SYSTEMATIC REVIEW

Herbal Dentifrices for Prevention of Dental Caries in Children and Adolescents: A Systematic Review

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Abstract

Despite a large number of trials conducted on the use of herbal oral care products to reduce dental plaque or gingivitis, the results are conflicting and inconclusive. This systematic review aimed to evaluate the effectiveness of herbal dentifrices in caries prevention in children and adolescents and to ascertain the potential of herbal dentifrices to remineralize white spot lesions, reduce halitosis, and improve gingival and periodontal health in children with special healthcare needs (SCHN) and among orthodontic patients. A comprehensive search was designed and conducted using several databases. The articles were independently screened for eligibility by two reviewers. Seven of the 6,940 studies were found to meet the eligibility criteria. A meta-analysis showed that for bacterial scores, the standard mean difference was estimated to be 0.6 [95% confidence interval (CI): −0.78, 1.99] and was statistically insignificant ($p = 0.39$). Herbal dentifrice is evidenced as equally effective in reducing bacterial count and altering bacterial plaque when compared to nonherbal dentifrices within the confines of the included studies. To verify the definitive use of herbal dentifrices for daily use, further research, including randomized controlled trials (RCT) of sufficient quality, would be recommended.

Keywords: Caries prevention, Carious primary dentin, Oral habits, Oral health, Oral health care, Systematic review and meta-analysis, Toothpaste.

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Introduction

Recent reports from the "Global Herbal Dentifrices Market Research Report" revealed an increase in the sale of herbal dentifrices in many regions across the globe.[1] The choice of dentifrice is critical for effective dental plaque removal and oral health maintenance.[2] The use of herbal dentifrice is a debated topic in oral health care, driven by its growing popularity over the past years.[3] Natural ingredients, such as *Azadirachta indica* (neem), sanguinarine, propolis, and miswak, have been reported as primary components of herbal dentifrices that aid in successful plaque removal, prevention of halitosis and improving gingival health in children and adolescents.[4–6]

Willershausen et al. reported a significant reduction in plaque and bleeding indices when using herbal dentifrices.[7] However, studies conducted by Hosadurga et al., Ozaki et al., Pentapati et al., and Mullaly et al. demonstrated the least reduction in plaque and gingival indices between the groups where herbal dentifrices were used.[8–11] Fereidooni et al. compared the effects of propolis and traditional dentifrices. The results of this study revealed a greater efficacy of propolis dentifrices in dental plaque reduction.[12] In 2017, a randomized controlled trial (RCT) conducted by Azaripour et al. showed superior results with miswak extract-containing dentifrices in reducing gingival inflammation.[13] Baeshen et al. concluded that miswak was effective only as an adjunct to fluoride dentifrice.[14] Another RCT conducted by Patel et al. compared and evaluated the effects of two commercially available herbal and nonherbal dentifrices on salivary bacterial counts in children aged between 5 and 10 years, and the results remain inconclusive.[15]

To clarify the impact of herbal dentifrices on oral health, this systematic review aimed to evaluate the effectiveness of herbal dentifrices in caries prevention among children and adolescents. In addition, this review also aimed to assess the effectiveness of

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Conflict of interest: None

herbal dentifrices in reducing halitosis, gingival, and periodontal health in children with special healthcare needs (SCHN) and among orthodontic patients.

Methods

This systematic review and meta-analysis is in concurrence with the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[16] This review was registered in PROSPERO (CRD42021273021).

Criteria for Considering Studies in this Review

- Participants: Children and adolescents, including those with special healthcare needs (SHCN) under 19 years of age.
- Interventions: Use of herbal dentifrices from botanical sources.
- Comparisons: Placebos without active herbal agents or fluoride-containing dentifrices.
- Outcomes: Caries prevention, change in bacterial counts, halitosis status, remineralization of white spot lesions, and gingival and periodontal health of orthodontic patients and children with SHCN.
- Study design: RCTs, quasi-randomized trials, and cluster randomized trials.

Information Sources and Literature Search

A systematic search was conducted in the following databases: MEDLINE *via* OVID; PubMed; EMBASE *via* OVID; Cochrane Oral Health Group's Trials Register; AMED, AYUSH portal; DHARA; United States National Library of Medicine (clinicaltrials.gov), and Clinical Trials Registry of India (www.ctri.nic.in) were systematically searched for relevant articles written in English, from inception to August 2022. The search was also done in SHODHGANGA (national dissertation abstracts database) to obtain potential gray literature. Medical Subject Headings, keywords coupled with free text such as "herbal and plant extracts," "dentifrices," "toothpaste," "dental caries," and "oral health" were used for search. General key words including Ayurveda [Dantagata/Dantamulagata Roga, Mukha/Jiva/Oshtha Roga, Mukha/Jhiva/Osthharoga], Siddha [Vai/Naakku/Udhadu Noigal and Pal Eru Noi], and Unani [dental caries (Taakkul E Asnan) and stomatitis (Qula)] were used in the Ayush research portal and digital helpline for Ayurveda research articles (DHARA).

