Review Article

Herbal Toothpastes as Desensitizing Agents: A Review

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ABSTRACT

Dentinal hypersensitivity (DH) is a common dental disorder in which brief, stinging pain occurs due to exposed dentin reacting to thermal, tactile, or chemical stimuli. In approximately one-third of adults, DH has a notable effect on quality of life and is often associated with enamel erosion, gingival recession, and periodontal treatment. Pain results, based on Brännström's hydrodynamic theory, from fluid movements in open dentinal tubules that activate nerve endings. Traditional desensitizing substances like potassium nitrate, stannous fluoride, and arginine-calcium carbonate exert their action either by nerve desensitization or tubule occlusion. Side effects and long-term safety concerns, though, have produced interest in more natural alternatives to traditional desensitizing materials. Plant-containing herbal toothpastes with cloves, neem, guava, and green tea provide plant-based ingredients anti-inflammatory, antimicrobial, and analgesic properties. These spices not only alleviate symptoms by soothing nerves and anti-inflammatory effects but can also contribute to dentinal tubule occlusion, offering a promising, safer option for controlling dentinal hypersensitivity.

Key words: Dentinal Hypersensitivity, Herbal Toothpaste, Tubule Occlusion, Natural Desensitizing Agents

Dentinal hypersensitivity (DH) is a common oral disorder defined by brief, sharp pain originating from exposed dentin in response to thermal, chemical, tactile, or osmotic stimuli. The prevalence of DH has been reported to be about 33.5% [1]. DH exerts a considerable impact on quality of life, particularly when eating, drinking, or applying oral hygiene measures. The disorder frequently occurs in association with enamel erosion, gingival recession, and periodontal treatment [2]. Based on Brännström's hydrodynamic theory, pain is caused by fluid movement within dentinal tubules that activates pulp nerve endings [3].

Conventional desensitizing toothpastes typically contain agents like potassium nitrate, stannous fluoride, or arginine-calcium carbonate complexes [4]. Although these substances work well, long-term use issues, side effects, and the growing consumer interest in natural products have created a need for herbal alternatives. Herbal toothpastes contain plant-based constituents renowned for their astringent, antimicrobial, analgesic, and anti-inflammatory effects. Clove, neem, guava, and green tea have demonstrated efficacious results in controlling dentinal hypersensitivity. Their bioactive compounds in nature can exhibit a double action of tubule occlusion as well as relief from symptoms without the adverse effects of synthetic products [5, 6]. This review aims to explore the current evidence on herbal ingredients used in desensitizing toothpastes, their mechanisms of action, comparative effectiveness, and potential as safe, sustainable alternatives in the management of dentinal hypersensitivity.

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PATHOPHYSIOLOGY OF DENTIN HYPERSENSITIVITY

DH occurs mainly as a result of dentinal tubule exposure, which is otherwise covered by enamel or cementum. When these covering layers are lost due to processes like attrition, abrasion, erosion, or gingival recession, the dentin underlying them becomes sensitive to external stimuli [7]. The most generally accepted theory for DH is the hydrodynamic theory, introduced by Brännström in 1966. This theory suggests that stimuli like cold, heat, air, or osmotic pressure induce swift movement of fluid in the open dentinal tubules. Fluid movement generates shear forces that stimulate mechanoreceptors near the pulp-dentin interface, which finally lead to pain sensation [3].

Pathological processes of major importance include: [8]

- Enamel loss is a prerequisite for dentin exposure above the cementoenamel junction and can result from erosion (acidic diet), abrasion (forceful brushing), and attrition

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(bruxism). These processes lead to enamel wear and subsequent dentin sensitivity.

- Cementum, covering the root dentin, can be lost due to periodontal disease, gingival recession, or periodontal therapy, exposing dentin and causing sensitivity. Cementum is thinner and less resistant than enamel, so its loss exposes dentinal tubules to stimuli.
- Increased or patent dentinal tubules, as observed using scanning electron microscopy (SEM), is highly associated with hypersensitivity.
- Inflammation in the pulp-dentin complex can sensitize nerve endings, enhancing pain perception in DH. This inflammatory response may amplify the pain signals generated by fluid movement in dentinal tubules.

