INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Article

Formulation, Anticaries Efficacy, And Desensitizing Potential Of A Polyherbal Toothpaste: A Comparative Evaluations

Shashank Ranjan Pandey* Anushal Mani Shrivastawa, Sumant Kumar Sharma, Rajesh Kumar Thakur

Shyam Sai Institute of Education, Karom, Mairwa, Siwan (Bihar)

ARTICLE INFO

Published: 10 Sept. 2026

Keywords:
Anticaries agents, Desensitizing agents, Dentifrice, Herbal toothpaste, Oral hygiene, Remineralisation, Tooth sensitivity

DOI:
10.5281/zenodo.22691016

ABSTRACT

Introduction: Oral hygiene is a cornerstone of general wellbeing, and toothpaste remains the most widely used vehicle for delivering active agents that protect the teeth and gums during daily brushing. Beyond simple plaque removal, modern dentifrices are expected to fight dental caries, curb tooth sensitivity, and support gum health without exposing users to the irritant or toxicological concerns associated with several synthetic additives. Objective: This work set out to formulate a polyherbal toothpaste using regionally available medicinal plants and to evaluate it not only for conventional physicochemical parameters but also for its potential contribution to two functional categories that are frequently underexplored in the existing herbal-toothpaste literature: anticaries agents and desensitizing agents. Materials and Methods: Aqueous extracts of neem, liquorice, banyan root, and strawberry were incorporated into a base of natural thickeners, humectants, and mineral abrasives. The resulting paste was assessed for organoleptic properties, pH, homogeneity, foaming power, moisture content, fineness, threading property, abrasiveness, and antimicrobial activity against a representative oral pathogen. A dedicated review of pharmaceutical agents currently used as anticaries and desensitizing actives was compiled to contextualise how the herbal formulation compares with, and could be supplemented by, these established classes of compounds. Results: The formulated toothpaste displayed acceptable physicochemical characteristics, a mildly alkaline pH conducive to reducing oral acidity, adequate foaming and abrasive power, and a measurable zone of microbial inhibition. Conclusion: The findings support the continued exploration of polyherbal dentifrices as a safer alternative to conventional toothpaste, while highlighting that combining herbal actives with well-characterised anticaries and desensitizing agents may offer a more complete oral-care profile than either approach alone.

***Corresponding Author:** Shashank Ranjan Pandey

Address: *Shyam Sai Institute of Education, Karom, Mairwa, Siwan (Bihar)*

Email : pandeyshashank1999@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

INTRODUCTION

The mouth is one of the most biologically active surfaces of the human body, hosting a dense and diverse microbial community that interacts continuously with diet, saliva, and oral-care habits. Oral diseases, principally dental caries and periodontal disease, remain among the most prevalent chronic conditions worldwide and represent a substantial and largely preventable public-health burden.[1] Toothpaste, used alongside a toothbrush, is the principal means by which most people deliver active ingredients to this environment twice a day. While its historical role was largely mechanical — removing food debris and surface stains — contemporary dentifrices are formulated to address a wider set of goals: controlling plaque-forming bacteria, neutralising the acids that demineralise enamel, easing the discomfort of exposed dentine, and freshening breath.

Public interest in herbal and 'natural' oral-care products has grown substantially over the past two decades, driven largely by concerns about additives such as sodium lauryl sulphate, triclosan, synthetic sweeteners, and certain preservatives that have been associated with irritation, sensitisation, or longer-term toxicological questions. Traditional systems of medicine, including Ayurveda, Unani, and Siddha, have long used plant material — neem twigs, liquorice root, banyan aerial roots, clove buds, and many others — for cleaning teeth and soothing the gums, and a substantial body of modern pharmacological work has since confirmed antimicrobial, anti-inflammatory, and antioxidant activity in many of these species.[2]

However, most published herbal-toothpaste projects concentrate narrowly on general antimicrobial testing and basic physicochemical characterisation, leaving two clinically important functional categories comparatively under-discussed: (i) the specific agents, herbal or synthetic, that are recognised to interfere with the caries process, and (ii) the agents used to manage dentine hypersensitivity. This article addresses that gap directly. In addition to formulating and evaluating a polyherbal toothpaste, it dedicates focused sections to reviewing the mechanisms and evidence behind established anticaries agents and desensitizing agents, and discusses how such agents might be rationally combined with, or substituted by, herbal actives in a future formulation.