Data Selection

All search results across databases were uploaded into the Rayyan software tool. The titles and abstracts were then screened by two reviewers (AS and SA) to identify potential studies after duplicate removal.[17] Following that, full texts were obtained and screened for eligibility by two independent reviewers. In instances of disagreement, an experienced third reviewer (AG) was contacted prior to consensus. Additionally, potential study authors were contacted for further clarification if required.

Data Extraction

Two reviewers (AS and SA) were independently involved in the data extraction process, while a third reviewer (AG) was contacted if any disagreements. In instances where different journals published the exact study, only one publication was taken into consideration for data extraction. The corresponding author was personally contacted through e-mail in cases of participants with overlapping age-groups and unclear reporting of data.

Quality Assessment

The methodological quality of all included studies was evaluated using the Cochrane risk of bias tool.[18,19] This tool includes domains such as sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, and selective outcome reporting that are to be marked as "low risk," "high risk," and "unclear risk." Two independent authors (AS and SA) conducted the risk of bias assessment.

Summary Measures

The clinical outcomes evaluated in this review were caries increments in primary decayed, extracted and filled teeth (deft/s) and permanent tooth surfaces decayed, missing, and filled teeth (for permanent teeth) (DMFT/S) reported as changes from baseline, change in bacterial count from saliva or plaque samples (*Streptococcus mutans*, *Lactobacillus*, or other cariogenic pathogens), remineralization of white spots in orthodontic patients as measured by the devices using laser fluorescence detection systems, change in halitosis status measured by any organoleptic devices, and change in gingival and periodontal health status measured by indices as a change from baseline.

Data Analysis

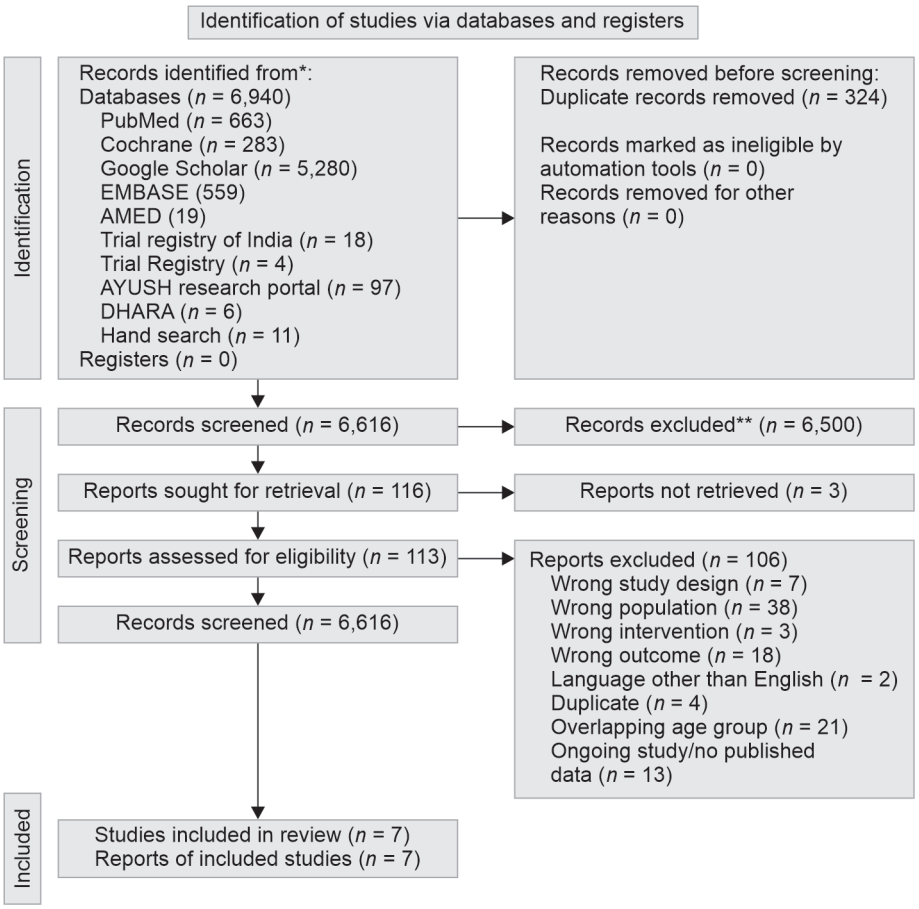
The analysis of the results was conducted using the Review Manager 2020 statistical software (RevMan 5.4.1, The Cochrane Collaboration, and London, United Kingdom), and the outcomes were estimated to be the standardized mean difference. For this meta-analysis, a random-effects model was used, and the heterogeneity was assessed using the χ^2 test and the I^2 index.

