Preparation And Development of Herbal Toothpaste from Neem & Babool

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***Abstract*—The present research focuses on the formulation and evaluation of a herbal toothpaste containing Neem (Azadirachta indica) and Babool (Acacia arabica) as the major herbal ingredients, with Honey (Apis mellifera) serving as a supportive natural component. The aim of the study is to develop a safe, effective, and natural oral hygiene product using traditional medicinal plants that possess proven therapeutic properties for maintaining oral health and preventing dental problems. Neem is a well-known medicinal plant valued for its antibacterial, antifungal, and anti-inflammatory activities. It helps in the prevention of dental plaque, tooth decay, and gum infections by inhibiting the growth of pathogenic microorganisms. Babool, another important Ayurvedic herb, is rich in tannins and flavonoids that exhibit astringent and antimicrobial effects. It helps to strengthen the gums, tighten soft tissues, and reduce gum bleeding. Honey, used in small quantity, functions as a natural humectant, mild preservative, and sweetening agent, improving the texture, moisture, and acceptability of the formulation. The formulated toothpaste was subjected to various evaluation tests, including physical appearance, texture, pH, foaming ability, spreadability, stability, and antimicrobial activity against common oral pathogens such as Streptococcus mutans and Lactobacillus. The results demonstrated that the Neem–Babool toothpaste possessed desirable consistency, acceptable flavor, good stability, and significant antimicrobial activity.**

***Index Terms*—HerbalToothpaste**

I. INTRODUCTION

Oral hygiene plays a vital role in maintaining overall health, as the mouth serves as the gateway to the body. A clean and healthy oral cavity prevents various dental problems such as tooth decay, gingivitis, bad breath, and periodontal diseases. In recent years, growing awareness about the side effects of synthetic chemicals used in commercial toothpastes—such as triclosan, sodium lauryl sulfate, and artificial sweeteners—has encouraged consumers to shift toward herbal formulations. Herbal toothpastes, prepared using natural plant extracts, not only clean and protect the teeth but also provide therapeutic benefits without harmful effects.

Among the numerous medicinal plants used in oral care, Neem (Azadirachta indica) and Babool (Acacia arabica) hold a prominent place in traditional Indian medicine (Ayurveda). These herbs have been used for centuries as natural remedies for maintaining oral health. Neem is often referred to as the "village pharmacy" because of its wide range of medicinal properties. It contains active compounds such as nimbidin, nimbin, and azadirachtin, which exhibit antibacterial, antifungal, antiviral, and anti-inflammatory effects. These constituents make Neem highly effective in controlling plaque formation, reducing gum inflammation, and preventing dental caries caused by microbial growth. Regular use of Neem-based formulations helps maintain fresh breath and strengthens the immune defense of the oral cavity.

Babool, also known as Kikar or Indian gum Arabic tree, is another important herb traditionally used in oral hygiene. The bark and pods of Babool are rich in tannins, flavonoids, and gallic acid, which exhibit astringent, antimicrobial, and anti-inflammatory properties. Babool strengthens the gums, tightens tissues, and helps in healing mouth ulcers and bleeding gums. Its natural astringent action makes it particularly beneficial for maintaining gum health and preventing periodontal infections.

In this formulation, Honey has been incorporated as a supportive ingredient. Although not a primary active agent, honey contributes several beneficial effects. It acts as a natural humectant, helping to maintain the moisture content of the paste, improves texture, and provides mild sweetness that enhances patient acceptability. Additionally, honey possesses antibacterial and healing properties, contributing to the overall stability and effectiveness of the formulation while avoiding the use of artificial sweeteners like saccharin or stevia.

The combination of Neem and Babool in a toothpaste offers a synergistic effect in promoting oral hygiene. While Neem helps to fight bacteria and prevent infection, Babool aids in gum tightening and overall mouth cleanliness. The aim of the present study is to formulate and evaluate an herbal toothpaste containing Neem and Babool as major ingredients, and honey as a natural adjunct, to provide a safe, effective, and eco-friendly oral care product. The formulated toothpaste was evaluated for parameters such as appearance, pH, spreadability, foaming ability, stability, and antimicrobial activity.

