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Mimusops elengi Linn. (Bakula): Pharmacognostic, Phytochemical and Therapeutic Perspectives in Oral and Dental Care – A Review

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Abstract: *Mimusops elengi Linn., commonly known as Bakula or Bakul and belonging to the family Sapotaceae, is a medicinal tree with a long history of use in Indian traditional medicine. Its bark, flowers, fruits, seeds, leaves and roots have been described for a range of applications, including conditions involving the teeth and gums. Modern pharmacognostic studies have established identifying anatomical and physicochemical features, while phytochemical investigations have reported tannins, flavonoids, triterpenoids, sterols, saponins and other constituents. [1–4] Interest in dentistry has increased because experimental studies have demonstrated antibacterial activity of M. elengi preparations against selected oral microorganisms, including Streptococcus mutans, and activity against multispecies dentinal biofilm. [5–8] Traditional uses such as chewing of twigs, bark-based gargles and tooth-strengthening preparations provide a historical basis for investigation, but they should not be interpreted as equivalent to evidence from controlled clinical trials. The present review integrates botanical identity, pharmacognosy, phytochemistry, ethnomedicinal evidence, oral and dental pharmacology, formulation possibilities, safety considerations and research gaps. Overall, the available literature supports M. elengi as a promising source of bioactive compounds for oral-health research, while the current evidence remains predominantly preclinical and formulation-specific. [1,5–10]*

Keywords: Mimusops elengi; Bakula; Bakul; pharmacognosy; phytochemistry; oral health; dental caries; antimicrobial; gingivitis; dentinal biofilm; herbal medicine

Scope of the review: This review focuses specifically on the pharmacognostic, phytochemical and therapeutic relevance of M. elengi to oral and dental care, while briefly discussing broader pharmacological observations where they help explain possible mechanisms relevant to oral health. Literature published in peer-reviewed journals and accessible scholarly sources was used to develop the synthesis. The numbering in square brackets corresponds to the reference list at the end of the paper. Prepared as an original literature synthesis; not a clinical treatment guideline.

I. INTRODUCTION

Oral diseases arise from interacting microbial, inflammatory, behavioural and host factors. Dental caries, gingivitis and periodontal disease remain major oral-health problems, and microbial biofilms have a central role in their development. The search for plant-derived agents has therefore continued alongside conventional approaches, particularly for compounds that may provide antimicrobial, anti-inflammatory or antioxidant activity. M. elengi is of particular interest because traditional medical systems have associated several parts of the plant with disorders of the mouth, teeth and gums. [1,5,9]

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M. elengi is an evergreen tree distributed in India and other tropical and subtropical regions. In Indian literature it is known by several names, including Bakula and Bakul, while English common names include Spanish cherry, Indian medlar and bullet wood. The plant belongs to Sapotaceae. Historical descriptions and Ayurvedic literature attribute astringent and tooth-supporting properties to the bark and other parts. These observations have subsequently stimulated pharmacognostic and pharmacological investigations. [1,2,3]

1.1 Rationale for dental interest

Three characteristics make Bakula relevant to oral-health research. First, its traditional use includes chewing of twigs or bark and the use of bark-based preparations for gum and tooth complaints. [1] Second, its chemical profile includes tannins, flavonoids, triterpenoids and sterols, classes of compounds frequently investigated for antimicrobial, astringent, antioxidant and anti-inflammatory properties. [2,3,4] Third, experimental studies have directly examined M. elengi against cariogenic organisms and oral microbial communities. [5–8]

1.2 Objectives

The objectives of this review are to: (i) summarize the botanical and pharmacognostic identity of M. elengi; (ii) organize the reported phytoconstituents according to plant part and chemical class; (iii) examine traditional and experimental evidence relevant to teeth, gingiva, plaque and dental infection; (iv) assess the strength and limitations of antimicrobial, anti-inflammatory and antioxidant findings; and (v) identify research priorities required before standardized Bakula preparations can be considered for routine dental use.