Results

The literature search yielded 6,940 articles, including a manual search based on the eligibility criteria of this review. After removing 324 duplicates and excluding studies based on their abstracts and thorough reading of their full texts, seven were eligible for inclusion. PRISMA flowchart illustrates the selection process recorded at each stage (Flowchart 1). All the included studies were published over the past 12 years. Of the seven included studies, five clinical trials, and two RCTs were reported. The studies contained baseline data from 468 participants (mean age range from 6 to 16 years). The sex distribution was skewed toward males, and all studies recruited children and adolescents aged <18 years. Of the included studies, three trials included patients younger than 12 years, whereas the remaining four studies included adolescents. This systematic review included participants from India, Brazil, Saudi Arabia, Poland, and New Zealand. Baseline sample sizes ranged from 40 to 100, with <50 participants in three (43%) included studies.

Of the seven included trials, no studies assessed the effectiveness of herbal dentifrices on caries increments using indices such as DMF, international caries detection and assessment system (ICDAS), DMFT/S. Changes in salivary bacterial counts (*S. mutans* and *Lactobacillus*) using plaque samples were reported in three studies. The gingival and plaque indices scores among adolescents undergoing orthodontic treatment and children with SHCN were reported in three included studies. However,

Flowchart 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the study screening process



no studies have assessed the effect of herbal dentifrices on the demineralization potential of white spots and halitosis. The seven studies described two unique comparisons of outcome assessment, and the studies were classified based on their intent (outcome assessment). Table 1 summarizes the characteristics of seven qualified RCTs.

Quality Assessments of Studies

The data quality varied substantially across the included studies. Of the included studies, one (14%) trial was rated as low-risk, four (57%) with some concerns, and two (29%) as high-risk. The most common study-level confounders found in the included studies were sex, parents' education, and level of preexposure to oral healthcare. Figures 1 and 2 demonstrate the risk of bias assessment for the included studies. A descriptive summary of the statistical analyses of the intervention and comparison groups is presented in Table 2.

Meta-analysis

The pooled results from the four studies reporting on the effect of herbal dentifrices on bacterial (*S. mutans*) reduction showed no statistical significance in the scores between herbal and nonherbal groups [heterogeneity $Tau^2 = 1.40$; $\chi^2 = 32.23$, degree of freedom (df) = 2 ($p < 0.00001$), $I^2 = 94\%$; 0.60 (−0.78, 1.99) 95% confidence interval (CI)], with large evidence of methodological heterogeneity between studies (Fig. 3).

Similarly, pooled results for the plaque index (PI) showed no significant difference between herbal and nonherbal groups (Fig. 4) (heterogeneity $Tau^2 = 168.77$; $\chi^2 = 15.39$, df = 1 ($p < 0.0001$), $I^2 = 94\%$; 3.30 [−15.29, 13.43] 95% CI).

Discussion

In the last decade, there has been an exponential growth and popularity of herbal dentifrices across the globe as an "over-the-counter" oral hygiene aid.[20,21] This review included seven RCTs covering a total population of 468 children and adolescents. Of the seven included studies,[22–28] four studies evaluated the impact of herbal dentifrice on bacterial load, while three studies evaluated the gingival and periodontal health of children and adolescents undergoing orthodontic treatment. One study evaluated the gingival and periodontal health of children with clefts treated with a fixed orthodontic appliance. However, no study assessed the impact of herbal dentifrices on caries increment, remineralization, and halitosis.

The authors would like to highlight the following points in the course of this review: (1) various interventional modalities and frequencies were used across the seven studies, which imposed challenges for the data analysis of the included studies; (2) the timing and follow-up period of the main outcome measurement lacked consistency throughout the seven studies; (3) a variety of herbal components, including Brazilian red propolis (BRP), aloe

