Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

Antimicrobial and Anti-Plaque Efficacy of Moringa Oleifera-Based Mouthwashes Compared to Conventional and Herbal Alternatives: A Systematic Review

Dr. Poonam Rai[1], Dr. Shrushti Sukalkar[2], Dr. Mancy Modi[3],

Dr. Jayesh Nikam[4], Dr. Varsha Rathod[5] & Dr. Meher Bindra[6]

[1,2,3,4,5,6]Academic Qualification: M.D. S

(Department of Periodontics & Oral Implantology) D.Y. Patil Deemed to be

University, School of Dentistry, Nerul, Navi Mumbai, India

Corresponding Author Email: jayeshnikam19@gmail.com

(Received: 05 January 2026 Revised: 15 February 2026 Accepted: 15 March 2026)

KEYWORDS

Moringa oleifera; mouthwash; plaque index; gingivitis; antimicrobial activity

ABSTRACT:

Background: Herbal mouthwashes are being explored to control plaque and gingival inflammation with fewer adverse effects than conventional chemical rinses. Objective: To evaluate the antimicrobial and anti-plaque efficacy of Moringa oleifera (MO)–based mouthwashes.

Methods: This PRISMA-guided systematic review followed a PROSPERO-registered protocol (CRD420251039855). Searches were performed in PubMed, Embase, Scopus, CINAHL, and Google Scholar. Eligible studies included clinical trials and in vitro experiments assessing MO formulations against oral pathogens and/or clinical plaque and gingival outcomes. RoB 2 and QUIN were used for quality appraisal, and GRADE was applied to clinical outcomes.

Results: Seven studies were included (five randomized clinical trials and two in vitro studies). MO concentrations ranged from 0.015% to 15% using aqueous or ethanolic extracts. Compared with chlorhexidine, fluoride mouthwash, saltwater, or other alternatives, MO generally produced significant short-term improvements in microbial measures and in plaque and gingival indices; one trial reported plaque index 1.83→0.98 and gingival index 0.88→0.37. In vitro inhibition zones reached 28 mm against Staphylococcus aureus. Four trials were low risk of bias and one had some concerns; QUIN ratings were low and moderate. GRADE certainty was high for plaque reduction, moderate for gingival and clinical antimicrobial outcomes, and low for acceptability.

Conclusion: MO mouthwashes appear promising for short-term plaque control and gingival health, but standardized formulations and longer trials are required.

Introduction

Periodontal diseases originate from a complex microbial biofilm that adheres to the tooth surface at and below the gingival margin [1]. After pellicle formation, early colonizers such as *Streptococcus sanguinis* and *Actinomyces naeslundii* attach and support microbial succession, while bridging organisms facilitate the entry of late, more pathogenic species [2,3]. The extracellular polymeric substance increases tolerance to salivary shear forces, host defenses, and antimicrobials, allowing the biofilm to persist [4]. With dysbiosis, this triggers an exaggerated inflammatory response that drives connective-tissue breakdown and alveolar bone loss [5-8].

Mechanical plaque control remains the cornerstone of prevention, but effective daily plaque removal is difficult

Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

for many individuals, especially children, elderly patients, and those with limited dexterity or special needs [9,10]. Mouthwashes can complement brushing by reaching difficult areas, lowering bacterial load, and helping to control gingival inflammation [11]. Chlorhexidine gluconate is the gold standard because of its broad antimicrobial activity and substantivity, yet prolonged use is limited by staining, taste alteration, and mucosal irritation in some users [12-14]. These drawbacks can reduce adherence and restrict its routine use when longer-term rinsing is desired.

Herbal mouthwashes are therefore being explored as potentially more acceptable alternatives [15-18]. *Moringa oleifera* is a widely cultivated medicinal plant; its leaves contain flavonoids, tannins, saponins, alkaloids, and phenolic compounds with reported antimicrobial activity against cariogenic and periodontopathogenic microorganisms [19-21]. In addition, its antioxidant and anti-inflammatory profile may support gingival health outcomes alongside microbial reduction [22]. It is generally considered safe for human use, which is relevant when small volumes are inadvertently swallowed during rinsing [23]. However, studies vary in extraction methods, concentrations, comparators, and outcomes, making conclusions inconsistent. Therefore, this systematic review aimed to synthesize the available evidence on the antimicrobial and anti-plaque efficacy of MO–based mouthwashes compared with conventional and herbal alternatives.

Materials and Methods

The present systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [24], and the protocol was registered in the PROSPERO repository (CRD420251039855).

Eligibility criteria

Eligibility was defined using the PICOS framework. For the clinical component, studies were eligible if they included human participants of any age and assessed plaque accumulation and/or gingival inflammation, or evaluated oral microbial outcomes after the use of a mouthwash. Studies in healthy volunteers were also eligible when oral microbial changes were assessed following mouthwash use. For the laboratory component, in vitro studies were eligible if they tested MO formulations or extracts against oral microorganisms relevant to plaque formation and gingival inflammation, such as cariogenic bacteria, periodontopathogens, and opportunistic organisms.