Prevention or reversal of these alterations requires either tubule occlusion, interference with nerve transmission, or management of inciting factors such as gingival recession or erosion. Herbal desensitizing agents are thought to counteract these mechanisms by occluding exposed dentinal tubules through precipitation of organic/inorganic substances, decreasing nerve excitability and inhibiting local inflammation or microbial activity that can exacerbate dentin exposure [2].

CONVENTIONAL DESENSITIZING AGENTS

Throughout the years, various synthetic substances have been developed and added into over-the-counter toothpaste to control dentinal hypersensitivity. These substances generally act through two mechanisms: occlusion of dentinal tubules and nerve desensitization.

Potassium Nitrate

Potassium nitrate is one of the most commonly used agents in over-the-counter desensitizing toothpastes. Potassium nitrate acts by diffusing along the dentinal tubules and depolarizing the nerve endings, thereby diminishing their capacity to conduct pain signals. It has symptomatic effect but has no effect on dentin structure or occluding tubules [9].

Stannous Fluoride

Stannous fluoride possesses anti-caries and desensitizing actions. Its action is due to the precipitation of stannous ions, which create a covering layer on the dentin surface and occlude the tubules. It also possesses antibacterial action that can diminish the biofilm load responsible for dentin exposure [10].

Strontium Salts

Strontium is a calcium imitator and can substitute for it in the hydroxyapatite crystal structure of dentin. It occludes dentinal tubules and decreases sensitivity. While once widely used, its popularity has decreased with the advent of newer agents [11].

Arginine-Calcium Carbonate Complex

This cement simulates the processes of natural salivary and deposits a calcium and phosphate plug into dentinal tubules. Arginine functions as a carrier and is capable of accelerating occlusion. It is successful both in vitro and clinically [12, 13].

Bioactive Glass

Bioactive glass releases calcium, phosphate, and sodium ions that deposit a hydroxycarbonate apatite layer on the dentin surface (*e.g.*, *NovaMin®*). This is a simulation of natural tooth mineral and occludes tubules well over time [14, 15].

However, certain limitations of conventional agents include: [16, 17].

- Temporary or incomplete relief
- Requirement for continuous application
- Risk of side effects such as changed taste or staining
- Growing patient demand for natural, chemical-free alternatives

As a consequence of such restrictions, interest in herbal products that can produce equal or even greater efficacy but fewer side effects with increased biocompatibility has arisen.

HERBAL INGREDIENTS IN TOOTHPASTE WITH DESENSITIZING PROPERTIES

Herbal toothpastes have increased popularity because they are of natural origin, non-toxic in nature, and possess multifunctional activities like anti-inflammatory, antibacterial, antioxidant, and analgesic activities. Several herbal ingredients have the potential to treat dentinal hypersensitivity by blocking tubules, diminishing inflammation, or calming nerve endings.

Clove (*Syzygium aromaticum*)

Clove is a popular medicinal plant used in dentistry because of its therapeutic properties, mostly attributed to its active ingredient, eugenol. Eugenol has strong analgesic, anti-inflammatory, antimicrobial, and antiseptic properties, making it a mainstay in traditional and contemporary dental procedures. Its analgesic action is due to its capacity to function as a local anesthetic, wherein it blocks voltage-gated sodium channels, thus decreasing nerve excitability and preventing the conduction of pain impulses. This action is especially beneficial in reducing the pain that occurs with dentinal hypersensitivity. Aside from analgesic effects, eugenol also has anti-inflammatory effects through inhibiting prostaglandin and other inflammatory mediator synthesis, which reduces pulpal inflammation and its related hypersensitivity [18, 19].

