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# Formulation and Evaluation of Polyherbal Toothpaste for Oral Health Care

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## ABSTRACT

Herbal toothpaste has gained significant popularity due to its natural composition and reduced side effects compared to conventional formulations. The present study focuses on the formulation and evaluation of a polyherbal toothpaste containing medicinal plant extracts such as neem (*Azadirachta indica*), clove (*Syzygium aromaticum*), tulsi (*Ocimum sanctum*), aloe vera (*Aloe barbadensis*), and licorice (*Glycyrrhiza glabra*). These ingredients have been traditionally used for their anti-inflammatory, gum-strengthening, and soothing properties, contributing to improved oral hygiene and reduced dental plaque formation.

The herbal toothpaste was formulated using a simple and reproducible method, incorporating natural abrasives like calcium carbonate and binding agents such as xanthan gum. The formulation was evaluated for various physicochemical parameters, including pH, spreadability, foamability, stability, and overall texture. Results indicated that the herbal toothpaste demonstrated satisfactory pH (6.5–7.5), good foaming ability, smooth texture, and stability over a storage period of 4 weeks.

The study concludes that herbal toothpaste, enriched with medicinal plant extracts, serves as an effective and safer alternative to commercial dentifrices. Future studies could explore clinical trials and optimization of formulations for enhanced efficacy.

# Introduction

Oral health is an essential component of overall well-being, influencing both general health and quality of life. Poor oral hygiene can lead to common dental problems such as cavities, plaque buildup, gingivitis, and periodontitis.

The primary means of maintaining oral hygiene is through regular brushing using toothpaste, which serves as a cleansing agent to remove food debris, prevent bacterial growth, and protect against oral diseases. Traditionally, most commercially available toothpastes contain synthetic ingredients such as fluoride, triclosan, sodium lauryl sulfate (SLS), and artificial sweeteners. While these compounds provide antimicrobial and cleansing effects, prolonged use may result in adverse effects like dental fluorosis, oral mucosal irritation, and altered taste perception. Additionally, synthetic chemicals contribute to environmental pollution, making them less sustainable. As a result, there has been a significant shift towards herbal formulations, which use plantbased ingredients known for their natural therapeutic properties.

#### Anatomy of Teeth

The human dentition plays a critical role in digestion, speech, and aesthetics. Each tooth is a highly specialized structure, anatomically designed to perform specific functions such as cutting, grinding, and tearing food. A single tooth is composed of four main tissues: enamel, dentin, cementum, and pulp.



Fig:1-Anatomy of teeth

#### 1. Enamel

Enamel is the outermost layer covering the visible part (crown) of the tooth. It is made up of 96% inorganic material (mostly hydroxyapatite crystals of calcium phosphate), 3% water, and 1% organic material.

#### 2. Dentin

Dentin is the layer beneath the enamel and forms the bulk of the tooth structure.Contains about 70% inorganic material, 20% organic material (mostly collagen), and 10% water.

#### 3. Cementum

Cementum is a bone-like substance covering the **roots** of the teeth.Made up of 45–50% inorganic material, 50–55% organic material (mostly collagen) and water.

#### 4. Pulp

The pulp is the innermost soft tissue of the tooth housed in the pulp chamber and root canals.Contains blood vessels, nerves, lymphatic tissue, and connective tissue.

#### Concept of Herbal Toothpaste

Herbal toothpaste is a dentifrice formulated using natural plant extracts, essential oils, and herbal powders, eliminating the need for harmful synthetic agents. These herbal ingredients have been traditionally used in Ayurveda, Unani, and traditional Chinese medicine for their medicinal properties, making them a safer and eco-friendly alternative to chemical-based toothpastes.

Herbal toothpastes typically contain antibacterial, anti-inflammatory, analgesic, and gum-strengthening agents derived from medicinal plants. Unlike conventional formulations, herbal toothpaste does not contain artificial foaming agents, preservatives, or synthetic sweeteners, making it ideal for individuals with sensitive gums, allergies, or those seeking natural oral care solutions.

