inflammatory, and anti-microbial properties. AGE contains active sulphur compounds like S-allylcysteine, S-1 propenylcysteine, and S-allyl-mercapto-cysteine, that aid in suppressing the growth of the periodontal pathogens and further reducing the production of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6. These are known to cause breakdown in the tissue structure, resulting in bone loss during periodontitis. Garlic is also a source of prebiotic fibre, known to be beneficial for gut health and digestion. In studies, these extracts demonstrated anti-proteolytic effect on *P. gingivalis* protease enzyme. Furthermore, the aqueous solution of garlic showed a higher bacteriostatic action. *A. actinomycetemcomitans* demonstrated greater resistance to both aqueous and ethanol extract versions of garlic, suggesting that these extracts can be used to treat periodontitis. Long-term studies have demonstrated that oral supplements containing AGE lead to a significant decrease in the gingival bleeding, periodontal pocket depth, overall inflammation, and inhibit resorption of the alveolar bone, supporting the regeneration of healthy tissues. Garlic's multi-versatile action makes it a promising adjunct therapeutic method for both prevention and the post-treatment phase in chronic periodontal disease.[6,18]

13. Grape seed extract (*Vitis vinifera*):

Grape seed extract (GSE) is known to be a naturally occurring compound containing polyphenols, such as proanthocyanidins, that exhibit anti-inflammatory, anti-oxidant, and anti-microbial properties, which makes it a promising adjunct in treating periodontal disease. GSE inhibits the growth of pathogenic oral bacteria in the oral cavity and causes a reduction in collagen degradation by blocking the interstitial pathway and extracellular collagenase activity. Further, it limits the breakdown of tissue structure due to the underlying periodontal condition. Clinical studies have demonstrated that GSE can reduce the inflammatory cell infiltration during the process of inflammation, supporting the connective tissue attachment, suppressing the bone-resorbing activity, and enhancing the levels of IL-10 and TGF-β in gingival tissues. Thus, helping in improving tissue healing and reducing the progression of the periodontal disease. GSE's anti-oxidant property helps in neutralizing the free oxygen species that lead to tissue destruction in periodontitis. Therefore, GSE acts as a natural therapeutic agent, reducing the periodontal inflammation, protecting the alveolar bone from resorption, and supporting the overall oral health.[6,19]

14. Polyherbs:

Polyherbs are obtained from different herbs and other plant extracts. Polyherbal formulations play a pivotal role in periodontal therapy by harnessing the synergistic actions of multiple medicinal plants, grouping all their anti-microbial, anti-inflammatory, and healing properties. They can be used to produce natural mouthwashes, toothpastes, and rinses. These formulations are combinations obtained from guava, turmeric, clove, aloe vera, tea tree oil, tulsi, and others, effectively aiding in the reduction of plaque accumulation, biofilm control, halitosis, gingival inflammation, and bleeding on probing, acting as the perfect adjunct for traditional treatment methods like scaling and root planning. The multitasking action of the polyherbs results in disruption of biofilm, microbial growth inhibition, and modulation of host inflammatory processes, improving the periodontal health. To alleviate the discomfort caused by the oral ulcers, polyherbal formulations contain licorice, chamomile, and calendula. They can be either topically applied or used as rinses. Clinical studies have proved that polyherbal mouthwashes can become a rival to the traditional chlorhexidine mouthwashes, but without producing side effects such as staining or alteration in the taste sensation, making them suitable for daily use. Furthermore, studies have proven that these formulations are completely safe to use,

affordable, well-tolerated, and compliant with the patients, which strengthens their potential to battle against gingivitis and periodontal problems.[6,20]

ADVANTAGES OF PHYTOTHERAPY IN PERIODONTAL TREATMENT:[26]

- It is completely of natural origin with a composition consisting of bioactive compounds that help in reducing plaque accumulation, biofilm control, inhibition of the inflammatory pathways, and decreasing the microbial load effectively in the oral cavity.
- Known for its low incidence of side effects on the host compared to other synthetic conventional drugs like chlorhexidine.
- These naturally occurring formulations are cost-effective, affordable, and widely accessible, even in a resource-limited environment.
- The multifaceted actions of these compounds include the anti-inflammatory, anti-microbial, anti-oxidant, and wound healing properties, which are essential for the prevention of further progression of the periodontal disease.
- Several clinically proven studies under experimental settings have demonstrated that phytotherapy shows increased patient compliance and acceptance due to a shift in treatment approach to natural and holistic methods.