Several in vivo studies and clinical reports have established its effectiveness in alleviating dental pain and discomfort through direct application to the sensitive area or in desensitizing preparations. In addition, in vitro experiments

employing scanning electron microscopy (SEM) have proved that clove extract partially occludes open dentinal tubules. The availability of bioactive phytochemicals within the extract aids the development of a smear-like layer on exposed dentin surfaces, which decreases fluid movement in the tubules, an essential component of the hydrodynamic theory of hypersensitivity. This combined action of tubule occlusion and nerve desensitization indicates that clove, especially eugenol, is very promising as a potent natural agent in the treatment of dentinal hypersensitivity [20, 21].

Neem (*Azadirachta indica*)

Neem has strong antibacterial, anti-inflammatory, and astringent activities. Its tannins and flavonoids contribute to tightening gum tissues and reducing inflammation. Neem extract has demonstrated antibacterial effects against periodontal pathogens and plaque reduction comparable to chlorhexidine in clinical trials, supporting its use in managing gingivitis and periodontal diseases. The astringent effect of neem's tannins helps in gum tissue tightening, while its anti-inflammatory compounds (e.g., nimbidin, azadirachtin) suppress inflammatory cells, reducing gum inflammation. Neem extract can contribute to dentinal tubule occlusion, and it is incorporated in many herbal toothpastes and mouth gel formulations aimed at improving oral health and reducing sensitivity [22, 23].

Guava (*Psidium guajava*)

Guava leaves (*Psidium guajava*) contain flavonoids, tannins, and vitamin C, which provide astringent, antioxidant, and anti-inflammatory effects. Research has demonstrated that guava leaf extract can reduce dentinal permeability and facilitate dentinal tubule occlusion, potentially alleviating dentin hypersensitivity. A relevant study assessing dentinal tubule occlusion was conducted in vitro using scanning electron microscopy (SEM) to observe the effect of guava leaf extract on dentin surfaces. The study showed that treatment with guava leaf extract led to partial occlusion of dentinal tubules, suggesting its potential to reduce dentin permeability and sensitivity. Additionally, a clinical trial evaluating a guava leaf extract-based mouthrinse demonstrated antimicrobial and antioxidant efficacy in patients with chronic gingivitis, supporting its multifactorial oral health benefits, which may contribute indirectly to dentin sensitivity management by reducing biofilm and inflammation [24, 25].

Green Tea (*Camellia sinensis*)

Green tea contains catechins, powerful antioxidants with anti-inflammatory and antibacterial properties that can reduce plaque formation and gingival inflammation, indirectly preventing dentinal exposure. Its astringent effect may also help decrease dentin sensitivity. An in vitro study showed that green tea and its main catechin, epigallocatechin-3-gallate (EGCG), inhibited matrix metalloproteinases (MMPs) that degrade dentin collagen, protecting against erosion-induced dentin damage. SEM analysis revealed that green tea treatments formed a protective layer on dentin surfaces, contributing to tubule occlusion and reduced dentin wear, although they did not completely prevent tissue loss [26]. An in situ clinical study with volunteers using green tea rinses demonstrated significant reduction in dentin wear under erosive and abrasive challenges compared to controls, indicating protective effects on dentin surfaces that can help maintain tubule occlusion [27].

Licorice (*Glycyrrhiza glabra*)

Licorice root extract contains glycyrrhizin, which exhibits anti-inflammatory and healing properties and has been traditionally used in Ayurveda for oral disorders. Its potential to calm hypersensitive sites and aid tissue repair is supported by reviews highlighting its beneficial effects against oral diseases such as gingivitis and periodontitis [28]. Regarding dentinal tubule occlusion, an in vitro study evaluating a herbal toothpaste containing liquorice along with other herbal extracts demonstrated significant dentinal tubule occlusion over time using scanning electron microscopy (SEM). The study showed progressive occlusion of tubules, reaching complete occlusion by day 45, suggesting that liquorice-containing formulations can contribute to tubule blockage and reduce dentin hypersensitivity [29].