Table 1: Characteristics of included studies

Serial number	*Author/year, country*	*Study design*	*Study setting*	*Sample size*	*Study groups*	*Outcome reported*	*Follow-up period*	*Main results*
1	Pieniazka et al., 2016 (Dutch, Poland)	Clinical trial	Children (9–16 years) with the presence of cleft lip and cleft palate (CL/P and CLP) having at least 10 permanent teeth and in the active phase of orthodontic treatment	96	• Group I: Ethanol extract of Brazilian propolis (EEP). • Group II: without EEP (placebo).	GI and PI	Baseline and after 5 weeks (35 days)	Propolis may be an effective agent used in oral hygiene in patients with CL/CLP who are treated with both fixed and removable appliances
2	Bhati et al., 2015 (Uttar Pradesh, India)	Clinical trial	Children in the age-group of 6–12 years had a DMF/def score of zero	60	• Group I: No dentifrices. • Group II: Fluoridated dentifrice Colgate. • Group III: Forever Bright Aloe Vera Toothgel. • Group IV: Dabur Miswak toothpaste.	Bacterial count	Baseline and washout period of 2 days, followed by 15 and 30 days	No significant difference was seen in the antimicrobial properties of all three test dentifrices
3	Patil et al., 2010 (Bengaluru, India)	Clinical trial	Children in the age-group of 4–6 years with DMF/def score zero	100	• Group I: Himalaya Herbals Dental cream containing "neem." • Group II: fluoride toothpaste Cheerio gel (458 ppm).	Bacterial count	Four phases: • 15 days. • 30 days. • 90 days. • 150 days.	Neem-containing toothpaste and fluoridated toothpaste are equally efficacious against dental caries-initiating bacteria (*S. mutans*)
4	Lotif et al., 2022 (Brazil)	Double-blind randomized control trial (RCT)	Children aged between 12 and 18 years; free of carious lesions (ICDAS II 0); use of fixed orthodontic appliance	42	• Group I: BRP fluoridated dentifrice. • Group II: Common fluoridated dentifrice	Visible PI and bacterial count	Baseline (D0) and 4 weeks after day 0 (D28)	BRP dentifrice was more effective for reducing the bacterial count and controlling dental biofilm over 28 days of treatment
5	Naqvi et al., 2019 (Saudi Arabia)	Clinical trial	Patients undergoing fixed orthodontic treatment	40	• Group I: Patients brush their teeth by using the bass technique. • Group II: Patients use miswak along with bass technique.	GI/PI	Baseline, 2, 4, and 6 months	Miswak has an additional advantage in the maintenance of periodontal health in orthodontic patients for a period of 6 months
6	Patel et al., 2018 (Maharashtra, India)	Clinical trial	Children in the age-group of 5–10 years with three to six decayed teeth	40	• Group I: children using fluoridated (Kidodent) toothpaste. Group II: children using herbal (Babool) toothpaste.	PI and bacterial count	Baseline and after 15 days	Herbal toothpaste is not superior to fluoridated toothpaste, but it is equally effective in reducing bacterial counts and plaque scores
7	Philip et al., 2019 (Australia/New Zealand)	Parallel three-group double-blinded, RCT	Above 10 years of age with at least four fully erupted permanent maxillary teeth	90	• Group I: Dentifrice containing 10% CPP-ACP. • Group II: 0.25% cranberry extract incorporated into the CPP-ACP dentifrice. • Group III: Standard fluoride dentifrice.	The bacterial load of 14 bacterial species was determined using real-time quantitative polymerase chain reaction (qPCR) analysis	5–6 weeks	Dentifrices containing CPP-ACP and polyphenol-rich cranberry extracts can influence the oral microbiome, resulting in a microbial community less associated with dental caries