The intervention of interest was any mouthwash formulation containing MO, including aqueous, ethanolic, mixed-solvent, or enhanced formulations. Studies were excluded if MO was used only as a systemic supplement or if it was combined with other active agents in a manner that prevented isolation of its specific effect. Acceptable comparators included conventional chemical mouthwashes (such as chlorhexidine or fluoride mouthwashes), herbal alternatives, placebo rinses, saline, or standard antimicrobial controls in in vitro experiments. Studies were included if they reported at least one relevant outcome: antimicrobial activity, and clinical anti-plaque and gingival outcomes (for example, plaque index and gingival index). Patient-reported acceptability and adverse effects were also extracted when reported. Eligible study designs included randomized controlled trials, controlled clinical trials, quasi-experimental clinical studies, and in vitro experimental studies. Case reports, narrative reviews, editorials, letters, and studies with insufficient methodological description were excluded.

Information sources and search strategy

A comprehensive electronic search was performed in major databases including PubMed, Embase, Scopus, MEDLINE, CINAHL, EBSCO-hosted resources, Science Citation Index, and Google Scholar. Supplementary searching was also undertaken using ScienceDirect to minimize the risk of missing relevant studies. No date restrictions were applied, and the search was restricted to studies published in English. To improve retrieval, reference lists of included studies and relevant review articles were hand-searched, and forward citation checking was performed where feasible. Duplicate records were identified and removed using Mendeley reference manager prior to screening.

Study selection process

Study selection was carried out in two stages. First, two reviewers independently screened titles and abstracts to identify potentially eligible studies. Full texts were then retrieved for records deemed relevant or unclear at the abstract stage, and eligibility was confirmed against the

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

predefined criteria. Any disagreements between reviewers were resolved through discussion, and when consensus could not be reached, a third reviewer adjudicated the decision.

Data extraction

Data extraction was performed independently by two reviewers using a pretested structured extraction sheet to ensure consistency. Extracted variables included study identification (author, year, and country), study design and setting (clinical or in vitro), sample size and participant characteristics for clinical studies, microbial strains or isolates for in vitro studies, details of the MO formulation (extract type, solvent system, concentration, additives, and duration of use), comparator intervention, outcome assessment methods (microbiological techniques and/or clinical indices), follow-up duration, statistical methods, key quantitative results, and any reported adverse effects or acceptability findings. Discrepancies in extracted data were resolved by rechecking the source article and reaching a consensus. Where the same study reported both clinical outcomes and laboratory antimicrobial assays, it was treated as a single included study and categorized under the clinical evidence base for synthesis, while the laboratory findings were recorded as supportive outcomes within the same study.

Risk of bias assessment

Methodological quality was assessed using tools appropriate to study design. Randomized clinical trials were evaluated using the Cochrane Risk of Bias tool (RoB 2), which assesses bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of the reported result [25]. an overall judgement was assigned for each trial based on domain-level assessments. In vitro studies were evaluated using the QUIN tool, which examines clarity of objectives, standardization of sample preparation, contamination control, validity of outcome assessment, and adequacy of statistical reporting [26]. Risk of bias assessments were completed independently by two reviewers after prior calibration to maintain consistency, and disagreements were resolved through discussion, with third-reviewer input when required.

Data synthesis and statistical analysis

A narrative synthesis was undertaken for all included studies, structured by study type (clinical versus in vitro) and outcome domain (antimicrobial, plaque outcomes, gingival outcomes, and acceptability/adverse effects). Summary tables were prepared to present study characteristics and outcome findings in a standardized manner. Where outcome measures, comparators, and follow-up periods were sufficiently comparable across at least two studies, meta-analysis was planned using RevMan 5.4. For continuous outcomes, effect estimates were intended to be calculated as mean difference or standardized mean difference with 95% confidence intervals, depending on whether studies used the same scale or different scales for comparable constructs. Statistical heterogeneity was assessed using the Chi-square test and quantified using the I^2 statistic. A fixed-effect model was planned for low heterogeneity, while a random-effects model was planned where heterogeneity was substantial (I^2 greater than 50%). When pooling was not appropriate due to clinical or methodological heterogeneity, findings were synthesized narratively without quantitative combination.

Subgroup and sensitivity analyses

Where data permitted, subgroup analyses were planned based on extract type (aqueous versus ethanolic versus other formulations), concentration ranges, comparator category (chlorhexidine versus other chemical agents versus herbal or placebo comparators), and study setting (clinical versus laboratory). Sensitivity analyses were planned by excluding studies judged to have higher risk of bias or key methodological concerns to examine the robustness of the overall conclusions.

Certainty of evidence assessment

The certainty of evidence for clinically relevant outcomes was assessed using the GRADE approach [27]. Evidence was evaluated across risk of bias, inconsistency, indirectness, imprecision, and publication bias to determine the confidence in effect estimates for each outcome domain. Final certainty ratings were categorized as high, moderate, low, or very low, and a summary evidence profile was prepared with explicit reasons for any downgrading decisions.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

Results

A total of seven studies were included in this systematic review (Figure 1), among which five were clinical studies conducted in human participants [29,31-34], while two were laboratory-based in vitro investigations [28,30]. The studies were conducted across South Asia, Southeast Asia, and North Africa, with n=3 studies from India, n=1 from Pakistan, n=1 from Thailand, and n=2 from Egypt. The data extracted from these studies are summarized in Table 1, Table 2, and Table 3.

