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DEVELOPMENT OF A NATURAL TOOTHGEL: A REVIEW ON NEEM AND GINGER-BASED FORMULATIONS

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ABSTRACT
The growing demand for plant-based pharmaceutical products has accelerated research into herbal oral care formulations. Continuous exposure to synthetic surfactants, preservatives, and antimicrobial agents present in conventional dentifrices has raised concerns regarding long-term safety and oral mucosal compatibility. As a result, herbal alternatives derived from medicinal plants are gaining increasing scientific attention. The present review comprehensively evaluates the pharmaceutical relevance of a natural tooth gel formulated with *Azadirachta indica* (neem) and *Zingiber officinale* (ginger). These plants are well documented for their antimicrobial, anti-inflammatory, antioxidant, and biofilm-inhibitory activities, making them particularly suitable for oral health applications. This article discusses the phytochemical profiles of neem and ginger, their mechanisms of action against oral pathogens, and their functional role in preventing plaque formation and periodontal inflammation. In addition, formulation considerations such as selection of gelling agents, excipients, and stability-enhancing components are critically reviewed, along with key physicochemical and microbiological evaluation parameters. Although individual effects of neem and ginger are supported by experimental and clinical evidence, limited studies have explored their combined application in toothgel formulations. The review highlights existing challenges related to extract standardization, sensory acceptability, and regulatory compliance, and emphasizes the need for further in vivo and clinical investigations to confirm long-term safety and therapeutic effectiveness.

KEYWORDS: Herbal toothgel; *Azadirachta indica*; *Zingiber officinale*; Neem; Ginger; Oral hygiene; Antimicrobial activity; Pharmaceutical formulation.

INTRODUCTION
Oral health is an integral component of overall health and well-being. Oral diseases such as dental caries, gingivitis, and periodontitis are among the most prevalent chronic conditions worldwide, affecting individuals of all age groups. These conditions are primarily caused by microbial plaque accumulation, poor oral hygiene, and inflammatory responses of the gingival tissues.[1,2,3] Dentifrices play a vital role in daily oral hygiene practices by facilitating mechanical plaque removal and delivering therapeutic agents to the oral cavity.[1,4]

Conventional toothpaste formulations commonly contain synthetic detergents, abrasives, preservatives, and antimicrobial agents. Although effective, prolonged exposure to these chemicals has been associated with adverse effects, including mucosal irritation, alteration of oral microbiota, and hypersensitivity reactions.[5,6,7] These concerns have led to increased consumer and scientific interest in herbal dentifrices that provide

effective oral care with improved safety and biocompatibility.[8,9,10]

Medicinal plants have been utilized for centuries in traditional systems of medicine, such as Ayurveda, for maintaining oral hygiene. Among them, neem and ginger are extensively studied due to their broad spectrum of pharmacological activities. Their incorporation into toothgel formulations represents a rational and scientifically sound approach toward the development of natural oral care products.[11,12,13]

Tooth gels as pharmaceutical oral care systems

Toothgels are semi-solid pharmaceutical dosage forms specifically designed for oral hygiene applications. Unlike conventional toothpaste, toothgels possess a smooth, transparent, and non-gritty texture, which enhances patient acceptability and compliance.[14,15] Toothgels allow uniform dispersion of active ingredients and ensure prolonged contact with oral tissues, thereby improving therapeutic efficacy.[16,17]

From a formulation perspective, toothgels offer flexibility in incorporating herbal extracts, bioactive compounds, and natural excipients. The absence of abrasive particles makes toothgels particularly suitable for individuals with sensitive teeth and gums. Additionally, toothgels provide controlled viscosity, better spreadability, and improved stability compared to traditional pastes.[14,17]

Pharmaceutical significance of *Azadirachta indica* (Neem).[11,18,19]

Table 1: Major Phytochemical Constituents of *Azadirachta indica* and Their Pharmacological Activities.

Phytochemical	Chemical Class	Pharmacological Activity	Relevance in Oral Care
Azadirachtin	Limonoid	Antimicrobial, antiplaque	Inhibits cariogenic bacteria
Nimbidin	Terpenoid	Anti-inflammatory	Reduces gingival inflammation
Nimbin	Glycoside	Antifungal	Controls oral candidiasis
Flavonoids	Polyphenols	Antioxidant	Protects oral tissues
Tannins	Polyphenols	Astringent	Strengthens gums

Phytochemical Constituents[11]

Neem is a rich source of biologically active compounds, including azadirachtin, nimbin, nimbidin, nimbolide, flavonoids, tannins, saponins, and glycosides. These phytochemicals are responsible for neem's wide range of pharmacological activities, such as antimicrobial, anti-inflammatory, antifungal, antioxidant, and immunomodulatory effects.

Role in Oral Health

Several studies have demonstrated the efficacy of neem extracts against common oral pathogens, including *Streptococcus mutans*, *Lactobacillus* species, and *Candida albicans.*[20,21] Neem exhibits plaque-inhibitory properties and has been shown to reduce gingival inflammation and bleeding. Its ability to disrupt bacterial adhesion and biofilm formation supports its inclusion in herbal dentifrice formulations.[4,20,22]

Pharmaceutical importance of *Zingiber officinale* (ginger)[12,23]

Table 2: Bioactive Compounds of *Zingiber officinale* and Their Therapeutic Effects.

