ORIGINAL ARTICLE

Formulation and Quality Evaluation of Polyherbal Toothpaste

Jithin Mathew[1], Nivedita L. Rao[2], Harish K. H. [3]

[1]Department of Pharmacology, Nitte (Deemed to be University), NGSM Institute of Pharmaceutical Sciences, Mangaluru, Karnataka, India, [2]Department of Biochemistry, Yenepoya Medical College, Yenepoya Deemed to be University, Mangaluru, Karnataka, India, [3]Department of Pharmaceutics, KLE College of Pharmacy, Hubballi, KLE Academy of Higher Education and Research, Deemed-to-be-University, Belagavi, Karnataka, India

Abstract

Background: Oral hygiene is essential for preventing dental issues such as plaque, tooth decay, and periodontal diseases. Herbal toothpaste formulations provide a safer alternative to synthetic products by offering antimicrobial, anti-inflammatory, and enamel-protective benefits without adverse effects. **Objectives:** This study aimed to develop and evaluate a polyherbal toothpaste using natural ingredients, including clove, mango leaves, tulsi, ivy gourd leaves, guava leaves, honey, and coconut oil, and to assess its physical, chemical, and antimicrobial properties. **Materials and Methods:** Three formulations (T1, T2, T3) were prepared by incorporating herbal actives and abrasives into a base gel. The formulations were evaluated for physical appearance, homogeneity, presence of abrasive particles, spreadability, fineness, pH, and antibacterial activity against *Staphylococcus aureus* using the disc diffusion method. **Results:** All formulations exhibited smooth texture, uniform appearance, and acceptable homogeneity. T3, containing the highest concentration of herbal actives, showed superior performance across most parameters: best spreadability, highest fineness with lowest abrasive residue (0.29%), optimal pH (7.31), and strongest antibacterial activity (20 mm zone of inhibition), closely approaching the standard neomycin control (21 mm). T1 and T2 showed moderate performance in comparison. **Conclusion:** The study successfully developed a safe, effective, and consumer-friendly polyherbal toothpaste. T3 demonstrated the most promising combination of physical stability, therapeutic potential, and oral safety. These findings support the potential of herbal oral care products as effective alternatives to conventional toothpastes. In addition, regulatory considerations in India and the USA were discussed to ensure quality, safety, and post-marketing surveillance.

Key words: Antibacterial activity, fineness, polyherbal toothpaste, spreadability, *Staphylococcus aureus*

INTRODUCTION

Oral hygiene plays a vital role in enhancing personal appearance, boosting self-confidence, and preventing dental issues such as tooth decay, plaque buildup, and periodontal diseases. Teeth consist of a crown covered by enamel, the hardest tissue, primarily composed of hydroxylapatite, an underlying dentin layer rich in collagen and water, with saliva maintaining an active oral environment. Common problems arise from bacterial action and poor care, but regular brushing with effective toothpaste can manage them, as formulations originated in ancient China and India around 300–500 BC.[1]

Toothpaste, or dentifrice, cleans teeth by removing food particles and plaque through abrasives, masks bad breath, and delivers active ingredients to prevent decay and gum disease. Modern synthetic versions offer antimicrobial benefits but often cause side effects such as enamel weakening, discoloration, irritation, dry mouth, and systemic issues, prompting the shift to herbal alternatives with natural antibacterials. These polyherbal formulations combat germs, reduce plaque and tartar, strengthen gums, and suit sensitive teeth without artificial additives, providing a soothing, saliva-soluble freshness.[2]

Herbal toothpaste offers key advantages, including disease prevention, thorough cleaning, odor control, periodontal protection, and resolution of issues through consistent use,

Address for correspondence:
Nivedita L. Rao, Department of Biochemistry, Yenepoya Medical College, Yenepoya Deemed to be University, Deralakatte, Mangaluru, Karnataka 575018, India.
E-mail: nlrdr@yahoo.com

Received: 03-11-2025
Revised: 16-12-2025
Accepted: 23-12-2025

all without adverse effects. Ideal properties encompass effective yet non-irritating abrasion, stain-free action, lasting freshness, and affordability.[3]

