

Herbal Toothpaste: A Critical Review of Formulation Design, Quality Evaluation, Clinical Evidence and Safety Gaps

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Abstract: *Herbal toothpastes are promoted as milder, safer alternatives to conventional dentifrices, and a growing number of small formulation studies describe them as stable and effective. This review asks whether the published evidence actually supports those claims. Formulation studies, quality standards, laboratory investigations, clinical trials and safety reports on herbal dentifrices and their common ingredients, such as neem, clove and turmeric, were examined and compared. Most formulation papers evaluate a single batch using simple organoleptic and physicochemical tests, while abrasivity, fluoride content, cytotoxicity and long-term stability are seldom measured by recognised methods. Laboratory work often reports strong antibacterial activity, yet the most potent preparations may also damage human cells, so antimicrobial strength alone is a poor guide to safety. Clinical trials suggest that short-term plaque control is comparable to conventional pastes, but the studies are small, brief and of low methodological quality. Several commercial products contain little effective fluoride, and irritant foaming agents are frequently retained in herbal bases. A plant origin therefore does not guarantee quality, efficacy or safety. A minimum reporting framework covering standardised plant material, validated physicochemical and abrasivity testing, fluoride declaration, cytotoxicity screening, biofilm-based antimicrobial assays and controlled clinical assessment is proposed for future work.*

Keywords: herbal toothpaste; dentifrice; formulation; quality evaluation; cytotoxicity; fluoride; antimicrobial activity

I. INTRODUCTION

Toothpaste is the most widely used oral-care product in the world. Its job is to clean and polish the teeth, freshen the breath and, in many products, to deliver an agent that lowers the risk of caries or gum disease. Most conventional pastes rely on synthetic components. Some of these have drawn criticism: parabens and chemical anti-streptococcal agents used in the industry have been linked to side effects such as tooth discolouration [1], and the foaming agent sodium lauryl sulphate (SLS) is a recognised mucosal irritant that has been associated with more frequent aphthous ulcers in susceptible people [2,3].

These concerns, together with a general preference for natural products, have driven demand for herbal toothpastes. Plant materials such as neem, clove, turmeric, guava, tulsi and mint are cheap, locally available and culturally familiar in many countries. As a result, academic laboratories, including many student projects, publish herbal toothpaste formulations at a high rate.

The resulting literature is large but uneven. Papers differ in the plant materials, the base, the tests and the acceptance limits used, and they seldom connect laboratory results to what happens in the mouth. A review that reads this literature critically, rather than listing formulations, is therefore useful to formulators, reviewers and clinicians.



This review has four aims: (i) to describe the components and manufacturing of herbal toothpastes; (ii) to examine how they are evaluated against recognised standards; (iii) to weigh laboratory, cytotoxicity and clinical evidence; and (iv) to propose a minimum framework for future studies.

Literature sources and approach

This is a narrative review. Sources were found in October 2026 by searching journal websites, open-access indexes (such as DOAJ) and publisher platforms with combinations of the terms *herbal toothpaste*, *polyherbal dentifrice*, *formulation and evaluation*, *abrasivity*, *ISO 11609*, *fluoride*, *cytotoxicity*, *plaque*, *gingivitis*, *neem*, *clove*, *eugenol*, *curcumin* and *sodium lauryl sulphate*. We included formulation studies, systematic reviews and meta-analyses, clinical trials, standards documents and safety studies. Conference abstracts and manufacturer reports were used only where marked as such. Because the search was not run in a fixed set of bibliographic databases with a registered protocol, some relevant work may have been missed, and the review should be read as a critical synthesis rather than a systematic review.

Composition and formulation

Components of the base

A herbal toothpaste has the same functional architecture as any other paste (Table 1). The herbal ingredient usually occupies only a few percent of the mass, so the base largely determines cleaning, texture, taste and stability.