In terms of study design, the included clinical studies varied as follows: one was a double-blind randomized controlled clinical trial [34], one was a randomized controlled trial [31], one was a single-blind randomized clinical trial [32], one was a single-blind randomized placebo-controlled trial [29], and one was a randomized clinical trial that also included laboratory-based antimicrobial testing as part of the same study protocol [33]. The remaining two studies were purely in vitro experimental investigations [28,30]. Four studies were set in clinical environments [29,31,32,34], and one clinical study included both clinical outcomes and accompanying in vitro antimicrobial assays but was categorized under the clinical evidence base for this review [33].

The sample sizes in clinical studies ranged from 25 to 90 participants, with most including either healthy adults or children diagnosed with gingivitis or dental plaque accumulation. One study focused on children aged 6–13 years [31]. The in vitro studies used either clinical microbial isolates or standard reference strains and applied various formulations of MO extracts for antimicrobial testing [28,30].

The formulations of MO used in the mouthwashes varied significantly across studies. Extracts were prepared using aqueous, ethanolic, or mixed solvents (including acetone and ethyl acetate), with ethanolic extraction being the most common method. Concentrations of the MO extract ranged from as low as 0.015% [29] to as high as 15% [31]. Other commonly used concentrations included 2%, 5%, and 0.2%, with some formulations additionally incorporating flavoring agents like peppermint oil, humectants like glycerine, sweeteners like aspartame, or nanoparticle enhancement using silver [30]. One study used a relatively high concentration of 400 mg/mL in plant extract form for in vitro testing [28].

Comparators used across studies included CHX in five studies, either at 0.2% or 0.12%, which served as the gold standard control [29,31-34]. One study used fluoride-based mouthwash (DG Wash) [31], another employed saltwater [34], and one used coconut oil alongside CHX and MO formulations for three-arm comparisons [32].

A broad range of microorganisms was tested, either as cultured isolates or through salivary/plaque-based total bacterial assessments. These included Streptococcus mutans (n=5), Staphylococcus aureus, Enterococcus faecalis, Candida albicans, Aggregatibacter actinomycetemcomitans, Veillonella parvula, and red-complex pathogens like Porphyromonas gingivalis, Tannerella forsythia, and Treponema denticola [28-34]. Shoukat et al. (2024) tested a panel of oral bacteria using differential plate count (DPC) methods [32], whereas Sultana et al. (2024) included MIC and MBC protocols alongside clinical plaque assessments [33].

The outcome measures varied but generally centered around microbial reduction (CFU/mL or zone of inhibition), plaque index (PI), and gingival index (GI), along with composite measures like the Oral Hygiene Index-Simplified (OHI-S). In vitro outcomes such as zone of inhibition were reported in studies evaluating antimicrobial activity under laboratory conditions [28,30]. Kumar et al. (2022) reported zones as high as 28 mm for S. aureus [30], while Elgamily et al. (2016) noted that toothpaste formulations had higher inhibition diameters than mouthwash [28]. Clinical microbial reductions included MO 15%, leading to 48.07% reduction in S. mutans [31], and MO 2%, achieving 61% total plate count reduction [32].

Among studies assessing plaque and gingival outcomes, significant reductions were noted. Kandukuri et al. (2025) demonstrated that in the MO group, plaque index reduced from 1.83 to 0.98, gingival index dropped from 0.88 to 0.37, and OHI-S score improved from 1.36 to 1.01 [34]. Similarly, Buakew (2021) and Sultana (2024) observed statistically significant improvements in both GI and PI compared to baseline in MO groups [29,33].

Statistical analyses included ANOVA, paired t-tests, Tukey post hoc tests, Wilcoxon signed-rank tests, and Kruskal–Wallis tests [29-34]. The majority of reported outcomes reached statistical significance ($p<0.05$), suggesting that reductions in microbial load and gingival inflammation were unlikely to be due to chance. In

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

studies with multiple arms, MO generally showed comparable improvements to CHX for several outcomes, although CHX remained numerically stronger in some comparisons [29,31-34].

In terms of tolerability and adverse effects, no serious adverse events were reported across studies. However, unpleasant taste was noted in the MO group in the study by Shoukat et al. (2024), though it did not result in participant dropout or discontinuation [32]. Overall, the evidence supports the antimicrobial, anti-plaque, and anti-gingivitis properties of MO-based mouthwashes, with favorable tolerability across the included clinical studies [29,31-34] and supportive in vitro findings [28,30].

Risk of bias

The four randomized clinical trials were judged as having low overall risk of bias (Figure 2) [29,31,33,34]. One trial was judged as having some concerns, mainly due to limited methodological detail regarding standardization of microbiological sampling/processing and the potential for measurement-related bias under single-blind conditions [32]. Among the in vitro studies (Table 4), QUIN assessment classified both in vitro studies as having medium risk of bias, with percentage scores of 59.1% and 54.5%, respectively [28,30]. In both studies, strengths included clear study objectives, use of comparator groups, adequate description of antimicrobial testing methods, and presentation of results; however, methodological reporting was limited for sample size calculation, operator and assessor details, and blinding procedures, which lowered the overall QUIN scores [28,30].