DISADVANTAGES OF PHYTOTHERAPY IN PERIODONTAL TREATMENT:[26]

- The lack of standardization and quality control in the production of these herbal formulations leads to variable efficacy of the end product, ultimately affecting the outcome of the treatment and further prognosis.
- Limitations in the manufacture of these formulations on a large scale, the need for high-quality clinical trials also affect the efficacy and safety of these herbal products.
- If not supervised by a certified medical professional, these herbal formulations have the potential to develop severe allergic reactions or herb-drug interactions upon varied dosages.
- The chances of variability in the concentration of bioactive compounds are purely based on plant source and extraction methods.
- The onset of action of these formulations will be relatively slower compared to the conventional pharmaceutical agents, thus affecting the compliance of the patients.

INDICATIONS FOR PHYTOTHERAPY:[27]

- Indicated when adjunctive treatment is needed in patients with mild to moderate gingivitis and periodontitis alongside the routine mechanical procedure, such as scaling and root planing.
- Used as maintenance therapy post-treatment to prevent the recurrence after active periodontal treatment.
- Indicated in patients who are allergic to conventional antimicrobials.
- Due to a recent shift in people's mindset, they demand and prefer natural, holistic treatment approaches for oral health management.
- Can be applied in a resource-limited environment, where supportive care is limited to only a few conventional drugs.

CONTRAINDICATIONS FOR PHYTOTHERAPY:[27]

- Should be contraindicated if any allergy or hypersensitivity reactions are evident in patients due to the presence of certain herbal components.
- During pregnancy and lactation, a professional must be well-aware of the patient's pregnancy history, their medications to prevent any medical complications that may occur due to the reaction between the drugs and herbal components.
- Use of unstandardized, non-clinically validated herbal products without any knowledge of the dosages.
- Contradicted in patients who are on a complex drug regimen for certain health problems. Further treatment should be carried out only after a referred medical opinion and consent.
- Severe or advanced periodontal disease requires an immediate conventional surgical approach, while herbal compounds might be used as an adjunct post-treatment in such patients.

CONCLUSION:

Phytotherapy stands as a promising and safe adjunct in periodontal therapy, harnessing its anti-microbial, anti-inflammatory, and anti-oxidant properties of medicinal herbs to enhance its clinical outcomes, patient satisfaction, and the overall oral health. While the research studies and their results support its efficacy and safety, marking their territory over mild to moderate cases of periodontitis, widespread clinical adoption is still hindered by

the challenges in standardized protocols and quality control. As patients are shifting their need for treatment to be done in natural and holistic methods, future integration of phytotherapy in periodontal management will require continuous and at-will research with professional supervision, and harmonization of the traditional wisdom with ethnical practice and contemporary scientific protocols, paving the way for sustainable and patient-centric advancements in oral care.[28]

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TABLE 1: Overview of Research Evidence Supporting Phytotherapeutic Applications in Periodontics

S.NO	AUTHOR & YEAR	HERB	FORM	STUDY	RESULT
1	Vennila K 2016[21]	Neem	10% non-absorbable neem oil chip	Adjunct to scaling and root planing (SRP), neem oil chip was used as a Local drug delivery system to evaluate the efficacy in the periodontal disease management.	Clinical parameters improved in sites that received neem oil chips along with SRP, and also a profound reduction in *P. gingivalis* when compared to the sites that received SRP only
2	Kaur D 2017[22]	Clove	Rinse	Potential of clove of *Syzygium aromaticum* in development of a therapeutic agent for periodontal disease[11]	Definite potential to be used as specific anti-plaque and anti-inflammatory agents for the treatment of periodontal disease.
3	S Tewari, RK Sharma 2018[17]	Amla (*Emblica officinalis*)	10% *Emblica officinalis* Irrigation solution	*Emblica officinalis* as an Irrigation and Adjunct to Scaling and Root Planing (SRP) compared to chlorhexidine.	10% irrigant adjunctive to SRP improved periodontal healing without side effects and may be considered as an alternative to chlorhexidine for chronic periodontitis treatment
4	Mangalekar SB	Guava extract	Aqueous guava extract	Evaluated the antimicrobial efficacy of guava extract on	The study supports guava's potential as an antimicrobial agent