1.3 Literature perspective

Earlier reviews described the ethnobotanical, phytochemical and pharmacological profile of M. elengi, while later work has expanded the discussion toward pharmacognostic standardization and oral microbiology. [1–4] Dental studies have included testing of crude extracts against S. mutans, evaluation against several oral microorganisms, examination of multispecies dentinal biofilm and comparison of different plant parts. [5–8] Recent reviews continue to describe the plant as pharmacologically promising, but also emphasize the need for mechanistic, standardization and clinical research. [4,10]

II. BOTANICAL PROFILE AND PHARMACOGNOSTIC CHARACTERISTICS

2.1 Taxonomy and nomenclature

Kingdom: Plantae; Order: Ericales; Family: Sapotaceae; Genus: Mimusops; Species: Mimusops elengi Linn. The plant is commonly called Bakula/Bakul in Indian languages. The nomenclature and traditional identity have been documented in pharmacognostic and ethnobotanical literature. [1,3]

2.2 Macroscopic characters

M. elengi is described as a medium-to-large evergreen tree with a dense crown. The leaves are generally glossy, green and elliptic to oblong with a short to pronounced acuminate tip. Flowers are small, white and strongly fragrant. The fruit is a fleshy berry that becomes yellowish when mature and usually contains a single compressed seed. The stem bark is grey to greyish-brown and develops a characteristic rough or scaly external appearance with age. [1,3,4]

2.3 Bark pharmacognosy

The bark has received particular attention because it is frequently used in traditional dental preparations. Published pharmacognostic descriptions report multiple layers of cork, a phellogen and phelloderm, followed by cortical tissue. The pericycle may contain thick-walled fibres, while the secondary phloem includes sieve elements, parenchyma, phloem fibres and rays. Calcium oxalate crystals, starch and other inclusions have also been reported in powder microscopy. [3,11]

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2.4 Leaf and flower characters

Leaf anatomy has been described as dorsiventral, with a thickened cuticle, stomata predominantly on the lower surface, distinct mesophyll differentiation and characteristic trichomes. Flower studies have examined macroscopic, microscopic, proximate and chromatographic parameters, supporting their use in crude-drug identification and quality assessment. [3,12]

2.5 Physicochemical and quality-control considerations

For a botanical ingredient intended for dental formulations, identity alone is insufficient. Moisture content, total ash, acid-insoluble ash, extractive values, foreign matter, microbial load, heavy metals, pesticide residues and marker compounds should be controlled. Published pharmacognostic studies demonstrate the usefulness of microscopy and extractive values, but a universally accepted pharmacopoeial monograph for every dental dosage form is still needed. [3,11]

Table 1. Selected diagnostic features relevant to crude-drug identification

Plant part	Selected diagnostic/quality features	Dental relevance
Bark	Cork, phellogen, phelloderm, fibres, and phloem rays; powdered material may exhibit starch grains and calcium oxalate crystals.	Frequently discussed in relation to astringent and antimicrobial preparations used in traditional dental care.
Leaf	Dorsiventral lamina, thick cuticle, characteristic stomata, and trichomes.	Potential source of phenolic and flavonoid constituents; investigated for possible antimicrobial activity.
Flower	Fragrant flowers with documented microscopic characteristics and chromatographic parameters.	Associated with traditional medicinal applications, although its direct application in dentistry has received comparatively less attention than bark.
Fruit/seed	Fleshy fruit containing a compressed seed; the seed contains fixed oil and reported bioactive proteins.	Fruit extracts and seed proteins have been investigated in studies examining activity against dental pathogens.

Sources: pharmacognostic reviews and primary investigations. [3,11,12]

III. PHYTOCHEMICAL PROFILE

The chemistry of M. elengi varies with plant part, geographic origin, season, extraction solvent and analytical method. Consequently, a crude bark extract should not be treated as chemically equivalent to a leaf, flower, fruit or seed extract. Published investigations have identified several broad phytochemical classes, with triterpenes and phenolic compounds being particularly relevant to pharmacological interpretation. [2,4]

3.1 Major chemical classes

Tannins and phenolics: Bark and other tissues have been reported to contain tannins and phenolic constituents. These compounds may contribute to astringency and antioxidant capacity, although the relationship between total phenolic content and a specific dental effect cannot be assumed without controlled mechanistic experiments. [2,4] Flavonoids: Quercetin, quercetin-related compounds and other flavonoids have been reported from different plant parts. Flavonoids are of interest because their hydroxylated structures can interact with microbial proteins, membranes and oxidative pathways; however, activity of a purified flavonoid does not prove that the same activity occurs in an unstandardized Bakula preparation. [1,2,4] Triterpenoids: Reported triterpenoid constituents include lupeol, betulinic acid, taraxerol and related compounds. These molecules are frequently discussed in relation to anti-inflammatory, antioxidant and other biological activities. Their presence provides a plausible chemical basis for further investigation of inflammatory oral conditions, but dose-response and pharmacokinetic data specific to oral tissues remain limited. [1,2,4]