1.1 Rationale and Objectives

- To prepare a polyherbal toothpaste from regionally sourced medicinal plants using simple, reproducible laboratory methods.
- To evaluate the formulated toothpaste against standard pharmacopoeial and industry evaluation parameters (organoleptic properties, pH, homogeneity, foaming power, moisture content, fineness, abrasiveness, and antimicrobial activity).
- To review, in depth, the classes of drugs and compounds used as anticaries agents in commercial and experimental dentifrices, including their mechanisms of action and safety considerations.
- To review, in depth, the classes of drugs and compounds used as desensitizing agents in commercial and experimental dentifrices, including their mechanisms of action and safety considerations.
- To discuss how herbal ingredients might complement, or in some cases substitute for, these pharmaceutical actives in an integrated formulation strategy.

2. ORAL DISEASES RELEVANT TO TOOTHPASTE DESIGN

A rational toothpaste formulation begins with an understanding of the conditions it is meant to help prevent or manage. Four conditions are particularly relevant to the choice of active ingredients discussed in this article: dental caries, periodontal (gum) disease, dentinal hypersensitivity, and enamel erosion.

2.1 Dental Caries

Dental caries is a multifactorial, bacterially mediated disease in which acid-producing organisms, most notably Streptococcus mutans and Lactobacillus species, metabolise dietary sugars to produce organic acids. Repeated acid challenge lowers the pH at the tooth surface below the critical threshold for enamel dissolution (approximately pH 5.5), leading to a net loss of calcium and phosphate from the hydroxyapatite lattice. Over time this demineralisation outpaces the mouth's natural remineralising capacity, and a cavity forms.[3]

2.2 Periodontal Disease

Gingivitis and periodontitis arise from the accumulation of bacterial biofilm (plaque) along the gum margin. Left undisturbed, this biofilm mineralises into calculus and triggers a host inflammatory response that can progress to loss of the supporting bone and connective tissue around the teeth.

2.3 Dentinal Hypersensitivity

When the protective enamel or cementum layer is lost — through erosion, abrasive brushing, gingival recession, or abfraction — the underlying dentine is exposed. Dentine is permeated by thousands of microscopic tubules running from the pulp to the tooth surface. According to the widely accepted hydrodynamic theory, external stimuli such as cold, sweet, or acidic substances cause fluid movement within these tubules, which mechanically stimulates nerve endings in the pulp and produces a short, sharp pain.[4]

2.4 Enamel Erosion

Erosion is the chemical dissolution of enamel by acids not of bacterial origin — most commonly dietary acids from citrus fruit, carbonated drinks, and vinegar-based foods, or gastric acid in cases of reflux. Repeated erosive episodes thin the enamel and, if unmanaged, expose dentine and set the stage for hypersensitivity.

3. DRUGS AND AGENTS USED AS ANTICARIES ACTIVES IN TOOTHPASTE

Anticaries agents are compounds incorporated into a dentifrice specifically to interrupt one or more steps of the caries process: bacterial acid production, enamel demineralisation, or the natural remineralisation cycle. They can be broadly grouped into fluoride-based agents, non-fluoride remineralising agents, antimicrobial/antiplaque agents, and plant-derived anticaries agents.

3.1 Fluoride-Based Anticaries Agents

Fluoride remains the most extensively studied and most widely used anticaries active in the world, and its inclusion in toothpaste is credited with a substantial share of the decline in caries prevalence observed in many countries since the mid-twentieth century.[6,7] Fluoride works through three complementary mechanisms: it promotes the formation of fluorapatite, a mineral phase that is more resistant to acid dissolution than native hydroxyapatite; it enhances remineralisation by attracting calcium and phosphate ions back into partially demineralised enamel; and, at higher local concentrations, it can inhibit bacterial enzymes involved in acid production.

Fluoride Compound	Typical Use Level	Notes
Sodium fluoride (NaF)	0.22–0.32% w/w (≈1000–1450 ppm F)	Most common form in adult toothpaste; stable, cost-effective
Sodium monofluorophosphate (SMFP)	0.76–1.14% w/w	Requires enzymatic hydrolysis in the mouth to release active fluoride
Stannous fluoride (SnF2)	0.4–0.454% w/w	Also has antimicrobial and anti-sensitivity action; can stain teeth if poorly stabilised
Amine fluoride	Variable, often combined with NaF	Organic fluoride with surfactant-like properties; used mainly in Europe

Regulatory bodies generally cap over-the-counter fluoride toothpaste at around 1500 ppm fluoride for adults and recommend lower concentrations or a pea-sized amount under supervision for young children, because excessive ingestion during tooth development can cause dental fluorosis — a cosmetic mottling of the enamel.[5] This safety margin is the main reason fluoride toothpaste packaging in several countries now carries an ingestion warning.

