Herbal oral care products in reducing dental plaque and gingivitis: an overview of systematic reviews

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ABSTRACT

Introduction: Herbal and conventional oral care approaches have been investigated for the reduction of plaque and gingivitis in numerous clinical trials and systematic reviews. However, the findings reported across these vary and are inconsistent. Thus, the objective of this umbrella review is to compile data from systematic reviews and provide an overview of the effects of herbal oral care products on tooth plaque and gingivitis.

Methods: A comprehensive search of the literature was performed from inception to May 30, 2023, in six databases for systematic reviews with or without meta-analyses without any language restrictions. We considered only the clinical trials comparing herbal oral care products (in form of mouth rinse or toothpaste) against standard oral care products or placebo.

Results: Few herbal oral care products particularly in form of herbal mouthrinse have a similar level of positive effect on plaque and gingivitis reduction and thus, can be used as an adjunct to traditional dentifrices. However, the shorter duration of trials (<4 weeks) and reported publication bias in the clinical trials signals towards interpreting this information with caution.

Conclusion: To accurately determine the impact of various herbal extracts on periodontal health, subsequent well-designed, long-term, and controlled trials which adhere to standardised protocols must be carried out.

Keywords: dental plaque; gingivitis; oral health; herbal

CDHA Research Agenda category: risk assessment and management

BACKGROUND

Oral health is of prime importance since it has a direct impact on an individual's entire well-being. However, oral health conditions as a consequence of poor oral hygiene remains an overlooked global health concern, affecting 3.5 billion people worldwide.[1] Dental plaque and Gingivitis are the most common oral health conditions that, if left untreated, can progress to tooth loss[2] and other systemic disorders such as cardiovascular diseases, rheumatoid arthritis, dementia, and stroke.[3] Recently a role of epigenetic processes involving microRNAs and NT-proBNP in periodontitis was observed that could influence host response against natural agents.[4-6] Thus, effective management and control of the dental plaque is an effective strategy for overall well-being and quality of life. Self-care efforts or mechanical management of dental plaque with typical oral care products such as toothpaste and mouthwash have been demonstrated success in maintaining oral hygiene and prevention of plaque formation; nevertheless, these alone will not prevent gingivitis.

Another approach that might help with eliminating and preventing microbial buildup of plaque is Chemical treatment of plaque.[7] Chemical agents such as chlorhexidine (CHX), essential oils, 0.454% stannous fluoride/sodium hexametaphosphate sodium monofluorophosphate, and cetyl pyridinium chloride have been shown to have the highest effect on gingivitis reduction.[8,9] However, following continuous usage, these chemical mouthwashes particularly alcohol-based, such as chlorhexidine, cetylpyridinium chloride can cause tooth and tongue discoloration, taste disruption, and harmful effects on the oral mucosa.[8,10,11] As a result, the hunt for alternatives persists, and the focus has switched to organic or herbal agents.

In recent years, herbal dental care products have gained popularity as a result of their perceived efficacy and effectiveness as well as possible natural and holistic advantages to oral hygiene2. It is predicated on the notion that certain plant extracts contain anti-inflammatory, anti-bacterial, and oxidative properties that may fight against the bacteria causing dental plaque while decreasing inflammation in the gums.[10,12] Thus, a number of oral care product producers and large corporations have added a variety of herbal ingredients to their products, claiming that they mimic the advantages of removal of plaque, breath freshening, and gum disease prevention.[13] These products frequently contain a blend of botanical extracts, essential oils, and other natural components with therapeutic characteristics. The most frequent herbal components mixed into oral care products are

Akarkara (anacyclus pyrethrum), Babool (acacia *arabica*), Haldi (*curcuma longa*), sanguinarine, propolis, *Azadirachta indica* (neem), charcoal, *Camellia sinensis* (Green tea), clove, and miswak.[11-13]

Herbal and conventional oral care approaches have been investigated for the reduction of plaque and gingivitis in numerous clinical trials and systematic reviews. However, the findings reported across these vary and are inconsistent.[7,10,13-15] As numerous systematic reviews (SRs) and meta-analyses (MA) are available, an umbrella review can detect evidence uncertainty and provide a high-level summary of data, resulting in a balanced and evidence-based evaluation of the effectiveness of herbal oral care products in reducing tooth plaque and gingivitis.

Objective of the study

The objective of this umbrella review is to compile data from systematic reviews to provide an overview of the effects of herbal oral care products on tooth plaque and gingivitis. This review summarizes and synthesizes the findings from published systematic reviews and/or meta-analyses to answer the following question:

"In systemically healthy individuals (P), do herbal oral care products (I) compared to conventional over-the-counter (OTC) products (C) exhibit greater efficacy in reducing dental plaque and gingivitis (O)?"

METHODS

Review registration

This overview of SRs was conducted in accordance with Cochrane Handbook for Systematic Reviews of Interventions[16], and the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2020 statement was used to conduct this review[17] as the Preferred Reporting Items for Overviews of Reviews (PRIOR) is not fully developed.[18] An a priori protocol for this study was registered with the International Prospective Register of Systematic Reviews (PROSPERO) (Registration Number CRD42022357899 dated 14th October 2022).

This overview of systematic reviews addresses the following research question: “Does herbal oral care products (toothpaste or mouthwash) have efficacy in reducing dental plaque and

gingivitis in comparison to commercial over the counter (OTC) products in adults?", focusing on:

P-Population: Participants of any age group (free from any systemic illnesses)

I-Intervention: Herbal oral care products (either toothpaste or mouth rinse)

C-Comparison: Over the counter (OTC) non-herbal oral care products (Fluoride toothpaste, non-fluoride/ non-herbal toothpaste, Chlorhexidine mouth rinse or non-herbal Mouth rinse).

Outcomes: Reduction in dental plaque levels or gingival inflammation.

Data source and search strategy

From inception to May 30, 2023, the following online databases have been sought to retriev systematic reviews irrespective of meta-analyses: Scopus, PubMed, Embase, Allied and Complementary Medicine Database, Complementary and Alternative Medicine (CAM), and Cochrane Register of Controlled Trials. Two independent reviewers (V.M. and A.M.) searched the repositories using Medical Subject Headings (MeSH) terms and text words, without no language restrictions. Boolean operators were used for combining the following search terms:

1. "herbal" OR "herb*"
2. "Hygiene, Oral" OR "Dental Hygiene" OR "Hygiene, Dental" OR "Dentifrice" OR "Mouth Rinse" OR "Mouth Rinses" OR "Rinse, Mouth" OR "Rinses, Mouth" OR "Mouth Bath" OR "Bath, Mouth" OR "Mouth Baths" OR "Mouth Wash" OR "Wash, Mouth"
3. "Indices, Dental Plaque" OR "Dental Plaque Indexes" OR "Dental Plaque Indices" OR "Index, Dental Plaque"
4. "Gingival Index" OR "Gingival Indices" OR "Index, Gingival" OR "Indices, Gingival" OR "Gingival Indexes" OR "Indexes, Gingival"
5. Systematic Review OR Meta-analysis.