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Sterols and saponins: β-sitosterol, α-spinasterol, sterol glycosides and saponin-related constituents have been reported. Seed and bark investigations have also described proteins and fixed oils. [1,2,13] Such chemical diversity means that extraction conditions can materially change the biological profile of the final product.

3.2 Plant-part distribution

Constituent/class	Reported source(s)	Potential relevance
Tannins/phenolics	Mainly bark; also flowers and other plant parts	Contribute to astringent properties and antioxidant activity, with potential antimicrobial effects.
Flavonoids	Leaves, flowers, and seeds	Associated with antioxidant activity and potential interactions with microbial targets and enzymes.
Lupeol and related triterpenes	Bark, roots, flowers, and other tissues	Investigated for anti-inflammatory and other pharmacological activities.
Betulinic acid	Bark fractions	A bioactive triterpenoid of pharmacological interest, with potential biological activities requiring further investigation.
Sterols/glycosides	Bark, flowers, seeds, and roots	Contribute to the overall phytochemical profile and may influence the biological properties of plant extracts.
Saponins/proteins	Bark and seeds	May exhibit antimicrobial or other biological activities; their effects require appropriate characterization and standardization.

The chemical profile summarized above is based on reported literature and should not be interpreted as a complete compositional fingerprint for every M. elengi preparation. [1–4]

IV. TRADITIONAL AND ETHNOMEDICINAL RELEVANCE TO ORAL CARE

The oral-health importance of Bakula is not a recent concept. Ethnobotanical and Ayurvedic literature describes the plant as an astringent and associates its bark, roots, seeds and twigs with tooth and gum care. Chewing of suitable plant material has historically served both mechanical and medicinal purposes. Bark-based decoctions or gargles were also described for tooth discomfort and gum conditions. [1,2,9]

4.1 Traditional tooth-strengthening practices

Historical sources describe chewing the root bark or tender twigs and the use of bark preparations as gargles. Some texts also describe rubbing seed powder on teeth or incorporating Bakula bark into tooth powders and compound formulations. These practices are valuable as ethnomedical leads because they identify the plant parts and routes of exposure that may deserve laboratory investigation. They do not, by themselves, establish efficacy, optimal concentration or safety for modern clinical use. [1]

4.2 Possible pharmacological interpretation

The traditional astringent description may be consistent with the presence of tannins, while the reported antimicrobial activity provides a second possible explanation for historical oral use. Anti-inflammatory and analgesic effects observed in experimental models may also be relevant to discomfort or inflammatory conditions. [2,14] These are hypotheses that require testing in standardized oral formulations rather than assumptions that traditional use proves a mechanism.

4.3 Position within contemporary dentistry

Modern dentistry relies on evidence-based prevention and treatment, including mechanical plaque control, fluoride use, professional periodontal care, restorative procedures and appropriate endodontic treatment. A plant extract such as M.

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elengi should therefore be considered, at present, as a candidate adjunct or source of compounds rather than a replacement for established dental care. This distinction is particularly important because many Bakula studies are in vitro, use crude extracts, or investigate non-clinical models. [5–8]

4.4 Ethnomedicine-to-evidence pathway

A rational development pathway can be summarized as: authenticated plant material → standardized extraction → chemical fingerprinting → target-specific antimicrobial and anti-inflammatory assays → cytotoxicity and mucosal-safety testing → formulation stability → animal/oral-tissue studies where appropriate → well-designed human trials. Each step reduces the risk of attributing a biological effect to a poorly defined herbal mixture. [3,4]

Table 2. Traditional claims and current evidence status

Traditional use	Possible rationale	Current evidence status
Bark/twig chewing for teeth	Mechanical cleaning plus astringent and antimicrobial constituents.	Ethnomedical support; laboratory evidence exists, but controlled clinical evidence is limited. [1,5–8]
Bark gargle for gum/tooth complaints	Astringent and antimicrobial activity.	Traditional reports plus in-vitro antimicrobial studies; formulation-specific trials are needed. [1,7,8]
Seed/fruit preparations	Antimicrobial proteins and phytochemicals.	Experimental activity against selected dental organisms; safety and clinical efficacy remain to be established. [13]