3.2 Non-Fluoride Remineralising Agents

A newer generation of anticaries technologies aims to deliver bioavailable calcium and phosphate directly to the tooth surface, either as an adjunct to fluoride or as an alternative for patients who avoid it.

- Casein phosphopeptide–amorphous calcium phosphate (CPP-ACP): a milk-derived peptide complex that stabilises calcium and phosphate in a soluble, bioavailable form and releases these ions at the tooth surface, supporting remineralisation; marketed in some toothpaste and creams under brand names built around the 'Recaldent' technology.[8,14]
- Bioactive glass / calcium sodium phosphosilicate: originally developed as a bone-regeneration material, this glass reacts with saliva to release calcium and phosphate ions that form a hydroxycarbonate apatite layer on the tooth surface; it is used in both anticaries and desensitizing formulations (see Section 4).
- Hydroxyapatite (nano- and micro-crystalline): synthetic hydroxyapatite particles are increasingly used as a fluoride-free remineralising agent, physically occluding porosities in enamel and providing a reservoir of calcium and phosphate.
- Xylitol: a sugar alcohol that cannot be fermented by cariogenic bacteria; regular exposure reduces the metabolic fitness of Streptococcus mutans populations in plaque and modestly lowers acid production, complementing rather than replacing fluoride.[9]
- Arginine–calcium carbonate technology: arginine, a naturally occurring amino acid, is metabolised by certain oral bacteria to raise plaque pH, shifting the biofilm environment away from the acidic conditions that favour demineralisation; it is frequently combined with an insoluble calcium source.

3.3 Antimicrobial / Antiplaque Agents with Anticaries Relevance

Because caries is ultimately a bacterially driven disease, agents that reduce the cariogenic bacterial load also function as anticaries actives, even when their primary indication is plaque or gingivitis control.

- Triclosan: a broad-spectrum antibacterial historically included in some toothpaste formulations to reduce plaque and gingivitis; its use has declined owing to concerns about antimicrobial resistance and endocrine effects, and it has been withdrawn from several product categories in various jurisdictions.
- Chlorhexidine gluconate: a highly effective antiplaque agent used mainly in mouth rinses and short-course toothpaste/gel formulations rather than everyday toothpaste, owing to its tendency to cause reversible tooth staining and taste alteration with prolonged use.[10]
- Cetylpyridinium chloride: a quaternary ammonium antimicrobial with milder plaque-reducing activity, used in some toothpaste and rinse products as a gentler long-term alternative to chlorhexidine.
- Zinc salts (zinc citrate, zinc chloride): contribute mild antibacterial and anti-calculus activity and are often paired with other actives rather than used alone.

3.4 Plant-Derived and Herbal Anticaries Agents

A substantial and growing pharmacological literature supports the anticaries relevance of several traditional plant materials, generally through antibacterial, anti-adhesive, or acid-buffering mechanisms rather than the direct remineralising action of fluoride.[11,12,13]

Plant / Extract	**Reported Mechanism Relevant to Caries**
Neem (Azadirachta indica)	Antibacterial activity against Streptococcus mutans; interferes with bacterial adhesion to enamel
Liquorice (Glycyrrhiza glabra)	Licoricidin and related flavonoids inhibit growth and acid production of cariogenic streptococci
Green tea catechins (Camellia sinensis)	Inhibit bacterial glucosyltransferase enzymes, reducing biofilm formation
Miswak / Salvadora persica	Contains antibacterial and mildly abrasive components; traditionally chewed as a natural toothbrush
Propolis	Broad antimicrobial resin from bees; reduces cariogenic bacterial counts in several in-vitro studies
Clove (Syzygium aromaticum)	Eugenol shows antibacterial activity alongside its better-known analgesic effect

These plant-derived agents are generally regarded as adjunctive rather than replacement actives for fluoride, since the clinical evidence base for direct remineralisation is far smaller than for fluoride or the calcium–phosphate technologies described above. A formulation strategy that pairs a low, safe level of fluoride (or a non-fluoride remineralising agent) with one or more of these herbal antibacterials is a reasonable direction for future polyherbal toothpaste development, including an extension of the formulation reported later in this article.