#### Key Ingredients in Herbal Toothpaste & Their Functions

The effectiveness of herbal toothpaste depends on its formulation, which includes medicinal plant extracts with specific oral care benefits. The key ingredients used in this formulation include:

- 1. Neem (*Azadirachta indica*) Well known for its antibacterial and anti-plaque properties, neem helps reduce oral bacteria, preventing cavities and gum infections.
- 2. Clove (*Syzygium aromaticum*) Contains eugenol, a natural compound that provides pain relief and antiseptic action, making it effective in treating toothaches and gum inflammation.
- 3. Tulsi (Ocimum sanctum) A potent antioxidant and antimicrobial agent that helps prevent gum infections and strengthens teeth.
- 4. Aloe Vera (*Aloe barbadensis*) Known for its soothing and healing properties, aloe vera helps reduce gum inflammation and accelerates wound healing in the oral cavity.
- 5. Calcium Carbonate A natural abrasive that helps remove plaque and stains without damaging tooth enamel.
- 6. Peppermint Oil (Mentha piperita) Provides a refreshing taste and freshens breath while offering mild antimicrobial effects.
- 7. Xanthan Gum A natural binding agent that helps in achieving the right toothpaste consistency.

Herbal Toothpaste: A Safer Alternative to Synthetic Formulations

Herbal toothpaste offers a holistic approach to oral care by combining natural ingredients with scientifically proven benefits. Unlike synthetic toothpaste, which relies on chemical additives, herbal formulations cleanse, protect, and heal while minimizing health risks. Additionally, herbal toothpaste is;

1. Eco-friendly & Sustainable - Uses biodegradable ingredients with minimal environmental impact.

2.Free from Artificial Chemicals - Avoids triclosan, parabens, and SLS, reducing potential toxicity.

3.Gentle Yet Effective - Provides antimicrobial and anti-inflammatory effects without irritating the oral mucosa.

With increasing consumer awareness, herbal toothpaste is becoming a preferred choice for maintaining oral hygiene naturally and effectively.

Advantages of Herbal Toothpaste Over Conventional Toothpaste

The demand for herbal oral care products has increased significantly due to consumer awareness of chemical-free alternatives. The key benefits of herbal toothpaste include:

- 1 Natural Antibacterial Protection Herbal extracts like neem (*Azadirachta indica*), clove (*Syzygium aromaticum*), and tulsi (*Ocimum sanctum*) naturally inhibit the growth of harmful bacteria responsible for dental cavities and gum infections.
- 2 Anti-inflammatory & Soothing Effect Aloe vera (*Aloe barbadensis*) and reduce gum inflammation, providing relief from gingivitis and swollen gums.
- 3 Non-Toxic & Fluoride-Free Many herbal toothpastes are formulated without fluoride, preventing the risk of fluorosis (tooth discoloration caused by excessive fluoride exposure), especially in children.
- 4 Sustainable & Eco-Friendly Unlike conventional toothpaste, herbal formulations do not contain synthetic foaming agents like SLS, which can harm aquatic life when washed into water bodies.
- 5 Safe for Long-Term Use Since herbal ingredients are naturally derived, they do not cause irritation or toxicity, making them suitable for people with sensitive teeth and gums.
- 6 Prevention of Bad Breath (Halitosis) Herbal ingredients like peppermint (*Mentha piperita*) and clove act as natural breath fresheners, neutralizing odor-causing bacteria.

Uses of Herbal Toothpaste in Oral Hygiene

Herbal toothpaste offers comprehensive oral health benefits and is used for:

- 1. Plaque Control: Neem, clove, and tea tree oil prevent plaque buildup and bacterial growth.
- 2. Gingivitis Prevention: Aloe vera and turmeric reduce gum inflammation and bleeding.
- 3. Tooth Sensitivity Relief: Herbal ingredients soothe sensitivity without harsh desensitizing agents.
- 4. Cavity Prevention: Herbal extracts have natural antimicrobial properties that protect against dental caries.
- 5. Fresh Breath Maintenance: Mint, eucalyptus, and cinnamon neutralize bad breath.

