THE ANTIMICROBIAL POTENTIAL OF GINGER: A PHYTOTHERAPEUTIC ALTERNATIVE IN BACTERIAL INFECTIONS

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RESEARCH ARTICLE

Abstract
Oral health is a vital component of general well-being, yet dental plaque and periodontal disease remain highly prevalent worldwide. In recent years, the use of natural products in oral care has gained growing attention, reflecting consumer demand for safer alternatives to conventional fluoride-based and synthetic antimicrobial agents. Zingiber officinale (ginger) is a medicinal plant widely recognized for its antimicrobial, antioxidant, and anti-inflammatory properties, which makes it a promising candidate for oral hygiene formulations.
This study focused on the development of a toothpaste incorporating an ethanolic extract of ginger and the evaluation of its antimicrobial activity, physicochemical stability, and organoleptic properties. The extract was obtained using Soxhlet extraction with 70% ethanol and tested against Staphylococcus aureus, Streptococcus pyogenes, and Escherichia coli using the Kirby-Bauer disk diffusion method. Organoleptic properties, including appearance, odor, and taste, were analyzed, and pH stability was assessed over a 30-day period.
The ginger extract demonstrated clear antimicrobial activity, with inhibition zones of 20 mm (S. aureus), 17 mm (S. pyogenes), and 15 mm (E. coli). The toothpaste exhibited a homogeneous emerald-green color due to spirulina, a mentholated odor, and a neutral taste, all contributing to good consumer acceptability. The pH remained stable within the neutral range (7.0–7.5) throughout storage, indicating physicochemical robustness.
Overall, the results highlight the potential of ginger extract as a natural active agent in toothpaste formulations, combining antimicrobial efficacy with acceptable stability and sensory properties.

Keywords: (max. 5) ginger, toothpaste, antimicrobial, dental plaque
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Oral health is considered an integral component of general health and quality of life. Poor oral hygiene can lead to the accumulation of bacterial plaque, which is the primary etiological factor in the development of caries and periodontal diseases (Petersen et al., 2005). According to the World Health Organization, periodontal disease affects up to 20–50% of the global population, making it one of the most prevalent chronic conditions worldwide (WHO, 2022). Despite advances in preventive dentistry, gingivitis and periodontitis remain significant public health challenges. These conditions are not only responsible for tooth loss but are also associated with systemic disorders such as diabetes, cardiovascular disease, and adverse pregnancy outcomes (Tonetti et al., 2017). Consequently, maintaining oral health through effective daily hygiene practices is critical in reducing both local and systemic disease burdens.

The conventional approach for preventing such conditions involves the use of fluoridated toothpastes and antimicrobial agents; however, concerns regarding side effects, microbial resistance, and consumer demand for natural products have spurred interest in alternative ingredients.

INTRODUCTION

Conventional oral hygiene products, particularly fluoridated toothpastes, have demonstrated efficacy in reducing caries and strengthening enamel. However, concerns regarding fluoride overexposure, allergic reactions, and the growing problem of antimicrobial resistance have raised questions about their long-term safety and effectiveness (Ten Cate, 2013). These challenges highlight the need for innovative approaches and safer alternatives.

In this context, the use of herbal and plant-derived agents has gained increasing attention. Natural products are perceived as safe, biocompatible, and environmentally sustainable, and their integration into oral care aligns with consumer preferences for "green" and holistic solutions (Kumar et al., 2013). A variety of medicinal plants, including neem, clove, and licorice, have been studied for their antimicrobial and anti-inflammatory potential, with encouraging results (Anwar et al., 2025). Among these, *Zingiber officinale* (ginger) has emerged as a promising candidate. Used for centuries in traditional medicine, ginger is rich in bioactive compounds such as gingerols, shogaols, paradols, and zingerone, which are responsible for a wide spectrum of pharmacological activities, including antioxidant, anti-inflammatory, and antimicrobial effects (Ali et al., 2008; Grzanna et al., 2005; Zare et al., 2019).

