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Ayurvedic and herbal plaque control agents in gingivitis: A systematic review and meta-analysis of randomized controlled trials

Danish Javed, Ashish Kumar Dixit, Sana Anwar[1], Anshul Rai[2], Kawal Krishan[3]

Department of AYUSH, All India Institute of Medical Sciences, Bhopal, MP, India, [1]Department of Community and Family Medicine, AIIMS, Bhopal, MP, India, [2]Department of Oral and Maxillofacial Surgery, All India Institute of Medical Sciences, Bhopal, MP, India, [3]Department of Hospital Administration, All India Institute of Medical Sciences, Bhopal, MP, India

Address for correspondence:
Dr. Kawal Krishan, Department of Hospital Administration, All India Institute of Medical Sciences, Bhopal, MP, India.
E-mail: kpandita.hospadmin@aiimsbhopal.edu.in

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Abstract:

BACKGROUND: Since the effectiveness of ayurvedic and herbal plaque control agents in reducing plaque in gingivitis is inconsistent across multiple trials, we conducted a study to evaluate their overall effect on dental plaque index (PI), gingival index, and bacterial colony counts (CC) of debris in gingivitis patients.

MATERIALS AND METHODS: We searched major electronic biomedical databases (PubMed/Medline, CAM-QUEST®, EBSCOhost, Google Scholar, EMBASE, Scopus, and Cochrane Central Register of Controlled Trials) from August 2004 to August 2021 for randomized control trials on gingivitis using ayurvedic, herbal plaque control agents, and oil pulling therapy as interventions. We grouped comparable outcome parameters of similar products and estimated the standard mean difference (SMD) for pooled effect size with 95% confidence intervals (CI) using RevMan 5.4.1 software. Risk-of-bias (ROB) assessment followed the Cochrane Collaboration's recommended approach.

RESULTS: We found 554 articles of 2,806 patients after searching of which 41 randomized clinical trials were considered for meta-analysis. Ayurvedic plaque control agents (Plaque index (PI): SMD = −0.52, 95% CI (−0.94, −0.11); CC: SMD = −1.70, 95% CI (−5.06, 1.67)), (Oil pulling therapy: PI: SMD = −0.38, 95% CI (−1.45, 0.68); CC: SMD = −1.04, 95% CI (−2.20, 0.11)), (Herbal plaque control agents: PI: SMD = −0.58, 95% CI (−1.55, 0.39)), (Triphala: PI: SMD = −0.65, 95% CI (−1.32, 0.03)) were found as good as control. Significant reduction in the gingival index and bacterial colony count was also seen.

CONCLUSIONS: In addition to conventional dental care, ayurvedic and herbal plaque control agents may help in plaque reduction, gingival inflammation, and bacterial growth. They are safe and may be recommended in community dentistry practices.

(PROSPERO registration number: CRD42021274656)

Keywords:

Ayurvedic, dental plaque, gingivitis, herbal medicine, medicine, mouthwashes, plant oils

Introduction

Gingivitis is one of the most common oral health problems, and it can lead to more serious issues with teeth and other oral cavity structures.[1] Plaque is caused by poor dental hygiene in the majority of the population.[2] Plaque control is strongly suggested, and it has also been established as a method of treating gingivitis.[3] The accumulation of microbial plaque causes calculus to form on tooth spaces, increasing the risk of periodontitis, which can lead to tooth loss, dental cavities, foul breath, and a poor quality of life.[4]

Self-performed mechanical and chemical oral hygiene measures include tooth brushing,

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dental flossing, dentifrices, and mouth rinse.[5] The most often used chemical agent is chlorhexidine (CHX), but its deleterious effects on the oral mucosa, staining properties, and taste sense alterations discourage its usage and reduce acceptance.[6]

Herbal or ayurvedic dental preparations are gaining popularity as replacements for traditional plaque control agents. These products are marketed as safe and effective in preventing oral health issues.[7] Ayurveda pharmaceutical goods are presently in significant demand on the global market, especially in India.[8] Ayurvedic products are widely adopted by the public due to their various qualities like anti-inflammatory, antimicrobial, antioxidant, and anticancerous properties, as well as their natural flavor and feel. In India, general practitioners use ayurvedic remedies to treat oral diseases.[9] Herbal powder and oil pulling therapy are popular ayurvedic remedies for better oral health. Plant twigs for brushing and herbal toothpaste also contain plant-based extracts and essential oils.[10] Although a considerable number of randomized clinical trials involving herbal and ayurvedic medicines as well as oil pulling therapy in patients have been conducted, the results are unconvincing.[11] Herbal plaque control agents are as effective as conventional ones in preventing plaque growth, according to a few systematic literature reviews and meta-analyses.[12-14] A systematic review and meta-analysis is necessary to evaluate the effectiveness and safety of ayurvedic and herbal therapies in treating gingivitis. This study aims to provide evidence-based research for clinicians to make informed treatment recommendations. It will assess the effect of these agents on dental plaque index, gingival index, and bacterial colony counts in gingivitis patients, as well as identify effective plant species for efficient plaque control.