#### MATERIALS AND METHOD

Herbal Ingredients

Table no.1

Herbal Ingredient	Botanical Name	Function	Source of Collection	Criteria for Selection
Neem	Azadirachta indica	Antibacterial, plaque control	Fresh leaves from a botanical garden/local market	Green, disease-free leaves
Clove	Syzygium aromaticum	Antiseptic, analgesic	Dried flower buds from a spice store/pharmacy	Whole, unbroken, aromatic buds
Aloe Vera	Aloe barbadensis	Anti-nflammatory, healing	Fresh leaves from an organic farm/homegrown	Thick, mature leaves
Mint	Mentha spp.	Freshness, mild antibacterial	Fresh leaves from a herbal garden/local market	Green, undamaged leaves

# Excipients

# Table no.2

Excipients	Function	Source of Collection	Criteria for Selection	
Calcium Carbonate	Mild abrasive, helps in cleaning teeth	Laboratory-grade chemical supplier	High purity, free from contaminants	
Glycerin	Humectant, maintains paste consistency	Pharmaceutical supplier	Colorless, odorless, high- grade glycerin	
Xanthan Gum	Thickening agent	Laboratory chemical supplier	Food-grade, fine powder	
Sorbitol	Sweetener and humectant	Chemical supplier/pharmacy	Non-crystalline, clear solution	
Sodium Benzoate	Preservative	Pharmaceutical supplier	High purity, free from impurities	

#### Method

#### Extraction of Herbal Ingredients

To obtain the active constituents from the selected medicinal plants (Neem, Clove, Aloe vera, and Mint), the **solvent extraction method** was used. All plant materials were shade-dried, powdered, and stored in airtight containers before extraction.

Preparation of Plant Extracts

a) Neem Leaves Extract (Azadirachta indica)

- Fresh neem leaves were washed, shade-dried, and ground into a fine powder.
- 50 g of powder was extracted with ethanol (95%) using the maceration technique for 72 hours with intermittent shaking.
- The mixture was filtered and concentrated using a **rotary evaporator** at 40°C to obtain a semi-solid extract.

b) Clove Bud Extract (Syzygium aromaticum)

- Dried clove buds were powdered and subjected to Soxhlet extraction using ethanol for 6-8 hours.
- The extract was filtered, and the solvent was evaporated to yield a concentrated extract.

# c) Aloe Vera Gel (Aloe barbadensis)

- Fresh leaves were washed, and the mucilaginous gel was manually extracted by peeling the outer skin.
- The gel was homogenized and filtered to remove fibers and stored at 4°C.

#### d) Mint Leaf Extract (Mentha spp.)

- Fresh mint leaves were crushed and macerated in ethanol for 48 hours.
- The extract was filtered and concentrated to a semi-solid form.

# Composition:

Table no. 3

Ingredients	Function	(F1)	(F2)	(F3)
		Quantity for 10g	Quantity for 20g	Quantity for 50g
Neem Extract	Antibacterial, Plaque control	0.5 g	1.0 g	2.5 g
Clove Extract	Analgesic, Antiseptic	0.3 g	0.6 g	1.5 g
Aloe Vera	Anti-inflammatory, Healing	0.5 g	1.0 g	2.5 g
Mint Extract	Flavoring, Mild antibacterial	0.2 g	0.4 g	1.0 g
Calcium Carbonate	Abrasive	4.0 g	8.0 g	20.0g

Glycerine	Humectant	1.5 g	3.0 g	7.5 g
Sorbitol	Sweetener, Humectant	1.0 g	2.0 g	5.0 g
Xantham Gum	Thickening agent	0.15 g	0.3 g	0.75 g
Sodium Benzoate	Preservative	0.05 g	0.1 g	0.25 g
Distilled water	Base	q.s. 10g	q.s. 20g	q.s. 50g

# **Procedure:**

- i. The solid components, including calcium carbonate, sodium lauryl sulfate, glycerin, sodium benzoate, and sodium saccharin, were precisely measured according to the formula and passed through a sieve with a mesh size of 80 to ensure uniform particle size.
- ii. The ingredients were combined in a mortar and pestle and subsequently triturated with accurately measured glycerin until a semisolid consistency was achieved.
- iii. Addition of herbal ingredients
- iv. Accurately weighed herbal extract in form of ginger oil were added to the base
- v. Finally, peppermint oil was incorporated to enhance the flavor.



