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Formulation and Evaluation of Herbal Toothpaste Incorporating Traditional Medicinal Plants

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KEYWORDS

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ABSTRACT

Background/Introduction: Oral hygiene plays a critical role in maintaining general health and preventing dental diseases. Conventional toothpastes often contain synthetic chemicals that may lead to side effects such as staining, altered taste, or sensitivity. With increasing awareness about natural and holistic health products, there has been a growing demand for herbal alternatives in personal care, including dental products. Medicinal plants like Tulsi (*Ocimum sanctum*), Mint (*Mentha piperita*), Clove (*Syzygium aromaticum*), and Neem (*Azadirachta indica*) have been traditionally used in various formulations due to their antimicrobial, anti-inflammatory, and therapeutic properties. This study explores the potential of these herbs in the formulation of a safe, effective, and naturally derived herbal toothpaste.

Aim and Objectives: The aim of this study was to develop and evaluate herbal toothpaste using natural ingredients with known oral health benefits. The objectives included selecting herbs for their antimicrobial and therapeutic properties; formulating the toothpaste with suitable excipients to ensure proper consistency and stability; and evaluating the prepared batches for physical and functional characteristics to identify the most effective formulation.

Materials and Methods: The formulation involved the selection of medicinal herbs, which were processed into powdered form. These active components were blended into a base prepared using sorbitol, glycerin, calcium carbonate, and other essential excipients to achieve the desired consistency and texture. Five trial batches were formulated initially. Each batch was evaluated for parameters such as homogeneity, spreadability, and foamability. One batch was selected for further analysis based on superior performance, while the other four were rejected due to undesirable consistency and lack of uniformity.

Results and Discussion: The final selected batch demonstrated a visually appealing greenish-brown color and a pleasant herbal aroma. It exhibited good homogeneity without the presence of lumps and had satisfactory spreadability. The formulation showed acceptable foaming characteristics and pH compatible with the oral cavity. These parameters indicate that the selected combination of herbs and base materials resulted in a product that can potentially meet both aesthetic and functional requirements of effective herbal toothpaste. The use of herbal ingredients not only imparts therapeutic effects such as antimicrobial and anti-inflammatory properties but also enhances the product's market appeal in the natural and organic segment.

Conclusion: The formulated herbal toothpaste successfully incorporated traditional medicinal herbs into a stable and acceptable formulation. Its physicochemical characteristics suggest its potential as a natural alternative to synthetic toothpastes. The presence of bioactive herbal components may contribute to better oral health outcomes with minimal side effects. Further *in-vitro* and clinical studies can substantiate its therapeutic claims and help in positioning the product as a viable commercial herbal dental formulation.

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1. INTRODUCTION

Maintaining oral health is essential for overall well-being, and the most effective and commonly adopted preventive strategy is the consistent use of toothpaste. While many types of toothpaste on the market assert antimicrobial and therapeutic advantages, there is a scarcity of scientific studies to support these claims [1]. Dentifrices have been utilized for more than 2,000 years, as ancient civilizations used natural materials such as ash, salt, and crushed herbs for dental hygiene [2]. Indeed, the utilization of toothpicks and basic brushes can be traced back even further than this practice. A multitude of concepts and ingredients developed centuries ago have undergone refinement yet continue to play a crucial role in the formulations of contemporary toothpastes [3].

An important element of Indian traditional medicine is the application of herbal and Ayurvedic remedies for the preservation of oral and systemic health [4]. A significant portion of the global population continues to depend on natural solutions for fundamental healthcare needs. The World Health Organization (WHO) reports that around 80% of the global population relies on herbal medicines for their primary health requirements [5]. Toothpaste is commonly used for oral hygiene in developed nations; however, traditional practices like employing neem sticks, miswak (*Salvadora persica*), or common salt for dental care continue to be widely adopted in rural and tribal areas throughout Asia and Africa [6].

