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Production of Herbal Tooth Paste, using Neem, Ginger, and Guava Leaves

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ABSTRACT

Oral diseases such as dental caries, gingivitis, and periodontal infections continue to constitute major public health concerns worldwide, necessitating the development of effective, affordable, and safer oral care products. This study aimed to formulate and evaluate a herbal toothpaste using extracts of neem (Azadirachta indica), ginger (Zingiber officinale), and guava (Psidium guajava) leaves combined with conventional toothpaste ingredients. The herbal toothpaste was produced using calcium carbonate as an abrasive agent, sorbitol as a humectant, sodium lauryl sulfate as a foaming agent, sodium fluoride as an anti-caries agent, peppermint for flavour enhancement, and plant extracts incorporated for their therapeutic properties. The formulation process involved extraction of the herbal materials, blending of ingredients under controlled conditions, and evaluation of the final product for physical appearance, consistency, taste, and user acceptability. The formulated toothpaste exhibited desirable organoleptic characteristics comparable to commercially available toothpaste products, including acceptable texture, colour, flavour, and foaming properties. The incorporation of neem, ginger, and guava extracts contributed antimicrobial, anti-inflammatory, and soothing effects that may enhance oral health maintenance and prevention of oral diseases. No irritation, hypersensitivity, or adverse reactions were observed during brushing trials, suggesting good tolerability and safety of the formulation. The inclusion of sodium fluoride further enhanced the preventive potential of the toothpaste through promotion of enamel remineralization and inhibition of bacterial acid production. The study demonstrates the feasibility of integrating locally available medicinal plants into toothpaste production without compromising product quality or functionality. The findings support the development of cost-effective, environmentally sustainable, and culturally acceptable herbal oral care products capable of improving oral hygiene and promoting indigenous natural product utilization.

Keywords: *Herbal, Toothpaste, Neem, Ginger, Guava, Leaves.*

Introduction

Toothpaste is a semi-solid preparation designed for application on a toothbrush to support oral hygiene practices. Its primary functions include cleaning and polishing the teeth, preventing dental caries, and promoting overall oral health. Modern formulations of toothpaste have evolved significantly from rudimentary mixtures to sophisticated blends enriched with therapeutic, cosmetic, and protective ingredients [1]. These formulations typically comprise abrasives, fluorides, humectants, surfactants, preservatives, thickeners, sweeteners, and sometimes medicinal or herbal extracts.

In recent years, the growing consumer awareness of oral hygiene and increasing preference for natural and sustainable products have driven research and innovation toward herbal-based formulations [2]. Herbal toothpastes are formulated with plant-derived bioactive compounds that possess antimicrobial, anti-inflammatory, and antioxidative properties.

Medicinal plants such as *Azadirachta indica* (neem), *Psidium guajava* (guava), and *Zingiber officinale* (ginger) are widely recognized for their traditional and scientifically proven therapeutic benefits in oral care [3] These herbs help combat oral pathogens, minimize plaque accumulation, and support gingival health, with fewer adverse effects than synthetic counterparts.

Despite the shift toward herbal ingredients, fluoride remains a cornerstone in caries prevention. Sodium fluoride, in particular, is commonly used for its efficacy in enhancing enamel re-mineralization and suppressing demineralization processes [4]. In this study, sodium fluoride was used as an alternative to sodium monofluorophosphate due to the latter's unavailability. Other essential ingredients such as sorbitol (used as a humectant), calcium carbonate (an abrasive), and sodium lauryl sulfate (a surfactant) were incorporated to ensure the toothpaste meets both functional and aesthetic standards.

Dental diseases such as caries, gingivitis, and periodontitis remain significant public health concerns globally, especially in developing nations where access to preventive oral care is limited. The oral cavity is exposed to constant microbial challenges, and without adequate hygiene, these can lead to the accumulation of dental plaque and eventual degradation of tooth enamel and soft tissues [5]. Traditionally, tooth cleaning involved natural methods like chewing sticks and herbal powders, many of which had proven antimicrobial effects.