Table 1. Typical components of a herbal toothpaste base

Component	Common choices	Function	Points to consider
Abrasive	Calcium carbonate, dicalcium phosphate, silica	Removes plaque and stain	Particle size and hardness decide enamel and dentine wear
Humectant	Glycerin, sorbitol	Prevents drying	Sorbitol has a lower sweetness-related caries risk than sucrose-type sugars
Binder	Sodium CMC, xanthan gum, gum acacia	Gives body, prevents separation	Influences viscosity and extrusion
Surfactant	SLS or milder alternatives	Foam, spreading	SLS may irritate mucosa [2,3]
Preservative	Parabens, sodium benzoate	Prevents microbial growth	Plant powders add microbial load
Flavour, sweetener	Peppermint, menthol, saccharin	Taste	Some mint-derived compounds raised cytotoxicity concern [11]
Active (herbal)	Powders, extracts, essential oils	Antibacterial, anti-inflammatory	Dose, solvent and standardisation are rarely reported
Fluoride (optional)	Sodium fluoride, monofluorophosphate	Anti-caries	Often absent from herbal pastes [11]

Commonly used herbal actives

Neem (*Azadirachta indica*). Reviews describe antibacterial, anti-cariogenic and anti-plaque actions of neem against oral bacteria such as *Streptococcus mutans* [4]. In a six-week clinical study, a mucoadhesive gel containing neem leaf extract (25 mg/g) lowered the plaque index and bacterial count significantly more than the control, with 0.2% chlorhexidine mouthwash as the positive control [5]. A small clinical study of a neem-leaf toothpaste also reported lower plaque and papillary bleeding scores within seven days in 40 subjects [6]. These studies are short, and most used gels or mouth rinses rather than finished toothpastes.

Clove (*Syzygium aromaticum*). The main constituent, eugenol, is antiseptic and mildly analgesic. Eugenol from clove leaf oil inhibited the periodontal pathogen *Porphyromonas gingivalis* at 31.25 μ M by damaging the cell membrane and



also reduced biofilm formation [7]. The same property raises a caution: pure eugenol was toxic to human gingival fibroblasts in an in vitro study [8], so concentration in a paste needs control.

Turmeric (*Curcuma longa*). Curcumin acts mainly as an anti-inflammatory agent. A systematic review of 14 clinical trials in gingivitis found that curcumin products lowered plaque, gingival and bleeding indices and were about as effective as chlorhexidine mouthwash, with no serious adverse effects [9]. Almost all of that evidence concerns rinses and gels. For toothpaste, a manufacturer-reported conference abstract described a fluoride paste with 0.3% tetrahydrocurcumin that reduced plaque and gingivitis from baseline over six months [10]; being an industry abstract, it needs independent confirmation.

Guava, tulsi, licorice, cinnamon and mint. In a survey of 15 commercial herbal pastes, the four with the strongest activity against *S. mutans* contained ingredients such as guava extract, licorice extract, peppermint extract, clove oil or cinnamon oil, although the authors could not assign the effect to any single ingredient [11].

What published formulation studies report

Table 2 summarises representative formulation papers. They agree on the broad finding that plant-based pastes can be made with acceptable physical properties, but they differ widely in depth.