V. ANTIMICROBIAL AND ANTICARIOGENIC EVIDENCE

The strongest dental-specific evidence for M. elengi concerns antimicrobial activity. Multiple investigations have tested bark, leaf, fruit or seed preparations against organisms associated with dental caries, plaque and endodontic infection. The results are encouraging but heterogeneous because studies differ in plant part, extraction solvent, concentration, test organism, assay method and outcome measure. [5–8,13]

5.1 Activity against cariogenic organisms

An in-vitro study of clinically isolated cariogenic pathogens reported that hexane, ethyl acetate, ethanol and methanol extracts of M. elengi showed antibacterial activity against Streptococcus mutans. In the same investigation, the M. elengi extracts did not demonstrate antifungal activity against Candida albicans under the tested conditions. [5] This distinction is important because antibacterial activity should not automatically be generalized to antifungal efficacy. A separate study of seed protein extracts reported anticariogenic activity of M. elengi against Staphylococcus aureus and Streptococcus pyogenes. The study attributed the observed activity to proteinaceous material because proteinase K treatment removed the inhibition effect. This suggests that, in addition to low-molecular-weight phytochemicals, biologically active proteins may contribute to some seed preparations. [13]

5.2 Activity against oral microflora

A 2023 experimental study evaluated ethanolic M. elengi extract against Streptococcus mutans, Lactobacillus acidophilus, Actinomyces species and Candida albicans using agar diffusion and minimum-inhibitory-concentration approaches. The authors reported significant antibacterial efficacy compared with the relevant controls. [7] The study supports continued oral microbiology research, while its in-vitro design limits direct translation to clinical effectiveness.

5.3 Dental biofilm and endodontic relevance

Mistry and colleagues examined methanolic M. elengi extract in a multispecies dentinal-biofilm model containing S. mutans, Enterococcus faecalis, Staphylococcus aureus and C. albicans. The extract demonstrated considerable

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antimicrobial activity relative to saline control. However, 2% chlorhexidine showed the strongest overall effect, and the authors concluded that additional research would be required before recommending M. elengi as a root-canal irrigant. [6]

5.4 Fruit and bark investigations

Bark extracts have been studied against dental pathogens and microorganisms isolated from tooth tartar, with chloroform extract reported as particularly active in an early investigation. [8] More recent work has also explored fruit extracts against organisms including S. mutans, S. salivarius, S. aureus, Lactobacillus acidophilus and S. sanguis. [15] Together, these studies indicate that activity is not restricted to a single plant part, but the lack of standardized extraction and marker-based dosing prevents direct comparison between studies.

5.5 What can and cannot be concluded

The literature supports the statement that selected M. elengi extracts possess in-vitro antimicrobial activity relevant to oral pathogens. It does not yet establish that Bakula prevents dental caries, treats periodontitis, replaces chlorhexidine or functions as a clinically effective root-canal irrigant. The distinction between antimicrobial activity in a laboratory assay and clinical benefit is essential. [5–8]

VI. ANTI-INFLAMMATORY, ANTIOXIDANT AND RELATED THERAPEUTIC

Perspectives

Although antimicrobial action is the most direct dental rationale, oral diseases also involve host inflammatory responses, oxidative stress and tissue injury. M. elengi has been investigated in broader pharmacological models for anti-inflammatory, analgesic, antipyretic and antioxidant effects. These findings may provide mechanistic hypotheses for oral applications, but most were not conducted in human dental populations. [2,14]

6.1 Anti-inflammatory and analgesic observations

Alcoholic extracts of M. elengi have been evaluated experimentally for anti-inflammatory, analgesic and antipyretic effects. Reported phytochemicals include tannins, ursolic acid, steroids, quercitol, lupeol and triterpenoid saponins. [14] If similar activity occurs locally in oral tissues, it could be relevant to inflammatory discomfort; however, oral mucosal exposure, bioavailability and therapeutic concentrations require dedicated studies.