In conclusion, the development of a Neem–Babool herbal toothpaste reflects a fusion of traditional Ayurvedic knowledge and modern pharmaceutical formulation. It represents a natural, chemical-free, and cost-effective alternative to conventional toothpastes, offering effective cleaning, protection, and long-term oral health benefits.

II. AIM AND OBJECTIVES

Aim:

The primary aim of this study is to formulate and evaluate a herbal toothpaste containing Neem (Azadirachta indica) and Babool (Acacia arabica) as the major active ingredients, with Honey incorporated as a supportive natural agent. The goal is to develop a natural, safe, and effective herbal formulation that can maintain oral hygiene, prevent microbial infections, strengthen gums, and promote overall dental health. The study also aims to replace synthetic ingredients commonly used in commercial toothpastes—such as artificial sweeteners, synthetic preservatives, and chemical foaming agents—with natural, biocompatible alternatives that are environmentally safe and well- tolerated by users.

III. OBJECTIVES

1. To explore and utilize traditional medicinal plants—Neem and Babool— for their proven therapeutic effects in oral health care, particularly their antibacterial, anti-inflammatory, and astringent properties.
2. To formulate a stable herbal toothpaste using appropriate excipients such as calcium carbonate (abrasive), glycerin (humectant), binding agents, and natural flavoring agents, ensuring desirable consistency and consumer acceptability.
3. To incorporate Honey as a natural humectant and mild preservative to enhance the product's moisture content, texture, and shelf life, while also contributing to its mild sweetness and antimicrobial properties.
4. To evaluate the physicochemical properties of the prepared toothpaste, including pH, spreadability, foaming ability, appearance, texture, and stability under different storage conditions.
5. To assess the antimicrobial efficacy of the herbal formulation against common oral pathogens such as Streptococcus mutans and Lactobacillus species.
6. To compare the overall performance of the developed herbal toothpaste with that of standard commercial formulations to determine its relative effectiveness and safety.
7. To encourage the use of eco-friendly herbal formulations as sustainable alternatives to synthetic chemical-based toothpastes, promoting the concept of "Green Pharmacy" and holistic oral care.

IV. REVIEW OF LITERATURE

Oral hygiene is an integral part of personal health, as the mouth serves as the entry point for nutrients and microbes alike. Maintaining good oral hygiene is crucial to prevent diseases such as dental caries, gingivitis, and periodontitis. The modern lifestyle, coupled with excessive use of synthetic products, has led to various oral health issues. Conventional toothpastes contain several chemical substances such as triclosan, sodium lauryl sulfate (SLS), artificial sweeteners, and preservatives that, though effective in cleansing, may cause mucosal irritation, allergic reactions, and environmental harm. Consequently, there is an increasing global trend toward the use of herbal and natural formulations that are safe, biocompatible, and environmentally sustainable.

Traditional Perspective of Herbal Oral Care

The use of herbal preparations for dental care dates back thousands of years. In ancient Indian Ayurvedic texts, herbs such as Neem (Azadirachta indica), Babool (Acacia arabica), Clove (Syzygium aromaticum), and Tulsi (Ocimum sanctum) have been documented as traditional remedies for maintaining oral hygiene. Chewing sticks made from these plants were used to clean teeth, strengthen gums, and freshen breath. These practices were not only mechanical but also pharmacological, as the bioactive compounds present in plant tissues provided antimicrobial, anti-inflammatory, and astringent effects. Over time, modern science has validated these traditional practices by isolating active constituents and understanding their therapeutic mechanisms.

Neem (Azadirachta indica)

Neem has been described as a "village pharmacy" due to its wide range of medicinal benefits. Every part of the Neem tree—leaves, bark, twigs, seeds, and oil—possesses therapeutic potential. Phytochemical analysis reveals that Neem contains compounds such as azadirachtin, nimbidin, nimbin, quercetin, and sodium nimbinate, which exhibit antibacterial, antifungal, antiviral, and anti-inflammatory properties.

Numerous studies support Neem's effectiveness in oral care. According to Chatterjee et al. (2011), Neem-based mouthwash significantly reduced plaque accumulation and bacterial growth when compared to chlorhexidine-based formulations. Similar findings were reported by Rao et al. (2014), showing that Neem extract inhibited Streptococcus mutans—a major causative organism in dental caries—without any toxic side effects. The anti- inflammatory properties of Neem also help reduce gum swelling and promote healing of oral ulcers. In addition, its antioxidant properties neutralize free radicals, preventing oxidative damage to the oral mucosa.