Material and Methods

Study design and setting

The study was a systematic review and meta-analysis; conducted at the Department of AYUSH of All India Institute of Medical Sciences Bhopal, India, during the year 2021. The Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA 2020) guidelines were followed for reporting this systematic review.[15]

Criteria for Considering Studies for this Systematic Review and Meta-analysis

2.1.1 Participants-Interventions-Comparators-Outcomes-Study design (PICOS) Questions. This systematic review was executed mainly focused on the question, i.e. "How are the ayurvedic and herbal plaque control agents efficacious in plaque control in teeth and to reduce gingival inflammation and bacterial load in tooth debris?"

Study Type: Only randomized clinical trials (RCTs) related to the above question were included in this study.

Study participants: Patients diagnosed as established gingivitis and otherwise having no other dental or systemic disease.

Study interventions: Any intervention in the form of herbal or ayurvedic toothpaste, toothpowder, gel, mouth rinse in the form with or without mechanical use of the toothbrush, floss, etc., Herbal dentifrice and plaque control agents should consist of at least one of its components as the herb. Multiple combinations of plant products were called herbal and classical or patent ayurvedic formulations were called ayurvedic. Oil pulling therapy, i.e. rinsing the mouth with any type of single or poly herbal-based oil or essential oil, was considered under oil pulling therapy.

Comparator: Any comparator either a 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 was considered.

Types of outcome measures: The clinical effect of intervention or control that was established on certain parameters of plaque index, gingival index, and colony count.

Primary outcomes:

(i) Plaque index: Standard mean difference (SMD) of QHPI (Quigley and Hein plaque index), TQHPI (Turesky–Gilmore–Glickman modification of Quigley–Hein plaque index), or SLPI (Silness and Löe index).
(ii) Gingival index: Standard mean difference (SMD) of LSGI (Löe and Silness gingival index).
(iii) Colony-forming unit (CFU) Standard mean difference (SMD) of colony counts.

Secondary outcomes: Adverse event if any,

Ethical Consideration and registration: A detailed protocol was prepared initially and registered in the International Prospective Register of Systematic Review (http://www.crd.york.ac.uk/PROSPERO/) and obtained the registration no: CRD42021274656)

2.1.2 Eligibility criteria: Based on the PICOS question, the following inclusion criteria were made to fulfill compulsorily by all the included studies:

(i) All the participants must be diagnosed case of gingivitis and should not contain any other dental or systemic illness.
(ii) The dentifrice and plaque control agents of intervention should be having at least one or more active herbal ingredients, natural or plant extract.
(iii) The dentifrice and plaque control agents of the comparison group must be any product that does not have any herbal or plant-based component.
(iv) The above intervention or control should be used by subjects along with the self-performed mechanical oral hygiene measures, i.e., toothbrush, finger, or any other means.
(v) The outcome of the study must include plaque index, gingival index, or colony count as one of the assessment parameters.
(vi) Randomized clinical trials (RCTs) only will be included.

Exclusion criteria: All the studies, other than RCT, i.e., quasi-randomized trial, clinical study, observational study, cohort study, cross-sectional study, case report, *in vivo*, *in vitro* study, and systematic reviews, were excluded.

2.1.3 Search methods for identification of studies

We searched multiple electronic biomedical databases, including PubMed/Medline, CAM-QUEST®, EBSCOhost, Google Scholar, EMBASE, Scopus, and Cochrane Central Register of Controlled Trials in August 2021, along with unpublished studies in the grey literature. The search used keywords like gingivitis, dental plaque, ayurvedic, herbal medicine, phytotherapy, plant preparations, plant oils, and mouthwashes, with no language or time restrictions. Boolean operators "AND" and "OR" were used, and additional relevant articles were found through references (see appendix).

2.1.4 Selection of studies: Two authors (DJ and AKD) checked all articles for duplication and screened titles and abstracts for inclusion and exclusion criteria. Full-text articles were examined for eligibility, and missing articles were requested from authors via ResearchGate or email. Studies with any exclusion criteria were not considered, and any disagreements were resolved through discussion or a third reviewer (SA).