3.5 Laboratory and Clinical Methods for Evaluating Anticaries Efficacy

Because 'anticaries activity' is a claim with real public-health weight, it is normally supported by a tiered body of evidence rather than a single test. In-vitro screening typically starts with antibacterial assays — disc diffusion, broth microdilution, or biofilm assays — against cariogenic species such as Streptococcus mutans and Lactobacillus acidophilus, to establish whether an ingredient can plausibly interfere with the bacterial side of the disease process. Mineral-exchange claims are usually tested using artificial enamel or dentine specimens that are deliberately demineralised with a mild acid buffer, treated with the candidate agent, and then assessed for mineral recovery using techniques such as surface microhardness testing, transverse microradiography, or laser fluorescence. pH-cycling models, which alternate specimens between demineralising and remineralising solutions over several days to simulate real dietary acid challenges, are considered a more realistic intermediate step before moving to human studies. Clinical evidence, where available, is generally drawn from randomised controlled trials measuring caries increment (new lesions or restorations) over one to three years, which is the gold standard but is time-consuming and costly, explaining why many published herbal-toothpaste studies — including much of the current literature on neem- and liquorice-based formulations — stop at the in-vitro antibacterial stage.

4. DRUGS AND AGENTS USED AS DESENSITIZING ACTIVES IN TOOTHPASTE

Desensitizing toothpaste is formulated to reduce the pain associated with dentinal hypersensitivity. Active agents in this category work through one of two broad mechanisms: nerve depolarising agents, which reduce the excitability of pulpal nerve fibres so they are less responsive to hydrodynamic stimuli, and tubule-occluding agents, which physically or chemically block the dentinal tubules to prevent fluid movement in the first place.

4.1 Nerve Depolarising Agents

- Potassium nitrate (5% w/w is the typical concentration): potassium ions are believed to diffuse along the dentinal tubules and raise the extracellular potassium concentration around pulpal nerve fibres, reducing their ability to repolarise after firing and thereby dampening the pain signal. It is one of the most widely used and best-studied desensitizing actives, usually requiring several weeks of regular use before maximal benefit is felt.
- Potassium chloride and potassium citrate: alternative potassium salts used in some formulations with a broadly similar proposed mechanism to potassium nitrate.

4.2 Tubule-Occluding Agents

Agent	Typical Mechanism
Stannous fluoride	Forms a tin-rich precipitate that physically occludes dentinal tubules while also providing anticaries benefit
Strontium chloride / strontium acetate	Strontium ions are deposited within the tubules and are thought to reduce fluid permeability

Arginine–calcium carbonate (Pro-Argin technology)	Forms an arginine–calcium carbonate plug within the tubule orifice, providing rapid occlusion
Calcium sodium phosphosilicate (bioactive glass / NovaMin-type technology)	Reacts with saliva to deposit a hydroxycarbonate apatite layer that seals tubules and mimics natural mineral
Oxalate compounds (potassium oxalate, calcium oxalate)	Precipitate calcium oxalate crystals within and over the tubule opening
Resin- and adhesive-based agents	Form a polymer film over exposed dentine, used mainly in professionally applied products rather than toothpaste
Nano-hydroxyapatite	Physically deposits within and over tubule openings, mimicking natural enamel/dentine mineral

4.3 Herbal and Natural Desensitizing Agents

Several traditional plant materials have documented soothing or mildly analgesic effects on exposed dentine, although their evidence base for tubule occlusion is generally weaker than that for the synthetic agents above.

- Clove oil (eugenol): a well-established topical dental analgesic; eugenol has direct local anaesthetic-like activity on nerve endings and has long been used in temporary dental dressings for pain relief.
- Propolis: in addition to its antibacterial activity, propolis resin has been explored for a protective, film-forming effect over exposed dentine surfaces.
- Neem and liquorice extracts: primarily valued for antibacterial and anti-inflammatory activity, which can indirectly reduce sensitivity associated with gingival inflammation and recession.
- Aloe vera gel: used in some natural formulations for its soothing, anti-inflammatory effect on irritated gum tissue adjoining sensitive root surfaces.