Table 2. Representative formulation studies

Study	Herbal actives	What was evaluated	Main limitation
Kiani et al., 2017 [1]	<i>Thymus vulgaris</i> essential oil (gel and opaque pastes)	Stability at three temperatures, pH, consistency, taste, smell, packaging compatibility, GC-MS of oil, lead and arsenic	No antimicrobial or clinical data
Annisa et al., 2023 [12]	Bay leaf essential oil (gel; four formulations)	Physicochemical standards, extrinsic stain removal	Stain removal comparable to control, no plaque or antibacterial outcome
Polyherbal paste, 2026 [13]	Neem, guava, clove, cardamom, turmeric with honey, baking soda, coconut oil	pH (7.5), appearance, odour, taste, irritancy, foaming, viscosity	Single formulation; no comparison or antimicrobial test
Comparative study, 2026 [14]	Herbal paste compared with four marketed herbal brands	Colour, odour, pH, homogeneity, spreadability, foam, moisture, gritty particles	Differences in pH, foam and moisture noted, no standard abrasivity
<i>Cajanus cajan</i> paste, 2022 [15]	<i>C. cajan</i> extract (F1 to F3)	Egg-shell abrasion, gritty matter, spreadability, foam, pH	Batch chosen by a subjective comparison with one marketed paste
<i>Pongamia pinnata</i> paste [16]	Seed extract (70% ethanol) with clove oil; SCMC and MCC polymers	Two methods of preparation, physicochemical and antimicrobial tests	Record is not a conventional journal article; details need verification
Polyherbal paste, IJCPR [17]	Pomegranate, lemon, mango	Antibacterial activity against <i>S. aureus</i> , <i>B. cereus</i> , <i>E. coli</i> , <i>P. aeruginosa</i> ; stability	Organisms are not the main caries pathogens
Neem oil paste, 2017 [18]	Solvent-extracted neem oil	Effect of foaming agent, humectant, binder, preservative on pH, viscosity, foam, lead and arsenic	Shows that excipients matter, but no biological evaluation

Three patterns stand out. First, most papers prepare and test a single batch or three batches that differ only in herbal level. Second, acceptance is judged by comparison with one marketed paste rather than against a standard. Third,



endpoints are almost entirely physical, with antimicrobial tests in a minority and cytotoxicity or clinical outcomes in almost none.

The fluoride question

Brushing with a fluoride paste remains the best-established way to prevent caries, because fluoride promotes remineralisation during acid challenges [11]. Many herbal pastes leave fluoride out. In a recent laboratory survey of 15 commercial herbal toothpastes in Thailand, 10 of 15 (66.7%) contained less than 600 ppm fluoride and only three (20%) contained about 1500 ppm [11]. Three products combined adequate fluoride, effective antibacterial activity and low cytotoxicity, which shows that a herbal formulation and an effective fluoride level are compatible [11]. A herbal formulation intended to prevent caries should state its fluoride content and justify it, and should not rely on plant extracts alone.

Quality evaluation: what should be measured

A herbal toothpaste is a dentifrice first and a herbal product second, so it should meet the same quality requirements as other dentifrices. The international standard ISO 11609 sets requirements and test methods for dentifrices [19]; a fourth edition appeared in 2026 and replaces the 2017 edition [20]. The Bureau of Indian Standards publishes the Indian specification, IS 6356 [21]. Earlier editions of ISO 11609 required a toothpaste to have a pH below 10.5 and asked for extra enamel testing when the pH is below 5.5 [22]. The upper limit of dentine abrasivity used in practice, Relative Dentine Abrasivity (RDA), is 250 [19].

Table 3. Evaluation parameters and how they are usually handled

Parameter	Common method	Reference point	Comment
Organoleptic	Visual and sensory	Pleasant, uniform	Subjective; use a defined panel
pH	Aqueous suspension, pH meter	Within the limits of the applicable standard [19,22]	Report the dilution used
Abrasivity	Egg-shell or glass-slide test (student level); RDA by profilometry (standard)	RDA not above 250 [19]	The egg-shell test is only a rough screen; the diluent can bias RDA for acidic pastes [23]
Spreadability, extrudability, viscosity	Slide method, tube extrusion, viscometer	Batch-to-batch consistency	Needed for scale-up
Foaming	Foam height after shaking	Adequate, stable foam	Depends on the surfactant chosen
Moisture	Loss on drying	Within specification	Linked to microbial stability
Heavy metals	Limit tests or atomic absorption	Within limits	Lead and arsenic were not detected in a thyme-oil paste [1]; plant powders can carry metals
Microbiological quality	Total count, specified organisms	Within limits for oral products	Plant powders raise bioburden [24]
Fluoride	Ion-selective electrode	Declared and justified	Rarely measured in herbal studies [11]
Stability	Real-time and accelerated storage	Principles of ICH Q1A(R2) [25]	Tubes and pH, viscosity, separation checked at intervals
Cytotoxicity	Fibroblast viability assay	Low toxicity at use dilution	Not reported in most formulation papers [11]
Antimicrobial	Well diffusion, MIC, biofilm	Active against caries organisms	Use <i>S. mutans</i> , lactobacilli, <i>C. albicans</i>