Inclusion and exclusion criteria

The retrieved citations were evaluated and duplicates were removed from the database. Two reviewers (V.M and A.M.) separately examined the titles and abstracts of all the systematic reviews with or without meta-analyses papers discovered via the electronic search. The full texts were then studied and examined for additional inclusion/exclusion criteria. Studies that did not match the inclusion criteria were omitted (Table 1). Any disagreements were settled through conversation among reviewers and consulting a third subject expert. Additionally, the included studies were carefully searched to identify further potentially relevant systematic

reviews with or without meta-analyses. In the case of inadequate or missing information, contact was made with the authors.

Study selection and data extraction

The citations found during the search and full-text publications from possibly relevant SRs were evaluated independently by two reviewers. Using a standardized form, one reviewer extracted the information in question. Any discrepancies were resolved with a third reviewer after a second reviewer independently assessed the retrieved data. The following information was sought out: author along with the year of publication, participants, intervention, comparator, outcome, quality assessment technique, meta-analysis, sample size, SR quality, and findings.

Methodological quality assessment

We utilised the Joanna Briggs Institute (JBI) critical assessment checklist for systematic reviews[19] to assess the methodological quality of the SRs with or without meta-analysis. There are 11 items on the checklist, and each one is worth 1 point. Consequently, a review's overall quality score might range from 0 to 11. The publications in this comprehensive evaluation that had scores of 0-4, 5-7, and 8-11 were classified as low-, medium-, and high-quality research, respectively based on independent evaluation by two authors (S.T. and A.M.). Discussion and agreement were employed to settle any disputes.

Data synthesis and analysis

The characteristics and methodological integrity of the included SRs were compiled in a table and presented narratively. Moreover, a narrative summary of the results of the natural product intervention was also provided.

RESULTS

Literature search

371 citations were found through electronic searches across all sources, 48 of them were deleted for being duplicates, and remaining 323 titles and abstracts were located and screened for eligibility (See Figure 1). Only 28 of these were identified to be potentially eligible for full text screening. After reading 28 full text articles, 16 studies[7,10,13-15,20-30] finally met the inclusion criteria.

Study characteristics

Of these 16 studies, seven were systematic reviews and nine were systematic reviews and meta-analyses. Table 2 lists all the PICO characteristics of the included studies. Moreover, table 3, 4, and 5 provides details of demographic characteristics, qualitative and quantitative synthesis of the included studies, respectively. The included studies have been published between 2014 and 2023. The included reviews drew their conclusions from primary research ranging from 2 to 47 RCTs. The average number of databases referenced by the included papers was 3.63±2.00 with PubMed, Cochrane clinical trial registry and Embase being the most common.

Participants in eight reviews were healthy people[7,13,14,20,24,25,27,29] while those in seven studies[10,15,21-23,28,30] had plaque or clinically confirmed gingivitis or biofilm related periodontal conditions in the absence of any other systemic illnesses. Only one study included individuals having fixed orthodontic therapy (OT).[26] The total number of participants involved in the included research ranged from 120 to over 3600. Only one study did not disclose the number of participants.[7] The length of the follow-up period in the research ranged greatly, from the shortest duration of 1 hour to the greatest duration of 63 weeks. Manipal et al. (2016) didn't report the duration of follow up in included studies.[27]

Summary of intervention

Of the 16 included studies, eleven[7,10,13-15,20,23,24,26-28] have looked into the use of herbal toothpastes or mouthwashes as interventions. In terms of the herbal constituents present in the toothpastes under study, the included papers have revealed significant variability. However, some commonly reported herbal ingredients include chamomile (Matricaria recutita), Neem (Azadirachta indica), Aloe vera (Aloe barbadensis), salvoadoral persica, chitosan, Sanguinaria canadensis L. extracts, Rosmarinus officinalis, Triphala, Cymbopogan citrates (lemon grass), Terminalia chebula, green tea (Camellia sinensis), Zingiber officinale, Curcuma, AND Miswak.[7,10,13-15,20,24,26-28]

Five studies, on the other hand, looked into using a single herbal ingredient as an intervention.[21,22,25,29,30] Triphala was mentioned as an adjuvant by Aljameel et al.[30] Terby et al. reported using curcumin as an intervention in a variety of ways (gel, subgingival irrigants, chips, or mouthwash).[29] Dhingra et al. reported aloe vera-based herbal dentifrices with aloe

vera as an active component.[21] *Azadirachta indica* (neem) mouth rinses have been studied by Dhingra et al.[22] *Salvoadora persica* mouthwash was also mentioned as an intervention by Jassoma et al.[25]

Summary of findings

Systematic reviews

The main findings of the systematic reviews varied due to variations in the intervention investigated. Participants in half of the studies were healthy people, while those in the other half had plaque or clinically confirmed gingivitis or biofilm related periodontal conditions in the absence of any other systemic illnesses. Dhingra et al. (2014) showed that in patients with gingivitis, aloe vera herbal dental dentifrices are just as effective—if not more so—than a placebo or traditional dentifrices at reducing plaque and gingival irritation.[21] However, reliable inferences cannot be drawn due to the data's intrinsic poor quality and significant bias likelihood. Another comprehensive analysis of the effectiveness of neem mouth rinse discovered no notable difference in the reduction of plaque and gingival inflammation in gingivitis patients when administered as an alternative to toothbrushing over the course of four weeks.[22] Similarly, Chen et al.[20] and Ingle et al.[24] also found that there were no appreciable differences in plaque or gingival inflammation between the test and control groups, proving that the efficacy of herbal formulations is comparable to that of the best available formulations.

Contrary to this, Suresh et al.[7] reported green tea, miswak, *Carica* papaya leaf extract, *S. baicalensis* toothpastes as effective in plaque, gingivitis and gingival bleeding. Similarly, Santi et al.[28] found the use of certain mouthrinses containing herbs such as *Camellia sinensis, Anacardium occidentale Linn, Azadirachta indica, Curcuma longa, and Schinus terebinthifolius* reduced dental plaque and gingival irritation more effectively than Chlorhexidine. Furthermore, in another study, *Camellia sinensis* was found to have the greatest positive results in lowering both plaque and gingival index and *Azadirachta indica* extracts shown effectiveness similar to CHX.[23] Ricinus communis oil decreased microbiological counts and GI but failed to surpass the hypochlorite solution, which was used as a replacement therapy for dentures. Melaleuca alternifolia oil, on the other hand, demonstrated a low reduction in plaque index (PI) but no effect on gingival index (GI) scores. Overall, herbal products demonstrated positive effects in reducing plaque and gingival inflammation, although the specific efficacy varied depending on the herb used.

However, due to non-adherence to established scientific protocols for RCTs exist (e.g., CONSORT) and shorter time of trial evaluation, all of these systematic reviews revealed uncertainty in their results. As a result of the evaluations, future clinical trials should follow rigorous methodological approaches including blinding, parallel study design and appropriate sample sizes to enable accurate evaluation of treatment differences in order to achieve more consistent results across investigations.