Babool (Acacia arabica or Acacia nilotica)

Babool, another vital plant in Ayurvedic dentistry, is traditionally used as a natural toothbrush. Its bark and pods are rich in tannins, flavonoids, catechins, and gallic acid, which impart astringent, antimicrobial, and anti-inflammatory actions. The astringent property of Babool strengthens the gums, prevents bleeding, and tightens oral tissues, while its antimicrobial action combats plaque-forming bacteria.

According to Kumar et al. (2015), Babool bark extract shows strong antibacterial activity against Staphylococcus aureus, Escherichia coli, and Streptococcus mutans. The study concluded that Babool is effective in controlling plaque formation and improving gum health. Another study by Mishra et al. (2017) demonstrated that patients using Babool-based toothpowder experienced reduced gum bleeding and fresher breath. The bark extract also aids in wound healing and alleviates minor oral infections, making it a suitable component for herbal toothpaste formulations.

Honey (Apis mellifera)

Honey, though not a main active ingredient, is used in this formulation as a supportive natural agent. It serves

as a humectant, mild preservative, and natural sweetener. Honey contains glucose oxidase, which slowly releases hydrogen peroxide, giving it mild antibacterial properties. Research by Allen et al. (2000) and Molan (2006) confirmed that honey exhibits bacteriostatic effects against Candida albicans and Streptococcus mutans. Its acidic pH, viscosity, and osmotic properties prevent bacterial growth and promote wound healing in the oral cavity.

Furthermore, honey adds smoothness and palatability to the toothpaste, eliminating the need for synthetic sweeteners like saccharin or stevia. Its moisturizing property helps maintain the texture and prevents the paste from drying out. Thus, honey acts as a natural stabilizer and enhancer of product quality.

Previous Studies on Herbal Toothpastes

Several research works have explored the formulation of herbal toothpastes using different plant extracts. Pandey et al. (2016) developed a herbal toothpaste containing Neem, Clove, and Mint extracts, which demonstrated significant antibacterial activity and good consumer acceptance. Similarly, Sharma and Joshi (2018) prepared a Babool-based toothpaste that effectively reduced gingival inflammation and improved oral cleanliness scores among users.

Another study by Prashant et al. (2007) compared Neem-based toothpaste with commercial fluoride toothpastes and found Neem equally effective in reducing plaque and gingivitis. These studies confirm that herbal ingredients can replace chemical components while maintaining similar or improved therapeutic effects.

Advantages of Herbal Toothpaste

Herbal toothpastes offer several advantages over conventional ones. They are biodegradable, safe for long-term use, and devoid of synthetic chemicals. The bioactive compounds in plants exhibit synergistic actions that not only clean the teeth but also provide healing, antimicrobial, and anti-inflammatory benefits. Herbal formulations are less likely to cause allergic reactions or mucosal irritation and are eco-friendly, contributing to sustainable health practices. Additionally, herbal ingredients contain natural flavoring and coloring agents, reducing the need for artificial additives.

Need for the Present Study

Although many herbal toothpastes are commercially available, several still contain chemical preservatives and artificial flavors that compromise their natural integrity. Therefore, there is a need to formulate a truly herbal toothpaste using 100% natural ingredients. This study focuses on developing a Neem–Babool herbal toothpaste, where Neem acts as a potent antimicrobial and anti-inflammatory agent, Babool functions as an astringent and gum strengthener, and Honey provides natural sweetness, moisture retention, and mild preservation.

This formulation aims to provide a safe, effective, and economical alternative to synthetic products, bridging traditional Ayurvedic wisdom with modern pharmaceutical practices. It also supports the “Green Pharmacy” initiative, which encourages sustainable production using renewable plant resources.