Fig:2- Physical toothpaste

# **Evaluation of Herbal Toothpaste**

#### 1. Organoleptic Properties

Table no. 4

Parameter	Observation
Color	Light green
Odor	Pleasant herbal
Taste	Slightly bitter with minty aftertaste
Texture	Smooth and uniform

The herbal toothpaste was found to be organoleptically acceptable with a pleasant aroma and smooth consistency.

2. pH Determination

1 g of the toothpaste was dispersed in 10 mL of distilled water and stirred thoroughly. The pH was measured using a calibrated digital pH meter. pH =  $6.8 \pm 0.1$ 

The pH lies within the ideal range (6.5–7.5) for toothpaste and is safe for oral mucosa without causing irritation.

3. Homogeneity Test

A small quantity of the toothpaste was pressed between the thumb and index finger and examined for uniformity.

The formulation was homogeneous, with no lumps or gritty particles.

A smooth and uniform texture indicates good mixing and proper dispersion of ingredients.

4. Spreadability

1 g of toothpaste was placed between two glass slides and a 500 g weight was applied. The diameter of the spread area was measured.

Formula:

Spreadability=M×L/T

Where M = weight (500 g), L = distance moved (7 cm), T = time (20 s)

Result: Spreadability = 175 g·cm/sec

The toothpaste showed adequate spreadability, ensuring ease of application on the toothbrush.

5. Foaming Ability

1 g of toothpaste was mixed with 10 mL of distilled water in a 100 mL graduated cylinder and shaken vigorously for 1 minute. Foam height was recorded after 5 minutes.

Result: Foam height = 6.5 cm

Herbal toothpaste produced moderate foam, which is considered satisfactory for natural formulations (as herbal products typically foam less than synthetic ones).

6. Abrasiveness Test

A glass slide was rubbed with the toothpaste-water mixture, washed, and observed under light for scratches.

Result: No visible scratches observed on the slide.

Indicates mild abrasiveness, suitable for safe cleaning of teeth without damaging enamel.

7. Antimicrobial Activity

Agar well diffusion method was used to test the toothpaste against:

- Streptococcus mutans
- Lactobacillus acidophilus

Microbial Strains Used: MTCC standard strains

Zone of Inhibition:

Table no. 5

Microorganism	Zone of Inhibition (mm)
Streptococcus mutans	14 mm
Lactobacillus spp.	12 mm

The herbal toothpaste showed good antibacterial activity, confirming the presence of active herbal ingredients with antimicrobial properties.

8. Stability Observation (15 Days)

Stored at room temperature in a sealed tube and observed for:

Observation:

- No discoloration
- No phase separation
- No unpleasant odor
- No visible microbial growth

The formulation was found to be physically and microbiologically stable over 15 days at room temperature.

#### 9. Moisture Content

To determine the amount of water/moisture present in the formulated toothpaste, which affects its shelf-life, microbial stability, and consistency.

Method (Loss on Drying Method):

- 1. Weigh about 1 g of the toothpaste sample accurately.
- 2. Place it in a pre-weighed crucible.
- 3. Dry the sample in a hot air oven at 105°C for 2 hours.
- 4. Cool in a desiccator and reweigh the sample.
- 5. Calculate moisture content using the formula:

Moisture Content (%)=Initial Weight-Final Weight/Initial Weight×100

### Result :

- $\circ$  Initial weight = 1.000 g
- $\circ$  Final weight after drying = 0.865 g
- $\circ$  Moisture content = 1.000-0.865/1.000×100=13.5%

The herbal toothpaste showed a moisture content of 13.5%, which is within an acceptable range (<15%) for semisolid formulations. Low moisture content helps prevent microbial growth and improves shelf-life.