Systematic reviews and meta-analysis

Majority SRMAs reported the similar efficacy of herbal and conventional dentifrices in reducing plaque and gingival inflammation.[10,13-15,27,30] Jankairam et al. compared the fluoridated and non-fluoridated dentifrice with herbal dentifrice and reported that herbal toothpaste is just as effective as conventional toothpaste [standardized mean difference (SMD) 4.64, 95% confidence interval (CI):2.23, 7.05] at removing plaque, but less effective than fluoride toothpaste (SMD 0.99, 95% CI 0.14 to 2.13) at 4 weeks and chlorhexidine mouthwashes (SMD -2.61, 95% CI (4.42 to 0.80) after 12 weeks.[13] Cai et al. findings also indicated that herbal mouthwashes were similarly effective in reducing plaque and gingivitis, comparable to Chlorhexidine Mouthwashes (CHX-MW).[10] Similarly, study by Aljameel et al[27] reported that triphala mouth rinses are similarly effective in improving plaque induced gingivitis as CHX-MW. The overall mean difference for both Gingival Index [weighted mean difference (WMD)= –0.29, 95% CI= –0.40 to –0.17, p<0.001] and Plaque Index (WMD= –0.43, 95% CI= –0.54 to –0.31, p<0.001) were statistically significant between tripahala and CHX-MX at follow-up.[30]

However, few reported conventional dentifrices or Chlorhexidine mouthwashes being superior in efficacy than herbal dentifrices. For instance, Mehta et al., in their meta-analysis found that conventional dentifrice had a significantly higher efficacy for plaque index (SMD: 7.34; 95% CI: 4.05–10.64) whereas there was similar effect of herbal and conventional dentifrice on gingival inflammation (SMD: 1.48; 95% CI: −0.59–3.55, P = 0.16; test for heterogeneity: P<0. 00001, I2 = 96%).[14] Another meta-analysis results of *Salvadora persica* showed significant inhibitory plaque formation effect (P < 0.00001, MD: 0.46, and 95% CI: 0.29 to 0.63), anti-streptococcal (P< 0.0001, MD: -1.42, and 95% CI: -2.08 to − 0.76) and anti-lactobacilli effects (P<0.00001, MD: -1.12, and 95% CI: -1.45 to − 0.79). However, its effectiveness was found to be inferior than chlorhexidine formulations.[25] Kommuri et al., revealed that approximately 40% of studies found that the chlorhexidine is superior to those of herbal-based mouthwashes.[26]

Findings of Janakiram et al., study also resonated that conventional mouth rinse were found significantly better than herbal mouth rinse for either short-term [SMD -0.15, 95% CI (0.32 to 0.01)] or long-term effects [SMD-0.09, 95% CI (0.25 to 0.08) impacts on gingival inflammation.[13]

One SRMA reported positive effect of herbal product curcumin in dental treatment.[29] The effectiveness of curcumin in various forms for the treatment of periodontitis was evaluated and the findings showed that over the long term, there was a statistically significant decrease in probing pocket depth when compared to the control group [SMD 0.87, 95% CI:1.31 to 0.43]. The short- and long-term plaque scores or gingival inflammation were better treated by curcumin topical gel (SMD 0.87, 95% CI:1.31 to 0.43) than by curcumin mouthwash (SMD 0.76, 95% CI: 2.25 to 0.73).

All studies, however, acknowledged that their results were equivocal because of heterogeneity in several parameters, variations in individual elements, and the chemical composition of the components in mouthwashes used in the control and intervention groups.

Adverse effects

Studies on herbal compounds have documented a range of adverse consequences. reviewers[10,14,20,23,28] discovered that both herbal and conventional dentifrices cause side effects such as mouth ulceration, a burning sensation, tissue sensitivity, dryness, tooth discoloration, hypogeusia, lightheadedness, and an unpleasant taste. Contrarily, camellia sinensis (green tea) mouthwash had no adverse effects.[28] According to Ingle et al., Herbal dentifrice caused hypersensitivity in one individual, but no other side effects or gingival desquamation were seen.[24] Other studies, did not found any negative events connected to the interventions.[7,13,15,21,22,26,27,29,30]

Quality assessment findings

Based on scoring system, it was determined that the methodological quality of one study[24] was low, four studies[7,21,23,27] had medium quality and remaining eleven had high quality.[10,13-15,20,22,25,26,28-30] According to the PICO structure, all research had explicitly and clearly stated their review statement. The majority of studies obtained score for appropriate inclusion criteria, assessment criteria, independently conducted critical appraisal, appropriate data synthesis, and defined research directions. Except for one study[27], the remaining studies reported performing risk of bias assessment with majority using the Cochrane risk of bias assessment method to

evaluate studies. Only seven of the sixteen research mentioned the possibility of publication bias.[10,14,15,20,25,26,30] Six research did not explicitly mentioned the procedures applied for reducing errors in data extraction.[7,20,21,24,26,27] Besides that, barely half of the studies made policy and practice recommendations based on their research findings.[13-15,22,25,26,27,29,30] (Table 6)

Fi-index tool: This manuscript has been checked with the Fi-index tool and obtained a score of 0.44 for the first author only on the date 20/02/2023 according to SCOPUS®.[31,32] The fi-index tool aims to ensure the quality of the reference list and limit any autocitations.

DISCUSSION

The present umbrella review has collated the available systematic reviews with and without meta-analysis of randomized controlled trials. Our results show that few herbal dental care products, particularly in the form of mouth rinse such as *curcumin, green tea, miswak, Carica papaya leaf extract S. baicalensis, Camellia sinensis, Azadirachta indica, Curcuma longa*, *Anacardium occidentale Linn, and Schinus terebinthifolius* have a similar level of positive effect on plaque and gingivitis reduction and thus, can be used as an adjunct to traditional dentifrices. However, the shorter duration of trials (<4 weeks) and reported publication bias in the clinical trials signals towards interpreting this information with caution and calls for further long-term clinical trials in this area.

Periodontal disease is the world's second most prevalent oral health problem, affecting approximately 1 billion people.[1] Despite tremendous advances in clinical oral health care technologies and interventions in recent years, there remain major concerns about its availability, accessibility, and affordability. Addressing these factors is crucial to reducing health disparities because they directly influence proper dental health care as well as appropriate health behaviors.[33] When dental health is compromised, eating patterns are significantly impacted, which may have a consequently lead to metabolic disorders such as diabetes mellitus where nutrition plays a significant role. An affordable approach is therefore extremely needed.[34]

CHX is widely considered as the cost effective and benchmark standard in periodontal antiseptic treatment. However, because of its negative effects and the rise in antibiotic resistance, people are seeking alternatives that are organic.[35] Herbs contain unique

physicochemical and therapeutic properties. Secondary metabolites, found in herbs, are effective in treating infections and other medical conditions. Identifying and characterizing these metabolites, as well as their independent and collaborative modes of action, is a significant challenge for contemporary pharmacology. Although numerous studies[7,10,13-15,20-30] have demonstrated the efficacy of some herbal plants in plaque and gingivitis, it is critical to comprehend the interactions of plant compounds (metabolites) with the human system as well as other medications. Based on that, appropriate guidelines for herbal products usage must be created, which may subsequently require modification depending on unique biological profiles. Furthermore, there is a risk of improper utilization or adulteration; thus, despite their therapeutic potential, precaution must be given when promoting for herbal treatments. It is critical to maximize the therapeutic effect of herbal medicine by paying close attention to both plant origin and quality control.[36]

Weakness and strength of umbrella review

The current umbrella review has several positive aspects, such as we explored six major electronic research databases using a comprehensive and rigorous search method in order to discover potentially suitable publications. Secondly, no language constraints were imposed on the inclusion of studies. Thirdly, two authors worked independently on the screening of search results, data extraction, and quality appraisal. Lastly, we settled differences at each stage by involving a third reviewer who was experts in topic area.