Conclusion of Literature Findings

The reviewed literature clearly establishes that Neem and Babool are effective herbal ingredients for maintaining oral hygiene and preventing dental infections. Their antimicrobial, anti-inflammatory, and antioxidant properties are well-documented. The supportive inclusion of Honey enhances texture, preservation, and patient acceptability. Combining these ingredients results in a synergistic formulation that offers broad-spectrum oral protection. Thus, the proposed Neem–Babool–Honey herbal toothpaste represents a promising, safe, and environmentally friendly approach to oral care, aligning traditional herbal knowledge with modern scientific validation.

V. MATERIALS AND METHODOLOGY

1. Materials:

The raw materials used in the preparation of herbal toothpaste were chosen for their therapeutic effectiveness, safety, and compatibility with other formulation components. Neem (Azadirachta indica) and Babool (Acacia arabica) were selected as the principal herbal ingredients because of their well-documented antimicrobial, anti-inflammatory, and gum-strengthening properties. Honey was used in small quantity as a natural humectant and mild preservative, contributing to the smooth texture and subtle sweetness of the product. Other ingredients like calcium carbonate, glycerin, and natural binders were included to provide the required consistency, abrasiveness, and stability. All ingredients used were of analytical or pharmaceutical grade, and purified water was used throughout the formulation process.

2. Formula for 60 g Herbal Toothpaste

Ingredients	% w/w	Quantity (g)	Function
Calcium carbonate	35%	21.0 g	Mild abrasive, cleaning agent
Glycerin / Sorbitol (70%)	20%	12.0 g (≈ 9.6 mL)	Humectant, prevents drying
Neem extract adirachta indica)	5%	3.0 g	tibacterial, anti- (inflammatory
Babool extract (Acacia arabica)	4%	2.4 g	Astringent, strengthens gums
Xanthan gum / CMC	1.5%	0.9 g	Thickening and binding agent
Sodium lauryl sulfate (SLS)	1.2%	0.72 g	Foaming agent
Honey (Apis mellifera)	0.25%	0.15 g (≈ 0.11 mL)	Mild sweetener and humectant
Peppermint oil	0.5%	0.3 g (≈ 0.33 mL)	Flavoring and refreshing
Clove oil (optional)	0.3%	0.18 g (≈ 0.2 mL)	Antibacterial and analgesic
Benzoic Acid	0.5%	0.5 g	Preservative
Purified water / herbal decoction	q.s.	To make 60 g	Vehicle and solvent

METHODOLOGY

Preparation of Herbal Extracts

The herbal extracts of Neem and Babool were prepared using the maceration method. Clean and shade-dried Neem leaves and Babool bark were powdered coarsely. About 50 g of each powdered plant material was soaked separately in 500 mL of distilled water for 24 hours with occasional stirring. The extracts were then filtered and concentrated on a water bath until a thick semi-solid consistency was obtained. The extracts were stored in airtight containers until further use.

Preparation of the Base

A measured quantity of purified water (about 10–15 mL) was taken in a clean beaker. The required amount of Xanthan gum or CMC was slowly sprinkled into the water with continuous stirring using a mechanical

stirrer until a smooth gel-like consistency was obtained. This step ensures uniform dispersion of the binder and prevents lump formation.

Addition of Humectant
Glycerin was added to the gel base under continuous stirring to form a uniform mixture. Glycerin not only acts as a humectant to retain moisture but also imparts smoothness and improves the texture of the toothpaste.

Incorporation of Herbal Extracts
The prepared Neem and Babool extracts were added to the base one by one. Continuous stirring was maintained to ensure the uniform distribution of herbal components throughout the mixture. These extracts impart medicinal value to the toothpaste and are responsible for its antibacterial and gum-strengthening effects.

Addition of Abrasive
Calcium carbonate was added gradually to the above mixture under slow stirring. This helps in maintaining the required consistency and provides gentle abrasiveness to remove plaque and stains from the teeth surface.

Addition of Other Ingredients
After thorough mixing, SLS was incorporated as a foaming agent to improve the cleansing property of the toothpaste. Then, honey was added in a small quantity to enhance the texture, add mild sweetness, and contribute to the preservative effect. Peppermint oil and clove oil were added as natural flavoring agents to impart freshness and antibacterial action. Potassium sorbate was added as a preservative to increase the shelf life of the product.

Adjustment of Consistency and Weight
Finally, the total weight of the formulation was adjusted to 60 g by adding purified water. The mixture was stirred continuously until a homogeneous and smooth paste was obtained. The final product was allowed to stand for 24 hours for deaeration.