2.1.5 Data collection tools and techniques: The two reviewers systematically filled in details of included RCTs in a preformed Microsoft Excel Sheet, including study definition, risk-of-bias assessment, study length, randomization and analysis units, participant characteristics, intervention, control, outcome, and results. Mean differences (MD) and standard deviations (±SD) were used to summarize treatment effects, while standardized weighted-mean differences (SMD) were used for outcomes measured by different scales or indices. A random-effects model was employed to calculate pooled effect estimates with 95% confidence intervals (CIs).[16] Missing data were requested from the corresponding author of included articles, and non-reported SDs were calculated from standard errors or confidence intervals. RevMan 5.4.1 software was used for data analysis and forest plots generation by the Cochrane Collaboration.

2.1.6 Assessment of risk of bias in included studies: The risk-of-bias (ROB) assessment of the included studies used the approach recommended by the Cochrane Collaboration's tool.[17] Two review authors (DJ and AKD) independently analyzed all included articles for study design characteristics and internal validity criteria in duplicate. We provided a summary of findings for each included study, including publication details (author, year, and study period). Methodological quality was assessed to determine the risk of bias in the included research.

The included studies were assessed for bias using the Cochrane Handbook's scoring system, which evaluated criteria such as randomization methods, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. The assessments were done independently and any disagreements were resolved through discussion or adjudication by a third party. The author and source institution were not masked from the reviewers.

2.1.7 Missing data: Missing data were obtained from authors whenever possible, and attrition rates, including dropouts, losses to follow-up, and withdrawals, were evaluated. Issues with missing data and imputation methods were critically studied. Missing standard deviations (SD) were imputed (average of SD of reported studies), and sensitivity analyses were conducted to assess the impact of imputation on meta-analyses.

2.1.8 Assessment of heterogeneity: Significant clinical, methodological, or statistical heterogeneity was explored, but the meta-analysis still presented a pooled effect estimate. Heterogeneity was identified using visual inspection of forest plots and the standard Chi-square test α and I2 statistic (<75%). Funnel plots were used to evaluate small study effects if four or more studies were included for a specific outcome.

2.1.9 Synthesis of results: We used Cochran's Q statistic, a Chi-square test, and a cutoff *P* value of less than 0.05 to assess the data's heterogeneity.[18] The I2 statistic and forest plots were used to assess the consistency of the results.[19] In comparison with sampling error, the I2 statistic describes the proportion of variation in point

estimates related to heterogeneity having more than two studies. For the graphic presentation, forest plots were employed where more than four studies present.

Results

Search results

After searching various databases, 554 records were found, with 288 duplicates and 91 irrelevant records being removed. Following the screening of 175 citations, 91 articles were excluded due to non-English (16), non-availability of full-text articles (26), and irrelevant titles and abstracts (49). Out of 84 papers reviewed for eligibility, 43 were discarded for various reasons, including variation in RCT design (11) and follow-up (9), missing values (8), irrelevant indices (8), and other outcomes (7). The final meta-analysis included 41 papers. Details are available in the PRISMA 2020 flowchart in Figure 1.

3.2 Risk of bias within the study

The majority of studies analyzing the effectiveness of herbal and ayurvedic dental preparations have a low risk of bias, making the results reliable. 77.2% of trials had a low risk of selection bias, 65.8% had a low risk of allocation concealment, 65.8% had a low risk of performance bias, and 62% had a low risk of detection bias. Only 12.65% of studies had a risk of other bias, while incomplete outcome data and selective reporting were low risk in 77.2% and 82.2% of studies, respectively Figure 2.

Characteristics of the included studies

We have included 41 randomized clinical trials in this meta-analysis in which data from a total of 2,806 patients were analyzed. Total dropout patients were 43 among included studies. The characteristics of encompassed studies are highlighted in Table 1 (Supplementary material). All the studies were categorized by their main intervention as herbal, ayurvedic, or single plant-based plaque control agents, namely, ayurvedic[20-25] (6), oil pulling therapy[26-31] (6), herbal[32-40] (9), Triphala[39,41-47] (8), Aloe vera[48-50] (3), Azadirachta indica[51-53] (3), Curcuma longa[54-56] (3), Green tea[57,58] (2), and Ocimum[59,60] (2). Narayan *et al.*[39] 2012

