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FORMULATION AND EVALUATION OF HERBAL TOOTHPASTE A NATURAL APPROACH TO ORAL HYGIENE

Nisha D. Masane[1], Vaibhav G. Akhand [2]and Swati P. Deshmukh[3].

[1] Department of Pharmacy, Shraddha Institute of Pharmacy, Washim, Maharashtra, India.
[2] Department of Quality Assurance, Shraddha Institute of Pharmacy, Washim, Maharashtra, India.
[3] Department of Pharmacology, Shraddha Institute of Pharmacy, Washim, Maharashtra, India.

ABSTRACT

The increasing awareness of the harmful effects of synthetic compounds in commercial oral hygiene products has led to a growing interest in herbal alternatives. This study focuses on the formulation and evaluation of an herbal toothpaste using natural ingredients such as Neem (Azadirachta indica), Clove (Syzygium aromaticum), and Turmeric (Curcuma longa), combined with safe excipients like baking soda, salt, coconut oil, and peppermint oil. These herbal agents were selected for their proven antibacterial, anti-inflammatory, antioxidant, and healing properties. The toothpaste was prepared in three different batches with varying ingredient ratios and evaluated for physicochemical characteristics including pH, spreadability, foamability, smoothness, and antimicrobial activity against Staphylococcus aureus. Results indicated that all formulations exhibited acceptable properties, with Batch 3 showing superior antibacterial activity. The study demonstrates that herbal toothpaste can be a safe, effective, and environmentally sustainable alternative to synthetic formulations, aligning with modern preferences for natural healthcare solutions.

1. INTRODUCTION

Oral hygiene is an essential component of overall health and well-being. Maintaining a clean and healthy oral cavity helps prevent not only dental issues such as cavities and gum diseases but also contributes significantly to the prevention of systemic illnesses. Poor oral hygiene has been closely linked with conditions such as tooth decay, gingivitis, periodontitis, and halitosis. These issues, if left untreated, can extend beyond the oral cavity and contribute to more serious health complications, including cardiovascular diseases, diabetes mellitus, respiratory infections, and adverse pregnancy outcomes. As such, maintaining effective oral hygiene is a public health priority. [1]

Traditional oral care products, while effective in maintaining dental hygiene, often contain synthetic and potentially harmful ingredients. These include fluoride, triclosan, artificial sweeteners, and foaming agents like Sodium Lauryl Sulfate (SLS). Though these substances serve specific functions—such as remineralization, bacterial control, and improved product usability—they have come under scrutiny due to increasing evidence of adverse effects. For instance, fluoride, though beneficial in small amounts, can lead to fluorosis when overused, especially in children. Triclosan has been associated with endocrine disruption, and SLS can cause mucosal irritation and allergic reactions. Additionally, the environmental impact of these chemical agents poses further concerns, as they are not easily biodegradable and may contribute to water pollution.[2]

In light of these issues, a paradigm shift is emerging in consumer preferences. There is a growing demand for natural, plant-based alternatives in oral care, driven by increasing awareness of the potential side effects of synthetic compounds and a broader societal movement toward wellness and sustainability. Herbal toothpaste, formulated from natural ingredients derived from medicinal plants, offers a promising alternative. These formulations are appreciated not only for their effectiveness but also for their safety profile, environmental compatibility, and alignment with holistic healthcare practices.[3]

The current formulation centers around three key herbal ingredients—Neem (Azadirachta indica), Clove (Syzygium aromaticum), and Turmeric (Curcuma longa)—each known for their potent medicinal properties and longstanding use in traditional medicine systems such as Ayurveda and Traditional Chinese Medicine. Neem possesses antibacterial, antifungal, antiviral, and anti-inflammatory properties. It is especially effective in combating oral pathogens such as Streptococcus mutans, a primary contributor to dental caries. Clove, rich in the compound eugenol, is widely used for its analgesic and antiseptic qualities, making it valuable for relieving toothaches and reducing gum inflammation. Turmeric, known for its active constituent curcumin, exhibits broad-spectrum antimicrobial, antioxidant, and anti-inflammatory effects, which contribute to oral tissue healing, reduction of gingivitis, and teeth whitening.[4]