Packaging
The prepared toothpaste was filled into clean, dry, collapsible aluminum tubes or plastic containers and stored in a cool, dry place until evaluation.

Evaluation Tests
To ensure the quality, stability, and effectiveness of the prepared herbal toothpaste, the following evaluation parameters were conducted:

Physical Appearance:
The color, texture, and odor were visually inspected. The formulation should be uniform, smooth, and free from grittiness.
pH Determination:
A 10% w/v dispersion of toothpaste in distilled water was prepared, and pH was measured using a digital pH meter. The ideal pH range for toothpaste is 6.5–8.0, which is safe for oral tissues.

Foaming Power:
10 g of toothpaste was mixed with 50 mL of water and shaken for one minute. The foam height was measured; adequate foam indicates proper cleansing action.

Spreadability:
Measured using two glass slides. The area of the paste spread under a specific weight indicates its ease of application.

Abrasiveness:
Tested to ensure the toothpaste effectively cleans without damaging tooth enamel.

Stability Studies:
Samples were stored at room temperature, 37°C, and 45°C for 30 days. Observations were made for color, odor, separation, and pH changes.

Antimicrobial Activity:
The antibacterial effect was tested using the agar diffusion method against Streptococcus mutans and Lactobacillus. The zone of inhibition was measured to confirm antimicrobial efficacy.

VI. CONCLUSION

The formulated Neem–Babool–Honey herbal toothpaste (60 g) exhibited desirable physical and chemical characteristics. The combination of Neem and Babool provided effective antimicrobial and astringent actions, while honey improved texture and preservation. The formulation proved stable and

suitable for routine oral hygiene, offering a safe, natural alternative to synthetic toothpastes.

Herbal Drugs Included in the Formulation

Neem (Azadirachta indica) Family: Meliaceae

Common Name: Indian Lilac Part Used: Leaves and Bark

Description:

Neem is one of the most well-known medicinal plants in Ayurveda, widely recognized for its strong antibacterial, antifungal, and anti-inflammatory properties. The leaves are bitter and contain numerous phytochemicals that contribute to its effectiveness in oral care formulations.

Active Constituents:

Azadirachtin, Nimbin, Nimbidin, Nimbosterol, Quercetin, and Sodium nimbinate.

Pharmacological Actions:

Antibacterial: Acts against Streptococcus mutans and Lactobacillus, the main causative bacteria for dental caries.

Anti-inflammatory: Reduces gum swelling and inflammation associated with gingivitis.

Astringent: Strengthens gums and reduces plaque formation. Antifungal: Prevents oral fungal infections like Candida albicans.

Role in Toothpaste:

Neem acts as a natural cleanser and disinfectant, preventing tooth decay and improving gum health. It provides the main antimicrobial activity in the formulation.

Babool (Acacia arabica / Acacia nilotica)

Family: Fabaceae (Leguminosae)

Common Name: Babool, Indian Gum Arabic Tree Part Used: Bark

Description:

Babool is a moderate-sized tree with spiny branches. The bark and pods have high tannin content, making them effective for oral health applications. Babool has been traditionally used in India as a natural toothbrush (chewing stick).

Active Constituents:

Tannins, Gallic acid, Catechol, Flavonoids, Mucilage, and Calcium.

Pharmacological Actions:

Astringent: Tightens gums and prevents bleeding.

Antimicrobial: Controls bacterial growth responsible for plaque and bad breath.

Healing: Promotes the regeneration of oral tissues and helps in the healing of mouth ulcers.

Anti-inflammatory: Reduces gum inflammation and soreness.

Role in Toothpaste:

Babool strengthens the gums, helps tighten loose teeth, and provides natural astringent action. It complements Neem's antibacterial properties, resulting in a synergistic effect for overall oral hygiene.

Honey (Apis mellifera) Family: Apidae
Common Name: Honey
Part Used: Natural secretion from honeybees

Description:
Honey is a natural product formed by bees from nectar collected from flowers. It is rich in sugars, amino acids, enzymes, vitamins, and minerals. Though used in small quantity, honey adds smoothness and natural sweetness to the toothpaste.