With scientific advancements, these traditional approaches have given way to modern toothpaste formulations. However, the inclusion of synthetic additives in conventional toothpaste has raised concerns about long-term exposure and potential side effects such as mucosal irritation and allergic reactions [6]. As a result, there has been a renewed interest in natural alternatives that are effective yet gentler on the oral tissues.

Nigeria is rich in medicinal flora, including neem, guava, and ginger, which have been used extensively in ethnomedicine for their healing properties. Studies have shown that neem possesses strong antibacterial and anti-plaque effects, guava is rich in tannins and flavonoids with antimicrobial activity, and ginger contains gingerol compounds with notable anti-inflammatory and antibacterial actions [7]. These plants present a viable source of ingredients for herbal toothpaste formulations.

Tooth decay and gum diseases remain prevalent oral health problems, especially in developing countries. Many commercial toothpastes rely heavily on synthetic ingredients, some of which may cause side effects like mucosal irritation or allergic reactions in sensitive individuals. Moreover, economic limitations and access to dental care products contribute to inadequate oral hygiene. There is a need to develop a toothpaste formulation that is effective, affordable, and integrates natural, locally sourced herbal components that can reduce the risk of oral infections and promote overall dental health. The aim of this study is to prepare an herbal-based toothpaste formulation using fluoride and other bioactive ingredients to reduce the incidence of dental caries and promote oral health.

Materials and Methods

Study Area

The formulation of this herbal toothpaste was carried out in the School of Applied Science, in a controlled environment outside of the laboratory.

Ingredients

The ingredients utilized in the formulation included both synthetic and herbal components, chosen based on their specific functional roles in toothpaste formulation.

Abrasive: Calcium carbonate
Fluoride source: Sodium fluoride
Detergent/Surfactant: Sodium lauryl sulfate
Moisturizer/Humectant: Sorbitol
Preservative: Sodium benzoated
Thickening agent: Guar gum
Flavoring agent: Peppermint oil
Sweetener: Granulated sugar
Coloring/Opacifying agent: Titanium dioxide
Herbal additives: Neem leaves, Guava leaves, Ginger leaves
Solvent: Distilled water

Equipment and Tools

1. Mixing bowls (plastic or stainless steel)
2. Spatula/stirrer
3. Measuring cups
4. Heating source (for dissolving solid solutes)
5. Filtration cloth or mesh (for herbal extract)
6. Storage jars for the final product

Methodology

Sample Collection

All herbs used were collected within Auchi Polytechnic environment. Neem and ginger leaves were collected from the school hostel, while guava was collected from staff quarters. Other ingredients were purchased from chemical shops.

Preparation of Herbal Extracts

Fresh neem (*Azadirachta indica*), guava (*Psidium guajava*), and ginger (*Zingiber officinale*) leaves were collected, washed thoroughly with clean water, and blended. After blending, the mixture was filtered using clean muslin cloth to obtain a concentrated aqueous extract. The filtrate was allowed to settle for about two to three hours. The supernatant was disposed of, then the extracted was collected.

Formulation Procedure

The formulation was carried out using the Toothpaste Cold Mixing Technique. This technique is widely used in both small-scale and industrial formulations of toothpaste, particularly non-heating formulations, where temperature-sensitive ingredients (like flavor oils, enzymes, and herbal extracts) are incorporated. (Sankar *et al.,* 2020)

The process follows a sequential set of steps to ensure optimal mixing, homogeneity, and quality.

Step 1: Hydration of Gum and Initial Mixing

1. 1000 g of distilled water was poured into the mixing bowl.
2. Guar gum and calcium carbonate were dry-mixed and then slowly added to the water with continuous stirring.
3. Mixing was continued for approximately 10 minutes to form a smooth, semi-viscous paste.

Step 2: Preparation of Soluble Phase

1. In a separate bowl, granulated sugar, sorbitol, sodium fluoride, sodium benzoate, and a small amount of vitamin C were mixed and gently heated to facilitate dissolution.
2. The resultant solution was slowly incorporated into the main mixing bowl and stirred continuously for 15 minutes.

Step 3: Addition of Active Solids

A pre-blend of calcium carbonate, titanium dioxide, and additional guar gum was slowly added to the mix and stirred for another 15 minutes to ensure dispersion.