However, it comes with some inherent limitation. These include not exploring grey literatures which could have resulted in the loss of potentially relevant literature. Second, while our investigation included both systematic reviews and meta-analyses, there was variability the composition, concentrations, and therapeutic properties of herbal ingredients utilized in the included studies. As a result, we were unable to pool and analyse the data in order to reach a conclusive decision.

Reporting gaps in the clinical studies and included systematic reviews

While reviewing the included studies, several methodological limitations of clinical trials as well systematic reviews were identified. Therefore, we recommend following suggestions to enhance the standard of subsequent research on herbal oral care products.

Recommendations

For clinical trials

Choosing a sample size that produces a certain level of statistical power has been an established method to conducting trials. Ingle et al.[24] in their systematic review reported of studies not following proper sample size. Conducting trials with either too small or too large samples are referred to as "underpowered" or "overpowered" trials, respectively, as they cannot capture true effect and are thus, frequently criticised as being scientifically pointless and unethical from a medical standpoint.[37] This implies that before beginning a trial, a thorough sample size calculation based on earlier studies must be made. Besides, all studies reported that included RCTs were carried out for a brief period (<6 months), therefore there is currently no information available regarding the potential negative effects of any herbal formulation when used over an extended period of time. Therefore, it is advised to conduct RCTs (randomised controlled trials) with established protocols, and defined population parameters with a bigger sample size and over a longer period of time. For instance, the minimum length of the research intervention should be taken into account so that a reduction in gingival inflammation may be shown. American Dental Association (ADA) specifies the long term studies to have ≥6 months duration for a seal of acceptance, with an intermediate evaluation at 3 months to determine the efficacy and safety of chemical agents and patient compliance.[38]

In addition, numerous studies have found that herbal formulations work well as dentifrices. Further rigorous and high-quality research involving trials at different concentrations and compositions is recommended, though, to improve the documentation of findings.[15] Additionally, three systematic reviews and meta-analyses have indicated uncertain risk of bias and methodological issues in included RCTs, which prevents drawing reliable inferences.[14,26,28] Therefore, additional clinical trials with a clear risk of bias assessment and following Consolidated Standards of Reporting Trials (CONSORT) guidelines is required to offer trustworthy and conclusive results.

For systematic reviews and meta-analysis

To avoid bias in study outcomes, SRs should seek to synthesise all relevant material, regardless of language of publication.[39]

The tool used for appraising included studies must be reported and its outcomes must be taken into account for drawing conclusions and making recommendations.

Two or more authors must independently appraise quality of included studies and extract data to reduce bias and improve accuracy of information.

To bridge the gap between research evidence and clinical decision making, all SRs and SRMAs must give policy and practise implications, supporting evidence-based clinical practise and guiding future research endeavours.

CONCLUSION

The present umbrella review highlights the fact that some herbal extracts produce results comparable to those of traditional dental care products. Consequently, herbal care products can be utilised as an alternative to treat plaque and gingivitis. Nevertheless, inferences cannot be drawn from the existing studies, because of their poor methodological quality, short duration of trials, and significant potential for bias. Therefore, clinicians should use caution when incorporating herbal products for the treatment of plaque and gingivitis, weighing the potential benefits and unanticipated events. Furthermore, to accurately determine the impact of various herbal extracts on periodontal health, subsequent well-designed, long-term, and controlled trials which adhere to standardised protocols must be carried out.

CLINICAL RELEVANCE

Scientific rationale for the study

Herbal oral care products have attracted a lot of attention from manufacturers, consumers, and researchers. However, there is insufficient degree of scientific evidence showing their efficacy.

Principal findings

Some herbal oral care products show similar effectiveness at preventing plaque and gingivitis as conventional products. But the research done so far has been biased, of lower quality, and done for shorter time period.

Practical implications

Within its boundaries, this umbrella review concluded that several herbal products are beneficial in treating plaque and gingivitis; nevertheless, these must be taken with precaution and furthermore, methodologically sound, long-term RCTs are needed to validate their effectiveness.

Additional Information

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Figure 1: Study selection process

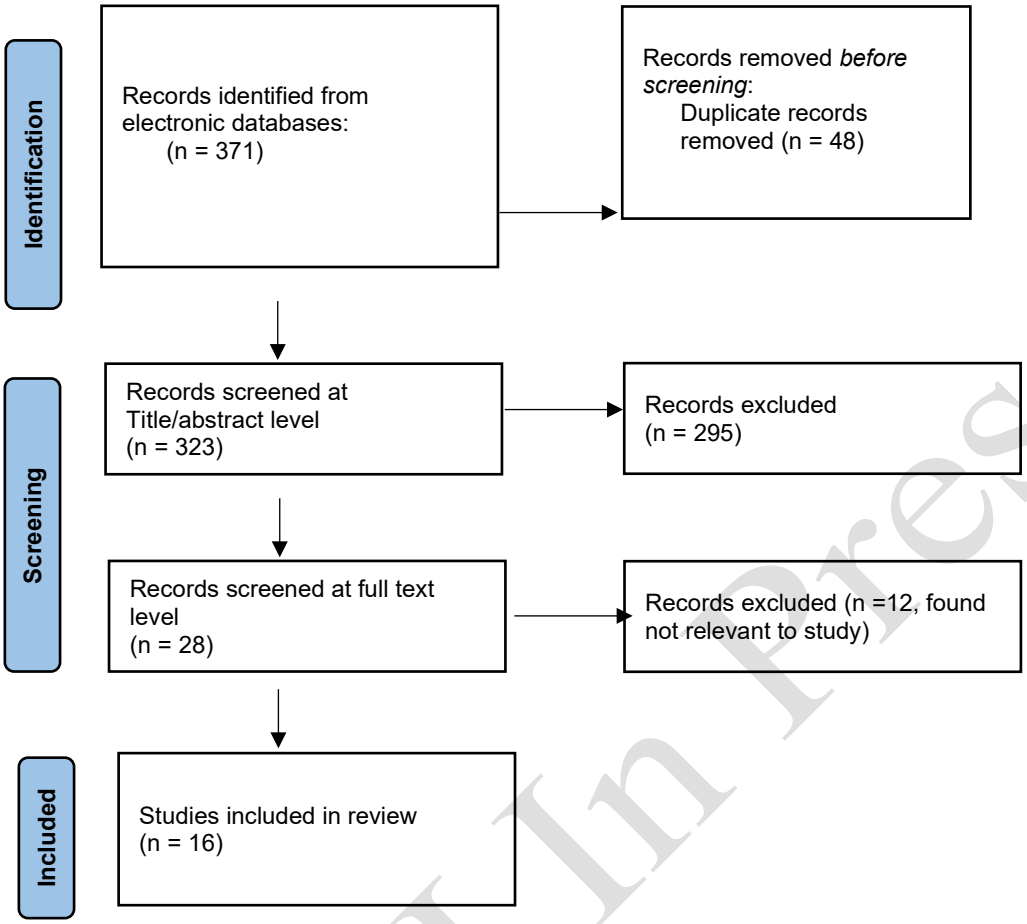

Table 1: Eligibility criteria concerning sources, design and characteristics of the studies included regarding population, intervention, comparison and outcome(s).