Active Constituents:
Fructose, Glucose, Flavonoids, Phenolic acids, Enzymes (invertase, glucose oxidase), and Organic acids.
Pharmacological Actions:

Mild Antimicrobial: Due to its low pH and hydrogen peroxide content. Antioxidant: Protects oral tissues from oxidative stress.
Humectant: Retains moisture, preventing toothpaste from drying. Healing: Promotes tissue repair in oral mucosa.

Role in Toothpaste:
Honey enhances the consistency and texture of the toothpaste, provides mild preservative effect, and supports the healing of minor oral lesions. It is used as an alternative to artificial sweeteners like stevia or saccharin.
Clove (Syzygium aromaticum) (optional but beneficial) Family: Myrtaceae
Part Used: Flower buds

Active Constituents:
Eugenol, Caryophyllene, and Tannins. Pharmacological Actions:
Analgesic and Antiseptic: Provides pain relief and kills germs in the mouth. Deodorizing: Removes bad breath and gives a pleasant aroma.
Role in Toothpaste:
Clove oil is often added in small quantity to impart flavor, fragrance, and pain-relieving properties. It enhances the mouthfeel and freshness of the toothpaste.
Peppermint (Mentha piperita) Family: Lamiaceae
Part Used: Leaves and Oil

Active Constituents:
Menthol, Menthone, and Flavonoids. Pharmacological Actions:
Refreshing Agent: Provides a cooling and soothing sensation. Antibacterial: Helps maintain oral hygiene. Flavoring: Masks unpleasant taste of herbal ingredients.

Role in Toothpaste:
Peppermint oil is included to impart pleasant taste and

aroma, ensuring patient acceptability and refreshing mouthfeel.

Summary

All the above herbal drugs were selected based on their traditional usage and proven pharmacological activities. The combination of Neem and Babool provides effective antibacterial and astringent actions, which help in maintaining oral hygiene, strengthening gums, and preventing tooth decay. Honey acts as a natural humectant and texture enhancer, while Peppermint and Clove improve flavor, freshness, and antimicrobial effect. Together, these natural ingredients form a safe, effective, and eco-friendly herbal toothpaste suitable for daily use.

Evaluation Parameters for Herbal Toothpaste

Sr. No.	Parameter	Method of Evaluation	Purpose/Significance
1	Appearance / Colour	Visual inspection under natural light	Ensures uniform colour and appearance indicating proper mixing of ingredients.
2	Odour	Sensory evaluation by smelling the sample	Confirms presence of characteristic herbal aroma (neem, babool, peppermint).
3	Taste	Organoleptic evaluation by trained panel	Ensures mild, acceptable taste suitable for daily use.
4	pH	Measured using digital pH meter (1% w/v solution)	Ideal pH (6.5–7.5) prevents enamel erosion and maintains oral health.
5	Foaming Ability	10 g paste shaken with water; foam volume measured	Indicates cleansing efficiency; herbal pastes usually produce moderate foam.
6	Spreadability	Two-glass slide method; time/weight noted	Assesses ease of application on toothbrush.
7	Consistency	Measured by penetrometer or visual observation	Checks uniformity and smooth texture without grittiness.
8	Viscosity	Brookfield viscometer used	Ensures paste is neither too thick nor too runny; ideal for extrusion.
9	Abrasiveness (RDA value)	Calcium carbonate abrasiveness test	Ensures safe cleaning without damaging enamel.
10	Homogeneity	Visual observation after storage	Ensures no lumps, phase separation, or uneven mixing.
11	Extrudability	Extrusion from collapsible tube measured by weight	Determines ease of dispensing paste from tube.
12	Moisture Content	Loss on drying (LOD) at 105°C	Ensures microbial stability and prevents drying or cracking.
13	Microbial Load	Total bacterial count, fungal count	Ensures safety; no pathogens like E. coli or S. aureus.

14	Stability Studies	Storage at 25°C, 40°C, 60°C for 30– 60 days	Observes colour, pH, texture, odour changes over time.
15	Cleaning Efficiency	Stain removal test using artificial teeth	Measures the paste's ability to remove stains and plaque.
16	Grittiness	Rub between fingers or microscope method	Ensures smooth texture without coarse particles.
17	Tube Compatibility	Storage in laminated/metal tubes	Ensures no reaction between paste and packaging material.
18	Weight Variation	Weighing multiple tubes	Confirms uniform quantity per tube according to label.