4.4 Selecting a Desensitizing Strategy for a Herbal Formulation

For a polyherbal toothpaste, the most pragmatic route to desensitizing activity without introducing synthetic actives is a combination of a mild mineral abrasive/occluding agent — such as finely divided calcium carbonate, which can lodge within tubule orifices during brushing — with clove oil or a comparable eugenol-containing extract for its topical analgesic contribution, together with an anti-inflammatory herb such as liquorice or aloe vera to address gingival contributors to sensitivity. Where a stronger, clinically validated desensitizing claim is required, incorporating a low-dose potassium salt or a calcium sodium phosphosilicate component alongside the herbal base would align the formulation with mainstream desensitizing toothpaste technology while retaining most of its natural ingredient profile.

It is also worth noting that the onset profile differs between mechanisms:[15] nerve-depolarising agents such as potassium nitrate typically require two to four weeks of twice-daily use before the user notices a meaningful reduction in sensitivity, because the effect depends on a gradual rise in peri-neural potassium concentration. Tubule-occluding agents, by contrast, can produce a more immediate reduction in symptoms because the physical or mineral plug forms within one or a few applications, although the durability of that plug varies — some occluding layers are removed relatively quickly by acidic foods, toothbrush abrasion, or salivary flow, while bioactive-glass-type layers are reported to be more resistant to such removal because they continue to react with saliva and 'self-repair' over time. A formulation aiming for a fast, noticeable benefit for the end user may therefore favour an occluding strategy, whereas a formulation aiming for sustained, cumulative desensitisation may favour a potassium-based strategy or a combination of both mechanisms.

4.5 Safety and Tolerability Considerations

Desensitizing agents are generally well tolerated, but a few points merit attention in formulation and labelling. Potassium salts are considered safe at cosmetic-product concentrations for topical oral use, though products are still typically advised against for very young children given the general caution around ingestion of any active ingredient. Stannous fluoride can cause superficial tooth staining with long-term use, usually reversible with professional cleaning, and combines fluoride's ingestion caution with its desensitizing role. Oxalate-based agents are used at low concentrations because oxalates are toxic at high systemic doses, so strict adherence to permitted use levels is essential. Bioactive-glass and arginine–calcium carbonate systems have a favourable safety profile reported in the literature, as their mechanism relies on materials (calcium, phosphate, silica, arginine) that are either naturally present in the body or metabolised through normal physiological pathways.

4.6 Laboratory and Clinical Methods for Evaluating Desensitizing Efficacy

Desensitizing claims are supported by a similarly tiered evidence base. At the laboratory stage, tubule-occlusion is commonly assessed using scanning electron microscopy of treated dentine discs, which allows direct visual scoring of how completely the tubule openings are blocked, together with a hydraulic conductance (fluid-flow) test that measures how much the treatment reduces fluid movement through the dentine under a standard pressure gradient — a direct laboratory analogue of the hydrodynamic mechanism believed to cause the pain in the first place. Acid-challenge resistance of the newly formed occluding layer is often tested by exposing treated specimens to a mild acid (such as diluted citric acid) and re-measuring conductance, since a clinically useful desensitizing layer needs to survive ordinary dietary acid exposure rather than dissolving after the first meal. Clinical evaluation of desensitizing toothpaste typically uses patient-reported pain scores in response to standardised stimuli — a timed air blast, a cold water rinse, or a light tactile probe on the exposed root surface — recorded at baseline and again after two, four, and eight weeks of product use, allowing both the immediate and cumulative components of the effect to be captured separately.

5. COMPARATIVE OVERVIEW: HERBAL vs. CONVENTIONAL FUNCTIONAL ACTIVES

Bringing together the anticaries and desensitizing agents discussed above alongside the herbal ingredients used in the present formulation allows a direct, side-by-side comparison of what each ingredient class is best supported to achieve, and where the evidence remains comparatively thin.

Functional Goal	Strongest Conventional Option	Strongest Herbal Option	Comparative Note
Enamel remineralisation	Fluoride (NaF, SMFP, SnF2)	Limited direct evidence; herbs	Fluoride remains first-line; herbal agents are

		mainly act indirectly via antibacterial effect	complementary, not substitutive, for this specific goal
Reducing cariogenic bacterial load	Chlorhexidine, triclosan, cetylpyridinium chloride	Neem, liquorice, green tea catechins, propolis	Herbal agents offer a favourable side-effect profile with reasonable antibacterial evidence
Reducing plaque acid production	Xylitol, arginine-based systems	Limited direct evidence	An area where herbal formulations could adopt an established non-fluoride technology
Rapid tubule occlusion for sensitivity	Bioactive glass, arginine–calcium carbonate, stannous fluoride, oxalates	Calcium carbonate abrasive lodging; weak evidence	Conventional occluding agents are considerably better validated
Nerve-level pain reduction	Potassium nitrate/chloride/citrate	Clove oil (eugenol) topical analgesia	Clove oil offers a genuinely evidence-based, if shorter-acting, herbal alternative
Anti-inflammatory gum support	Limited dedicated conventional actives (mainly antimicrobial routes)	Liquorice, aloe vera, banyan root extracts	A category where herbal ingredients have a comparatively strong, distinct contribution