In addition to these primary herbal agents, the formulation incorporates natural abrasives such as baking soda and salt. These ingredients help gently polish the teeth, remove dental plaque, and neutralize acidic conditions in the oral cavity that may lead to enamel erosion. Coconut oil, another component, serves as both a base and an antimicrobial agent. Its use in oil pulling is well-documented for reducing oral bacteria and promoting detoxification. Although a small amount of Sodium Lauryl Sulfate (SLS) is retained in the formulation to enhance the foaming property of the toothpaste and improve user experience, it is used at a concentration deemed safe and non-irritating to most users.

Furthermore, peppermint oil is added to provide a refreshing taste and additional antimicrobial action, enhancing the overall user experience and promoting fresh breath. The incorporation of essential oils not only contributes to sensory appeal but also aids in maintaining a balanced oral microbiome.[5]

The formulation of herbal toothpaste involves precise measurement, thorough mixing, and homogenization processes to ensure the final product is consistent in texture, effective in application, and stable over time. The choice of ingredients and methods also ensures that the product maintains its efficacy throughout its shelf life without the use of synthetic preservatives.

An often-overlooked benefit of herbal formulations is their reduced environmental impact. These products are typically biodegradable and can be packaged using sustainable, recyclable materials. In contrast to synthetic-based formulations, herbal toothpaste aligns with green chemistry principles and supports the broader goals of eco-friendly and sustainable healthcare.

This research aims to develop and evaluate a novel herbal toothpaste that balances efficacy, safety, and environmental responsibility. The study includes a multi-faceted approach, encompassing physicochemical analysis (such as pH, spreadability, foaming capacity, and texture), microbial efficacy testing, stability evaluations over time, and consumer feedback through sensory trials. By integrating traditional herbal knowledge with modern scientific validation, this formulation aspires to contribute meaningfully to holistic oral care and sustainable health practices.[6]

ANATOMY AND PHYSIOLOGY OF TEETH

The human dentition typically includes 28 to 32 teeth, divided between the upper (maxillary) and lower (mandibular) jaws. These are classified into:

- Incisors (8): Front teeth for cutting.
- Canines (4): Pointed teeth for tearing.
- Premolars (8): For crushing and grinding.
- Molars (8–12): Broad-surfaced teeth for grinding food.
- Each tooth has three main parts:
- Crown: The visible part, covered in enamel, the hardest tissue in the body.
- Neck: The area where crown meets root at the gum line.
- Root: Embedded in the jawbone, anchoring the tooth in place.

Internally, a tooth consists of:

- Enamel: Hard outer covering protecting the tooth.
- Dentine: Calcified tissue beneath enamel, containing microscopic tubules.
- Pulp: The central chamber with nerves and blood vessels.
- Cementum: A bone-like material covering the root and aiding in attachment.

Teeth perform vital functions including:

- Mastication: Mechanical breakdown of food.
- Speech: Assisting in articulation.
- Aesthetic support: Maintaining facial structure.
- Protection: Proper alignment helps prevent tissue injury.[7]

IDEAL PROPERTIES OF TOOTHPASTE

An ideal toothpaste should effectively clean the teeth, promote oral health, and be safe for daily use. Key properties include:

- **Cleansing Ability:** Gentle abrasives and surfactants help remove plaque, stains, and debris without harming enamel.
- **Antimicrobial Action**: Ingredients like neem, clove, and turmeric can inhibit harmful bacteria responsible for cavities and gum disease.
- **Anti-inflammatory Effects**: Natural compounds reduce gum inflammation and support healing.
- **Non-toxic and Safe:** The formulation must be safe even if ingested, particularly for children.
- **Pleasant Taste:** Flavors like peppermint enhance the user experience and freshen breath.
- **Balanced pH:** Slightly alkaline pH helps protect enamel and maintain oral health.
- **Good Spreadability and Foam**: Ensures even application and effective cleaning.
- **Stability**: The product should retain texture, appearance, and effectiveness over time.
- **Cosmetic Appeal:** Some ingredients help whiten teeth and remove stains.
- **Eco-friendly**: Natural, biodegradable ingredients and recyclable packaging are ideal.[8]