Contemporary herbal toothpaste formulations frequently take cues from these traditional remedies. They generally include medicinal plants recognized for their antibacterial, anti-inflammatory, antifungal, and antioxidant properties [7]. Ingredients such as clove, cinnamon, neem, and tulsi have long been recognized for their therapeutic properties and are increasingly incorporated into herbal dentifrices. Neem (*Azadirachta indica*) demonstrates notable antibacterial and anti-inflammatory properties, contributing to the reduction of plaque, gingival inflammation, and microbial load. Additionally, the bitter elements present may play a role in oral hygiene and detoxification [8].

While herbal toothpaste products are gaining traction, the assertions associated with them frequently do not stand up to thorough scientific scrutiny. Many consumers depend on sensory characteristics like flavor, texture, and overall satisfaction, yet the effectiveness concerning foaming, pH balance, and homogeneity is often overlooked. Furthermore, factors like spreadability, the presence of coarse particles, and moisture content play a crucial role in determining product quality and user experience, yet they are rarely examined in a systematic manner [9, 10].

Consequently, it is increasingly important to conduct thorough evaluations of these herbal formulations to confirm their safety and efficacy. This study aimed to develop five distinct herbal toothpaste formulations utilizing specific medicinal plants recognized for their advantages in oral health. Every formulation underwent assessment for essential physical and functional characteristics, including color, odor, taste, texture, viscosity, pH, homogeneity, spreadability, particle smoothness, foaming ability, and moisture content. This study employs comparative analysis to determine the most effective formulation, ultimately contributing to the creation of scientifically validated and consumer-friendly herbal dental products.

2. MATERIALS AND METHODS

Procurement and Processing of Ingredients

All selected herbal ingredients- Neem leaves (*Azadirachta indica*), Clove buds (*Syzygium aromaticum*), Cinnamon bark (*Cinnamomum verum*), Khair heartwood (*Acacia catechu*), Babul bark (*Acacia nilotica*), Black pepper fruits (*Piper nigrum*), and Arjun bark (*Terminalia arjuna*) were procured from a reputable Ayurvedic/herbal shop in Dehradun. Excipients including Rock Salt, Calcium Carbonate, Carboxymethyl Cellulose (CMC), Methyl Paraben, Sodium Saccharin, Glycerine, and Distilled Water were sourced from the Pharmacognosy Laboratory, College of Pharmacy, Shivalik Campus, Dehradun, India.

The herbs were carefully cleaned to remove dirt and foreign matter, shade-dried to preserve phytoconstituents, and ground using a mechanical grinder. The powdered herbs were sieved through a #80

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mesh sieve (approximately 180 microns) to achieve a smooth, fine texture ideal for dental applications. This particle size was selected to- ensure a non-abrasive texture for teeth and gums; promote uniform dispersion of ingredients; enhance the release of active constituents; and improve shelf-life stability and aesthetic appeal of the final formulation.

Formulation Design and Selection

Based on literature precedents and herbal formulation strategies, the quantities of each ingredient were calculated to maintain a total composition of 100% w/w, targeting the production of 100 g of toothpaste per batch. Five different formulations (F1 to F5) were prepared by varying the proportions of herbal ingredients and excipients to identify the most effective combination. Each formulation's detailed composition is provided in Table 1. These formulations were subjected to preliminary evaluations including homogeneity, spreadability, foamability, and texture. Among the five, one formulation exhibited superior characteristics and was selected for further evaluation. Two formulations were rejected due to poor texture and lack of uniformity.

Toothpaste Preparation Using Dry Gum Method

The dry gum method was adopted for the preparation of the herbal toothpaste. The procedure followed these sequential steps [11-14].