This comparison suggests that the greatest opportunity for a polyherbal formulation is not necessarily to replace fluoride or potassium-based technologies outright, but to identify the specific functional goals — antibacterial action, anti-inflammatory gum support, and mild topical analgesia — where the plant-derived evidence is already comparatively strong, while being transparent about the goals — deep remineralisation and rapid, durable tubule occlusion — where a conventional or non-fluoride mineral-based active currently offers better-substantiated performance.

6. MATERIALS AND METHODS

The formulation and evaluation protocol followed below was adapted from standard herbal-dentifrice methodology reported in the literature.[16]

6.1 Collection and Authentication of Plant Material

Fresh neem (Azadirachta indica) leaves were collected from a medicinal garden and identified prior to use. Liquorice root, strawberry, and banyan (Ficus benghalensis) aerial root material, along with rosemary oil, olive oil, rose water, calcium carbonate, clove oil, vegetable glycerine, and rock salt, were procured from standard commercial suppliers. Rice starch and calcium carbonate of laboratory grade were used as thickening and abrasive components respectively.

6.2 Preparation of Aqueous Extracts

Dried and coarsely powdered neem leaves, banyan root, liquorice root, and strawberry were individually macerated in distilled water for 48 hours with intermittent agitation, then filtered. Each filtrate was gently concentrated below its boiling point to avoid degrading heat-sensitive constituents and stored under refrigeration in an amber container until formulation.

6.3 Morphological and Organoleptic Evaluation

Each dried plant material was assessed for colour, odour, taste, size, and shape prior to extraction, in order to confirm identity and rule out contamination or spoilage before it was carried forward into the formulation.

6.4 Toothpaste Preparation

The gum and humectant components were first dispersed in the aqueous phase to form a uniform mucilage. Powdered ingredients — calcium carbonate, rice starch, and rock salt — were then incorporated gradually with continuous trituration to avoid lump formation. The herbal extracts, oils (clove, rosemary, olive), rose water, and citric acid were finally blended in, and mint oil was added last as a flavouring/cooling agent to preserve its volatile character. The finished paste was packed into collapsible tubes for evaluation.

6.5 Formulation Composition

The finished paste combined mineral, humectant, thickening, and flavouring components with the herbal extracts described above. An indicative composition, to be adjusted during optimisation trials, is summarised below.

Component	Indicative Quantity (per batch)	Functional Role
Calcium carbonate	~40% of solid phase	Mild abrasive / binder
Vegetable glycerine	~40–45% of liquid phase	Humectant
Rice starch	~1–1.5%	Thickening agent
Liquorice extract	~1–1.5%	Foaming agent, antibacterial
Banyan root extract	~0.8–1%	Anti-inflammatory contribution
Strawberry extract	~0.2%	Mild whitening contribution
Neem extract	~0.05%	Antibacterial agent
Clove oil	~0.02%	Antibacterial and mild analgesic
Rosemary oil	~1.5–2%	Supportive antioxidant / re-mineralising folk use
Olive oil	~2–2.5%	Emollient, anti-inflammatory
Citric acid	~0.1%	pH adjustment / preservative support
Rock salt	~0.2%	Traditional anti-cavity/cleansing agent
Rose water, mint oil	q.s.	Flavouring and cooling agents

6.6 Evaluation Parameters

- Physical examination: colour, odour, and taste assessed by direct sensory evaluation.
- Threading property: paste extruded onto a toothbrush and scored for smooth placement, light threading, or difficult threading.

- pH: measured with a calibrated pH meter on a 1:1 w/v aqueous suspension of the toothpaste.
- Homogeneity: assessed by extruding the paste under standard force and observing consistency of texture.
- Moisture content: determined gravimetrically by oven-drying a weighed sample at 105 °C to constant weight.
- Fineness: assessed by passing a dispersed sample through a 150-micron sieve and weighing the retained residue.
- Foaming power: assessed by agitating a diluted sample in a graduated cylinder and recording foam height.
- Abrasiveness and sharp-particle test: assessed qualitatively by expressing the paste onto butter paper and running a fingertip along its length.
- Antimicrobial activity: evaluated by the disc diffusion method on Mueller–Hinton agar against Staphylococcus aureus, with the zone of inhibition recorded in millimetres after 24 hours of incubation at 37 °C.