2. DRUG PROFILE:

➢ **Neem (Azadirachta indica)**

1. **Botanical Name:** Azadirachta indica
2. **Common Name:** Neem, Indian Lilac
3. **Family**: Meliaceae
4. **Plant Parts Used:** Leaves, bark, twigs, seeds, oil, flowers
5. **Geographical Source:** Indigenous to the Indian subcontinent; widely cultivated in tropical and subtropical regions across Asia, Africa, and South America

Therapeutic Uses:

- Prevention of dental caries
- Management of gingivitis and periodontitis
- Antiseptic mouth rinses
- Herbal toothpaste and gels

- Neem twigs (chewing sticks) for mechanical and antimicrobial cleaning[9]

➢ **Colve**

1. **Common Name:** Clove
2. **Botanical Name**: Syzygium Aromaticum L.
3. **Family**: Myrtaceae
4. **Part Used**: The dried flower buds of the clove plant are primarily used for medicinal and dental purposes. In the formulation of herbal toothpaste, clove is often included in the form of essential oil (clove oil) or finely ground powder of the dried buds.
5. **Description and Organoleptic Characters:** Clove buds are dark brown in color, with a characteristic strong aromatic odor and a pungent, spicy taste. The essential oil extracted from clove is pale yellow to colorless and is rich in bioactive constituents.

➢ **Turmeric**

1. **Common Name:**Turmeric
2. Botanical Name:Curcuma longa L.
3. **Family**:Zingiberaceae (Ginger family)
4. **Part Used**:The rhizome (underground stem) of turmeric is primarily used for medicinal purposes. In herbal toothpaste formulations, turmeric is usually incorporated in the form of powdered rhizome or turmeric extract, including curcumin.
5. **Description and Organoleptic Characters:**Turmeric is a bright yellow-orange powder derived from the dried rhizomes of the Curcuma longa plant. The powdered form has an earthy, bitter, and slightly peppery flavor. The essential oil is pale yellow and has a distinct aromatic odor, characteristic of turmeric.[10]

3.EXCIPIENTS PROFILE

➢ Salt

❖ **Synonyms:**

Common salt; Table salt; Rock salt; Sea salt; Halite; NaCl

❖ **Chemical Name and CAS Registry Number:**

Sodium chloride — [7647-14-5]

❖ **Empirical Formula and Molecular Weight:**

NaCl and 58.44 g/mol

❖ **Structural Formula:**

Na^+ Cl^-

❖ **Functional Category:**

Tonicity agent; Osmotic agent; Preservative; Tablet diluent; Lubricant in oral formulations[11]

➢ Coconut Oil

❖ **Synonyms:**

Cocos Oil; Copra Oil; Coconut Butter; Virgin Coconut Oil

❖ **Chemical Name and CAS Registry Number:**

Coconut oil — [8001-31-8]

❖ **Empirical Formula and Molecular Weight:**

Mixture of triglycerides — MW ~638–689 g/mol

❖ **Structural Formula:**

Glycerol esterified with lauric/myristic/capric acid

❖ **Functional Category:**

Emollient; Vehicle; Solubilizer; Lubricant[12]

➢ Sodium Lauryl Sulfate (SLS)

❖ **Synonyms:**

SLS; SDS; Lauryl sodium sulfate; Duponol; Texapon

❖ **Chemical Name and CAS Registry Number:**

Sodium dodecyl sulfate — [151-21-3]

❖ **Empirical Formula and Molecular Weight:**

$C_{12}H_{25}NaO_4S$ and 288.38 g/mol

❖ **Structural Formula:**

$CH_3(CH_2)_{11}OSO_3^-Na^+$

❖ **Functional Category:**

Surfactant; Foaming agent; Wetting agent[13]