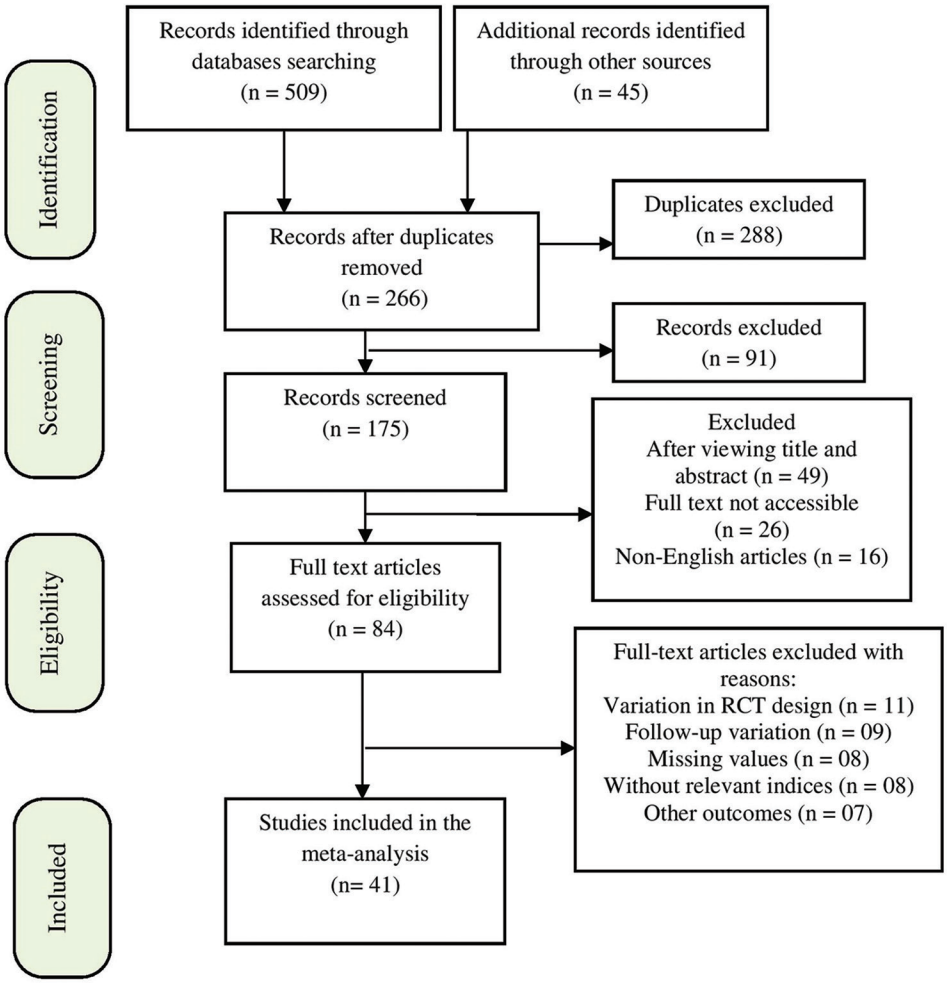

Figure 1: Study flow diagram

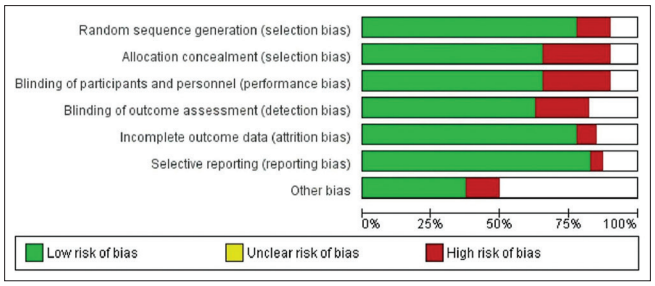

Figure 2: Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies

included "Triphala" and "herbal" in both groups in the study, so this study was comprised of both categories. Included studies were published from 2004 to 2020 in various indexed biomedical journals. The reviewed studies were randomized clinical trials, including participants of both genders ranging from 8 to 70 years old. They involved individuals with mild or severe plaque-induced gingivitis, DMFT (decayed/missing/filled teeth) scores of 2 to 6, PI > 1, or GI > 1. The majority of the trials (21) had two groups, with 16 using three groups and 2 involving four groups. In 30 studies, 0.1% chlorhexidine was used as a control, while standard or branded plaque control agents were used in eight studies. The placebo was saline or distilled water in 10 trials. Follow-up durations ranged from one hour to 90 days without any adverse events observed.