6.2 Antioxidant potential

Phenolic and flavonoid constituents reported in M. elengi provide a plausible basis for free-radical-scavenging activity. Studies summarized in earlier reviews describe antioxidant effects in chemical assays. [2,4] Such assays are useful for screening but cannot alone predict antioxidant effects in saliva, gingival tissue or dental plaque. Future studies should connect chemical antioxidant capacity with biologically relevant biomarkers.

6.3 Astringency and gingival applications

The astringent character historically attributed to Bakula bark is compatible with its tannin content and may explain why bark preparations were used in gum-related complaints. [1,2] Gingival bleeding, plaque accumulation and inflammation are multifactorial, so a standardized Bakula preparation would need to demonstrate effects on plaque, gingival indices and bleeding outcomes in controlled human studies.

6.4 Evidence from polyherbal preparations

Reviews of herbal interventions for gingivitis have identified polyherbal preparations containing M. elengi among combinations studied in clinical settings. Some reported improvements in plaque, gingival or bleeding-related indices

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and bacterial counts. However, when M. elengi is only one component of a multi-ingredient formulation, its individual contribution cannot be isolated without appropriate comparator groups. [16]

6.5 Broader pharmacology: relevance and limitations

M. elengi has also been investigated for antifungal, gastroprotective, antihyperglycemic, cytotoxic and other activities. [2,4] These findings demonstrate chemical diversity but should not be presented as direct evidence for dental efficacy. For an oral-care review, the most informative endpoints remain activity against oral pathogens, biofilm disruption, anti-inflammatory effects in oral tissues, mucosal safety, formulation stability and clinical outcomes.

VII. FORMULATION POSSIBILITIES AND SAFETY CONSIDERATIONS

7.1 Potential oral dosage forms

Based on the available literature, M. elengi could be investigated in several dosage-form concepts: mouthwash, gargle, toothpaste or tooth powder, dentifrice gel, topical gingival gel, and experimental endodontic irrigant. The choice of dosage form should follow the intended target. A mouthwash requires acceptable taste, pH, viscosity, microbial stability and short contact-time efficacy; a gingival gel requires tissue compatibility and adequate residence time; an endodontic irrigant requires penetration, antimicrobial spectrum and compatibility with dentin and restorative materials.

7.2 Standardization requirements

A reproducible Bakula product should begin with authenticated plant material and a defined plant part. Extraction conditions should specify solvent composition, drug-to-extract ratio, extraction time and temperature. Chemical fingerprinting by suitable chromatographic methods should be combined with one or more quantitative marker compounds or validated surrogate markers. Microbial limits, heavy metals, pesticide residues, aflatoxins and residual solvents should also be controlled.

7.3 Safety and cytotoxicity

Traditional use does not guarantee safety at concentrated extract doses. A stem-bark investigation reported cytotoxicity and genotoxicity signals for some fractions in cell-based assays, while an animal study of selected fractions found no overt toxicity at a tested dose in that particular experimental setting. [17] These findings illustrate why safety assessment must be performed for the exact standardized fraction and route intended for oral use rather than extrapolated from a different preparation.

For dental products, local safety is especially important. Studies should examine oral keratinocytes, gingival fibroblasts, mucosal irritation, haemolysis where relevant, sensitization and repeated-exposure effects. If a preparation is intended for daily use, longer-duration safety testing becomes essential. A preparation with strong antimicrobial activity but poor mucosal tolerance would have limited practical value.

7.4 Interaction with conventional dental materials

Before an M. elengi extract is proposed for endodontic or restorative applications, compatibility with dentin, sealers, adhesive systems, composite materials and instruments should be assessed. Plant-derived polyphenols can interact with proteins and surfaces, so effects on dentin bonding, smear-layer removal and material setting cannot be assumed to be neutral.

Table 3. Development considerations for an M. elengi oral formulation

Development domain	Key questions
Botanical identity	Is the plant authenticated, and is the correct plant part used consistently?
Extraction	Are the solvent, drug–extract ratio, and process conditions fixed and reproducible?
Chemical standardization	Are marker compounds and fingerprint profiles defined and validated?

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Microbiology	Does the formulation inhibit relevant planktonic organisms and mature biofilms?
Mucosal safety	Is repeated exposure non-irritant and non-cytotoxic at the intended concentration?
Clinical performance	Does it improve validated oral-health outcomes in controlled trials?