An important methodological point concerns abrasivity. A clean paste with no gritty particles is not the same as a safe paste, because wear of enamel and dentine depends on the hardness, size and shape of the abrasive and on pH. In an



experimental study, using deionised water as the diluent, as the ISO method recommends, increased the measured absolute dentine abrasion and the RDA of an acidic paste by 35% and 14% compared with a buffer simulating saliva, but did not change the result for a neutral paste [23]. This means that the choice of method matters most for pastes with an unusual pH, which can include herbal pastes that contain acidic plant extracts. For quality control, plant raw materials should be authenticated and tested with the methods described in the WHO manual on herbal materials [24].

Biological evidence in the laboratory

Antimicrobial activity

Laboratory studies often show that herbal pastes inhibit oral bacteria. In the Thai survey, four of 15 commercial herbal pastes had strong activity against *S. mutans*, with inhibition zones comparable to vancomycin used as the positive control [11]. A systematic review of caries prevention concluded that herbal and fluoride dentifrices have similar antimicrobial activity against cariogenic organisms, but all included studies, five clinical and five in vitro, were at high risk of bias [26].

The efficacy-toxicity trade-off

Strong activity does not come free. The same Thai study found that antibacterial activity was associated with greater cytotoxicity, whereas fluoride content was not associated with either [11]. Ingredients such as clove oil, camphor, menthol, borneol and peppermint were suggested as possible contributors to cytotoxicity through membrane disruption and oxidative stress, while a product built on antioxidant-rich plant extracts and a mild surfactant showed the lowest cytotoxicity [11]. This supports the point made in Section III-B for eugenol [8]. The study used cell cultures and single-species assays, so its findings do not prove harm in daily use, but they show that antimicrobial strength alone is a poor marker of product quality.

Clinical evidence

A systematic review and meta-analysis of 24 randomised trials in adults aged 18 to 65 years analysed 15 trials of herbal toothpaste (899 participants) and nine of herbal mouth rinse (698 participants) [27]. Herbal toothpaste reduced plaque more than non-herbal toothpaste overall (SMD 1.95, 95% CI 0.97 to 2.93), but it was not shown to be superior to fluoride toothpaste (SMD 0.99, 95% CI 0.14 to 2.13), and it was favoured over non-fluoride toothpaste [27]. The authors concluded that for short-term plaque reduction herbal toothpaste is about as effective as non-herbal toothpaste, but that the evidence comes from low-quality studies [27]. A student dissertation that compared herbal and fluoride dentifrices in randomised trials found a small difference in plaque index and no difference in gingival index, with very high heterogeneity, and concluded that herbal dentifrices add no benefit over fluoride pastes [28]; as an unreviewed dissertation it should be treated cautiously.

A 24-week randomised clinical trial compared a herbal toothpaste with a triclosan/copolymer paste and an amine/stannous fluoride paste. The herbal paste gave significantly lower plaque and oral-hygiene index values than the fluoride paste during the study and was as good as the controls, which led the authors to describe it as a suitable alternative for improving periodontal conditions [29]. A recent narrative review, summarised in a news report, also found that herbal pastes containing neem, triphala or green tea reduced plaque and gingival scores from baseline to a degree equivalent to conventional standards [30]. Taken together, these results are encouraging for plaque and gingivitis, but they say little about caries, which depends on fluoride, and almost no trial follows participants for more than a few months.