Step 4: Incorporation of Surfactant

Sodium lauryl sulfate was first dissolved in water, then mixed with the remaining sorbitol to reduce irritation, then added to the mixture and stirred for 15 minutes.

Step 5: Flavor and Herbal Integration

1. Peppermint oil was introduced and stirred for 10 minutes to distribute the flavor evenly.
2. The prepared herbal extract (from neem, guava, and ginger leaves) was then added as the final active component, and the entire mixture was homogenized until uniform.

Step 6: Stability and Consistency Check

1. The paste was allowed to stand undisturbed for 24 hours to allow proper gelling, hydration, and consistency evaluation.
2. After confirming acceptable texture and viscosity, the toothpaste was packed into sterilized containers.

Table 1: Constituents, functions, and approximate percentage used in product formulation

S/N	Ingredient	Function	Approximate Percentage (%)
1	Calcium carbonate	Mild abrasive for plaque and stain removal	20–30%
2	Sodium fluoride	Anti-caries agent; strengthens enamel	0.2–0.3%
3	Sodium Lauryl Sulfate	Surfactant and foaming agent	1–2%
4	Sorbitol	Humectant and sweetener; prevents drying	20–25%
5	Sodium benzoate	Preservative to prevent microbial growth	0.2–0.5%
6	Guar gum	Thickening agent for paste consistency	1–2%
7	Peppermint oil	Flavoring agent; improves taste and breath	0.5–1%
8	Granulated sugar	Natural sweetener to improve palatability	1–2%
9	Titanium dioxide	Whitening and opacifying agent	0.5–1%
10	Neem leaf extract	Herbal antibacterial and anti-inflammatory agent	2–5%
11	Guava leaf extract	Anti-microbial, anti-inflammatory, anti-plaque	2–5%
12	Ginger leaf extract	Antioxidant, digestive aid, anti-inflammatory	2–5%
13	Distilled water	Solvent and base of formulation	Sufficient

Results

The formulated toothpaste appeared as a milky green, thick, and smooth paste with uniform consistency and no visible separation of phases. The product exhibited a pleasant herbal aroma, largely due to the presence of peppermint flavor and herbal extracts (neem, guava, and ginger leaves). After 24 hours, the toothpaste retained its structure, showing no sedimentation, foul odor, or microbial growth.

When tested during tooth brushing, the toothpaste demonstrated:

1. Moderate foaming ability
2. Pleasant minty taste and refreshing sensation
3. Effective cleansing action, particularly in removing surface debris
4. No observed irritation or sensitivity

A summary of the physical characteristics after 24-hour standing is presented in the table below:

Table 2: Physical characteristics of formulated product after 24 hours

Parameter	Observation
Appearance	Smooth, thick paste
Color	Milky green
Odor	Pleasant herbal-mint aroma
Phase stability	No separation observed
Texture	Uniform and cohesive
Foaming ability	Moderate
Irritation or sensitivity	None reported during testing.

Discussion

The results obtained from this study confirm the successful formulation of a semi-solid, stable, and functional herbal toothpaste. The smooth, thick, and cohesive texture observed after mixing and standing for 24 hours indicates that the choice of guar gum as a thickening agent was appropriate. Guar gum is widely used in toothpaste formulations due to its viscosity-enhancing and stabilizing properties, which contribute to a uniform paste consistency (Pundir & Rana, 2020).

The milky green coloration of the final product was primarily due to the incorporation of herbal extracts, particularly neem, guava, and ginger leaves. These extracts are known to impart a natural green hue and have been used traditionally in herbal toothpaste due to their phytochemical content (Oboh et al., 2022). The greenish tint may also serve as a visual indicator of its herbal origin, which has been shown to positively influence consumer perception and acceptance (Singh *et al.,* 2021).

The pleasant herbal-mint aroma and taste were largely influenced by the peppermint oil, which acts as a flavoring and breath-freshening agent. Peppermint oil contains menthol, which has a cooling effect and is widely used in oral care products to enhance palatability and freshness (Sharma & Ali, 2021). In a sensory evaluation study by Mladenovic *et al.* (2022), herbal toothpaste containing peppermint oil ranked higher in consumer preference due to its taste and freshening ability.