Systematic reviews Eligibility	**Inclusion Criteria**	**Non-Inclusion Criteria**
Sources		
Databases	Electronic and Manual	None
Language	No restrictions	None
Publication status	Published	None
Publication date	From inception till 30th May 2023	No restrictions
Design	Systematic Reviews exclusively including Randomized Clinical Trials (RCTs) with or without a meta-analysis.	Prospective, retrospective, case-control, pre-clinical in vivo, in vitro studies, as well as conference communications, books and chapters papers, oral presentation.
Characteristics of the studies included in the eligible systematic reviews		
RCTs Population	Healthy participants	Participants with systemic disorders
Study sample size	No restrictions	No restrictions
Age	No restrictions	No restrictions
Gender	No restrictions	No restrictions
Intervention		
Route of administration	Either brushed or rinsed	Application of toothpowder
Type of products	Herbal oral care products (either toothpaste or mouth rinse) which had an active herbal ingredient, or a natural or plant extract as claimed by the manufacturer.	Ayurvedic or proprietary medicine formulation without manufactures instructions or absence of active ingredient
Comparison	Active controls using formulation containing non-herbal active ingredients in toothpaste and mouth rinse that were commercially available OTC or manufactured as placebos for the study.	Combination of herbal and non-herbal oral care products
Outcome(s)	Reduction in Dental plaque and gingivitis	Periodontitis, Bleeding on probing

OTC: Over the counter

Table 2: PICO of included studies

S.No.	Study ID	Participants	Intervention	Comparison	Outcome
1	AlJameel_ 2020[29]	Humans clinically diagnosed with plaque-induced gingivitis	Triphala mouth wash	chlorhexidine	Primary; gingival index (GI) and/or secondary; plaque index (PI)
2	Cai_2020[10]	Systematically healthy participants with gingivitis	Application of herbal mouthwashes from botanical sources	placebo and chlorhexidine	The clinical effects of mouthwashes as a supplement to daily oral hygiene (i.e., toothbrushing) on plaque and inflammation control
3	Chen_ 2014[19]	Adults with good general health	NCCM used either alone (as a monotherapy) or as an adjunct to another therapeutic agent	Placebo or conventional mouthwash	plaque index (PI) and/or gingival index (GI)
4	Dhingra_ 2014[20]	Patients with gingivitis	Aloe vera herbal dentifrices	placebo/ conventional dentifrices.	Effectiveness of aloe vera containing herbal dentifrices in improving plaque control and gingival health.
5	Dhingra_ 2017[21]	Gingivitis patients	Neem mouth rinses	chlorhexidine	Effectiveness of Azadirachta indica (neem)-based herbal mouthrinse in improving plaque control and gingival health
6	Furquim Dos Santos Cardoso_2021[22]	Presenting dental plaque, gingivitis, and/or periodontal-associated biofilm disorders, without any physiological	Plant-derived extracts (tinctures, essential oils, hydroalcoholic extracts) incorporated in appropriated pharmaceutical formulations (gels, toothpastes, chewing gums, tablets, powders, mouthwashes, etc.)	Chlorhexidine, antibiotics, other similar substances, or placebo	changes in plaque indexes (PI), gingival bleeding index (GBI), gingival index (GI), volume modified gingival index (MGI), bleeding on probing (BOP), papillary bleeding index (PBI), plaque accumulation (PLA), periodontal probing depth (PD), clinical attachment level (CAL), microbial colonization, gingival crevicular fluid (GCF) parameters

		restrictions were included			
7	Ingle_ 2021[23]	Healthy adults	Herbal formulation	Conventional Mouthwashes or CHX	plaque index (PI) and/or gingival index (GI)
8	Janakiram _2020[12]	Healthy adults	Herbal Toothpastes or Mouth rinses (chamomile (Matricaria recutita), neem (Azadirachta indica), Aloe vera (Aloe barbadensis) and calendula (Calendula officinalis), salvoadoral persica, chitosan, ajamoda satva (Apium graveolens), lippia sidiodes (Pepper-rosmarin) and vaikrantha bhasma (Dolichos biflorus	Over the counter (OTC) non-herbal oral care products (Fluoride toothpaste, non-fluoride/non-herbal toothpaste, Chlorhexidine mouth rinse or non-herbal Mouth rinse)	Mean reduction in the plaque measured by Silness and Loe Plaque index or modified Quigley Hein plaque index; 2. Mean reduction of the gingival inflammation by Loe and Silness Gingival index; 3. Short-term effects (studies with 4-week follow-up acceptability range ± 3 days) 4. Long-term effects (studies with 12-weeks follow-up acceptability range ± 3 days)
9	Jassoma_2 019[24]	Healthy individuals	Salvadora persica mouthwash	Chlorhexidine	a decrease in the mean plaque score and cariogenic bacterial counts
10	Javed _2022[14]	Patients diagnosed as established gingivitis and otherwise having no other dental or systemic disease	herbal or ayurvedic toothpaste, toothpowder, gel, mouth rinse in form with or without mechanical use of the toothbrush, floss etc .	negative placebo, control having chlorhexidine or any other antiseptic compound, and conventional toothpaste or mouth rinse not containing any herbal or botanical component as a constituent	Plaque Index, gingivial index
11	Kommuri _2022[25]	Patients undergoing fixed OT	Herbal based mouth washes	Chlorhexidine based mouthwashes	The comparison between efficacy of herbal and chlorhexidine towards OHM in patients undergoing fixed OT remains debatable.

12	Manipal _2016[26]	Healthy human subjects	Herbal Mouth rinse	Chlorhexidine	Effect of two broad categories of mouth washes namely chlorhexidine and herbal mouth washes
13	Mehta-2018[13]	Healthy adults	Herbal dentifrices	Conventional dentifrices	plaque index (PI) and/or gingival index (GI)
14	Santi_ 2021[27]	Systemically healthy adults, >=18 years old, with a diagnosis of gingivitis	Mouth rinse with herbal products (Camelia sinensis, Azadirachta indica, Anacardium occidentale Linn, Schinus terebinthifolius and Curcuma longa)	Conventional Mouthwashes	dental plaque and/or gingival inflammation reductions as measured by plaque score and bleeding on probing. potential side/adverse effects
15	Suresh_ 2021[7]	Healthy adults	Herbal toothpastes	chlorhexidine or fluoride toothpaste	plaque index (PI) and/or gingival index (GI)
16	Terby_2021[28]	Adults > 18 years	Curcumin topical gels (CTG), local delivery gels (CLDG), chips (CC), mouth rinses (CMR) and subgin gival irrigation (CSGI)	Chlorhexidine (CHX) mouth rinse, CHX chips, CHX gel, saline, ornidazole gel, metronidazole gel	Reduction in gingival inflammation, plaque scores and periodontal pocket depth

Abbreviations: CHX- Chlorhexidine; PI- Plague Index; GI: gingival Index; NCCM: Natural component containing Mouthwashes

Table 3: Demographic characteristics of the included studies

Study ID	**No. of trials**	**Total sample size (n)**	**Country**	**Sources**	**Duration**	**Follow Up period**
AlJameel_ 2020[29]	7	1270	India, Saudi Arabia	MEDLINE/ PubMed, EMBASE and Cochrane Central Register of Controlled Trials (CENTRAL)	up to April 2020	2 to 63 weeks
Cai_2020[10]	11	959	Chinese, African, Tibetan, Mongolian, Japanese, Indian, Korean, Arabic, Unani	PubMed,EMBASE, Cochrane Database of Systematic Reviews (CDSR), and Cochrane Central Register of Controlled Trials (CENTRAL) databases	From inception to 22 February 2019	10 days to 24 weeks
Chen_ 2014[19]	11	474	India, Germany, Iran	MEDLINE-PubMed); the Cochrane Central Register of Controlled Trials; and EMBASE	up to feb 2013	4 to 12 weeks
Dhingra_ 2014[20]	2	120 120	Brazil, India	A manual and electronic literature (MEDLINE and Cochrane Central Register of Controlled Trials)	up to July 2012	4 weeks to 24 weeks