Herbal active ingredients

Mango leaf extract provides antibacterial and anti-inflammatory effects, helping reduce plaque and soothe gums. Clove offers analgesic properties to relieve toothache, antimicrobial action against oral bacteria, and freshens breath. *Moringa* leaf extract acts as an antioxidant and anti-cariogenic agent, supporting enamel protection and gum health.[4] Guava leaf extract delivers strong antibacterial benefits to prevent decay and fight gingivitis. Licorice root extract soothes irritated gums, reduces inflammation, and inhibits bacterial growth in the mouth.[5]

Calcium carbonate serves as a mild abrasive to clean teeth and remove stains without damaging enamel. Glycerin functions as a humectant to retain moisture, preventing the paste from drying out and ensuring a smooth texture. Xanthan gum thickens the formulation, stabilizes the mixture, and provides a consistent gel-like consistency.[6] Soapnut acts as a natural surfactant for foaming and gentle cleansing, aiding in plaque removal. Sodium chloride mildly abrades, balances pH, and offers antiseptic properties for fresher breath. Purified water hydrates the paste, dissolves ingredients, and forms the vehicle for even distribution.[7]

This polyherbal toothpaste formulation targets comprehensive oral health by combating bacteria, reducing inflammation, strengthening enamel and gums, freshening breath, and minimizing decay risks without synthetic chemicals or side effects.

MATERIALS AND METHODS

Materials

Mango leaf, Clove, Moringa Leaf Extract, Guava leaf, Licorice Root Extract, and Soapnut were local purchased from an ayurvedic shop in Deralakatte, Karnataka, India. Calcium carbonate, Glycerin, Xanthan gum, and Sodium chloride were purchased from Hi media.

Methodology

Preparation of herbal toothpaste

Prepare herbal toothpaste formulations T1, T2, and T3 [Table 1] by first creating a base gel, then incorporating actives and abrasives in a clean, sterile environment using a mechanical mixer or mortar for small batches.[8]

Mix glycerin (20%) with purified water (35% for T1, 34% for T2, 31.5% for T3) under constant stirring. Slowly add xanthan gum (1%) to form a smooth gel, allowing hydration for 15–30 min.[9]

Evaluation

Physical appearance

Color, odor, and visual texture of the toothpaste were organoleptically assessed for appeal and uniformity.

Homogeneity

Toothpaste from collapsible tubes was extruded under normal force at 27°C ± 2°C, confirming uniform mass extrusion and smooth rollout without separation.[9]

Determination of sharp and edge abrasive particles

A 15–20 cm ribbon of toothpaste from 2 to 3 tubes was spread on butter paper and fingertip-pressed to detect any sharp, hard-edged particles, ensuring enamel safety.[10]

Spreadability

Approximately 1 g of the toothpaste sample was weighed and placed at the center of a 10 × 10 cm glass plate. A second glass plate of the same size was gently positioned on top to avoid sliding. To maintain this position, a 1-g weight was applied at the center of the upper plate. After 15 min, the diameter of the spread paste was measured in centimeters. The spreadability (S) was then calculated using the formula.[11]

$$\text{Spreadability (S) was calculated using: } S = m \times l/t$$

Where, S: Spreadability, m: Weight applied to the upper plate (1 g), l: Distance the upper plate moved (spread diameter), t: Time elapsed (15 min).

Determination of fineness

For fineness determination, about 10 g of toothpaste was placed in a 100 mL beaker, and 50 mL of water was added. The mixture was stirred and allowed to stand for 30 min until the paste completely dispersed. This suspension was then passed through a 150-µm IS sieve, which was rinsed thoroughly with tap water. The sieve was dried in an oven at 105 ± 2°C, and the residue left on the sieve was transferred to a watch glass and weighed.[12]

Determination of pH

The pH of the toothpaste was determined by mixing 5 g of the sample with 45 mL of distilled water in a 150 mL beaker. The mixture was stirred thoroughly to form a uniform suspension, and the pH was measured with a pH meter within 5 min.[13]

Evaluation of anti-bacterial activity

Antibacterial activity was evaluated using the disc diffusion method. Pure cultures of *Staphylococcus aureus* were

subcultured on Mueller–Hinton agar plates. The bacterial lawn was prepared evenly using sterile cotton swabs. Uniform holes were made in the agar using a sterile cork borer, into which the prepared toothpaste gels were placed. Neomycin was used as a standard control in a separate hole. The plates were incubated at 35°C for 18–24 h to observe zones of inhibition indicating antibacterial efficacy.[14]

RESULTS AND DISCUSSION

Physical appearance

As observed in Table 2, the physical parameters of all the formulations were found to be light brownish green in color, mild (HT1), moderate (HT2), and strong (HT3) in odor and smooth in appearance.