7. RESULTS

The formulated polyherbal toothpaste presented as a smooth, beige-coloured paste with a mild, characteristic herbal odour and an acceptable, non-synthetic taste, consistent with the absence of artificial colourants or strong synthetic flavouring agents.

Parameter	Observation
Colour	Beige
Odour	Mild, characteristic (herbal)
Taste	Acceptable, characteristic
Threading property	Smooth
pH	9.18 (mildly alkaline)
Homogeneity	Good
Abrasiveness	Good, non-damaging
Foaming power (foam height)	1.5 cm
Moisture content	9.6% w/w
Fineness	Fine, free of gritty particles
Zone of inhibition (S. aureus)	12 mm

The mildly alkaline pH is consistent with the aim of reducing oral acidity between brushings, while the measured foam height and fine particle profile indicate adequate spreadability and a low risk of enamel abrasion during normal use. The 12 mm zone of inhibition against Staphylococcus aureus indicates measurable antimicrobial activity attributable to the combined effect of the neem and liquorice extracts.

8. DISCUSSION

The physicochemical results obtained for this formulation fall within ranges generally regarded as acceptable for a dentifrice intended for daily use: a pH close to neutral-to-mildly-alkaline avoids the risk of the paste itself contributing to erosion, while the recorded moisture content and fineness support a stable, comfortable-to-use product over its shelf life.

Positioning these results against the wider dentifrice landscape described in Sections 3 and 4, the present formulation should be understood as offering primarily antibacterial, low-abrasion, and mild anti-inflammatory benefits through its herbal constituents, rather than the direct remineralising action associated with fluoride or calcium-phosphate technologies, or the validated nerve-depolarising action associated with potassium salts. This is not a shortcoming unique to this formulation — it reflects a genuine gap between what most plant extracts have been shown to do (chiefly antibacterial and anti-inflammatory activity) and what the strongest anticaries and desensitizing evidence supports (mineral exchange and ion-mediated nerve modulation).

A logical next iteration of this work would therefore explore two development paths in parallel: first, supplementing the existing herbal base with a well-tolerated non-fluoride remineralising agent, such as a calcium-phosphate or arginine-based system, to add a genuine anticaries mineral-exchange mechanism; and second, incorporating a validated desensitizing component — either a low-dose potassium salt or a bioactive-glass-type occluding agent — alongside the existing clove oil content, to move from an anecdotal 'soothing' claim toward a substantiated desensitizing claim. Both additions could, in principle, be made while retaining the plant-derived antibacterial core (neem, liquorice) and the natural humectant/thickener system that gave this formulation its favourable organoleptic profile.

Some limitations should be acknowledged. The present work reflects a single formulation batch and a single antimicrobial test organism, and did not include a head-to-head comparison against a marketed conventional or herbal toothpaste. The anticaries and desensitizing sections presented here are a literature-based review intended to guide future formulation choices rather than a report of new pharmacological testing of those specific agents in this paste. Confirmatory work — larger batch sizes, a wider microbial panel including cariogenic species such as Streptococcus mutans, remineralisation assays on artificially demineralised enamel specimens, and, ultimately, controlled clinical evaluation of any sensitivity claim — would be required before therapeutic claims could be made with confidence.

9. CONCLUSION AND FUTURE PROSPECTS

This work formulated and characterised a polyherbal toothpaste built around neem, liquorice, banyan root, and strawberry, and found it to have favourable organoleptic, physicochemical, and antimicrobial properties consistent with safe daily use. Beyond the formulation itself, this article has set out, in structured detail, the principal classes of anticaries agents (fluoride compounds, non-fluoride remineralising technologies, antimicrobial actives, and plant-derived antibacterials) and desensitizing agents (nerve-depolarising potassium salts and a range of tubule-occluding technologies, alongside herbal soothing agents such as clove oil) currently used in oral-care formulation.

Bringing these two strands together, the most promising direction for future development is a rationally combined formulation: a herbal antibacterial base retained for its safety and consumer appeal, deliberately supplemented with a modest, well-characterised anticaries mineral-exchange agent and a validated desensitizing component. Such a hybrid approach could offer a more complete oral-care profile than a purely herbal or purely synthetic formulation alone, and represents a natural next phase of research building on the present study. Randomised, controlled, and adequately powered clinical trials, together with long-term stability and safety testing, remain necessary before any such formulation could be recommended as a substitute for established therapeutic dentifrices.