Dhingra K_2017[21]	3	129	Brazil, India	PubMed, Cochrane Central Register of Controlled Trials and EMBASE and manual searching.	Search up to February 2015	3-4 weeks
Furquim Dos Santos Cardoso _2021[22]	47	2914	USA, Brazil, Japan, Italy, Australia, India, Germany, Sweden, Thailand, China, Malaysia	MEDLINE database, Scopus, Web of Science	1988 - aug 30, 2020	7 days- 18 months
Ingle _2021[23]	18	1190	India, Saudi arabia	PubMed- Medline data base, Scopus and Journal of Web	2000-2019	3 days – 30 days
Janakiram _2020[12]	24	1597	India, Iran, USA, Jordan, Brazil, Netherlands	MEDLINE Ovid, EMBASE Ovid, WHO clinical trial register, ClinicalTrials.gov and Cochrane Library	Inception to June 2018	4-12 weeks
Jassoma_ 2019[24]	19	1139	Iraq, Iran, India, Saudi Arabia	MEDLINE-PubMed, Cochrane Central Register of Controlled Trials, Wiley Online Library, ScienceDirect, and Google Scholar	published up to December 2018	1 day – 2 months
Javed _2022[14]	41	2810	India, Brazil, Saudi	PubMed/Medline, CAM-QUEST, and the Cochrane Central Register	upto August 2021	1 hour – 84 days
Kommuri _2022[24]	8	>400	Not mentioned	PubMed, embase, OVID Medline, Scopus and ISI web of science	upto august 2021	3 days- 8 weeks
Manipal _2016[26]	11	445	India	Pub Med Central listed studies	2003 to 2014	Not mentioned
Mehta_ 2018[13]	10	459	Brazil, India, Yemen, Iran	MEDLINE, Cochrane Central Register of Controlled Trials, and major journals	up to September 30, 2017	2 weeks – 6 months
Santi _2021[27]	20	1887	USA, India, Brazil, Egypt	(PubMed/MEDLINE), Cochrane—Central Register of Controlled Trials (CENTRAL), EMBASE, Web of Science, Latin American and Caribbean Center on Health Sciences (LILACS/BIREME), Clinical Trials Registry, PROSPERO, The National Dental Trial Registry, US Clinical Trials Registry and grey literature (OpenGrey, CAPES thesis bank and reference lists of the selected studies)	upto April 2018	14 days- 6 month

Suresh _2021[7]	7	NA	Germany, Brazil, India, Spain, Sri Lanka	PubMed, Cochrane, LILACS and Google Scholar	till December 2020	21 days- 6 months
Terby_2021[28]	27	>3600	India	Pubmed/Medline and Cochrane Library and hand searching was done	Inception to June 2019.	2-4 weeks

Abbreviations: LILACS: Latin American and Caribbean Center on Health Sciences; NA: Not applicable.

Table 4: Qualitative Synthesis

Study ID	Methodology quality assessment	Quality Appraisal	Heterogeneity	Findings
AlJameel_2020[29]	Consolidated Standards of Reporting Trials statement	A total of 4 studies were considered as having moderate risk of overall bias whereas 3 studies had an overall high risk of bias. The high risk of bias in the included studies was mainly due to lack of reporting sequence generation and selective reporting. All studies reported the completion of the trial and clear explanation of withdrawals	Significant heterogeneity for both GI and PI was observed between both TRP-MW and CHX-MW groups	All studies showed that TRP administration was significantly effective as compared to CHX in the treatment of plaque-induced gingivitis.
Cai_2020[10]	Cochrane Collaboration's tool	11 studies were of low and unclear risk of bias, and two studies included a high risk of bias. Six studies had a low risk of bias for random sequence generation, and five provided clear information in terms of allocation conceal ment. 2 studies failed to blind the participants and personnel, which introduced a high risk of bias	Substantial heterogeneity was observed in those meta-analyses. For herbal vs CHX it was unable to detect the exact sources of heterogeneity within the review due to the limited number of included studies	Significant differences were observed in favour of herbal mouthwashes compared with placebos in both plaque- and inflammation-related indices No significant difference was found between herbal and CHX mouthwashes
Chen_2014[19]	Center of Evidence-Based Medicine and the Jadad scale	Five studies were considered to be low quality, having Jadad scale scores of 2 or less. The remaining studies were of relatively high quality, having Jadad scale scores of 3 or more. For the "level of evidence" assessment, all of the selected studies were ranked in Level 2b because of their small	Considerable heterogeneity was observed in the demographic background of the participants and in the interventions, regimens, duration, clinical indices and outcomes of the studies.	The clinical outcome parameters included plaque and/or gingival bleeding and/or gingivitis scores

		sample size (no study justified their sample size determination) and low level of study design		
Dhingra _2014[20]	Cochrane Collaboration's tool	The overall risk of bias was estimated to be 'high' for both the RCTs as the proportion of information from studies at high risk of bias was sufficient to affect the interpretation of the results.	A marked heterogeneity was evident in study characteristics (populations, interventions, outcomes, design, quality and results), meta-analysis was not performed and synthesis of data was determined from the evidence tables	The clinical effectiveness of aloe vera herbal dentifrices is not sufficiently defined at present and warrants further investigations based on reporting guidelines of herbal CONSORT statement.
Dhingra _2017[21]	Cochrane Collaboration's tool	The overall risk of bias was estimated to be 'unclear' across all the RCTs.	A marked heterogeneity, which was evident in study characteristics (study population, intervention regimen and comparison, outcomes, evaluation period, design, quality and results)	Although the included RCTs showed statistically significant results with respect to efficacy of neem-based mouthrinses, the inherent methodological limitations of these studies warrant their conclusions to be interpreted with great caution.
Furquim Dos Santos Cardoso_2021[22]	Cochrane Collaboration's tools evaluation system	For the trials, 42.5% of the manuscripts had a final score of 3 (n = 20), 31.9% of 4 (n = 15), while 21.3% had a score of 5 (n = 10) and 4.3% a score of 6 (n = 2 trials).	There was a heterogeneity in drug administration forms (mouthwash, toothpaste, gel, chewing gum and powder), patient collection data, standardization of plant extracts, associations among plant extracts and randomization in every trial.	Camellia sinensis was the most commonly used species (8 studies), with positive results in reducing both the PI and GI in the form of mouthwash, toothpaste and gel. The Melaleuca alternifolia oil (5 studies) demonstrated low reduction in PI but important effects on GI scores. Azadirachta indica (4 studies) extracts presented efficacy similar to CHX to improve the periodontal parameters, including PI and GI. Ricinus communis oil (3 studies), despite reducing microbiological counts and GI, did not prove to be better than the hypochlorite solution, used as an alternative treatment for dentures.