Homogeneity

The three formulations – T1, T2, and T3 – were evaluated for extrusion properties, homogeneity, and overall handling characteristics using collapsible laminated tubes at 27°C ± 2°C. All three formulations extruded smoothly under moderate hand pressure; however, noticeable performance differences were observed. T1, with the lowest concentration of herbal ingredients, showed good flow and uniformity but exhibited slightly lower paste cohesiveness compared to the others due to its higher water content. T2 demonstrated improved viscosity and consistency, offering smoother extrusion with minimal resistance and good mass uniformity. T3, containing the highest proportion of herbal actives and the lowest water content, exhibited the best overall performance. It dispensed easily from the tube, maintained superior uniformity in color and texture, and showed no signs of phase separation, grittiness, or clumping. In addition, more than 95% of T3 could be extruded without excessive force, indicating excellent homogeneity and well-balanced rheological properties. The stronger structural integrity of T3 suggests optimal interaction between the herbal components, gelling agents, and humectants, making it the most stable and efficient formulation among the three.[11,12]

Table 1: Formulation chart of herbal toothpaste

Ingredients	T1	T2	T3
Herbal active ingredients			
Mango leaf	0.3	0.5	1
Clove	0.3	0.5	1
Moringa leaf extract	0.3	0.5	1
Guava leaf	0.3	0.5	1
Licorice root extract	0.3	0.5	1
Herbal toothpaste base			
Calcium carbonate	40	40	40
Glycerin	20	20	20
Xanthan gum	1	1	1
Soapnut	2	2	2
Sodium chloride	0.5	0.5	0.5
Purified water	35%	34%	31.5

Determination of sharp and edge abrasive particles

All three formulations – T1, T2, and T3 – were assessed for the presence of sharp, gritty, or hard-edged abrasive particles by extruding a 15–20 cm length of paste and gently pressing it between the fingertips. Across all samples, the tactile evaluation showed no detectable sharp or gritty particles, demonstrating that each formulation possessed a smooth and soft consistency. T1 exhibited a uniform and fine texture, with no abrasive irregularities, indicating effective dispersion of calcium carbonate within the base. T2 similarly displayed a fully smooth texture throughout its length, reflecting well-controlled milling and consistent particle size distribution. T3, despite having the highest concentration of herbal components, also maintained a uniform, smooth consistency with no sharp particles, suggesting excellent homogenization and compatibility between the abrasives and herbal actives. Overall, the results confirm that T1, T2, and T3 all meet quality standards for abrasive safety, with no formulation showing signs of coarse particles that could potentially damage enamel or irritate soft oral tissues. The uniform smoothness across all three samples highlights efficient blending and milling processes and supports their suitability for safe daily oral use.[12]

Spreadability

Based on the visual spreadability assessment, all three formulations demonstrated satisfactory performance, with differences in the uniformity of layer formation. T1 and T2 showed intermediate spreadability, creating mostly uniform layers but displaying slight fragmentation and minor changes in shape on application. In contrast, T3 exhibited the best spreadability, forming a smooth, fully uniform layer without

Table 2: Physical appearance of the prepared polyherbal toothpaste

S. No.	Parameter	HT1	HT2	HT3
1.	Color	Light Brownish Green	Light Brownish Green	Light Brownish Green
2.	Odor	Mild	Moderate	Strong
3.	Appearance	Smooth	Smooth	Smooth

fragmentation or noticeable deformation of the toothpaste mass. This enhanced performance indicates that T3 has an ideal balance of viscosity and cohesiveness, enabling it to spread effortlessly while maintaining structural stability. Overall, the findings confirm that T3 provides the most favorable spreadability characteristics among the three formulations evaluated.[12]

As observed in Table 3, the results indicate that Formulation T3 exhibited the best spreadability characteristics, forming a uniform layer without fragmentation or shape deformation.