Certainty of evidence

To avoid indirectness from laboratory-only endpoints, GRADE ratings were applied to **c**linical outcomes, while in vitro findings were used as supportive mechanistic evidence (Table 5). Antimicrobial efficacy received a moderate certainty rating because clinical microbial outcomes were assessed using varying sampling and microbiological methods, with heterogeneity in formulations and concentrations contributing to inconsistency and imprecision [29,31-33]. Anti-plaque efficacy was supported by high-certainty evidence as plaque index outcomes were assessed across multiple trials using comparable indices and showed consistent improvements [29,31-34]. Gingival health outcomes were rated as moderate certainty due to fewer contributing studies and smaller sample sizes leading to imprecision [29,33,34]. Patient acceptability and side effects were rated as low certainty because reporting was inconsistent and outcome collection was subjective and limited to a small number of trials [32-34].

Discussion

The present systematic review found that mouthwashes containing MO have a significant clinical impact on caries and periodontal microorganisms. All the clinical trials and laboratory studies included in this review found a reduction in the microbial load using CFU, total plate count, MIC/MBC, and inhibition zones, similar to the effects of CHX [28-34]. Moreover, the effects of MO on Streptococcus mutans, Staphylococcus aureus, and periodontopathogens also confirmed the biological plausibility of MO as a multi-target phytochemical. The flavonoids, tannins, saponins, alkaloids, and glucosinolate-derived isothiocyanates are the main components of MO [15,16]. They are responsible for their actions on the bacterial cell membrane, on cellular survival mechanisms, and quorum-sensing molecules, essential for biofilm maturation [35].

Recent studies that have shown improvements in plaque and gingival indices have also confirmed the role of MO as an oral hygiene product. These short-term studies have shown improvements in both plaque and gingival indices, and whilst the degree of improvement has varied between studies, they generally suggest significant improvements [28-34]. In addition to the bacterial action of the MO, the quercetin and kaempferol present may also have an anti-oxidative role in reducing the inflammatory mediators [36,37]. Despite this, the MO should not replace mechanical control of plaque [35]. It may be a useful adjunctive oral rinse for patients with poor dexterity, or those with an inconsistent oral hygiene regime and with increased inflammatory responses.

A common theme in both laboratory and field tests was the concern over the significance of the formulations and concentrations of the active ingredients in the various concoctions. As with most plant derived antifungal remedies ethanol-based solutions were generally most effective at the mid-to-high concentrations of 10–15% v/v. Ethanol can cause lipophilic components of plant secretions to become soluble (28–34). In the in vitro

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

studies, the effect of including nanoparticles in antifungal mixtures was also tested, and in a number of trials they also were found to have useful activity [38]. However, these same lower concentration solutions were used as the control treatments in a number of clinical trials where the more concentrated alcohol-based solutions were the active treatments. Hence, this also would require standardisation of formulations to confirm that any differences in concentration between the various treatments was effective [39].

In the present analysis, MO-based rinses generally performed as well as CHX. In multi-arm trials, there was generally the same trend for MO and CHX, and of a similar magnitude to each other, but with an advantage of CHX for most of the outcomes [28-34]. In a couple of single arm studies, where MO was compared with non-CHX alternatives, the MO performed as well as or even better than these [40]. Again, these are comparisons of short-term comparable efficacy and not of the more rigorous non-inferiority type, as the non-inferiority margins were not predefined in any of the included studies. The tolerability of the two products was assessed in both studies and was generally good. There were no adverse effects of clinical significance, and minor adverse effects, in the form of an occasional unpleasant taste, were not such as to cause withdrawal of the product.

Caution should be exercised when drawing conclusions about long term tolerability because of the inconsistent reporting of adverse effects and short observation period. The review has identified a number of limitations which include differences in the herbal extract used, concentration of extract (0.015% to 15%) and different comparison groups and different outcome measures. The short follow-up period in the studies has also not allowed direct head-to-head comparisons and data pooling. However, the short term consistent improvements in clinical and patient reported outcomes give some basis for cautious optimism about their use. Further clinical studies are required with standardisation of product formulations and longer term clinical and patient reported outcome studies needed to fully assess their clinical benefits.

Conclusion

Within the limitations of this systematic review, *Moringa oleifera*–based mouthwashes showed short-term antimicrobial activity and were associated with reductions in plaque and gingival indices across the included studies. In several comparisons, their effects were broadly comparable to standard rinses such as chlorhexidine, with few reported adverse effects, although acceptability outcomes were inconsistently measured. Further well-designed trials with standardized formulations, consistent outcome reporting, and longer follow-up are needed to clarify optimal concentrations and sustained clinical benefit.