The antimicrobial potential of ginger is particularly relevant for oral health. *In vitro* studies have demonstrated inhibitory effects of ginger extracts against *Streptococcus mutans*, *Staphylococcus aureus*, and *Candida albicans*, microorganisms that play critical roles in dental plaque formation and oral infections (Park et al., 2008). These findings suggest that ginger could help prevent or mitigate conditions such as gingivitis, dental caries, and oral candidiasis. The mechanisms of action involve both direct antimicrobial activity and indirect modulation of inflammatory and oxidative processes. Gingerols and shogaols act by disrupting bacterial cell walls, inhibiting biofilm formation, and reducing the production of pro-inflammatory mediators. In addition, the antioxidant capacity of ginger compounds may reduce oxidative stress in gingival tissues, potentially slowing the progression of periodontal disease (Chrubasik et al., 2005; Arefnehzad et al., 2025). Despite extensive pharmacological evidence, the incorporation of ginger into pharmaceutical formulations for oral care remains limited. Most available studies are laboratory-based and do not extend to product development or consumer-ready formulations. Clinical research is needed to confirm safety, efficacy, and acceptability in real-world use.

Therefore, the aim of the present study was to formulate a toothpaste containing ethanolic extract of *Zingiber officinale* and to evaluate its antimicrobial activity against clinically relevant bacterial strains, alongside its physicochemical stability and organoleptic properties. This work contributes to the growing body of evidence supporting the use of natural plant-based agents in oral hygiene products and explores the potential of ginger as a safe and multifunctional ingredient.

MATERIAL AND METHOD

Plant material and preparation of extract

Fresh rhizomes of *Zingiber officinale* (ginger) were collected in January 2024 and authenticated by the Department of Pharmacognosy, Faculty of Medicine and Pharmacy, Oradea. The rhizomes were cleaned, dried at 40°C, and ground into a fine powder. For extraction, 20 g of powdered ginger was placed in a Soxhlet apparatus and extracted with 70% ethanol for 2 hours. The resulting solution was concentrated under reduced pressure using a rotary evaporator (Heidolph Vap Core) at 200 rpm, yielding 59 mL of concentrated extract. The extract was stored at 4°C until further analysis. The pH of the extract was measured with a calibrated Inolab 7310 pH-meter and recorded at 6.0 ± 0.1.

Preparation of toothpaste formulation

The toothpaste formulation was prepared in three successive homogenization steps using a mortar and pestle. The detailed composition is presented in Table 1. First, guar gum was dispersed in distilled water to form a gel, into which the ginger extract was incorporated. Second, calcium carbonate was blended with spirulina powder and pre-wetted with glycerin to form a homogeneous paste. Finally, the two phases were combined, followed by the addition of peppermint oil and Cosgard preservative. The resulting product was packed in 50 mL tubes and stored at room temperature.

Table 1

Toothpaste formulation

Ingredient	Quantity	Role in formulation
Ginger extract	11 g	Active antimicrobial, anti-inflammatory, antioxidant agent
Guar gum	0.5 g	Gelling agent, viscosity stabilizer
Peppermint oil	23 drops	Flavoring, refreshing effect
Spirulina	0.1 g	Natural colorant, antioxidant
Calcium carbonate	43 g	Mild abrasive, opacifier, texturizer
Cosgard	20 drops	Broad-spectrum preservative, antimicrobial
Distilled water	44 g	Solvent
Glycerin	q.s.	Humectant, moisture retention

Organoleptic evaluation

The toothpaste was evaluated for color, homogeneity, odor, and taste according to pharmacopeial standards. Color and texture were examined visually, odor was assessed at 2–4 cm distance, and taste was tested in small quantities for acceptability.

Determination of pH and stability

The pH of the toothpaste was measured in triplicate at baseline and after 30 days of storage using the Inolab 7310 pH-meter equipped with a SenTix 81 Plus electrode. Stability was defined as maintenance of neutral pH values (7.0–7.5) without significant deviation.