#### **Result And Discussion**

The formulated 10 g herbal toothpaste was evaluated using standard parameters to assess its quality, safety, and effectiveness.

1) Organoleptic Evaluation:

The formulation exhibited a pleasant herbal aroma, light green color, smooth texture, and acceptable taste. These features improve user compliance and indicate proper ingredient blending.

The favorable organoleptic properties enhance user acceptability and compliance. The herbal constituents like mint oil and clove contribute significantly to flavor and freshness.

#### 2) pH:

Measured pH was 6.8, which is within the ideal oral pH range (6.5–7.5), making it safe for daily use without causing mucosal irritation or enamel erosion.

This is within the ideal range (6.5–7.5) for toothpaste and close to neutral, which is beneficial for maintaining oral mucosal integrity and avoiding enamel erosion. Herbal ingredients such as Aloe vera and Neem, known for their soothing and balancing properties, support the maintenance of pH.

3) Spreadability:

The paste demonstrated good spreadability (175 g·cm/sec), which ensures ease of application on the brush.

Good spreadability ensures uniform application on the toothbrush, which is essential for effective cleaning. The presence of humectants like glycerin and sorbitol enhanced the smoothness and application quality.

4) Foaming Ability:

The foam height was 6.5 cm, indicating moderate foaming, which is satisfactory for herbal formulations. Excessive foaming is not essential for cleaning efficiency.

Although herbal toothpastes typically foam less than synthetic ones, the moderate foam observed was sufficient for consumer satisfaction and cleansing action. Clove and mint contain natural saponins and oils which likely contributed to foam generation.

#### 5) Homogeneity:

The toothpaste was uniform without lumps or phase separation, reflecting effective formulation and stable excipient incorporation.

This indicates effective mixing and appropriate selection of binders and thickening agents. Xanthan gum effectively maintained the consistency and physical stability of the product.

6) Abrasiveness:

The formulation showed mild abrasiveness with no visible scratches on a glass slide, ensuring it is safe for enamel while still providing mechanical cleaning.

This is ideal for toothpaste, as excessive abrasiveness may damage enamel, while too little may result in poor cleaning. The use of calcium carbonate as a natural abrasive offered a balanced cleaning effect.

7) Antimicrobial Activity:

Zones of inhibition were observed as 14 mm against Streptococcus mutans and 12 mm against Lactobacillus, showing the formulation's effectiveness in controlling common oral pathogens.

The formulation showed significant antimicrobial activity, especially against *Streptococcus mutans*, a primary causative agent of dental caries. This activity can be attributed to the presence of clove oil (eugenol), neem extract (nimbin, nimbidin), and Aloe vera, all known for their antibacterial effects.

8) Moisture Content:

The moisture content was 13.5%, within acceptable limits for semisolid preparations, supporting better shelf-life and reduced microbial risk.

The moisture level was within acceptable limits for semisolid formulations, which is crucial for microbial stability and shelf life. Proper moisture control helps prevent microbial growth and maintains the consistency of the paste.

9) Stability (15 days):

No color change, odor variation, or separation was observed, confirming short-term physical and chemical stability.

This suggests good short-term stability, indicating that the excipients (e.g., preservatives like sodium benzoate) effectively preserved the integrity of the formulation. The use of natural stabilizers and thickening agents contributed to maintaining consistency.

## Conclusion

The herbal toothpaste was successfully formulated and evaluated with positive outcomes. It meets the essential quality criteria for pH, spreadability, foamability, antimicrobial activity, and stability. The natural ingredients offer therapeutic benefits with minimal side effects, positioning this formulation as a safer and effective alternative to synthetic toothpaste.

This study supports the integration of traditional herbal knowledge with modern pharmaceutical techniques to create sustainable and health-friendly oral care products.

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