Determination of fineness

As presented in Table 4, the fineness test results indicate that all three formulations – T1, T2, and T3 – meet acceptable limits, demonstrating that the abrasive materials were adequately milled and well incorporated into the toothpaste base. Among the formulations, T3 exhibited the highest degree of fineness, with the lowest residue weight (0.29%) compared to T1 (0.82%) and T2 (0.71%). This low percentage of coarse particles suggests that T3 has a smoother and more refined texture, which enhances comfort during brushing and reduces the risk of enamel abrasion or irritation to the gums. The minimal residue also reflects efficient processing, likely due to finer grinding and thorough mixing, resulting in uniform dispersion of the abrasive agents and superior overall product quality.[12]

Determination of pH

As presented in Table 5, the pH values of all three formulations – T1 (6.82), T2 (7.08), and T3 (7.31) – fall within the optimal range of 6.5–8.0, indicating that the products are suitable for oral use. Maintaining an appropriate pH is essential for oral health, as it ensures the toothpaste is non-irritating to soft tissues, non-erosive to enamel, and capable of neutralizing acids in the mouth, thereby contributing to caries prevention. Among the formulations, T3 exhibited the highest pH (7.31), reflecting a slightly alkaline profile that may provide better buffering of acidic conditions in the oral cavity. T1 (6.82) and T2 (7.08) were closer to neutral, making them suitable for sensitive users, but T3 demonstrates the most favorable pH balance, indicating optimal formulation with well-integrated herbal actives and excipients, ensuring both stability and comfort during use.[13,14]

Table 3: Spreadability of prepared lip balm

Formulation	Spreadability
T1	Intermediate
T2	Intermediate
T3	Good

Evaluation of anti-bacterial activity

As presented in Table 6, the antibacterial activity evaluation showed that all three polyherbal toothpaste formulations exhibited inhibitory effects against *S. aureus*, confirming the presence of bioactive antimicrobial constituents in the herbal ingredients. Among the formulations, T3 demonstrated the highest antibacterial activity, with a 20 mm zone of inhibition, closely approaching the standard neomycin control (21 mm). This suggests that T3 contains a potent or synergistic combination of antibacterial herbs, such as clove, neem, and tulsi, which are commonly incorporated in herbal oral care products. T2 (15 mm) and T1 (12 mm) also exhibited measurable antibacterial activity, though less pronounced than T3, indicating that the concentration or effectiveness of active components in these formulations may be comparatively lower. These results are consistent with previous studies reporting strong antimicrobial effects of herbal constituents such as eugenol from clove, neem extracts, and tulsi. Overall, the findings highlight the superior therapeutic potential of T3 for oral care, particularly in preventing bacterial infections such as gingivitis, plaque formation, and dental caries caused by *S. aureus* and other Gram-positive organisms.[15]

SUMMARY

This study focused on the development and evaluation of a polyherbal toothpaste formulated with natural ingredients such as clove, mango leaves, tulsi, ivy gourd leaves, guava leaves, honey, and coconut oil, which are known for their antimicrobial, anti-inflammatory, and oral health-promoting properties. Three formulations (T1, T2, and T3) were prepared and assessed for various parameters, including physical appearance, homogeneity, abrasiveness, spreadability, fineness, pH, and antibacterial activity against *S. aureus*. Among the formulations, T3 demonstrated superior overall performance, exhibiting the best spreadability, highest degree of fineness with the lowest abrasive residue (0.29%), optimal pH (7.31), and the most significant antibacterial activity (20 mm zone of inhibition), approaching the neomycin standard (21 mm).

Table 4: Fineness test

Formulation	Initial weight (g)	Residue weight (g)	% Coarse particles	Grade
T1	10.00	0.082	0.82	Acceptable
T2	10.00	0.071	0.71	Acceptable
T3	10.00	0.029	0.29	Best

Table 5: The pH of the formulation

Formulation	T1	T2	T3
pH	6.82	7.08	7.31

Table 6: Evaluation of antimicrobial activity

Sample	Zone of inhibition (mm)
T1	12 mm
T2	15 mm
T3	20 mm
Neomycin Std	21 mm

CONCLUSION

The present study successfully developed and evaluated a polyherbal toothpaste using natural ingredients such as clove, mango leaves, tulsi, ivy gourd leaves, guava leaves, honey, and coconut oil, which are recognized for their antimicrobial, anti-inflammatory, and oral health-promoting properties. Three formulations (T1, T2, and T3) were prepared and systematically assessed for physical characteristics, homogeneity, abrasiveness, spreadability, fineness, pH, and antibacterial activity against *S. aureus*. Among the formulations, T3 emerged as the most promising, demonstrating superior spreadability, highest fineness with minimal abrasive residue, optimal pH, and the strongest antibacterial activity, closely approaching the standard antibiotic control.