10. REGULATORY AND LABELLING CONSIDERATIONS

A formulation intended to carry an anticaries or desensitizing claim, rather than a general cosmetic cleaning claim, generally falls under stricter regulatory scrutiny than a purely cosmetic dentifrice, since such claims imply a therapeutic effect. In most regulatory frameworks, fluoride concentration limits, ingestion warnings for young children, and permitted maximum levels for actives such as triclosan or oxalates are specified in pharmacopoeial or cosmetic-regulation monographs and should be checked against the current requirements of the jurisdiction in which the product will be marketed, since these limits are periodically revised as new safety data emerge. Herbal ingredients are not exempt from this scrutiny merely because they are 'natural': extracts intended for daily oral use should still be characterised for heavy-metal contamination, microbial load, and batch-to-batch consistency of their active constituents, and any anticaries or desensitizing claim attached to a herbal ingredient should be supported by evidence proportionate to the strength of the claim being made, in the same way as for a synthetic active.

REFERENCES

1. World Health Organization. Oral health [Internet]. Geneva: World Health Organization; 2023 [cited 2026 Aug 7]. Available from: https://www.who.int/news-room/fact-sheets/detail/oral-health
2. Kumar G, Jalaluddin MD, Rout P, Mohanty R, Dileep CL. Emerging trends of herbal care in dentistry. J Clin Diagn Res. 2013;7(8):1827–9.
3. Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet. 2007;369(9555):51–9.
4. Addy M. Dentine hypersensitivity: new perspectives on an old problem. Int Dent J. 2002;52(S5):367–75.
5. American Dental Association Council on Scientific Affairs. Fluoride toothpaste use for young children. J Am Dent Assoc. 2014;145(2):190–1.
6. Featherstone JD. The science and practice of caries prevention. J Am Dent Assoc. 2000;131(7):887–99.
7. Marinho VC, Higgins JP, Logan S, Sheiham A. Fluoride toothpastes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2003;(1):CD002278.
8. Reynolds EC. Casein phosphopeptide-amorphous calcium phosphate: the scientific evidence. Adv Dent Res. 2009;21(1):25–9.
9. Riley P, Moore D, Ahmed F, Sharif MO, Worthington HV. Xylitol-containing products for preventing dental caries in children and adults. Cochrane Database Syst Rev. 2015;2015(3):CD010743.
10. James P, Worthington HV, Parnell C, Harding M, Lamont T, Cheung A, et al. Chlorhexidine mouthrinse as an adjunctive treatment for gingival health. Cochrane Database Syst Rev. 2017;3:CD008676.
11. Kankariya AR, Patel AR, Kunte SS. The effect of different concentrations of water soluble azadirachtin (neem metabolite) on Streptococcus mutans compared with chlorhexidine. J Indian Soc Pedod Prev Dent. 2016;34(2):105–10.
12. Tian M, Yan H, Row KH. Extraction of glycyrrhizic acid and glabridin from licorice. Int J Mol Sci. 2008;9(4):571–7.
13. Jeon JG, Rosalen PL, Falsetta ML, Koo H. Natural products in caries research: current (limited) knowledge, challenges and future perspective. Caries Res. 2011;45(3):243–63.
14. Ahrari F, Hasanzadeh N, Rajabi O, Forouzannejad Z. Effectiveness of sodium

bicarbonate combined with hydrogen peroxide and CPP-ACPF in whitening and microhardness of enamel. J Clin Exp Dent. 2017;9(3):e344–50.
15. West NX. Dentine hypersensitivity: preventive and therapeutic approaches to treatment. Periodontol 2000. 2008;48:31–41.
16. Deshmukh P, Telrandhe R, Gunde M. Formulation and evaluation of herbal toothpaste: compared with marketed preparation. Int J Pharm Drug Anal. 2017;5(10):406–10.

HOW TO CITE: Shashank Ranjan Pandey* Anushal Mani Shrivastawa, Sumant Kumar Sharma, Rajesh Kumar Thakur, Formulation, Anticaries Efficacy, And Desensitizing Potential Of A Polyherbal Toothpaste: A Comparative Evaluations, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 9, 1088-1101. https://doi.org/10.5281/zenodo.22691016