Powder Preparation: All herbal materials were shade-dried, powdered, and sieved through a #80 mesh for a uniform and smooth consistency.
Dry Blending of Powders: Accurately weighed herbal powders and powdered excipients such as Calcium Carbonate, Rock Salt (as applicable), and CMC were blended uniformly in a dry mortar to ensure homogeneity.
Gum Hydration: CMC, used as the binding agent, was hydrated by mixing it with a portion of Glycerine to form a uniform gel base, essential for achieving proper paste consistency.
Wet Phase Preparation: In a separate container, Methyl Paraben, Sodium Saccharin, and the remaining Glycerine were mixed thoroughly. Distilled Water was gradually added with continuous stirring to fully dissolve the components.
Combining Phases: The dry blended powders were gradually incorporated into the hydrated gum-glycerine mixture with continuous trituration to form a smooth, lump-free, homogeneous paste. Care was taken to prevent air entrapment during mixing.
Final Adjustment and Packaging: Additional distilled water was added q.s. (quantum satis) to adjust the final weight to 100 g and achieve desired consistency. The final toothpaste was packed in collapsible laminated tubes or airtight jars, sealed, and labeled appropriately.

Evaluation of Herbal Toothpaste

Physical Characteristics

The physical properties of the formulated herbal toothpaste were evaluated based on the following parameters [13, 14].

Color: The appearance of the toothpaste was assessed visually under natural light to observe its uniformity and appeal.
Odor: The fragrance or smell of the formulation was evaluated by gently sniffing the sample to ensure it was pleasant and characteristic of the herbal ingredients used.
Taste: A manual taste test was performed using a small quantity of the formulation to assess its flavor and palatability.
Texture: The smoothness and consistency of the toothpaste were evaluated by rubbing a small amount between the fingers to check for grittiness or abrasiveness.
Thickness (Viscosity): The viscosity or thickness of the paste was observed to ensure it was neither too runny nor too stiff, providing optimal application and spreadability.

Evaluation of pH

To determine the pH of the herbal toothpaste, a 50% aqueous suspension was prepared. Ten grams of the toothpaste were weighed and transferred into a 50 mL beaker. To this, 10 mL of freshly boiled and cooled distilled water (maintained at approximately 27°C) was added. The mixture was stirred thoroughly to ensure complete dispersion and uniform suspension. After allowing the mixture to stand for five minutes, the pH

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of the suspension was measured using a calibrated digital pH meter. This test helps determine the formulation's compatibility with the oral environment, as toothpaste should ideally be close to neutral pH to avoid enamel erosion and maintain oral health [13-15, 16].

Homogeneity

To determine homogeneity, the herbal toothpaste was evaluated by gently applying normal force at 27°C. The paste was extruded from a collapsible tube or another suitable container. A uniform and consistent mass of toothpaste was expected without any signs of phase separation or granularity. Additionally, the bulk of the contents within the container was gradually rolled or pressed out to observe for even consistency throughout the entire sample, indicating proper mixing and formulation uniformity [13-16].

Spreadability

The spreadability of herbal toothpaste was determined using the slip and drag method, which evaluates the ease with which the paste spreads under an applied force. Approximately 1–2 grams of the herbal toothpaste was placed between two glass slides (each measuring 10 × 10 cm). The slides were stacked one over the other without any sliding pressure initially. Then, the upper slide was gently moved in the opposite direction to the lower one. After 3 minutes, the diameter of the spread toothpaste was measured in centimeters. The procedure was repeated three times, and the average spread was calculated to determine the paste's spreadability [13-16].

Test for Sharp and Coarse Particles

To evaluate the presence of any sharp or abrasive particles in the herbal toothpaste, a small amount of the paste was applied onto a clean finger and gently rubbed over a sheet of butter paper for a distance of approximately 15 to 20 cm. This procedure was repeated multiple times (over ten trials) to ensure consistency and accuracy. Throughout the evaluation, no sharp edges or coarse particles were detected. The formulation was found to be smooth, indicating that it is safe for use and unlikely to cause abrasion to the gums or enamel during brushing [13, 14].