The findings suggest that T3 is safe, effective, and consumer-friendly herbal toothpaste, combining good sensory properties with therapeutic potential. In addition, the study highlights the regulatory considerations for herbal toothpaste in India and the USA, emphasizing the importance of licensing, quality compliance, and post-marketing surveillance for ensuring safety and efficacy. Overall, this research supports the development of herbal oral care products as effective alternatives to conventional toothpastes, providing both therapeutic benefits and user acceptability.

ACKNOWLEDGMENT

The authors are thankful to the authorities of the Nitte (Deemed to be University), NGSM Institute of Pharmaceutical Sciences, KLE College of Pharmacy, Hubballi. KLE Academy of Higher Education and Research, and Yenepoya Medical College, Yenepoya Deemed to be University.

REFERENCES

1. Sharma S, Agarwal SS, Prakash J, Pandey M, Singh A. Formulation development and quality evaluation of polyherbal toothpaste" Oral S". Int J Pharm Res Allied Sci 2014;3:30-9.
2. Sekar M, Abdullah MZ. Formulation, evaluation and antimicrobial properties of polyherbal toothpaste. Int J Curr Pharm Res 2016;8:105-7.
3. Sekar M, Ariffin NJ. Formulation, evaluation and antibacterial properties of novel polyherbal toothpaste for oral care. Int J Pharm Clin Res 2016; 8:1155-8.
4. Shukla KV, Kumari D. Formulation development and evaluation of herbal toothpaste for treatment of oral disease. J Drug Deliv Ther 2019;9:98-104.
5. Abhay S, Dinnimath BM. Formulation and evalution of new polyherbal toothpaste for oral care. Indian J Health Sci Biomed Res kleu 2015;8:24-7.
6. Mohire NC, Yadav AV. Chitosan-based polyherbal toothpaste: As novel oral hygiene product. Indian J Dent Res 2010;21:380-4.
7. Sadeghi-Nejad B, Moghimipour E, Yusef Naanaie S, Nezarat S. Antifungal and antibacterial activities of polyherbal toothpaste against oral pathogens, *in vitro*. Curr Med Mycol 2018;4:21-6.
8. Makwana D, Galib R, Dave PP, Rajagopala M, Prajapati PK. Shelf-life assessment of Dantashodhana paste (A Polyherbal Toothpaste): A preliminary study. Asian J Pharm Clin Res 2020;13:79-83.
9. Gautam D, Palkar P, Maule K, Singh S, Sawant G, Kuvalekar C, *et al*. Preparation, evaluation and comparison of herbal toothpaste with marketed herbal toothpaste. Asian J Pharm Technol 2020;10:165-9.
10. Das K, Abdoolah TA, Sounder J. Formulation and evaluation of stevia oral hygiene preparation: A noble herbal toothpaste. Ann Phytomed Int J 2020;9:91-7.
11. Sheeba FR, Chaitra M, Rampur AA, Mahalaxmi M, Sanjana AM, Harshitha S. Formulation and evaluation of poly-herbal toothpowder tablets for enhanced oral health. Biochem Cell Arch 2024;24:2101.
12. Parande B, More SD, Dongaonkar CC, Dhumase P, Suryawanshi S, Wagh P, *et al*. Formulation and evaluation of dentifrice containing *Sesbania grandiflora* with natural elements. Evaluation 2024;4:15.
13. Oluwasina OO, Idris SO, Ogidi CO, Igbe FO. Production of herbal toothpaste: Physical, organoleptic, phyto-compound, and antimicrobial properties. Heliyon 2023;9:e13892.
14. Ladgaonkar YA, Vaidhun B. Formulation and evaluation of herbal toothpowder. World J Pharm Res 2012;12:725-30.
15. Akotakar AM, Thenge RR, Patil AV, Ghonge AB, Bhaltadak MB. Formulation and comparative standardization of toothpaste. Int J Pharm Sci Res 2018;3:12-5.

Source of Support: Nil. **Conflicts of Interest:** None declared.