Safety, labelling and regulation

Irritants kept in the base. Many herbal pastes still contain SLS. A scoping review reported mucosal desquamation, irritation, inflammation and ulceration as possible harmful effects of SLS in toothpastes, with limited evidence that people with recurrent aphthous ulcers benefit from SLS-free pastes [3]. A systematic review of four small crossover trials found fewer ulcers, shorter ulcer duration and less pain with SLS-free pastes, although the studies were small and at risk of bias [2]. A herbal paste that keeps SLS therefore removes only part of the irritant load that motivates the switch.



Active ingredients. Plant actives can also irritate or cause allergy, and high eugenol levels are cytotoxic in cell models [8,11]. Safety testing in herbal pastes is usually limited to a skin or mucosal irritancy check, which cannot reveal subtle cytotoxicity.

Labelling. An analysis of ten marketed herbal pastes noted that some products sold as herbal listed no herbal ingredient in their composition, and that several herbs included were not needed for daily use [31]. Fluoride labelling has also been inconsistent: in the Thai survey, manufacturers were not required at the time to declare fluoride on labels [11]. Consumers cannot, therefore, rely on the word "herbal" to judge either content or benefit.

Critical appraisal and research gaps

The formulation literature shows a recurring set of weaknesses:

Single-batch design. One formulation is prepared and described, so reproducibility and variability are not known.

Weak comparators. A marketed paste is used as the benchmark without matching its abrasive, surfactant or fluoride content.

Non-standard abrasivity testing. Egg-shell and finger-rub tests replace RDA, even though abrasivity is central to enamel and dentine safety [19,23].

Omission of fluoride and cytotoxicity. Most papers neither measure fluoride nor test effects on oral cells [11].

Unstandardised plant material. Species authentication, extraction solvent, marker compounds and heavy-metal content are often missing [24].

Short or absent clinical follow-up. Clinical trials are small and short, and evidence on caries prevention is limited to antimicrobial surrogates [26,27].

Publication bias. Almost all published formulations are reported as safe and effective, and negative or neutral results are rare.

A minimum evaluation framework

Based on the gaps above, we suggest that future herbal toothpaste studies report the items in Table 4. The list is intended as a practical checklist for authors and reviewers and is not a regulatory requirement.

Table 4. Proposed minimum reporting framework

Domain	Minimum content
Raw materials	Botanical name, part used, voucher specimen, extraction method, marker compound, heavy-metal and microbial limits
Formulation	Full composition in % w/w, number of batches, justification of surfactant, preservative and fluoride level
Physicochemical	pH, viscosity, spreadability, extrudability, foam, moisture, homogeneity, with replicate data
Safety	Abrasivity by a standard method such as RDA, cytotoxicity on relevant oral cells, irritancy
Stability	Storage in the final pack under at least two temperatures with scheduled checks
Biological	MIC and MBC or biofilm assay against <i>S. mutans</i> , lactobacilli and <i>C. albicans</i> , with a fluoride and a marketed control
Clinical (where possible)	Registered randomised design, plaque and gingival indices, adverse events, follow-up of at least 12 weeks
Reporting	Negative and neutral findings, conflicts of interest, full raw data on request

II. CONCLUSION

Herbal toothpastes are easy to formulate and generally meet basic physical tests, and short-term trials suggest they control plaque about as well as conventional pastes. The evidence is limited by small and low-quality trials, a lack of standard abrasivity and cytotoxicity testing, widespread omission of fluoride, and inconsistent labelling. The finding that strong antibacterial activity can accompany cytotoxicity means that the most active product is not automatically the



best. Future work should combine standardised plant material, an evidence-based base with a justified fluoride level, validated safety and abrasivity testing, and well-designed clinical trials. Until then, "herbal" should be read as a description of the ingredients, not as proof of efficacy or safety.

Declarations

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