Foaming Ability

To evaluate the foaming ability of the herbal toothpaste, 2 grams of the toothpaste were accurately weighed and transferred into a measuring cylinder. Then, 5 milliliters of distilled water were added to it. The contents were shaken vigorously ten times. After shaking, the total volume of foam generated was recorded. This assessment helps determine the surfactant property and cleansing efficiency of the toothpaste [13, 14, 17].

Determination of Moisture and Volatile Matter

To evaluate the moisture and volatile matter content, 5 grams of the herbal toothpaste was weighed and placed in a clean porcelain dish measuring approximately 6–8 cm in diameter and 2–4 cm in depth. The sample was then dried in a hot air oven at 105°C until a constant weight was achieved, indicating the removal of moisture and volatile components. The loss in weight before and after drying was recorded and used to calculate the percentage of moisture and volatile matter present in the toothpaste formulation [13, 18].

3. RESULTS AND DISCUSSION

Five herbal toothpaste formulations (F1–F5) were successfully prepared using selected medicinal plant ingredients and pharmaceutical excipients. Each formulation was developed with a target batch size of 100 g. The formulations differed in the type and proportion of herbal components, aiming to optimize physical characteristics and therapeutic efficacy. All selected plant materials were processed into fine powder (#80 mesh) and incorporated into the base using the dry gum method. The prepared formulations were packed in collapsible tubes or airtight containers and labeled for further analysis. The composition of each formulation is summarized in Table 1.

Evaluation of Herbal Toothpaste

Physical Characteristics and Performance: The five herbal toothpaste formulations (F1 to F5) were evaluated for their physical properties, pH, homogeneity, spreadability, sharp/coarse particles, foaming ability, and moisture content to assess their suitability for oral use.

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Physical Characteristics: All formulations exhibited a smooth, uniform appearance with visually acceptable color and texture. The odor was pleasantly herbal, consistent with the active ingredients such as Neem, Clove, and Cinnamon. Taste evaluation showed that formulations containing Clove and Cinnamon (F1 and F4) had a slightly stronger and more pleasant flavor compared to others. Texture was smooth with no detectable grittiness or abrasiveness upon manual testing. Thickness was optimal for all formulations, allowing easy application and spread (Table 2).

pH Evaluation: The pH values of the toothpaste suspensions ranged from 6.8 to 7.2, indicating a near-neutral pH compatible with the oral environment. F3 exhibited the highest pH (7.2), making it less likely to cause enamel erosion, while F2 had the lowest (6.8) but still within safe limits (Table 2).

Homogeneity: All five formulations were extruded smoothly from collapsible tubes without any phase separation or granularity. The paste consistency was uniform throughout, indicating proper mixing and formulation stability (Table 2).

Spreadability: The spreadability measurements ranged from 3.2 to 4.0 cm, with F4 showing the highest spreadability, indicating better slip and drag characteristics, thus easier application on teeth surfaces. F2 had the lowest spreadability but was still acceptable for toothpaste use (Table 2).

Sharp and Coarse Particles: None of the formulations showed the presence of sharp or abrasive particles during multiple trials of the butter paper test, confirming the safety of the herbal toothpaste for gums and enamel (Table 2).

Foaming Ability: Foam volume ranged between 8 to 12 mL after shaking. F1 and F4, containing Clove and Cinnamon, exhibited higher foam volume, likely due to their surfactant activity, enhancing cleansing efficiency. Formulations without these essential oils showed slightly lower foamability (Table 2).

Moisture and Volatile Matter Content: Moisture content varied slightly among the formulations, with values ranging from 5.5% to 7.0%. F2 showed the highest moisture content, possibly due to higher glycerine levels, while F3 had the lowest, reflecting better drying during preparation (Table 2).