Compound	Nature	Pharmacological Effect	Oral Health Benefit
Gingerol	Phenolic	Antimicrobial	Inhibits oral pathogens
Shogaol	Phenolic	Anti-inflammatory	Reduces periodontal inflammation
Zingerone	Phenolic	Antioxidant	Protects the gingival tissues
Essential oils	Volatile oils	Antiseptic	Controls oral malodor

Phytochemistry

Ginger rhizomes contain an array of phenolic and volatile compounds such as gingerols, shogaols, paradols, zingerone, and essential oils. These constituents are primarily responsible for ginger's pungency and therapeutic properties.

Therapeutic Effects in Oral Care

Ginger exhibits significant antimicrobial activity against oral pathogens and demonstrates potent anti-inflammatory and antioxidant effects. It inhibits the production of inflammatory mediators and scavenges free radicals, thereby contributing to the management of gingivitis and periodontal inflammation. Ginger also aids in reducing oral malodor and maintaining microbial balance in the oral cavity.[23.24.25]

NEEM AND GINGER-BASED TOOTHGEL FORMULATION STRATEGIES[14,15,19]

Table 3: Typical Composition of Neem and Ginger-Based Herbal Toothgel.

Ingredient Category	Example	Pharmaceutical Role
Active agents	Neem extract, Ginger extract	Antimicrobial, anti-inflammatory
Gelling agent	Carbopol, Xanthan gum	Provides gel structure
Humectant	Glycerin, Sorbitol	Prevents drying
Sweetener	Xylitol	Improves taste, anti-cariogenic
Preservative	Sodium benzoate	Enhances shelf life
Flavoring agent	Peppermint oil	Improves acceptability

The formulation of herbal tooth gels requires careful selection of gelling agents such as Carbopol, xanthan gum, or sodium alginate to achieve optimal viscosity and stability. Humectants like glycerin and sorbitol are used to prevent drying, while natural sweeteners and flavoring agents improve palatability. Preservatives of natural origin may be incorporated to enhance shelf life.

The combined incorporation of neem and ginger extracts may produce synergistic antimicrobial and anti-inflammatory effects, thereby enhancing the overall therapeutic performance of the formulation. Standardization of extracts and optimization of concentration are critical factors influencing formulation success.[5,10,11]

EVALUATION OF HERBAL TOOTHGELS

Table 4: Evaluation Parameters for Herbal Tooth gels.

Parameter	Method	Significance
Appearance	Visual inspection	Ensures consumer acceptance
pH	Digital pH meter	Prevents enamel erosion
Viscosity	Brookfield viscometer	Controls spreadability
Spreadability	Glass slide method	Ease of application
Stability	Accelerated studies	Shelf-life prediction
Antimicrobial activity	Agar diffusion method	Therapeutic efficacy

Evaluation of herbal tooth gels is a critical step to ensure their quality, safety, stability, and therapeutic efficacy. Both physicochemical and microbiological parameters are assessed according to standard pharmaceutical guidelines.

Physical appearance and homogeneity are evaluated by visual inspection to ensure uniform color, absence of lumps, phase separation, or grittiness. A smooth and homogeneous formulation enhances consumer acceptability and ensures uniform distribution of active ingredients.[14,16]

pH determination is carried out using a calibrated digital pH meter. The pH of toothgels should ideally range between 6.0 and 7.5 to prevent enamel demineralization and mucosal irritation. Maintaining an appropriate pH is essential for product safety and compatibility with oral tissues.[4,14]

Viscosity is measured using a Brookfield viscometer at specified rotational speeds. Viscosity influences the flow behaviour, spreadability, and extrusion characteristics of the tooth gel. Adequate viscosity ensures easy application while maintaining sufficient retention on the tooth surface.[14,17]

Spreadability is evaluated using the glass slide method, which measures the ease with which the gel spreads under applied weight. Good spreadability facilitates uniform distribution of the formulation over the teeth and gingiva during brushing.[16,17]

Extrudability assesses the force required to expel the tooth gel from a collapsible tube. This parameter is important for patient convenience and dosage consistency, particularly during routine use.[16]

Stability studies are conducted under different storage conditions, including room temperature and accelerated conditions, to evaluate changes in appearance, pH, viscosity, and phase separation over time. Stability testing helps predict shelf life and ensures formulation integrity throughout its intended storage period.[5,17]

Antimicrobial activity is commonly assessed using agar diffusion or broth dilution methods against oral pathogens such as *Streptococcus mutans*, *Lactobacillus* species, and *Candida albicans*. This evaluation confirms the therapeutic efficacy of the herbal tooth gel in inhibiting plaque-forming and pathogenic microorganisms.[1,20,23,26]

Collectively, these evaluation parameters provide a comprehensive assessment of the quality, performance, and clinical relevance of neem and ginger-based herbal tooth gels.

CHALLENGES AND FUTURE PERSPECTIVES

Despite their therapeutic potential, herbal toothgels face challenges such as variability in phytochemical composition, difficulties in extract standardization, taste

masking issues, and limited clinical evidence. Future research should focus on advanced formulation techniques, bioadhesive delivery systems, and well-designed clinical trials to support regulatory approval and commercialization.

CONCLUSION

Neem and ginger-based toothgels offer a promising natural alternative to conventional synthetic dentifrices. Their proven antimicrobial and anti-inflammatory properties support their role in oral hygiene maintenance and prevention of dental disorders. However, extensive in vivo and clinical studies are required to establish long-term safety, efficacy, and patient acceptability.

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