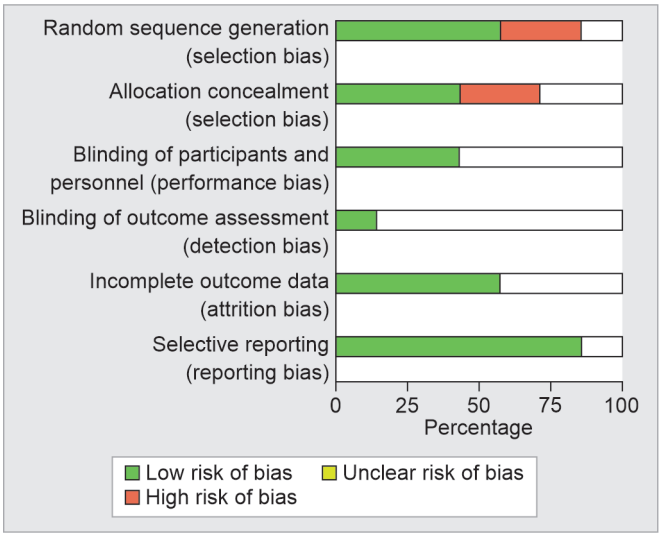


Fig. 1: Risk of bias graph

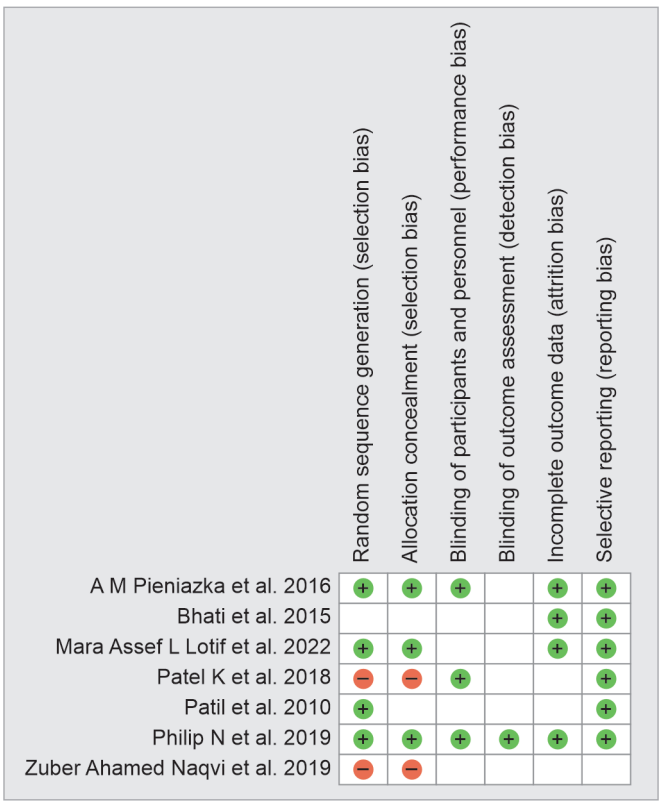


Fig. 2: Risk of bias summary

vera, miswak, Himalayan herbs containing neem, and cranberry extracts were used; (4) of all the included studies, only four studies compared the herbal to fluoride dentifrice, while two studies compared different herbal dentifrices. Pieniazka et al. compared herbal dentifrices to placebo; (5) a varied range of age-groups were considered in the included studies; (6) there was an unequal distribution of sample sizes across the included studies; (7) out of the seven studies, five were clinical trials, and two (Mara et al. and Philip et al.) were double-blinded RCTs; (8) five studies assessed outcomes such as "bacterial load," while four studies assessed the gingival and plaque indices.

Our systematic analysis revealed a marginal difference in the effectiveness of herbal when compared with nonherbal dentifrices with regard to reduction of dental plaque and gingival inflammation. All included studies used fluoridated-based dentifrices against herbal dentifrices to assess their effectiveness in the reduction of dental caries and gingival inflammation. There is strong evidence for the caries-preventive effects of fluoridated toothpaste.[29–32] However, in this review, no studies have reported caries outcomes from baseline values. The evidence established that herbal extracts have effective cleansing, antibacterial, and refreshing properties.[33] The anti-plaque and remineralizing action of fluoride is specific to oral microorganisms and dental plaque. Hence, a plausible similar action may be observed with herbal dentifrices.

Reports in the past attribute the mechanism of herbal dentifrices to its active ingredients that penetrate the biofilm, thereby preventing plaque accumulation and subsequent colonization of bacteria on the tooth surface.[34] The reduction of dental plaque after 4 weeks of herbal dentifrices has been reported previously; however, there are no strong reports on its effectiveness beyond 2 months.[35] The reports of this systematic review indicate a lack of strong evidence to confirm the effectiveness of herbal dentifrices on dental caries. However, a greater effect was noted in reducing gingival index (GI) scores or plaque scores. It is critical to investigate the long-term effectiveness of herbal dentifrice to validate its potency. Currently, the pooled evidence indicates that reams of herbal ingredients are being investigated, but there is no concrete report on specific ingredients.[36] This calls for robust multi-regional replicable clinical trials comparing potential herbal ingredients.

The major strength of this review was that it is the first of its kind in assessing the impact of herbal dentifrices in children and adolescents with regards to caries prevention, halitosis, remineralization, periodontal and gingival health during orthodontic treatment and in children with SHCN. The search databases included AMED, Ayush Portal, and DHARA to ensure the capture of all potential studies. A possible limitation of this study is the exclusion of non-English studies. Furthermore, authors of overlapping age-group studies were contacted for raw data; however, none could be retrieved.

Considering the limitations reported, future RCTs with robust methodology, larger sample sizes, better allocation concealment, and confounding bias are warranted for testing different components of potential herbal dentifrices with superior nonherbal counterparts. This needs to be emphasized more for clinical data on each potential herbal component and its combined effects.

Conclusion

Within the confines of included studies, herbal dentifrices appear to be equally effective in reducing bacterial count and altering bacterial plaque when compared to nonherbal dentifrices. To verify their definitive use, future studies must focus on testing different herbal components of dentifrices and their combined effects on caries reduction. Furthermore, high-quality RCTs are recommended to justify the dilemma of whether herbal dentifrice could be a superior replacement to nonherbal dentifrices for children and adolescents.