Ingle NA_2021[23]	Cochrane Risk of Bias Tool	Studies were included only if they had low risk of bias which independently reviewed by the author	Not mentioned	There were no significant differences in the outcome parameters evaluated between the test and control group in all studies, proving the efficacy of herbal formulation as similar to that of a gold standard formulation
Janakiram C_2020[12]	Cochrane Collaboration's tool	Among all, allocation concealment or selection bias and blinding of the participants had higher proportions of bias across the studies. Three studies showed low risk of bias seven studies had unclear risk and the remainder were high risk	Substantial heterogeneity across the studies	Participants using HTP were more likely to experience a reduction in dental plaque scores during a four-week period compared to those using NHTP. HTP reduce dental plaque over non-fluoride toothpaste. HMR there was substantial evidence of mean reduction of dental plaque by users of NHMR compared to HMR in 6 studies.
Jassoma_2019[24]	CONSORT 2010 checklist	Studies with scores of 9 or less were regarded as being of low quality; 10–18 were considered to be of moderate quality; and studies with a score of 19 or more were considered as being of high quality. Seven papers were regarded as high quality while the remaining papers were of moderate quality	The heterogeneity observed between studies might have resulted from different methodologies followed, study designs, and small sample sizes in the individual studies. Heterogeneity was overcome by the use of random effects instead of fixed effects analysis.	Salvadora persica rinses exhibited strong antiplaque effects.
Javed D_2022[14]	Cochrane Collaboration	The majority of studies have a low risk of bias, indicating that the analysis' results are trustworthy. Random sequence generation had a low risk of selection bias in 77.2 % of trials, and allocation concealment had low risk in 65.8% of studies. In 65.8% of trials, blinding of participants	the composition of these ayurvedic preparations was heterogeneous	Ayurvedic and herbal dentifrices may help in plaque reduction, gingival inammation, and bacterial growth.

		and personnel (performance bias) was determined to be low risk. In 62 % of trials, blinding of outcome assessment (detection bias) was a low risk. In the reviewed studies, incomplete outcome data (attrition bias) was 77.2 %, while selective reporting (reporting bias) was 82.2 % low risk. In these studies, the risk of other bias was only 12.65%.		
Kommuri_2022[25]	Cochrane ROB	Four studies have low, 2 studies have moderate and 2 studies have high risk	Heterogeneity of I2= 0%–65% was identified between CFU, GI and PI parameters on comparing the parameters before the use of chlorhexidine and herbal mouthwash group	Out of eight RCTs, results from one RCT favoured chlorhexidine and the results from a second RCT favoured herbal mouthwashes. Results from three RCTs showed comparable effects for the respective investigated OHM-related parameters. Chlorhexidine demonstrated higher antimicrobial efficacy against Streptococcus mutans (S. mutans) in two studies, and one RCT found comparable antimicrobial efficacies.
Manipal _2016[26]	NR	NR	Heterogeneity: $\chi 2$ = 369.01, I2 =97%; df=10 ($p<0.00001$)	Out of 11 studies that were analyzed four studies favor the use of chlorhexidine in comparison with only two studies that favor the effect of herbal extract. The rest of the five studies remain neutral agreeing to the null hypothesis that there is no difference in the effect of both the mouth washes

Mehta_2018[13]	Cochrane Collaboration's tool	Random sequence generation, blinding of participants and personnel, and other bias showed more than 50% low risk of bias. Blinding of outcome assessment and incomplete outcome data showed more 75% low of risk of bias. No bias was seen for selective reporting. Allocation concealment showed 50% unclear risk of bias	Plaque intervention test for heterogeneity: P < 0.00001, I^2 = 96%; gingivitis test for heterogeneity: P < 0.00001, I^2 = 94%	Subgroup analysis for plaque intervention and gingival inflammation in case of long-term (more than 4 weeks and up to 6 months) and short-term effects (minimum of 4 weeks) of herbal dentifrice showed no difference when compared to conventional dentifrice.
Santi_2021[27]	The criteria were adapted and divided into seven domains	The estimated potential risk of bias was uncertain in the majority of studies. more than 75% of the studies exhibited an uncertain risk with regard to allocation concealment and selective reporting of the outcome. Taken together the high and uncertain risk of bias, around 40%– 50% of studies presented selection, performance and attrition biases	Considerable clinical heterogeneity was found in the interventions. The herbal products used as an intervention involved 17 different types of plants.	Five studies found per cent reductions higher than CHX, favouring the herbal product for the outcome of dental plaque. All studies found significant differences favouring the herbal products when compared to placebos in both outcome, plaque index and gingival inflammation
Suresh _2021[7]	Cochrane Risk of Bias Tool	3 has low risk, 3 has medium risk and 1 has high risk	Due to lack of more clinical studies comparing the conventional and herbal dentifrices, the study found heterogeneous outcome variables.	As all the studies were randomized controlled trials, level of evidence was II. Among all studies, green tea dentifrice toothpastes showed significant reduction when compared with conventional dentifrice, and ayurvedic toothpaste and Carica papaya leaf extract were also effective.
Terby_2021[28]	Cochrane Collaboration's tool	It was observed that allocation concealment and blinding of participants had higher proportions of bias across the studies	Clinical heterogeneity was observed with regard to concentrations and forms of curcumin used in the included studies. Few studies had small sample sizes which could probably be the reason for the high statistical heterogeneity	We found that for a long-term evaluation of probing pocket depth in nine studies each with 400 participants, there was a statistically significant difference in the reduction when curcumin topical gel was used as compared with the control.

Abbreviations

NA: Not applicable; NR: Not reported; SMD: Standard mean difference; CI: Confidence interval; PI: Plaque index; GI: Gingival index; MD: Mean difference; TRP: Triphala; CHX: Chlorhexidine; HTP: Herbal toothpaste; HMR: Herbal mouth rinses; NHTP: Non Herbal toothpaste; HMR: Non- Herbal mouth rinses; CHX: Chlorhexidine; BOP: Bleeding on Probing; CFU: Colony forming unit; CPI: Community Periodontal Index; PPD: Probing pocket depth; MW: Mouth wash; RCTs: Randomized controlled trials; ROB: Risk of bias; CONSORT: Consolidated Standards of Reporting Trials; OT: Orthodontic treatment; OHM: Oral hygiene maintenance.

Table 5: Quantitative Synthesis

Study ID	Meta-analysis	Statistical analysis	Subgroup analysis	Sensitivity analysis	Significance/ Direction
AlJameel_2020[29]	yes	For analyses, if the test showed substantial heterogeneity (I^2>75%), a random effects model was applied, or else (I^2 ≤75%), a fixed effects model would be used. Forest plots were produced describing weighted mean difference (WMD) of outcomes and 95% confidence intervals (CI).	NA	NA	TRP-MW seem to significantly improve the clinical gingival inflammatory parameters in plaque induced gingivitis with equal clinical efficacy as CHX-MW. The overall mean difference for both GI (WMD= –0.29, 95% CI= –0.40 to –0.17, p<0.001) and PI (WMD= –0.43, 95% CI= –0.54 to –0.31, p<0.001) were statistically significant between TRP-MW and CHX-MW at follow-up, respectively.
Cai_2020[10]	yes	Considering the sample size of individual studies and the heterogeneity across trials, either a fixed effects model or a random effect model was applied.	NA	NA	Significant differences were observed in all these analyses in favour of herbal mouthwashes rather than placebos. herbal to placebo: QHPI: WMD − 0.61, 95% CI (− 0.80, − 0.42), P < 0.001). gingival inflammation-related indices, herbal mouthwashes had a significantly higher decrease in GI (− 0.28 (− 0.51, − 0.06), P>0.01), MGI (− 0.59 (− 1.08, − 0.11), P 0.02), and GBI (− 0.06 (− 0.09, − 0.04), P < 0.001) compared to placebos. No significant difference was found between herbal and CHX mouthwashes.
Dhingra _2017[21]	yes	Difference in mean values of parameters (clinical and/or	NA	NA	The included RCTs showed that there was no statistically significant difference between