References:

1. Ray RR. Periodontitis: an oral disease with severe consequences. Applied Biochemistry and Biotechnology. 2023 Jan;195(1):17-32. https://doi.org/10.1007/s12010-022-04127-9
2. Pugazhendhi AS, Wei F, Hughes M, Coathup M. Bacterial adhesion, virulence, and biofilm formation. In: Musculoskeletal Infection. Cham: Springer International Publishing; 2022 Feb 1. p. 19-64. https://doi.org/10.1007/978-3-030-83251-3_2
3. Aryah US, Prasanth N, Stani R, Kandanattu B, George N. Dental Disease Association with Bacterial Biofilm. In: Bacterial Biofilm and Chronic Infections: Role in Disease Pathogenesis and Therapeutic Strategies. Singapore: Springer Nature Singapore; 2025 Oct 1. p. 99-134. https://doi.org/10.1007/978-981-96-8975-0_6
4. Marsh PD. In sickness and in health—what does the oral microbiome mean to us? An ecological perspective. Advances in Dental Research. 2018 Feb;29(1):60-5. https://doi.org/10.1177/0022034517735295
5. Lamont RJ, Koo H, Hajishengallis G. The oral microbiota: dynamic communities and host interactions. Nature Reviews Microbiology. 2018 Dec;16(12):745-59. https://doi.org/10.1038/s41579-018-0089-x
6. Miller DP. Microbial Biofilms and Pathobiology of Gingivitis and Periodontitis. In: Oral Biofilms in Health and Disease. Cham: Springer Nature Switzerland; 2025 May 31. p. 275-309. https://doi.org/10.1007/978-3-031-82202-5_10
7. Hajishengallis G, Diaz PI. Porphyromonas gingivalis: Immune subversion activities and

role in periodontal dysbiosis. Current Oral Health Reports. 2020 Mar;7(1):12-21. https://doi.org/10.1007/s40496-020-00249-3

8. Sell AM, de Alencar JB, Visentainer JE, e Silva CD. Immunopathogenesis of chronic periodontitis. In: Periodontitis – A Useful Reference. IntechOpen; 2017 Nov 15. https://doi.org/10.5772/intechopen.69045
9. Sälzer S, Graetz C, Dörfer CE, Slot DE, Van der Weijden FA. Contemporary practices for mechanical oral hygiene to prevent periodontal disease. Periodontology 2000. 2020 Oct;84(1):35-44. https://doi.org/10.1111/prd.12332
10. Park S, Kim DE, Park SJ, Song J, Kim HJ, Lee SK, Shin HY, Cho HJ, Park SM. Association of Toothbrushing, Dental Flossing, and Interdental Brushing with Stroke Risk. medRxiv. 2025 Aug 6. https://doi.org/10.1101/2025.08.04.25332999
11. Brookes ZL, McCullough M, Kumar P, McGrath C. Mouthwashes: implications for practice. International Dental Journal. 2023 Nov 1;73:S98-101. https://doi.org/10.1016/j.identj.2023.08.013
12. Brookes ZL, Belfield LA, Ashworth A, Casas-Agustench P, Raja M, Pollard AJ, Bescos R. Effects of chlorhexidine mouthwash on the oral microbiome. Journal of Dentistry. 2021 Oct 1;113:103768. https://doi.org/10.1016/j.jdent.2021.103768
13. Rajendiran M, Trivedi HM, Chen D, Gajendrareddy P, Chen L. Recent development of active ingredients in mouthwashes and toothpastes for periodontal diseases. Molecules. 2021 Apr 1;26(7):2001. https://doi.org/10.3390/molecules26072001
14. Deus FP, Ouanounou A. Chlorhexidine in dentistry: pharmacology, uses, and adverse effects. International Dental Journal. 2022 Jun 1;72(3):269-77. https://doi.org/10.1016/j.identj.2022.01.005
15. Tzimas K, Antoniadou M, Varzakas T, Voidarou C. Plant-derived compounds: A promising tool for dental caries prevention. Current Issues in Molecular Biology. 2024 May 26;46(6):5257-90. https://doi.org/10.3390/cimb46060315
16. Anwar MA, Sayed GA, Hal DM, Hafeez MS, Shatat AA, Salman A, Eisa NM, Ramadan A, El-Shiekh RA, Hatem S, Aly SH. Herbal remedies for oral and dental health: a comprehensive review of their multifaceted mechanisms including antimicrobial, anti-inflammatory, and antioxidant pathways. Inflammopharmacology. 2025 Mar;33(3):1085-160. https://doi.org/10.1007/s10787-024-01631-8
17. Ahuja A, Singh S. Impact of the current scenario and future perspectives for the management of oral diseases: Remarkable contribution of herbs in dentistry. Anti-Infective Agents. 2022 Oct 1;20(5):27-45. https://doi.org/10.2174/2211352520666220405124929
18. Dinu S, Talpos-Niculescu S, Smeu A, Sasco D, Alexandrescu-Bauer A, Popa M. Plant-Derived Essential Oils− An Alternative Option for Oral Health Management. Medicine in Evolution. 2025 Jun 16;31(2):166-76. https://doi.org/10.70921/medev.v31i2.1298
19. Arshad S, Sajjad B, Aftab A, Yousaf Z, Alotaibi MO. Moringa. In: Essentials of Medicinal and Aromatic Crops. Cham: Springer International Publishing; 2023 Oct 10. p. 1063-1089. https://doi.org/10.1007/978-3-031-35403-8_41
20. Arora S, Arora S. Nutritional significance and therapeutic potential of Moringa oleifera: The wonder plant. Journal of Food Biochemistry. 2021 Oct;45(10):e13933. https://doi.org/10.1111/jfbc.13933
21. Hashem AH, Al-Askar AA, Abd Elgawad H, Abdelaziz AM. Bacterial endophytes from Moringa oleifera leaves as a promising source for bioactive compounds. Separations. 2023 Jul 6;10(7):395.
22. Kumar R, Khatak S, Vandana, Shukla AK, Panwar S, Kumar A. Deciphering of nutritional profile, therapeutic potential, and networking of bioactive compounds of Moringa oleifera: A comprehensive review. Food Biomacromolecules. 2025 Sep;2(3):271-87. https://doi.org/10.1002/fob2.70013
23. Waterman C, Castro RP. Perspectives on regulatory status of moringa products and