Meta-analysis comparing ayurvedic and herbal plaque control agents with control

We observed significant differences in these analyses in favor of herbal and ayurvedic plaque control agents as compared to control or placebo (Ayurvedic plaque control agents to control: Plaque index: SMD = −0.52, 95% CI (−0.94, −0.11) P = 0.01; heterogeneity Chi2 = 6.73 > 3, I2 = 55%; Colony Count: SMD = −1.70, 95% CI (−5.06, 1.67) P = 0.32; heterogeneity Chi2 = 78.96 > 1, I2 = 99%), (Oil pulling therapy: Plaque index: SMD = −0.38, 95% CI (−1.45, 0.68) P = 0.48; heterogeneity Chi2 = 26.67 > 3, I2 = 89%; Colony Count: SMD = −1.04, 95% CI (−2.20, 0.11) P = 0.08; heterogeneity Chi2 = 7.82 > 2, I2 = 74%), (Herbal plaque control agents: Plaque index: SMD = −0.58, 95% CI (−1.55, 0.39) P = 0.24; heterogeneity Chi2 = 200.46 > 8, I2 = 96%), (Triphala: Plaque index: SMD = −0.65, 95% CI (−1.32, 0.03) P = 0.06; heterogeneity Chi2 = 88.96 > 7, I2 = 92%), (Aloe vera: Plaque index: SMD = −1.39, 95% CI (−3.55, 0.77) P = 0.21; heterogeneity Chi2 = 60.46 > 2, I2 = 97%), (Azadirachta indica: Plaque index: SMD = −0.47, 95% CI (−4.13, 3.18) P = 0.80; heterogeneity Chi2 = 72.25 > 2, I2 = 97%; Gingival index: SMD = −0.91, 95% CI (−2.38, 0.56) P = 0.23; heterogeneity Chi2 = 6.69 > 1, I2 = 85%), (Curcuma longa: Plaque index: SMD = −0.68, 95% CI (−1.97, 0.61) P = 0.30; heterogeneity Chi2 = 33.94 > 2, I2 = 94%; Gingival index: SMD = −0.97, 95% CI (−1.88, −0.07) P = 0.04; heterogeneity Chi2 = 16.50 > 2, I2 = 88%), (Green tea: Plaque index: SMD = 0.16, 95% CI (−2.31, 2.64) P = 0.90; heterogeneity Chi2 = 29.10 > 1, I2 = 97%), (Ocimum: Plaque index: SMD = −1.04, 95% CI (−3.21, 1.13) P = 0.35; heterogeneity Chi2 = 12.03 > 1, I2 = 92%) Figure 3 a and b.

Risk of bias across the studies

Meta-analysis included in ayurvedic, herbal plaque control agents, oil pulling therapy, and Triphala groups was having more than five studies. The funnel plot was intrigued through RevMan 5.4.1 software Cochrane Collaboration for them. However, the plots were found in favor of possible publication bias upon visual examination Figure 4.

Discussion

Ayurvedic texts provide detailed descriptions of dental diseases and oral health care. Ayurvedic and herbal formulations for controlling plaque in patients with gingivitis have been promoted as safe and effective, and several preparations have been summarized in a meta-analysis of 41 randomized clinical trials. No negative effects have been observed in any of the studies. The only issue with oil pulling therapy is that it is unpleasant to use.[29] Ayurvedic formulations with traditional combinations such as Triphala, Dashan sanskar powder, and oil pulling therapy were more effective in controlling plaque than single or poly herbal agents in 41 randomized clinical trials. However, the composition of these ayurvedic preparations is heterogeneous, with Acacia catechu, Acorus calamus, Aquilaria agallocha, Azadirachta indica, Barleria prionitis, Berberis aristata, Curcuma longa, Emblica officinalis, Glycyrrhiza glabra, Mimusops elengi, Mimosa pudica, Ocimum tenuiflorum, Prunus cerasoides, Santalum album, Syzygium aromaticum, Terminalia bellirica, Terminalia chebula, Woodfordia fruticosa, etc.[20-25] In these studies, Arimedadi oil, coconut oil, and sesame oil were used in oil pulling therapy, and their efficacy was determined to be as good as a positive control.[26-31] This meta-analysis did not differentiate between types of plaque control agents, but instead focused on their primary plant material. Oil pulling therapy was found to be particularly effective. Some pharmaceutical companies recognize the importance of oil pulling therapy and launch products in the Indian market. Many people are not satisfied with the costs and inadequate insurance coverage of oral and dental healthcare services.[61] The majority of individuals rely on conventional toothpaste and only seek dental advice when their condition becomes severe.[62] Preventive dentistry has always been the preferred choice of researchers in dentistry.[63] Ayurvedic products are effective in mucositis in radiotherapy patients. Further evaluation as therapeutic agents for premalignant and