Table 2: Descriptive summary of statistical analysis between groups and the suitability to be included in meta-analysis

				Caries status						
				Caries increments		*Change in bacterial count*				
No.	*Study (author/ year)*	*Intervention*	*Comparison*	*DMFT (S)/ dmft (s)*	*ICDAS*	*SM (CFU/ mL)*	*LB (CFU/ mL)*	*CA (CFU/ mL)*	*Authors estimated the risk of bias*	*Suitable for meta-analysis*
1	Bhati et al., 2015	Forever Bright Aloe Vera Toothgel and Dabur Miswak toothpaste	Fluoridated dentifrice Colgate and with no dentifrices	ND	ND	NS	ND	ND	Low	No
2	Patil et al., 2010	Himalaya herbals dental cream containing "neem"	Fluoride toothpaste Cheerio gel (458 ppm)	ND	ND	>	ND	ND	Low	Yes
3.	Lotif et al., 2022	BRP fluoridated dentifrice	Common fluoridated dentifrice	ND	ND	ND	>	NC	Low	No
4	Patel et al., 2018	Group I: children using fluoridated (Kidodent) toothpaste	Group II: Children using herbal (Babool) toothpaste	ND	ND	>	ND	ND	Low	Yes
5	Philip et al., 2019	Group I: dentifrice containing 10% CPP-ACP	• Group II: 0.25% cranberry extract incorporated into the CPP-ACP dentifrice. • Group III: standard fluoride dentifrice.	ND	ND	>	ND	ND	Low	Yes
			Gingival and periodontal health during orthodontic treatment							
No	*Study (author/year)*	*Intervention*	*Comparison*	*PI*		*GI*			*Authors estimated the risk of bias*	*Suitable for meta-analysis*
1	Naqvi et al., 2019	Patients use miswak along with bass technique	Patients brush their teeth by using the bass technique	>		>			Low	Yes
2	Lotif et al., 2022	BRP fluoridated dentifrice	Common fluoridated dentifrice	>		ND			Low	Yes
			Gingival and periodontal health among children with SCHN							
1	Pieniazka et al., 2016	EEP	Without EEP (placebo)	>		ND			Low	No

>, Significant reduction; <, lower than; NS, no significant difference; ND, no data available; NA, not applicable; DMFT, decayed, missing, and filled teeth (for permanent teeth); dmft, decayed, missing, and filled teeth (for primary teeth)

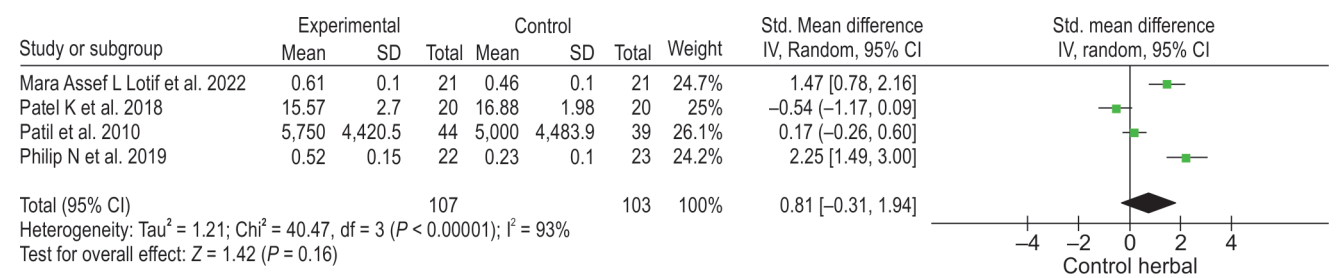


Fig. 3: Forest plot comparing *S. mutans* count between herbal and nonherbal dentifrices

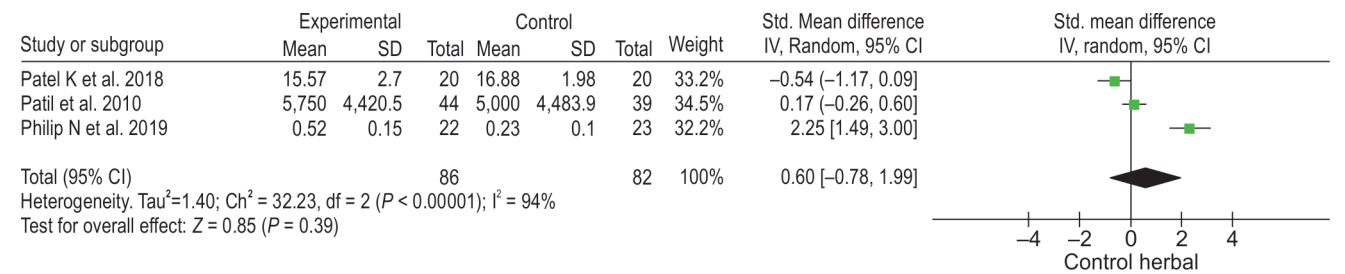


Fig. 4: Forest plot comparing PI between herbal and nonherbal dentifrices

Author Contributions

SA and AS conceptualized and designed the study, collected data, participated in risk-of-bias assessment of studies, analyzed and interpreted the data, drafted the initial manuscript, and critically reviewed and revised the manuscript. MSM and AG conceptualized and designed the study, supervised data collection, analyzed and interpreted the data, drafted the initial manuscript, and critically reviewed and revised the manuscript. KC and RK conceptualized and designed the study, analyzed and interpreted the data, and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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References