unwarranted health claims. In: II International Symposium on Moringa 1306. 2019 Nov 10;163-70. https://doi.org/10.17660/ActaHortic.2021.1306.20

24. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. bmj. 2021 Mar 29;372.
25. Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JA. Assessing risk of bias in a randomized trial. Cochrane handbook for systematic reviews of interventions. 2019 Sep 23:205-28.
26. Sheth VH, Shah NP, Jain R, Bhanushali N, Bhatnagar V. Development and validation of a risk-of-bias tool for assessing in vitro studies conducted in dentistry: The QUIN. The Journal of Prosthetic Dentistry. 2024 Jun 1;131(6):1038-42.
27. Goldet G, Howick J. Understanding GRADE: an introduction. Journal of Evidence-Based Medicine. 2013 Feb;6(1):50-4. https://doi.org/10.1111/jebm.12018
28. Elgamily H, Moussa A, Elboraey A, El-Sayed H, Al-Moghazy M, Abdalla A. Microbiological assessment of Moringa oleifera extracts and its incorporation in novel dental remedies against some oral pathogens. Open Access Macedonian Journal of Medical Sciences. 2016 Nov 28;4(4):585-91. https://doi.org/10.3889/oamjms.2016.132
29. Buakaew W, Sranujit RP, Noysang C, Sangouam S, Suphrom N, Thongsri Y, Potup P, Usuwanthim K. Evaluation of mouthwash containing Citrus hystrix DC., Moringa oleifera Lam. and Azadirachta indica A. Juss. leaf extracts on dental plaque and gingivitis. Plants. 2021 Jun 6;10(6):1153. https://doi.org/10.3390/plants10061153
30. Kumar GK, Ramamurthy S, Ulaganathan A, Varghese S, Praveen AA. Moringa oleifera mouthwash reinforced with silver nanoparticles–preparation, characterization and its efficacy against oral aerobic microorganisms–in vitro study. Biomedical and Pharmacology Journal. 2022 Dec 20;15(4):2051-9. https://dx.doi.org/10.13005/bpj/2542
31. Salem G, Elhiny OA, Rashed MF, El Mansy M. Evaluation of the antibacterial potency of different new herbal mouthwashes against oral plaque-forming bacteria: a randomized controlled trial. Evaluation. 2023 Jan;57(01).
32. Shoukat AB, Rana BK, Khan RA, Kiyani A, Malik SZ, Muhammad M, Zahra R. Comparative efficacy of Moringa oleifera and coconut oil-based mouthwashes versus chlorhexidine in reducing human oral microbial populations in healthy adults: a single blind clinical trial. Journal of Herbal Medicine. 2024 Mar 1;44:100855. https://doi.org/10.1016/j.hermed.2024.100855
33. Sultana A, Tasneem A, Krishnappa P, Shwetha KM. Effectiveness of Moringa oleifera Mouthwash in Young Adults as an Anti Plaque Agent–An Interventional Study. Journal of Indian Association of Public Health Dentistry. 2024 Apr 1;22(2):185-90. https://doi.org/10.4103/jiaphd.jiaphd_242_23
34. Kandukuri S, Guttiganur N, Aspalli S, Bhavana. Comparing the anti-plaque and anti-gingivitis efficacy of Moringa oleifera mouthwash to chlorhexidine and salt-water concentration in treating gingivitis: a randomized controlled clinical trial. IOSR Journal of Dental and Medical Sciences. 2025 Feb;24(2 Suppl 2):49-57. https://doi.org/10.9790/0853-2402024957
35. Kamolnarumeth K, Thussananutiyakul J, Lertchwalitanon P, Rungtanakiat P, Mathurasai W, Sooampon S, Arunyanak SP. Effect of mixed chlorhexidine and hydrogen peroxide mouthrinses on developing plaque and stain in gingivitis patients: A randomized clinical trial. Clinical Oral Investigations. 2021 Apr;25(4):1697-704. https://doi.org/10.1007/s00784-020-03470-7
36. Singh S, Singh TG, Mahajan K, Dhiman S. Medicinal plants used against various inflammatory biomarkers for the management of rheumatoid arthritis. Journal of Pharmacy