		microbiological/immunological outcomes) measured at baseline and at the end of evaluation period.			neem and chlorhexidine mouth rinses. However, the short study duration (of up to 4 weeks), inherent poor quality of reporting and unclear risk of bias of these RCTs precludes the drawing of firm conclusions.
Janakiram _2020[12]	yes	Subgroup analyses were performed to assess the impact of the HTP on duration of intervention (4 vs. 12 weeks). heterogeneity of the data using Cochran's Q statistic, a chi-square test, a threshold p-value of less than 0.10	Yes	NA	We found that HTP was superior over NHTP (SMD 1.95, 95% CI (0.97–2.93)) in plaque reduction. The long-term use of NHMR was superior in reduction of dental plaque over HMR (SMD -2.61, 95% (CI 4.42–0.80)
Jassoma_2019[24]	yes	Odd ratios with a fixed effect model was used for homogenous studies, whilst a random effect model was used for the heterogeneous studies. Forest plots were used to display MD and their 95% confidence in CI of individual studies and a summary estimate of effect.	Yes	Yes	The meta-analysis showed that Salvadora persica rinses exhibited strong antiplaque effects (P<0.00001, MD: 0.46, and 95% CI: 0.29 to 0.63). In addition, it had statistically significant anti-streptococcal (P < 0.0001, MD: -1.42, and 95% CI: -2.08 to − 0.76) and anti-lactobacilli effects (P < 0.00001, MD: -1.12, and 95% CI: -1.45 to − 0.79) when compared to placebo.
Javed D_2022[14]	yes	MD and standard deviations (±SD). The standardized weighted-mean differences (SMD) were calculated for outcomes (measured by different scales or indices) for each study. Randome effects models were used to calculate a pooled estimate of effect and its 95% confidence intervals (CIs).	NA	Yes	Significant differences in these analyses in favour of herbal and ayurvedic dentifrices as compare to control or placebo.
Kommuri_2022[25]	yes	Mean and standard deviations (SD), mean differences (MD)	NA	NA	3 studies show OHM properties of chlorhexidine is

		[GI, HI, BOP, PPD and CPI] and standardized mean differences (SMD) [CFU and PI] were calculated. In addition to 95% confidence intervals (CI), random effect models were used to estimate pooled and non-pooled effect. Sub-group analysis for each OHM-related parameter was performed across studies before and after the use of chlorhexidine and herbal mouthwashes in the control and intervention groups. To identify consistency between studies, heterogeneity was calculated using the I^2 statistic; forest plotting was used.			superior, 4 shows both herbal and chlorhexidine were equal. Chlorhexidine and herbal-based mouthwashes seem to be effective towards OHM in patients undergoing fixed OT. However, based on the high risk of bias and methodological variations, the reported outcomes should be interpreted with caution.
Manipal _2016[26]	yes	The fixed effects model was used for analysis when compared to the random effects model as the data was more heterogeneous. Chi square was used to compute heterogeneity based on the standard deviation and confidence levels of all the selected studies. Meta-analysis was performed for 11 studies.	NA	NA	The present situation supports the use of chlorhexidine can be labelled as the 'gold standard'. The widespread usages of herbal products now need to be advocated and prescribed only with substantial documented and scientific studies. Hence more number of clinical and randomized control trials on a larger scale to continue their development and usage.
Mehta_2018[13]	yes	Primary outcome variables from each study were combined for continuous data using a random effects model	Yes	NA	MA with a subgroup of herbal dentifrice compared to conventional dentifrice (fluoridated or nonfluoridated) revealed that that efficacy of conventional dentifrice was significantly higher for plaque intervention (SMD: 7.34; 95% CI: 4.05–10.64, P = 0.0001.
Terby_2021[28]	yes	Heterogeneity of the data was evaluated using the Cochran's Q statistic, with the threshold p-value of less than 0.10 and I2 statistic). Forest plots were generated for visual interpretation.	NA	NA	There was a statistically significant difference in the reduction when curcumin topical gel was used as compared with the control [SMD 0.87, 95% CI: 1.31 to 0.43]. However, in the evaluation of short-term plaque and gingival scores, we found no statistically significant differences in the reduction when curcumin mouth rinse was used [SMD 0.76, 95% CI: 2.25 to 0.73]

Abbreviations

NA: not applicable; SMD: Standard mean difference; CI: Confidence interval; PI: Plaque index; GI: Gingival index; WMD: weighted mean difference; NCCM: natural compound containing mouthwashes; TRP: Triphala; CHX: Chlorhexidine; SD: Std. Deviation; BOP: Bleeding on Probing; CFU: Colony forming unit; CPI:

Community Periodontal Index; PPD: Probing pocket depth; MD: Mean differences; MW: Mouth wash; NHMR: Non-herbal mouth rinse; HTP: Herbal toothpaste; HMR: Herbal mouth rinse; NHTP: Non-herbal toothpaste; RCTs: Randomized controlled trials; OT: Orthodontic treatment; OHM: Oral hygiene maintenance

Table 6: Critical appraisal of included studies

Sr. No.	Study ID	Is the review question clearly and explicitly stated?	Were the inclusion criteria appropriate for the review question?	Was the search strategy appropriate?	Were the sources and resources used to search for studies adequate?	Were the criteria for appraising studies appropriate?	Was critical appraisal conducted by two or more reviewers independently?	Were there methods to minimize errors in data extraction?	Were the methods used to combine studies appropriate?	Was the likelihood of publication bias assessed?	Were recommendations for policy and/or practice supported by the reported data?	Were the specific directives for new research appropriate?	Scores
1	AlJameel_ 2020[29]	Yes	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9
2	Cai_ 2020[10]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
3	Chen_ 2014[19]	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	No	Yes	8
4	Dhingra K_2014[20]	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	No	Unclear	Yes	7
5	Dhingra K_2017[21]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	10
6	Furquim Dos Santos	Yes	Yes	Yes	No	Yes	Yes	Yes	Unclear	No	No	Yes	7

	Cardoso V_ 2021[22]												
7	Ingle NA_2021[23]	Yes	Unclear	Unclear	No	Yes	No	Unclear	Yes	N/A	No	Yes	4
8	Janakiram C_2020[12]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	10
9	Jassoma_ 2019[24]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
10	Javed D_2022[14]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
11	Kommuri _ 2022[25]	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	9
12	Manipal _2016[26]	Yes	Yes	Unclear	No	Unclear	Unclear	Unclear	Yes	No	Yes	Yes	5
13	Mehta_2018[13]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
14	Santi SS_ 2021[27]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Unclear	8
15	Suresh S_2021[7]	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Unclear	No	Yes	7
16	Terby_2021[28]	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	No	Yes	No	9