Aloe Vera (*Aloe barbadensis miller*)

Aloe vera gel contains aloins, enzymes, and amino acids that provide anti-inflammatory, soothing, and healing effects, which may calm nerve endings and support gingival health, indirectly aiding in dentin hypersensitivity control. Regarding dentinal tubule occlusion, an in vitro study assessed experimental saliva substitutes containing aloe vera extract and propolis on demineralized dentin. Using scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX) analysis, the study found that while aloe vera alone had minimal effect, formulations with propolis showed significant mineral precipitation and tubule occlusion. Aloe vera contributed to increased viscosity and showed some remineralization potential, suggesting it may support dentin repair and sensitivity reduction when combined with other agents [30].

Other Herbs

Miswak (*Salvadora persica*)

Multiple in vitro and clinical studies confirm *S. persica* extracts have strong antibacterial effects against oral pathogens like *Streptococcus mutans*, *Lactobacillus acidophilus*, *Porphyromonas gingivalis*, and *Candida albicans*, contributing to plaque reduction and oral hygiene.Its mechanical and chemical cleansing efficacy is comparable or superior to toothbrushes, and it contains bioactive compounds like benzyl isothiocyanate with potent antimicrobial activity [31].

Babool (*Acacia arabica*)

Acacia arabica is rich in tannins and flavonoids, which have astringent properties that tighten and tone gums, reducing inflammation and risk of gum disease. Traditionally used in oral hygiene as chewing sticks and in herbal dentifrices for its antimicrobial and anti-inflammatory properties [32].

Turmeric (*Curcuma longa*)

Turmeric contains curcumin, a bioactive compound with strong anti-inflammatory and antioxidant properties that reduce gingival inflammation and promote wound healing. It is used in traditional and modern oral care formulations to alleviate pain and support tissue repair.

All of these herbs play a role in the prevention of hypersensitivity through a synergistic action involving tubule occlusion, nerve desensitization, or improvement of gingival health, with fewer side effects than the synthetic agents.

SAFETY AND ACCEPTABILITY

Herbal toothpastes generally demonstrate high biocompatibility and lower incidence of adverse effects, such as staining or taste alteration, which are more common with stannous fluoride or potassium nitrate.

Many patients report greater satisfaction and willingness to continue herbal toothpaste due to the perceived safety and natural origin.

LIMITATIONS

Although herbal toothpastes demonstrate promise in controlling dentinal hypersensitivity, various limitations remain. A key issue is the absence of standardization in formulation, with differing levels of active ingredients among products. Numerous studies have limited sample sizes, brief durations, and few comparators, such that clinical evidence remains weak. Herbal products are frequently treated as cosmetics rather than therapeutic products, resulting in uneven quality control. Furthermore, certain components such as cinnamon or clove can induce an allergic response among sensitive users. Variations in taste or degree of foaming can also impinge on patient compliance. All these constraints identify the necessity of improved formulation, regulation, as well as evidence-based verification.

FUTURE PERSPECTIVES

Progress in herbal toothpaste composition relies on enhanced standardization and clinical proof. Standardized extraction and manufacturing procedures will improve reliability and effectiveness. Contemporary delivery systems such as nanoencapsulation can enhance retention and activity of herbal actives. Blending herbs with established agents might provide synergistic effects. Large, well-conducted clinical trials are required to compare herbal pastes with synthetic pastes and to evaluate long-term results. Mechanistic investigations must examine the mechanism by which herbs influence dentin and nerve physiology. Consumer education and professional instruction will serve to incorporate herbal desensitizing agents into standard care, as the industry moves toward natural, eco-friendly oral care products.

CONCLUSION

Herbal toothpastes provide a natural choice for the treatment of dentinal hypersensitivity via tubule occlusion, anti-inflammatory action, and nerve desensitization. Active components such as clove, guava, and green tea exhibit favourable outcomes in in vitro as well as clinical investigations. Compared to their synthetic counterparts, herbal products are typically safer and have fewer adverse effects. With better formulation methods, quality control, and more robust clinical studies, herbal desensitizing agents may go mainstream. Educating dental professionals and the public will also aid their acceptance. Overall, herbal toothpastes are a safe, effective, and environmentally friendly alternative for long-term sensitivity relief.

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