VII. RESULTS AND DISCUSSION

The present research was undertaken to formulate and evaluate a herbal toothpaste containing Neem (Azadirachta indica), Babool (Acacia arabica), and Honey as major natural ingredients. The goal was to develop an effective, safe, and eco-friendly oral care product that could provide antimicrobial, anti-inflammatory, and cleansing benefits without the adverse effects of synthetic agents. The results obtained from various evaluation tests are discussed below.

Organoleptic Characteristics

The formulated herbal toothpaste exhibited an attractive greenish-brown color, which reflected the natural pigment of the plant extracts. The odor was pleasant and refreshing due to the inclusion of peppermint oil, which masked the characteristic smell of neem. The taste was mildly sweet because of the addition of honey, improving acceptability compared to purely herbal pastes that often taste bitter or astringent. The texture was smooth and homogenous without any gritty particles, suggesting that all excipients were well-blended. These sensory characteristics play an important role in consumer compliance and were found satisfactory for daily use.

pH and Chemical Stability

The pH of the toothpaste remained within the range of 7.0–7.3, which is ideal for maintaining oral pH balance. A neutral to slightly basic pH prevents enamel demineralization and suppresses bacterial acid production. During the stability study, no significant change in pH was observed even after one month of storage at varied temperatures, indicating good chemical stability of the herbal ingredients and excipients. The use of glycerin and honey helped buffer the formulation and maintain moisture equilibrium.

Foaming Ability

Although herbal toothpastes are expected to produce less foam than synthetic varieties, the present formulation showed moderate, stable foam formation. The small amount of sodium lauryl sulfate (1.2 %) provided sufficient cleansing action without irritation. The foam produced was fine and stable, facilitating effective dispersion of active ingredients in the oral cavity. This suggests that the formulation achieved an optimal balance between natural gentleness and satisfactory cleaning performance.

Abrasiveness and Cleaning Power

The mild abrasive calcium carbonate (35 %) effectively removed surface stains and plaque without damaging the enamel. The abrasiveness test on glass slides confirmed minimal scratching, indicating that the formulation is gentle enough for daily use. When tested on stained enamel models, the formulation demonstrated good cleaning ability. The mechanical cleansing action, combined with the antimicrobial effects of neem and babool, makes the toothpaste effective for maintaining oral hygiene.

Spreadability and Viscosity

Spreadability is crucial for easy application of toothpaste onto the brush and even distribution on teeth. The Neem–Babool–Honey formulation spread uniformly under gentle pressure, owing to the presence of glycerin and honey which acted as natural humectants. The viscosity values obtained through

Brookfield viscometer readings confirmed a moderate consistency—neither too stiff nor runny—ensuring smooth extrusion from the tube. Good rheological behavior is a sign of stable emulsion and proper polymer hydration within the system.

Moisture Content and Homogeneity

The moisture content of the toothpaste was around 10–12 %, within the acceptable limit for semisolid formulations. Controlled moisture prevents microbial contamination and drying of the product during storage. The paste showed excellent homogeneity, confirming uniform distribution of herbal actives. No lumps or phase separation were observed. Honey and glycerin helped maintain this consistency by retaining water molecules and preventing syneresis.

Antimicrobial Activity

The antimicrobial activity of the toothpaste was tested against common oral pathogens such as Streptococcus mutans and Lactobacillus acidophilus using the agar diffusion method. The formulation produced distinct zones of inhibition, indicating significant antibacterial potential. Neem contains azadirachtin and nimbidin, while babool possesses tannins and flavonoids—compounds known for antimicrobial and astringent properties. These phytochemicals inhibit bacterial adhesion to enamel surfaces and reduce plaque formation. The results confirmed that the herbal ingredients retained their biological activity even after formulation.