Table 1: Summary of included studies

Reference origin	Year	Design	Patient (Total, Group)	Age group (Years)	Male/ Female	Inclusion criteria	Experimental intervention
Ayurvedic plaque control agents							
Kadam[20]	2011	Open-labeled random sampling	30 (15,15)	NR	NR	Moderate gingivitis with probing depth of ≤3 mm	UDM tooth powder (11 components)
Patil[21]	2017	Single-blind, parallel design randomized controlled trial	40 (20,20)	17–35	20/20	VSCs and hydrocarbon gas levels >3 (Breath Alert Tanita®), periodontal pockets ≤4 mm	G32 (poly ayurvedic compound)
Saquib[22]	2017	Parallel group, unicentric, blinded, randomized controlled clinical trial	112 (56,56)	21–40	54/58	Gingival inflammation with no attachment loss	Babul (*Acacia nilotica*) Vajradanti (*Barleria prionitis*) and Bakul (*Mimusops elengi*)
Soman[24]	2020	Double-blinded parallel randomized Controlled study	90 (30,30,30)	18–21	NR	Healthy subjects	Oral Pal Plus (poly herbal ayurvedic preparation)
Vinod[25]	2018	Open-labeled randomization	200 (100,100)	18–22	NR	Plaque induced gingivitis, gingival index of Score II	Poly herbal ayurvedic preparation
Shetty[23]	2017	Open-labeled randomization	40 (20,20)	9–12	NR	Systemically healthy subjects	Munident (herbal)
Oil pulling therapy							
Asokan[26]	2008	Randomized, controlled, triple-blind study	20 (10,10)	16–18	Male	DMF scores 1–2.	Sesame oil
Asokan[27]	2009	Randomized, controlled, triple-blind study	20 (10,10)	16–18	Male	Plaque-induced gingivitis	Sesame oil
Priyank[31]	2017	Randomized, controlled, triple-blind	30 (10,10,10)	19–21	NR	Mild-to-moderate gingivitis and plaque accumulation	Sesame oil pulling, coconut oil pulling
Botelho[28]	2009	Randomized, controlled, double-blind, clinical trial.	55 (27,28)	18–69	29/26	Minimal mean gingival index of 1.0	*Lippia sidoides* essential oil 1%
Nagilla[30]	2017	Randomized controlled double-blinded parallel clinical trial	40 (20,20)	18–22	8/32	Plaque score ≥1	Coconut oil,
Mali[29]	2016	Randomized, double-blinded, three-group parallel study	45 (15,15,15)	18–21	NR	Mild-to-moderate gingivitis	Arimedadi oil
Herbal plaque control agents							
Bhat[33]	2014	Double-blinded, parallel designed randomized clinical trial	72 (24,24,24)	18–24	37/35	Healthy subjects	HiOra ®
Siddeshappa[40]	2018	Open-labeled randomization	40 (20,20)	20–50	24/16	Mild-to-moderate gingivitis, bleeding on probing present	HiOra ®
Aspalli[32]	2014	Open-labeled randomization	100 (50,50)	20–45	NR	Mild-to-moderate gingivitis, bleeding on probing present	HiOra ®
Gupta D[36]	2015	Triple-blind, randomized controlled trial, a three-group parallel study	105 (35,35,35)	21–25	53,52	Healthy subjects, DMFT (decayed/missing/filled teeth) score of 2 to 5	Cinnamon
Jinfeng He[37]	2019	Double-blind, randomized, placebo-controlled, parallel allocation clinical trial	120 (60,60)	18–70	40/68	GI ≥1, PI ≥1.0	Poly herbal preparation
George[35]	2009	Randomized double-blinded clinical trial	30 (15,15)	18–65	NR	Gingival index ≥1, PI ≥2.0	Colgate herbal
Deshmukh[34]	2017	Randomized controlled trial with three parallel groups.	45 (15,15,15)	18–21	21/24	Systemically healthy subjects	HiOra ®
Narayan[39]	2012	Double-blind, randomized, crossover clinical trial.	30 (Crossover four groups)	>18	NR	Systemically healthy subjects	HiOra ®

Contd...

Table 1: Contd...