1. Herbal Toothpaste Market 2017 Key Growth Drivers, Challenges, Demand and Upcoming Trends by Forecast to 2023 – ABNewswire – Press Release Distribution Service – Paid Press Release Distribution Newswire [Internet]. Available from: http://www.abnewswire.com/pressreleases/herbal-toothpaste-market-2017-key-growth-drivers-challenges-demand-and-upcoming-trends-by-forecast-to-2023_175131.html
2. Freires IA, Rosalen PL. How natural product research has contributed to oral care product development? A critical view. Pharm Res 2016;33(6):1311–1317. DOI: 10.1007/s11095-016-1905-5
3. Janakiram C, Venkitachalam R, Fontelo P, et al. Effectiveness of herbal oral care products in reducing dental plaque & gingivitis - a systematic review and meta-analysis. BMC Complement Med Ther 2020;20(1):43. DOI: 10.1186/s12906-020-2812-1
4. Estafan D, Gultz J, Kaim JM, et al. Clinical efficacy of an herbal toothpaste. J Clin Dent 1998;9(2):31–33.
5. Tatikonda A, Debnath S, Chauhan VS, et al. Effects of herbal and non-herbal toothpastes on plaque and gingivitis: a clinical comparative study. J Int Soc Prev Community Dent 2014;4(Suppl 2):S126–S129. DOI: 10.4103/2231-0762.146220
6. Nivethaprashanthi S, Kavya R, Priyanga R, et al. Comparing the efficacy of herbal and nonherbal toothpastes in controlling plaque and gingivitis: a review. J Sci Den 2020;10(1):25–27. DOI: 10.5005/jp-journals-10083-0920
7. Willershausen B, Gruber I, Hamm G. The influence of herbal ingredients on the plaque index and bleeding tendency of the gingiva. J Clin Dent 1991;2(2):75–78.
8. Ozaki F, Pannuti CM, Imbronito AV, et al. Efficacy of a herbal toothpaste on patients with established gingivitis–a randomized controlled trial. Braz Oral Res 2006;20(2):172–177. DOI: 10.1590/s1806-83242006000200015
9. Pentapati KC, Kukkamalla MA, Siddiq H, et al. Effectiveness of novel herbal dentifrice in control of plaque, gingivitis, and halitosis - Randomized controlled trial. J Tradit Complement Med 2020;10(6):565–569. DOI: 10.1016/j.jtcme.2019.06.006
10. Mullally BH, James JA, Coulter WA, et al. The efficacy of a herbal-based toothpaste on the control of plaque and gingivitis. J Clin Periodontol 1995;22(9):686–689. DOI: 10.1111/j.1600-051x.1995.tb00827.x
11. Hosadurga R, Boloor VA, Rao SN, et al. Effectiveness of two different herbal toothpaste formulations in the reduction of plaque and gingival inflammation in patients with established gingivitis - A randomized controlled trial. J Tradit Complement Med 2018;8(1):113–119. DOI: 10.1016/j.jtcme.2017.04.005
12. Fereidooni M, Samani MK, Amiri A, et al. Comparison of the effect of propolis and traditional toothpaste on bacterial plaque. J Babol Univ Med Sci 2014;16:17–22.
13. Azaripour A, Mahmoodi B, Habibi E, et al. Effectiveness of a miswak extract-containing toothpaste on gingival inflammation: a randomized clinical trial. Int J Dent Hyg 2017;15(3):195–202. DOI: 10.1111/idh.12195
14. Baeshen H, Salahuddin S, Dam R, et al. Comparison of fluoridated miswak and toothbrushing with fluoridated toothpaste on plaque removal and fluoride release. J Contemp Dent Pract 2017;18(4):300–306. DOI: 10.5005/jp-journals-10024-2035
15. Patel K, Karkare S, Pustake B, et al. Comparative evaluation of antimicrobial efficacy of two commercially available herbal and nonherbal (fluoridated) toothpastes on salivary microbial count: an in-vivo study. Int J Pharm Sci Res 2018;9:3042–3046. DOI: 10.13040/IJPSR.0975-8232.9(7).3042-46
16. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. DOI: 10.1136/bmj.n71
17. Johnson N, Phillips M. Rayyan for systematic reviews. J Electron Resour Librarianship 2018;30:46–48.
18. Higgins JP, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928. DOI: 10.1136/bmj.d5928
19. Higgins JPT, Thomas J, Chandler J, et al. Cochrane Handbook for Systematic Reviews of Interventions, 2nd edition. Chichester (UK): John Wiley & Sons; 2019.
20. Wu-Yuan CD, Green L, Birch WX. In vitro screening of Chinese medicinal toothpastes: their effects on growth and plaque formation of mutans Streptococci. Caries Res 1990;24(3):198–202. DOI: 10.1159/000261265
21. Kanth MR, Prakash AR, Sreenath G, et al. Efficacy of specific plant products on microorganisms causing dental caries. J Clin Diagn Res 2016;10(12):ZM01–ZM03. DOI: 10.7860/JCDR/2016/19772.9025
22. Naqvi ZA, Salama MH. Periodontal evaluation of tooth brushing technique with and without miswak in orthodontic patients with fixed orthodontic appliances-a clinical study. Asian Pac J Health Sci S 2019;6(1):44–48.
23. Philip N, Leishman SJ, Bandara HMHN, et al. Randomized controlled study to evaluate microbial ecological effects of CPP-ACP and cranberry on dental plaque. JDR Clin Trans Res 2020;5(2):118–126. DOI: 10.1177/2380084419859871
24. Patil S, Venkataraghavan K, Anantharaj A, et al. Comparison of two commercially available toothpastes on the salivary streptococcus mutans count in urban preschool children—an in vivo study. Scientific 2010;12(4):72–81.
25. Lotif MAL, Valadas LAR, Fechine FV, et al. A double-blind randomized clinical trial of Brazilian red propolis dentifrice efficacy in orthodontic patients. J Oral Sci 2022;64(1):28–32. DOI: 10.2334/josnusd.21-0270
26. Bhati N, Jaidka S, Somani R. Evaluation of antimicrobial efficacy of *aloe vera* and Meswak containing dentifrices with fluoridated dentifrice: an *in vivo* study. J Int Soc Prev Community Dent 2015;5(5):394–399. DOI: 10.4103/2231-0762.165924
27. Machorowska-Pieniążek A, Skucha-Nowak M, Mertas A, et al. Effects of Brazilian propolis on dental plaque and gingiva in patients with oral cleft malformation treated with multibracket and removable appliances: a comparative study. Evid Based Complement Alternat Med 2016;2016:2038407. DOI: 10.1155/2016/2038407
28. Wong MC, Clarkson J, Glenny AM, et al. Cochrane reviews on the benefits/risks of fluoride toothpastes. J Dent Res 2011;90(5):573–579. DOI: 10.1177/0022034510393346
29. Wright JT, Hanson N, Ristic H, et al. Fluoride toothpaste efficacy and safety in children younger than 6 years: a systematic review. J Am Dent Assoc 2014;145(2):182–189. DOI: 10.14219/jada.2013.37
30. Twetman S, Axelsson S, Dahlgren H, et al. Caries-preventive effect of fluoride toothpaste: a systematic review. Acta Odontol Scand 2003;61(6):347–355. DOI: 10.1080/00016350310007590
31. Shaheen SS, Reddy P, Shaheen SS, et al. Antimicrobial efficacy of ten commercially available herbal dentifrices against specific oral