	2018[16]	(aqueous guava extract)	Ethanolic guava extract	periodontal pathogens like *A. actinomycetemcomitans* and *Porphyromonas gingivalis* is an in vitro study.	against periodontal pathogens
5.	Sparabombe S 2019[20]	Polyherb-composed of *Propolis* res in extract, *Plant ago lanceolata*, *Salvia officinalis* leav es extract, and 1.75% of essential oils	Mouthwash	Evaluated the anti-inflammatory effect and the adverse effects of an all-natural polyherbal mouthwash in patients with periodontitis following 3 months of use	Use of polyherbal mouthwash in patients with periodontitis had proved safe and effective in reducing bleeding score and plaque accumulation, after 3 months, when compared with placebo
5	Zini A 2020[18]	Garlic (aged garlic extract)	Tablet	To explore the beneficial effects of aged garlic extract (AGE) on periodontitis, whether daily supplementation with AGE could prevent or improve periodontitis progression in adult patients, as measured by clinical periodontal parameters	Aged garlic extract is an effective supplement for preventing or improving periodontal disease and may also be used as a means to improve general health

6	Guru SR 2020[23]	TURMERIC (2% curcumin with nanocarrier)	GEL	Compared the clinical efficacy of 2% curcumin with nanocarrier gel and 1% chlorhexidine gel as local drug delivery (LDD) adjuncts to scaling and root planing (SRP) in patients with periodontitis	2% curcumin delivered showed results comparable to chlorhexidine gel and hence can be considered as a promising LDD agent in the treatment of periodontal pockets.
7	Taalab MR 2021[12]	Tea tree oil	Gel	Intrapocket application of tea tree oil (TTO) gel in the treatment of stage 2 periodontitis	The local delivery of TTO gel adjunctive to SRP proved to be effective in the treatment of stage II periodontitis.
8	Deepika BA 2023[15]	Tulsi (*Ocimum sanctum L*)	Gel (2% *Ocimum sanctum L*)	Evaluate and compare the efficacy of *Ocimum sanctum L* (Tulsi) gel with Tetracycline fibers (Actisite) for the treatment of periodontitis patients.	2% *Ocimum sanctum L* (Tulsi) gel can be effectively used as an adjunct to scaling and root planing, bringing reduction of pocket depth and gain of clinical attachment and showed promising results when compared to Tetracycline fibers (Actisite).

9	Ramamurthy J 2024[19]	Grape Seed Oil	Grape seed oil infused with silver nanoparticles, incorporated into a gel	Antimicrobial efficacy of a nano-formulated grape seed oil gel against *Staphylococcus aureus*, *Streptococcus mutans*, *Lactobacillus sp.*, *Enterococcus faecalis*, *and Candida albicans* against standard chlorhexidine gel in an in vitro study	Nano-formulated grape seed oil gel holds promise as a potent antimicrobial agent for managing periodontal diseases, particularly at higher concentrations, making it a promising alternative for managing periodontal disease
10	Aljuboori IW 2024[13]	Sage (*Salvia officinalis*)	Gel	Compared the clinical efficacy in a randomized, controlled split-mouth clinical trial of Sage (*Salvia officinalis*) gel as a local drug delivery (LDD) adjunct to scaling and root planing (SRP) in patients with periodontitis, while the other site received SRP alone	*Salvia officinalis* gel, used as an adjunct to scaling, significantly improved clinical periodontal parameters in patients with periodontitis. Its anti-inflammatory properties, underscored in this study, suggest its use as a safe alternative to traditional chemical pharmaceuticals.
11	Ashifa N 2025[24]	Aloe vera	Gel	Aimed to evaluate the clinical effect of aloe vera gel as an adjunct to scaling and root planing (SRP) in periodontitis treatment.	As an adjunct to SRP and aloe vera gel significantly improved clinical parameters like plaque index, gingival index, and probing pocket depth in periodontitis patients.

12	Rengaraj S 2025[7]	Green tea	GEL	Compared the clinical efficacy of green tea extract gel and ornidazole gel as adjuncts to scaling and root planing (SRP) in patients with periodontitis	As an adjunct to SRP, green tea extract gel showed greater efficacy in improving periodontal parameters when compared to ornidazole gel
13	Pauly A 2025[25]	Pomegranate	GEL	Compared the clinical efficacy of pomegranate gel and as a local drug delivery (LDD) adjunct to scaling and root planing (SRP) in patients with periodontitis	Improvement in all clinical parameters, such as probing pocket depth (PPD) and Clinical attachment level (CAL), suggesting that local application of 5%-pomegranate gel after SRP is effective in periodontitis patients and hence can be recommended as an adjunctive non-surgical therapy.