and Pharmacology. 2020 Oct;72(10):1306-27. https://doi.org/10.1111/jphp.13326

37. Kumar S, Shukla A, Verma PK, kant Singh R, Kumar N, kumar Patel A, Yadav L, Kumar S, Acharya A. Methanolic extract of Moringa oleifera leaves induces Cell cycle arrest and downregulates Mitochondrial membrane potential in Dalton's Lymphoma cells. Preprint. https://doi.org/10.21203/rs.3.rs-953524/v1
38. Azlan UK, Khairul Annuar NA, Mediani A, Aizat WM, Damanhuri HA, Tong X, Yanagisawa D, Tooyama I, Wan Ngah WZ, Jantan I, Hamezah HS. An insight into the neuroprotective and anti-neuroinflammatory effects and mechanisms of Moringa oleifera. Frontiers in Pharmacology. 2023 Jan 5;13:1035220. https://doi.org/10.3389/fphar.2022.1035220
39. El-Sherbiny GM, Alluqmani AJ, Elsehemy IA, Kalaba MH. Antibacterial, antioxidant, cytotoxicity, and phytochemical screening of Moringa oleifera leaves. Scientific Reports. 2024 Dec 16;14(1):30485. https://doi.org/10.1038/s41598-024-80700-y
40. Mashele SS. Phytochemicals as Multifunctional Agents: Antimicrobial, Enzyme Inhibitory, and Wound-Healing Potentials in the Era of Drug Resistance. Preprints. 2025;2025101183. https://doi.org/10.20944/preprints202510.1183.v1

Tables:

Table 1. Study characteristics, participants, groups, and duration (chronological order)

Study (Year)	Country	Design	Setting	Sample size / samples	Participants / sample type	Groups / arms	Duration
Elgamily et al. (2016)	Egypt	In vitro experimental	In vitro	324 plant extract discs; 144 dental remedy samples	Lab strains of oral pathogens	Extracts (leaf/root/seed/mix); toothpaste; mouthwash	NA (single-time assay)
Buakew (2021)	Thailand	Single-blind randomized placebo-controlled trial	Clinical	47 participants	Adults 20–48 y (mean 23.51 y)	Placebo; KL; KL+MO; KL+NE; 0.12% CHX	14 d
Kumar et al. (2022)	India	In vitro experimental	In vitro	Not specified (100 µL tested)	Oral aerobic clinical isolates	MO-AgNPs mouthwash	NA (single-time assay)
Salem et al. (2023)	Egypt	RCT	Clinical	70 children (10/group; 7 groups)	Children 6–13 y	MO 5%, 10%, 15%; star anise 5%, 10%, 15%; fluoride control	7 d
Shoukat et al. (2024)	Pakistan	Single-blind randomized clinical trial	Clinical	90 (30/group)	Adults 18–40 y	MO 2%; 0.2% CHX; coconut oil	14 d

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

Sultana et al. (2024)	India	RCT + supportive in vitro component	Clinical + lab	25 participants + 3 strains	Young adults with plaque + lab strains	MO mouthwash vs 0.2% CHX	28 d + 2-wk washout
Kandukuri et al. (2025)	India	Double-blind RCT	Clinical	36 (12/group)	Dental students 18–25 y	MO 0.2%; CHX 0.2%; saltwater	14 d

Abbreviations: RCT: randomized controlled trial; CHX: chlorhexidine; MO: *Moringa oleifera*; KL: kaffir lime; KL+MO: kaffir lime plus *Moringa oleifera* formulation; KL+NE: kaffir lime plus nanoemulsion formulation; AgNPs: silver nanoparticles; y: years; d: days; wk: week; NA: not applicable.

Table 2. Moringa oleifera formulation details and comparators

Study (Year)	MO formulation	MO concentration	Extract type	Other ingredients (if any)	Comparator(s)
Elgamily et al. (2016)	Ethanol extract of MO leaves (also plant-part extracts tested in dental products)	400 mg/mL (extracts); toothpaste/mouthwash concentration NR	Ethanolic, acetone, ethyl acetate	NR	None
Buakew (2021)	KL+MO mouthwash	0.015% w/w	Ethanolic	NR	0.12% CHX
Kumar et al. (2022)	MO-AgNPs mouthwash (5% MO leaf extract + silver nanoparticles)	5%	Aqueous (AgNP-enhanced)	Sucralose, sodium benzoate, menthol	Amoxicillin; fluconazole
Salem et al. (2023)	Ethanolic extract-based herbal mouthwash	5%, 10%, 15%	Ethanolic	Propylene glycol, Tween, sorbitol, tegobetaine, methylparaben	Fluoride mouthwash (DG Wash)
Shoukat et al. (2024)	MO leaf extract mouthwash	2%	Ethanolic	PEG, glycerine, SLS, Tween 80, saccharin, sorbitol, ethanol, lemon flavor	0.2% CHX; coconut oil
Sultana et al. (2024)	MO mouthwash (aqueous + ethanolic extracts)	1 mg/mL (in vitro); in vivo concentration NR	Aqueous and ethanolic	NR	0.2% CHX
Kandukuri et al. (2025)	Aqueous MO leaf mouthwash	0.2%	Aqueous	Aspartame, glycerine, peppermint oil	0.2% CHX; saltwater

Abbreviations: MO: *Moringa oleifera*; CHX: chlorhexidine; AgNPs: silver nanoparticles; PEG: polyethylene glycol; SLS: sodium lauryl sulfate; NR: not reported.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