➢ Peppermint Oil

❖ **Synonyms:**

Mentha piperita oil; Oil of Peppermint

❖ **Chemical Name and CAS Registry Number:**

Mentha piperita, ext. — [8006-90-4]

❖ **Empirical Formula and Molecular Weight:**

Mainly menthol ($C_{10}H_{20}O$, MW 156.27) and menthone ($C_{10}H_{18}O$, MW 154.25)

❖ **Structural Formula:**

Mixture — primarily menthol and menthone

❖ **Functional Category:**

Flavoring agent; Cooling agent; Antimicrobial[14]

➢ **Water (q.s.)**

❖ **Synonyms:**

Distilled water; Aqua; Deionized water

❖ **Chemical Name and CAS Registry Number:**

Water — [7732-18-5]

❖ **Empirical Formula and Molecular Weight:**

H_2O and 18.02 g/mol

❖ **Structural Formula:**

H–O–H

❖ **Functional Category:**

Solvent; Vehicle; Processing aid[15]

4.MATERIALS AND METHODS :

1. Materials

- Neem powder
- Clove powder
- Turmeric powder
- Baking soda
- Common salt (Sodium chloride)
- Coconut oil
- Peppermint oil
- Sodium Lauryl Sulfate (SLS)
- Water (q.s.)[16]

2. Methodology

A. Preparation of Ingredients

Neem leaves were collected washed with clean water, shade-dried for 5–7 days, and ground into a fine powder.

Clove and turmeric powders were obtained directly or freshly prepared by grinding dry cloves and turmeric rhizomes.

Baking soda, salt, coconut oil, peppermint oil, and SLS were used as received.

B. Formulation Procedure

Powder Mixing:

Accurately weigh neem powder, clove powder, turmeric powder, baking soda, and salt. Transfer all powders into a clean mortar and pestle and mix uniformly for about 10 minutes.

Preparation of Premix:

Dissolve Sodium Lauryl Sulfate (SLS) in about 5 mL of water separately to form a foaming premix.

Wet Mixing:

Gradually add 10 mL coconut oil into the dry powder mix while continuously stirring with a glass rod to form a smooth paste.

Addition of SLS Solution:

Slowly add the prepared SLS solution into the paste with continuous mixing to avoid lump formation.

Adjustment of Consistency:

Add small quantities of water (q.s.) drop by drop to adjust the paste to a smooth and spreadable consistency.

Flavoring:

Finally, add 2 mL peppermint oil to the paste to improve taste and freshness. Stir thoroughly to ensure uniform distribution.

Packaging:

Transfer the prepared toothpaste into clean, labeled containers and store in a cool, dry place.[17]

Formulation Table

Table No. 7.1 Formulation Table

Category	Ingredient	Batch 1 (g)	Batch 2 (g)	Batch 3 (g)
Active Ingredients	Neem Powder	3.2 g	2.4 g	2 g
	Clove Powder	1.6 g	2 g	2.4 g
	Turmeric Powder	1.2 g	1.6 g	1.6 g
Cleaning Agents	Baking Soda	10 g	12 g	11.2 g
	Salt	2 g	1.6 g	2 g
Base & Binding	Coconut Oil	12 g	11.2 g	12 g
	Water (q.s.)	Adjust	Adjust	Adjust
Foaming Agent	Sodium Lauryl Sulfate (SLS)	0.8 g	0.8 g	0.8 g
Flavoring	Peppermint Oil	0.8 g	0.8 g	0.8 g
Preservative	Neem Extract	0.4 g	0.4 g	0.4 g
	Total	**40 g**	**40 g**	**40 g**

5. EVALUATION PARAMETERS

All three formulations (F1, F2, and F3) were evaluated individually, and the results obtained are noted below. The methods of evaluation are represented below.

1. pH:

A sample quantity of 5 g was weighed precisely and placed in 45 ml of distilled water in a 150 ml beaker. It was then boiled for some time at 27°C and allowed to cool. More distilled water was added to make the suspension, which was then thoroughly swirled.