VIII. EVIDENCE SYNTHESIS

The dental literature on M. elengi can be interpreted as a continuum from traditional knowledge to laboratory and early translational research. The evidence is strongest for the presence of measurable antimicrobial activity in selected extracts. Evidence for clinical effectiveness in humans is much less developed, and evidence for a standardized single-ingredient Bakula dental product is especially limited.

Table 4. Summary of selected dental and oral-health evidence

Study area	Material/model	Main observation	Evidence level
Cariogenic pathogens [5]	Hexane/ethyl acetate/ethanol/methanol extracts; clinical isolates	M. elengi extracts showed antibacterial activity against S. mutans.	In vitro
Dentinal biofilm [6]	Methanolic extract; multispecies biofilm on extracted teeth	Considerable antimicrobial activity was observed; 2% CHX was stronger overall.	In vitro/ex vivo model
Oral microflora [7]	Ethanolic extract; S. mutans, L. acidophilus, Actinomyces, C. albicans	Significant antibacterial efficacy was reported in the tested system.	In vitro
Bark/dental pathogens [8]	Solvent extracts; dental isolates/tartar-associated organisms	Chloroform extract showed prominent antibacterial activity in preliminary testing.	In vitro
Seed proteins [13]	Crude seed protein extract; selected bacteria	Activity against S. aureus and S. pyogenes was reported; activity was lost after proteinase K treatment.	In vitro
Fruit extracts [15]	Petroleum ether/chloroform/methanol/water extracts; dental organisms	Extracts were investigated against several oral bacteria, supporting fruit as a potential research source.	In vitro
Polyherbal gingivitis preparations [16]	Multi-ingredient clinical preparations containing M. elengi	Improvements in selected periodontal/gingival indices were reported in clinical studies of the combinations.	Clinical, but attribution limited

8.1 Interpretation

Across studies, the direction of evidence is generally consistent with antimicrobial potential, but quantitative comparisons are difficult. A plant extract's activity depends strongly on solvent polarity and extraction yield. A reported zone of inhibition also cannot be compared directly across different laboratories unless inoculum, medium, extract concentration and assay geometry are standardized. [5–8]

The clinical evidence gap is therefore the key issue. Demonstrating activity against S. mutans in vitro is a useful first step, but a clinically useful dentifrice or mouthwash must also demonstrate acceptable taste, stability, mucosal safety, sustained effect during use and a meaningful improvement in plaque, gingival inflammation or caries-related outcomes. These endpoints have not yet been established for a standardized M. elengi monotherapy.

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IX. RESEARCH GAPS AND FUTURE DIRECTIONS

9.1 Need for chemically standardized extracts

Future investigations should move from broad phytochemical screening toward quantitative standardization. Untargeted LC-MS/MS, HPLC or comparable fingerprinting approaches can help define batch-to-batch similarity. Candidate markers may include selected triterpenoids, flavonoids or phenolic compounds, but the most useful markers should ultimately be linked to biological activity.

9.2 Mechanistic antimicrobial studies

Future work should determine whether M. elengi inhibits bacterial growth, adherence, acid production, glucosyltransferase activity, biofilm maturation, membrane integrity or quorum-related pathways. Time-kill experiments and mature-biofilm models would provide more clinically meaningful information than inhibition-zone testing alone.

9.3 Oral-biofilm models

Single-organism assays are useful but incomplete representations of dental plaque. Multispecies biofilm systems containing cariogenic, commensal and periodontal organisms can better evaluate selectivity. A promising oral antiseptic should ideally reduce pathogenic activity without indiscriminately disrupting the entire oral microbiome.

9.4 Clinical trials

Well-designed randomized controlled trials are required. For a mouthwash, an appropriate study could compare standardized M. elengi formulation with placebo and an established active comparator, using plaque index, gingival index, bleeding measures, microbial counts and adverse events as outcomes. For toothpaste or gel, longer follow-up would be required. Clinical studies should report the botanical authentication, extraction process, marker concentrations and exact dose.

9.5 Pharmacokinetics and local exposure

For topical oral products, systemic pharmacokinetics may be less important than local exposure. Research should therefore quantify how long active constituents remain in saliva or on oral surfaces and whether they penetrate plaque or dentinal tubules. This is particularly relevant if M. elengi is developed as an endodontic adjunct.