Table 3. Microbiological/clinical outcomes, key findings, and tolerability

Study (Year)	Microorganisms tested	Assessment methods	Primary outcomes	Secondary outcomes	Zone of inhibition	CFU / microbial reduction	Plaque / gingival outcomes	Key results	Adverse effects / tolerability	Conclusion
Elgamily et al. (2016)	*S. aureus, S. mutans, C. albicans*	Disc diffusion (extracts/mouthwash); agar well diffusion (toothpaste)	Zone of inhibition	None	Toothpaste: *S. aureus* 17.75 mm; mouthwash: *S. aureus* 11.75 mm; no effect on *C. albicans*	NR	NA	Toothpaste > mouthwash; ethanolic leaf extract best	None reported	MO leaf extract shows strong antimicrobial potential for dental products
Buakew (2021)	*Staphylococcus* spp., *Candida* spp.	GI, PI; microbial colony counts	GI/PI reduction	Colony count reduction	NR	45.53% (*Staph*), 20% (*Candida*)	Significant GI and PI reduction (KL+MO and CHX)	KL+MO comparable to CHX for GI, PI, microbial load	None reported	MO effective and safe for gingivitis management
Kumar et al. (2022)	*S. mutans, S. aureus, E. faecalis, C. albicans*	Agar well diffusion	Zone of inhibition	None	*S. aureus* 28 mm; *S. mutans* 20 mm; *E. faecalis* 18	NA	NA	Strong antimicrobial action of MO-AgNP mouthwash	None reported	Effective against plaque pathogens; further studies needed

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

					mm; *C. albicans* 16 mm					
Salem et al. (2023)	*S. mutans*	CFU/mL on MSBA agar	CFU reduction	None	NA	MO 5%: 39.5 %; MO 10%: 47.36 %; MO 15%: 48.07 %	Not measured	MO 10%/15% comparable to fluoride; MO 5% less effective	None reported	MO supports anti-cariogenic use
Shoukat et al. (2024)	8 oral species (incl. *S. mutans, S. aureus, A. actinomycetemcomitans*)	TPC, DPC; biochemical colony identification	TPC/DPC reduction	Taste acceptability	NA	61% TPC reduction (MO group)	NA	Similar bacterial reduction across MO, CHX, coconut oil	Unpleasant taste (MO group)	MO comparable to CHX/coconut oil; safe and effective
Sultana et al. (2024)	*P. gingivalis, T. denticola, T. forsythia*	ZOI, MIC, MBC, CFU, PI	PI + antimicrobial outcomes	Stability	MO ethanolic: 13–19 mm; MO aqueous: 9–10 mm; CHX: 16–19 mm	Significant CFU drop in MO group	MO PI: 1.69 →1.24; CHX PI: 1.78 →1.32	MO nearly equivalent to CHX	None reported	MO is a clinically safe alternative to CHX
Kandukuri et al. (2025)	None cultured (clinical indices only)	TQHPI, Löe GI, OHI-S	PI, GI, OHI-S	Self-reported advers	NA	NA	PI 1.83 →0.98; GI 0.88	MO equivalent to CHX; both >	Taste alteration reported	MO significantly reduces plaque/gi

Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(2), 802-814 | ISSN:2251-6727

				e effects			→0.37; OHI-S 1.36 →1.01	saltwater		ngivitis; safe herbal choice

Abbreviations: MO: *Moringa oleifera*; CHX: chlorhexidine; GI: gingival index; PI: plaque index; OHI-S: Oral Hygiene Index-Simplified; TQHPI: Turesky modification of Quigley-Hein Plaque Index; ZOI: zone of inhibition; CFU: colony-forming units; MIC: minimum inhibitory concentration; MBC: minimum bactericidal concentration; TPC: total plate count; DPC: differential plate count; MSBA: Mitis Salivarius Bacitracin Agar; NA: not applicable; NR: not reported; *Staph*: *Staphylococcus*.

Table 4: Risk of bias across in vitro studies using QUIN tool

Study	QUIN score (obtained / maximum)	Final score (%)	Overall risk of bias	Adequately specified (score 2)	Inadequately specified (score 1)	Not specified (score 0)	Not applicable
Elgamily et al. (2016)	**13 / 22**	**59.1%**	**Medium**	**C1, C4, C5, C8, C11, C12**	**C3**	**C2, C6, C9, C10**	**C7**
Kumar et al. (2022)	**12 / 22**	**54.5%**	**Medium**	**C1, C4, C5, C8, C12**	**C3, C11**	**C2, C6, C9, C10**	**C7**

Table 5: GRADE Evidence Profile Summary

Outcome	Number of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Overall Certainty
Antimicrobial efficacy (clinical microbial outcomes such as CFU/plate counts)	3	RCTs	Not serious	Serious	Not serious	Serious	Not assessed	Moderate
Anti-plaque efficacy (plaque index reduction)	5	RCTs	Not serious	Not serious	Not serious	Not serious	Not assessed	High
Gingival health (gingival index / bleeding-related outcomes)	3	RCTs	Not serious	Not serious	Not serious	Serious	Not assessed	Moderate
Patient acceptability and side effects	3	RCTs	Not serious	Serious	Not serious	Serious	Not assessed	Low

Figure Legends:

Figure 1: PRISMA Flow Diagram

Figure 2: Risk of bias in the included randomized clinical trials