Antimicrobial activity

The antimicrobial activity of the ginger extract was evaluated by the disk diffusion method (Kirby–Bauer). Bacterial strains included *Staphylococcus aureus* ATCC 25923, *Streptococcus pyogenes* ATCC 19615, and *Escherichia coli* ATCC 35218. Bacterial suspensions were standardized to 0.5 McFarland and spread on Mueller–Hinton agar plates. Sterile paper discs impregnated with 40 µg of extract were placed on the inoculated agar. Plates were incubated at 37°C for 24 h, and zones of inhibition were measured in millimeters, including the 6 mm disc diameter. Each experiment was performed in triplicate. Reference antibiotics included clindamycin (2 µg/disc), gentamicin (120 µg/disc), and nystatin (100 UI/disc).

RESULTS AND DISCUSSIONS

Phytochemical and physical characteristics of the extract

The Soxhlet extraction yielded a brown ethanolic extract with neutral pH. The concentrated extract retained a characteristic aromatic odor. These findings are consistent with previous reports that ethanolic solvents efficiently recover gingerols and shogaols, which are considered the major bioactive compounds .

Antimicrobial activity

The ethanolic extract exhibited clear inhibitory effects on all tested bacterial strains. Mean inhibition zones were 20 mm for *S. aureus*, 17 mm for *S. pyogenes*, and 15 mm for *E. coli* (Image 1). Although smaller than those observed with standard antibiotics, the zones confirmed significant antibacterial activity, particularly against Gram-positive bacteria (Table 1).

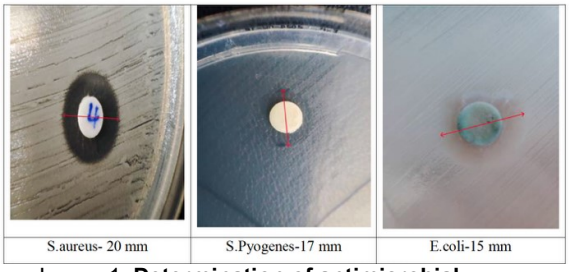

Image 1. **Determination of antimicrobial activity by measuring the diameters of the zones of inhibition**

Table 1

Antimicrobial exam results

Probe/ standard antibiotic	Staphylococcus aureus mm	Streptococcus pyogenes mm	E. coli mm
P1/(Ginger extract) 40µg/disk	20	17	15
Clindamycin	27	26	-
Gentamicin	33	28	2
Nystatin	-	-	-

The stronger effect on *S. aureus* aligns with prior studies demonstrating high sensitivity of Gram-positive organisms to gingerols. This suggests potential for adjunctive use in reducing oral bacterial load.

Organoleptic properties

The formulated toothpaste showed a homogeneous emerald-green color due to the spirulina content, with no visible separation after 30 days of storage. The odor was pleasant and mentholated, attributed to peppermint oil, and the taste was neutral, favoring compliance

in daily use. The texture allowed easy extrusion from the tube and uniform spreading, comparable to commercial products. These organoleptic characteristics are essential for consumer acceptance.

pH stability

The toothpaste displayed an initial pH of 7.47 (Table 2), which remained within the neutral range (7.0–7.5) after 30 days.

Table 2
pH values of Ginger extract and toothpaste

Ginger extract pH	6,014
Toothpaste pH	7,478

The pH values of toothpaste are neutral, which is beneficial for the oral cavity. These values prevent the multiplication of acidophilic microorganisms and the occurrence of dental caries.

Maintaining a neutral pH is critical for preventing enamel demineralization and for reducing the growth of acidogenic bacteria associated with caries. The stability of pH over time indicates robustness of the formulation and absence of degradation or microbial contamination during storage.

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Interpretation and relevance

The results confirm that toothpaste containing ginger extract combines antimicrobial activity with favorable physicochemical and sensory properties. While its antimicrobial effect was not as strong as conventional antibiotics, the advantage lies in its natural origin, reduced risk of resistance development, and added antioxidant and anti-inflammatory benefits. The formulation can thus serve as a supportive measure in daily oral hygiene, potentially reducing reliance on synthetic chemicals.

CONCLUSIONS

The toothpaste formulated with ginger extract exhibited antimicrobial activity, neutral pH, and satisfactory organoleptic characteristics. These results highlight the potential of Zingiber officinale as a natural, effective ingredient for oral hygiene products.

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