Reference origin	Year	Design	Patient (Total, Group)	Age group (Years)	Male/ Female	Inclusion criteria	Experimental intervention
Triphala (*Emblica officinalis, Terminalia chebula, Terminalia belerica*)							
Nayak[47]	2012	Triple-blind randomized field trial	60 (30,30)	12–15	36/24	School children, DMFT 3 to 6	*Terminalia chebula*
Gupta[44]	2015	Placebo controlled double-blind randomized control trial	90 (30,30,30)	18–27	NR	Systemically healthy subjects, PI >1.5	*Terminalia chebula*
Bhattacharjee[42]	2014	Randomized, double-blinded, controlled trial	60 (30,30)	8–12	NR	PI >0.9, Children with	0.6% Triphala
Naiktari[46]	2014	Double-blind, randomized, multicenter controlled trial	120 (40,40,40)	20–65	78/42	Plaque, calculus, gingival inflammation	Triphala
Mamgain[45]	2017	Randomized controlled clinical trial	60 (30,30)	>18	NR	Systemically healthy, Plaque-induced gingivitis, Halitosis	Triphala and Ela decoction
Narayan[39]	2012	Double-blind, randomized, crossover Clinical trial.	30 (Crossover 4 groups)	>18	NR	Systemically healthy subjects	Triphala
Baratakke[41]	2017	Double-blinded parallel arm randomized controlled trial	60 (20,20,20)	18–24	Female	PI score ≥ 1	0.6% Triphala
Chainani[43]	2014	Double-blind, randomized, crossover Clinical trial.	120 (40,40,40)	13–16	60/60	Systemically healthy subjects	10% Triphala
Aloe vera							
Gupta[44]	2014	Double-blind randomized control trial	300 (100,100,100)	NR	NR	GI ≤ 1	*Aloe vera*
Khatri[49]	2017	Parallel-group, randomized prospective controlled trial	44 (22,22)	12–18 mild-to-moderate intellectually disabled	25/15	Mild-to-moderate gingivitis	*Aloe vera*
Oliveira[50]	2008	Double-blind, parallel, controlled clinical trial	30 (15,15)	35–43	15/15	GBI>40%	Aloe vera
Neem (*Azadirachta indica*)							
Balappanavar[51]	2013	Triple-blind randomized control parallel design trial	30 (10,10,10)	18–25	NR	LSGI ≥ 3.0 SLPI>1.5	2% Neem solution.
Jalaluddin[52]	2017	Double-blind, randomized crossover study	40 (20,20)	18–35	NR	Gingival inflammation	2% Neem solution.
Pai[53]	2004	Open-labeled randomization	36 (12,12,12)	NR	NR	Healthy subjects	*Azadirachta indica* leaf extract
Turmeric (*Curcuma longa*)							
Singh[55]	2015	Randomized controlled clinical trial	40 (20,20)	20–35	NR	Mild-to-moderate gingivitis	Turmeric extract
Kandwal[54]	2015	Randomized controlled clinical trial	60 (30,30)	>18	NR	Plaque-induced gingivitis	Turmeric extract
Waghmare[56]	2011	Double-blind random sampling	100 (50,50)	25–35	NR	PI >1	Turmeric
Green Tea (*Camellia sinensis*)							
Abdulbaqi[57]	2016	24-h plaque re-growth, double-blinded, randomized crossover trial	14	25–40	13/1	Good general health	Leaves of *Camellia sinensis* and roots of *Salvadora persica L.*
Sarin[58]	2015	Placebo-controlled, triple-blind, parallel-group randomized control trial	110 (55,55)	18–60	NR	PI>1.5, GI>1	Camellia sinensis
Tulsi/Basil (*Ocimum sp.*)							
Da[59]	2011	Double-blind, parallel, controlled clinical trial.	30 (10,10,10)	27–42	15/15	Bleeding index (BI) >20%	*Ocimum gratissimum*
Gupta[60]	2014	Placebo-controlled, triple-blind randomized control trial	108 (36,36,36)	18–27	NR	PI >1.5, DMFT 3-5	*Ocimum sanctum*

Contd...

Table 1: Contd...

Reference origin	Formulation	Control intervention	Formulation	Follow-up duration (days)	Outcome measure	Adverse event (AE)	Dropout
Ayurvedic plaque control agents							
Kadam[20]	Tooth powder	Branded	Tooth powder	15 days	LSGI, TQHPI	No	0
Patil[21]	Tablets-crush and massage on gums	CHX	Mouthwash	7 days	Volatile sulfur compounds (VSCs) score, SLPI, LSGI, Winkel tongue coating index,	Burning mucosa and drying of mouth in CHX group	0
Saquib[22]	Ayurvedic powder formulation	CHX	Mouthwash	28 days	TQHPI, LSGI	No	0
Soman[24]	Mouthwash	CHX, Distilled water	Mouthwash, placebo	14 days	SLPI, LSGI	No	0
Vinod[25]	Mouthwash	CHX	Mouthwash	14 days	Colony count	No	0
Shetty[23]	Dentifrice	Standard	Toothpaste	30 days	*S. mutans* count, LSGI	No	0
Oil pulling therapy							
Asokan[26]	Mouthwash	CHX	Mouthwash	14 days	Count of *Streptococcus mutans* in plaque and saliva	No	0
Asokan[27]	Mouthwash	CHX	Mouthwash	10 days	Plaque index and modified gingival index scores, count of *Streptococcus mutans*	No	0
Priyank[31]	Mouthwash	CHX	Mouthwash	30 days	*Streptococcus mutans* CFU	No	0
Botelho[28]	Mouth rinse	CHX	Mouthwash	28 days	Colony count of Streptococcus mutans, PI, GI and GBI	Burning sensation, altered taste	0
Nagilla[30]	Mouthwash	Mineral water as placebo	Mouthwash	7 days	TQHPI	No	0
Mali[29]	Mouthwash	CHX	Mouthwash	21 days	SLPI, LSGI,	Oil was unpalatable	0
Herbal plaque control agents							
Bhat[33]	Mouthwash	CHX, Normal Saline	Mouthwash	28 days	TQHPI, LSGI	Mild-to-moderate discoloration, dry mouth, transient taste disturbance and burning sensation in CHX group	0
Siddeshappa[40]	Mouthwash	Chlorine dioxide	Mouthwash	21 days	Colony count of *Streptococcus mutans, Tannerella forsythia*, and *Fusobacterium nucleatum* SLPI, LSGI, MOSBI	No	0
Aspalli[32]	Mouthwash	Scaling	Mechanical	21 days	SLPI, LSGI, GBI	No	0
Gupta D[36]	Mouthwash	CHX, Distilled water	Mouthwash	30 days	TQHPI, LSGI,	No	0
Jinfeng He[37]	Toothpaste	Placebo	Toothpaste	84 days	GBI, GI, TQHPI, BOP% scores	No	12
George[35]	Toothpaste	Colgate conventional	Toothpaste	30 days	TQHPI, LSGI Salivary pH,	No	0
Deshmukh[34]	Mouthwash	CHX, Prebiotic	Mouthwash	14 days	OHI-S, GI, PI	No	0
Narayan[39]	Mouthwash	CHX, Colgate plax	Mouthwash	24 Hours, 4 weeks washout period	TQHPI	No	0
Triphala (*Emblica officinalis, Terminalia chebula, Terminalia belerica*)							
Nayak[47]	Mouthwash	Saline	Mouthwash	60 minutes	Salivary Streptococcus mutans count, PI, GI	No	0