Microbial Limit and Stability

Microbial limit tests revealed no growth of pathogenic organisms such as E. coli, Staphylococcus aureus, or fungi. This demonstrated that the preservative action of honey and the inherent antimicrobial nature of neem and babool were sufficient to maintain product safety. In accelerated stability studies conducted at 4 °C, 25 °C, and 40 °C for one month, the formulation remained physically and chemically stable. There were no observable changes in color, odor, or consistency, and all parameters stayed within acceptable ranges. This indicates that the herbal actives were stable under different environmental conditions, enhancing the product's shelf life.

Extrudability and Packaging Performance

The extrudability test confirmed that the toothpaste could be easily squeezed out of the collapsible tube without excessive force, demonstrating suitable viscosity and tube compatibility. The smooth extrusion also ensured accurate dosage during brushing. The formulation's non-sticky nature prevented residue buildup at the nozzle, improving user experience.

Comparative Discussion

When compared with standard commercial toothpastes, the Neem–Babool– Honey formulation offered several advantages. It is free from artificial sweeteners, synthetic preservatives, and harsh chemicals, thus minimizing the risk of irritation or allergic reactions. The herbal actives provide therapeutic effects—Neem acts as an antibacterial and anti-inflammatory agent, Babool strengthens gums through its astringent tannins, and Honey serves as a natural humectant and healing agent. Together, they create a synergistic blend that supports oral health through both mechanical cleaning and pharmacological action.

Although the foaming was lower than synthetic formulations, the cleansing and freshness effect were comparable. The mild taste and natural aroma were well-accepted during preliminary sensory trials, suggesting high consumer acceptability for natural products.

Overall Interpretation

The combined results clearly indicate that the formulated toothpaste meets all essential quality parameters for a safe and effective oral hygiene product. Its balanced pH, optimal abrasiveness, smooth texture, and natural antimicrobial properties make it a potential substitute for conventional toothpaste. The formulation aligns with the growing consumer preference for chemical-free and sustainable products. Moreover, the success of this formulation supports the use of traditional medicinal plants like neem and babool in modern pharmaceutical preparations.

Discussion on Future Scope

The study opens avenues for further research such as in-vivo clinical evaluation, optimization of herbal extract concentrations, and inclusion of other natural flavoring or whitening agents. Large-scale stability studies and packaging evaluations can also be

undertaken to ensure commercial feasibility. Standardization of herbal extracts using phytochemical markers will help maintain batch-to-batch consistency and quality assurance.

VIII. CONCLUSION

The Neem–Babool–Honey herbal toothpaste demonstrated excellent physical, chemical, and microbiological stability with significant antimicrobial activity. The formulation fulfilled the aim of producing a natural, safe, and effective oral care product. It can serve as a promising herbal alternative to chemical-based commercial toothpastes, contributing to the concept of "Green Pharmacy" and sustainable healthcare.

Conclusion:
The present study was undertaken to formulate and evaluate a herbal toothpaste containing Neem (Azadirachta indica) and Babool (Acacia arabica) as major active herbal ingredients, with Honey serving as a natural humectant and mild preservative. The objective was to develop a safe, effective, and eco-friendly oral care formulation using natural ingredients that can maintain oral hygiene and prevent common dental issues such as plaque, gingivitis, and cavities.

The results obtained from various evaluation parameters revealed that the formulated herbal toothpaste possessed desirable organoleptic properties, suitable pH, adequate foamability, and appropriate consistency. The product showed smooth texture, pleasant flavor, and good extrudability, ensuring consumer acceptability. The presence of calcium carbonate provided mild abrasiveness necessary for cleaning teeth without damaging enamel. Neem and Babool extracts contributed potent antibacterial and anti-inflammatory actions, while Honey improved the texture and provided additional antimicrobial support.

Antimicrobial testing confirmed that the formulation exhibited significant activity against oral pathogens like Streptococcus mutans and Lactobacillus acidophilus, validating the traditional use of Neem and Babool in dental care. The formulation also remained stable during the stability testing period, showing no signs of phase separation, discoloration, or changes in odor and pH.

Thus, it can be concluded that the developed Neem–Babool–Honey herbal toothpaste is an effective and safe natural oral care product. It provides the combined benefits of traditional herbal ingredients with modern formulation techniques. The study supports the growing preference for herbal-based cosmetic and pharmaceutical preparations and highlights the potential of natural ingredients as reliable alternatives to synthetic compounds in oral hygiene products.

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