The pH of the suspension was measured using a digital pH meter after calibrating the meter with distilled water. The pH was recorded after 5 minutes of measurement.

2. Physical Examination:(Colour, Odour, Taste, And Smoothness)

- **Colour:** The formulation's colour was examined and visually verified.
- **Odour:** The odour of the toothpaste was assessed by smelling the material and identifying its characteristic smell.
- **Taste:** The taste was checked manually by applying a small amount of the formulation to the finger and brushing or placing it on the teeth.
- **Smoothness:** The smoothness was tested by taking the material in hand and rubbing it between fingers**.**spreading on the finger to confirm the spreading paste formulation.[18]

3. Foamability:

The foamability of formulated toothpaste was evaluated by taking 2.0 g of formulation in 50 ml water in measuring cylinder, initial volume was noted and then shaken for 10 minutes. Final volume of foam was noted.

4. Anti-bacterial Activity of Formulation

Antibacterial activity of the formulated paste was performed by the disc diffusion method in triplicate using Muller Hinton Agar media with Staphylococcus aureus strain. The formulated paste was placed on the bacterial plates and incubated at 37 °C for 24 hours, with ciprofloxacin HCl as the positive control. The diameter of the zone of inhibition was measured in millimeters.[19]

5. Spreadability

Spreadability of the toothpaste determines how easily it spreads under slight pressure. A good spreadability ensures easy application on the toothbrush and uniform distribution during brushing.

6. Homogeneity

The toothpaste shall extrude a homogeneous mass from the collapsible tube by applying normal force.

7. Smoothness

Water in the toothpaste helps to get a nice, smooth paste when you squeeze the tube. Humectants are the ingredients that keep your toothpaste from drying out and becoming crumbly.[20]

6. RESULTS

1. pH Values

Table 6.1 pH

Formulation	pH
1	8.2
2	8.0
3	7.5

2. Physical Parameters:

Table 6.2 Physical Parameters

Parameter	Formulation 1	Formulation 2	Formulation 3
Colour	Light green	Light green	Light green
Odor	Aromatic	Aromatic	Aromatic
Taste	Little sweet	Little sweet	Little sweet
Smoothness	Smooth	Smooth	Smooth

3. Foamability

Table 6.3. Foamability

Formulation	Volume of Foam
1	50 ml
2	45 ml
3	40 ml

4. Antibacterial Assay

Table 6.4. Antibacterial Assay

Formulation	Zone of Inhibition
1	14 mm
2	12 mm
3	16 mm

5. Spreadability

Table 6.5. Spreadability

Formulation	Spread Diameter
1	9 mm
2	6 mm
3	8 mm

6. Homogeneity

Table 6.6: Evaluation of Homogeneity of Herbal Toothpaste

Formulation	Observation
1	Uniform, no lumps
2	Slight lumps, fairly uniform
3	Smooth and uniform mass

7. Smoothness

Table 6.7: Evaluation of Smoothness of Herbal Toothpaste

Formulation	Observation
1	Very smooth paste
2	Slightly gritty texture
3	Extremely smooth, creamy paste

10. CONCLUSION

The present study successfully formulated and evaluated three batches of herbal toothpaste using natural ingredients such as Neem, Clove, and Turmeric, along with supportive components like baking soda, salt, coconut oil, and peppermint oil. All formulations exhibited acceptable physicochemical properties, including pH, spreadability, foamability, homogeneity, and smoothness.

Among the three, **Formulation 3 demonstrated the most effective antibacterial activity**, particularly against Staphylococcus aureus, suggesting a promising role for herbal ingredients in combating oral pathogens. The pH values of the formulations remained within a mildly alkaline range, which supports enamel protection and oral health. The consistency and physical appearance of the toothpaste were stable and user-friendly.

This research highlights the potential of herbal toothpaste as a **safe, effective, and environmentally friendly alternative** to conventional synthetic formulations. By integrating traditional medicinal knowledge with modern evaluation techniques, the study supports further development and potential commercialization of herbal dental care products.

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