9.6 Safety priorities

Repeated-use oral toxicity, mucosal irritation, allergenicity, interaction with conventional dental products and effects on beneficial oral bacteria should be studied. Safety evaluation should use the final formulation rather than relying only on literature about the crude plant.

9.7 Suggested research sequence

A practical sequence would be: authenticate and standardize the plant → establish chemical fingerprint → screen antimicrobial and anti-biofilm activity → identify active fractions → evaluate mechanism → perform cytotoxicity and mucosal-safety testing → optimize a dosage form → conduct stability and compatibility studies → progress to controlled clinical trials. This approach would convert a promising ethnobotanical lead into a scientifically testable dental product.

Table 5. Priority research questions

Priority	Research question
High	Which chemical markers predict antibacterial and antibiofilm activity across batches?
High	What concentration is effective against mature multispecies oral biofilms while remaining safe for the oral

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	mucosa?
High	Does a standardized formulation improve clinical plaque and gingival outcomes?
Moderate	Does M. elengi selectively affect cariogenic pathogens while preserving beneficial oral microbes?
Moderate	Which plant part and extraction method provide the best benefit-to-safety profile?

X. CONCLUSION

Mimusops elengi Linn. (Bakula) is a botanically well-recognized medicinal tree with a long record of traditional use in Indian healthcare. Its bark, leaves, flowers, fruits, seeds and roots have been investigated to different extents, and pharmacognostic studies provide useful parameters for identification and quality control. [1–4,11,12] From a phytochemical perspective, the plant contains a diverse mixture of tannins, phenolic compounds, flavonoids, triterpenoids, sterols, saponins and other constituents. The chemical diversity offers several plausible biological mechanisms, including antimicrobial, antioxidant, astringent and anti-inflammatory actions. Nevertheless, chemical presence should not be equated with clinical efficacy, and biological activity may differ substantially according to plant part and extraction method. [2–4]

The dental literature provides the most consistent support for antimicrobial potential. Extracts of M. elengi have shown activity against S. mutans and other oral or dental-associated microorganisms, and methanolic bark preparations have demonstrated activity in multispecies dentinal-biofilm models. [5–8] Seed protein extracts and fruit preparations have also shown antibacterial activity against selected organisms. [13,15] These findings justify further development work but remain largely preclinical.

The principal scientific gap is the absence of sufficient clinical evidence for a standardized single-ingredient M. elengi oral-care product. Existing clinical observations involving M. elengi are often embedded in polyherbal preparations, making it difficult to attribute benefit to Bakula alone. [16] In addition, differences in extraction and chemical composition limit comparison between studies. A future dental product therefore requires botanical authentication, chemical standardization, reproducible manufacturing, mucosal-safety evaluation and controlled clinical testing.

In summary, M. elengi should be regarded as a promising pharmacognostic and phytochemical resource for oral-health research rather than as an established substitute for conventional dental therapy. The next generation of studies should emphasize standardized extracts, mature oral-biofilm models, mechanism-based experiments, formulation science and appropriately designed human trials. Such work would determine whether the traditional reputation of Bakula can be translated into a reproducible, safe and clinically meaningful dental intervention.

XI. KEY TAKE-HOME POINTS

1. Bakula has a documented traditional association with teeth and gum care. [1] 2. Bark is the most extensively discussed dental plant part, but leaves, fruits and seeds also show experimental activity. [5–8,13,15] 3. Tannins, flavonoids, triterpenoids, sterols and saponins are among the major reported phytochemical groups. [2–4] 4. In-vitro antibacterial activity against oral pathogens is repeatedly reported, but clinical efficacy is not yet established. [5–8] 5. Standardization and safety testing are essential before routine therapeutic use. [3,4,17]

Conflict of interest and funding

No specific funding source or conflict of interest was assumed for this literature synthesis.

Methodological note

This paper is a narrative literature review. It does not claim to be a systematic review or meta-analysis. Findings were synthesized from the cited literature with emphasis on oral and dental relevance. Because individual studies differ in methods and extracts, the evidence should be interpreted qualitatively rather than by direct numerical pooling.

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Reference-use note

Reference numbers [1]–[17] in the body are intended to show the source basis for the corresponding statements. Before academic submission, the final reference list should be checked against the target journal's required style

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