Foaming ability, although moderate, was sufficient to meet consumer expectations for a cleaning product. This was due to the presence of sodium lauryl sulfate (SLS), a commonly used surfactant that lowers surface tension, enabling the paste to spread and lift debris during brushing (Arora *et al.*, 2023). SLS has been noted for its cleansing efficiency, though its concentration must be controlled to minimize mucosal irritation (Raj *et al.*, 2020). The moderate foam suggests an optimal balance between cleansing effectiveness and oral tolerability.

The cleansing and mild abrasive action were achieved using calcium carbonate, which is a well-tolerated dental abrasive. Its function is to physically remove dental plaque and stains without damaging the enamel when used within the recommended particle size and concentration (Osorio *et al.*, 2020). Calcium carbonate is especially favored in natural formulations for its biocompatibility, affordability, and gentle nature.

Importantly, the therapeutic potential of the toothpaste was enhanced by the inclusion of neem (*Azadirachta indica*), guava (*Psidium guajava*), and ginger (*Zingiber officinale*) leaves. These herbs are rich in bioactive compounds such as tannins, flavonoids, and terpenoids, which have been documented to exhibit strong antimicrobial, anti-inflammatory, and antioxidant effects (Ghosh *et al.,* 2020; Idu *et al.*, 2022). Neem leaf extract, in particular, has been reported to reduce Streptococcus mutans and other plaque-forming bacteria, supporting its use in caries prevention (Patil *et al.*, 2023).

Similarly, guava leaf extract is known to inhibit enzymes involved in bacterial colonization, and it has been used effectively in managing gingivitis and oral ulcers (Anitha *et al.*, 2021). Ginger, through its active compound gingerol, contributes additional antimicrobial effects and has shown promise in reducing oral inflammation (Hossain *et al.*, 2021). These herbal ingredients align with the global shift toward natural, sustainable, and side-effect-free alternatives in oral health care (Sankar *et al.*, 2022).

Sodium fluoride, although a substitute for sodium monofluorophosphate due to availability issues, remains a potent anti-caries agent. Fluoride works by enhancing enamel remineralization, inhibiting bacterial metabolism, and reducing acid production from dental plaque (Whelton *et al.*, 2019). Its inclusion in the formulation strengthens the toothpaste's preventive capacity against dental caries, a key function of modern toothpaste formulations.

The absence of irritation, sensitivity, or adverse reactions during brushing trials suggests that the combination of ingredients was safe and well-tolerated, at least in the short term. This supports prior findings that properly balanced herbal and chemical agents can provide effective cleaning without compromising oral tissue integrity (Nayak & Nayak, 2020).

The study also demonstrates the viability of using locally available natural resources in the formulation of oral care products. Utilizing herbs like neem and guava, which are readily available in many tropical regions, can reduce production costs and promote sustainable health care solutions (Ezeonu *et al.*, 2023). Moreover, this approach encourages innovation within indigenous systems of medicine and fosters local enterprise in natural product development.

Conclusion

This study successfully demonstrated the formulation and production of a functional toothpaste using a blend of synthetic and herbal ingredients. The final product possessed the appearance, consistency, and taste comparable to standard commercial toothpastes, with added benefits from the herbal components. The combination of calcium carbonate, sorbitol, sodium lauryl sulfate, sodium fluoride, peppermint, and extracts from neem, guava, and ginger leaves resulted in a safe, effective, and aesthetically pleasing formulation suitable for promoting oral hygiene.

The project also underscored the potential of incorporating locally available plant materials with known therapeutic properties into personal care products. These natural extracts contributed antimicrobial, anti-inflammatory, and soothing effects, making the product beneficial for oral health maintenance. The preparation process followed in this study can serve as a reference model for future formulation work in herbal oral care.

Overall, the successful completion of this project reflects the feasibility of integrating herbal components into toothpaste formulations without compromising quality or functionality. It provides a foundation for further innovation in natural dental care products.

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Dispute of Interest

No conflicts of interest are disclosed by the writers. The paper's writing and content are solely the authors' responsibility.

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Data and Materials Availability

The consent for all relevant data used in this study is declared by the authors.

Contributions of the Authors

All authors participated in the entire study process.

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