microflora - in vitro study. J Clin Diagn Res 2015;9(4):ZC42–ZC46. DOI: 10.7860/JCDR/2015/11127.5829
32. Chandra Shekar BR, Nagarajappa R, Suma S, et al. Herbal extracts in oral health care - a review of the current scenario and its future needs. Pharmacogn Rev 2015;9(18):87–92. DOI: 10.4103/0973-7847.162101
33. Dhingra K. Aloe vera herbal dentifrices for plaque and gingivitis control: a systematic review. Oral Dis 2014;20(3):254–267. DOI: 10.1111/odi.12113
34. Löe H. The gingival index, the plaque index and the retention index systems. J Periodontol 1967;38(6):610–616. DOI: 10.1902/jop.1967.38.6.610
35. Arweiler NB, Müller-Breitenkamp F, Heumann C, et al. Antibacterial action, substantivity and anti-plaque effect of different toothpaste slurries - a randomised controlled trial. Oral Health Prev Dent 2021;19(1):529–536. DOI: 10.3290/j.ohpd.b2182977
36. Saimbi CS, Chanan S, Amrit N. Comparative anti-plaque activity of a plant preparation vis-a-vis modern dentifrices. J Indian Dent Assoc 1986;58(3):93–98.
37. Moustafa MH, Sadek SI. The efficiency of miswak concentrate toothpaste. I: clinical report. Egypt Dent J 1987;33(1):75–84.
38. Shasmitha RS, Gurunathan D, Mani G. Evaluation of antioxidant-essential toothpaste as a treatment for gingivitis in orthodontic patients. Drug Invent Today 2019;12.