Among the five formulations evaluated, Formulation F4 emerged as the best overall herbal toothpaste. It demonstrated the most balanced profile with a pleasant and strong herbal flavor contributed by Clove and Cinnamon essential oils, which enhances user acceptability. F4 exhibited the highest spreadability (4.0 cm), indicating optimal slip and drag characteristics for easy and effective application. Its near-neutral pH (7.1) ensures compatibility with the oral environment, minimizing the risk of enamel erosion or irritation. Additionally, F4 showed superior foaming ability (12 mL), suggesting better cleansing efficiency due to effective surfactant action from its ingredients. The uniform homogeneity and absence of sharp particles confirmed its safety and formulation stability. These combined attributes make F4 the preferred choice, balancing efficacy, safety, and sensory appeal, which are critical factors in toothpaste formulation.

4. CONCLUSION

Herbal toothpaste has been shown to be effective in preventing dental cavities and improving oral hygiene. The herbal toothpaste has fewer negative effects and is safer. The developed herbal toothpastes are assessed using a variety of tests, including physical examination, pH measurement, homogeneity, sharp and edge abrasive particles, moisture and volatile matter determination, spreadability, stability analysis, and extrudability, among others. The chemicals utilized in this investigation were chosen and evaluated for their ability to maintain oral hygiene and have antibacterial properties, as evidenced by their efficacious toothpaste results. It is acceptable to use any herbal toothpaste twice a day; it doesn't have any negative effects and instead promotes freshness and keeps unwanted odors at bay. With herbal tooth pastes, oral hygiene can be maintained in a dependable, secure, and affordable manner.

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Table 1: Composition of Herbal Toothpaste

S. No.	Common Name	Scientific Name	Part Used	Composition Toothpaste (per 100 gm w/w)				
				F1	F2	F3	F4	F5
1.	Neem	*Azadirachta indica*	Leaves	5	3	5	5	3
2.	Clove	*Syzygium aromaticum*	Flower Buds	0.5	-	-	0.7	-
3.	Cinnamon	*Cinnamomum verum*	Bark	0.5	-	-	0.5	-
4.	Khair	*Acacia catechu*	Heartwood	-	5	-	-	3
5.	Babul	*Acacia nilotica*	Bark	-	-	5	-	3
6.	Black Pepper	*Piper nigrum*	Fruits	0.50	0.25	0.1	-	-
7.	Arjun Bark	*Terminalia arjuna*	Bark	4	4	-	-	3
8.	Rock Salt	-	Mineral	-	-	1	1.5	-
9.	Calcium Carbonate	-	Mineral	30	25	20	25	30
10.	Carboxymethyl Cellulose	-	Binding Agent	1.8	1.8	1.8	1.8	1.8
11.	Methyl Paraben	-	Preservative	0.2	0.2	0.5	0.2	0.2
12.	Sodium Saccharine	-	Sweetning Agent	1	1	1.5	1	1.2
13.	Glycerine	-	Anticrusting Agent	15	20	18	15	20
14.	Distilled Water	-	Vehicle	Q.S	Q.S	Q.S	Q.S	Q.S

Table 2: Comparison of Key Parameters for Herbal Toothpaste Formulations (F1 to F5).

Parameter	F1	F2	F3	F4	F5
Color	Light green	Light brown	Light brown	Light green	Light brown
Odor	Herbal, strong Clove & Cinnamon	Mild herbal	Mild herbal	Strong herbal, pleasant Clove & Cinnamon	Mild herbal
Taste	Pleasant, spicy	Slightly bitter	Mild	Pleasant, strong flavor	Mild
Texture	Smooth	Smooth	Smooth	Smooth	Smooth
Thickness (Viscosity)	Moderate	Moderate	Moderate	Moderate	Moderate
pH	7	6.8	7.2	7.1	6.9
Homogeneity	Uniform, no separation	Uniform, no separation	Uniform, no separation	Uniform, no separation	Uniform, no separation
Spreadability (cm)	3.5	3.2	3.4	4	3.6
Sharp/Coarse Particles	None detected	None detected	None detected	None detected	None detected
Foaming Ability (mL foam)	11	8	9	12	8
Moisture Content (%)	6	7	5.5	6.2	6.5

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