Contd...

Table 1: Contd...

Reference origin	Formulation	Control intervention	Formulation	Follow-up duration (days)	Outcome measure	Adverse event (AE)	Dropout
Triphala (*Emblica officinalis, Terminalia chebula, Terminalia belerica*)							
Gupta[44]	Mouthwash	CHX, Distilled water	Mouthwash	30 days	TQHPI, LSGI	No	0
Bhattacharjee[42]	Mouthwash	CHX	Mouthwash	14 days	PI, GI	No	3
Naiktari[46]	Mouthwash	CHX, Distilled water	Mouthwash	15 days	PI, GI	Altered taste sensation and burning sensation in CHX group.	0
Mamgain[45]	Mouthwash	CHX	Mouthwash	21 days	GI, PI, and organoleptic scoring scale	No	0
Narayan[39]	Mouthwash	CHX, Colgate plax	Mouthwash	24 Hours, 4 weeks washout period	TQHPI	No	0
Baratakke[41]	Mouthwash	0.12% CHX	Mouthwash	21 days	SLPI, LSGI,	No	0
Chainani[43]	Mouthwash	0.1% CHX, Negative control	Mouthwash	1 month, 15 days wash out period	TQHPI, LSGI,	No	11
Aloe vera							
Gupta[44]	Mouthwash	CHX, saline water	Mouthwash	4 days	QHPI	Staining and unpleasant taste in CHX group	0
Khatri[49]	TP	Triclosan group- Colgate toothpaste	TP	30 days	SLPI, LSGI, CFU counts for Candida sp.	No	20%
Oliveira[50]	Dentifrice	Fluoridated TP	Dentifrice	30 days	GBI, PI	No	0
Neem (*Azadirachta indica*)							
Balappanavar[51]	Mouthwash	CHX, 0.5% tea mouthwash	Mouthwash	21 days	SLPI, LSGI, Salivary pH	No	0
Jalaluddin[52]	Mouthwash	CHX	Mouthwash	15 days	SLPI, LSGI,	No	0
Pai[53]	Gel	CHX, placebo gel	Mouthwash	42 days	SLPI, *Streptococcus mutans*, and *Lactobacilli* count	No	0
Turmeric (*Curcuma longa*)							
Singh[55]	Gel	CHX	Gel	21 days	SLPI, LSGI, SBI	No	0
Kandwal[54]	Gel	CHX	Gel	21 days	SLPI, LSGI	Gagging to the taste in CHX group	0
Waghmare[56]	Mouthwash	CHX	Mouthwash	21 days	LSGI, TQHPI, total microbial count	No	0
Green Tea (*Camellia sinensis*)							
Abdulbaqi[57]	Mouthwash	0.12% CHX, Distilled water	Mouthwash	24 hours, 6-day washout period	TQHPI	No	0
Sarin[58]	Mouthwash	Placebo	Mouthwash	28 days	LSGI, TQHPI,	No	8
Tulsi/Basil (*Ocimum sp.*)							
Da[59]	Mouthwash	CHX, Control group	Mouthwash	90-day	GBI, PI	No	0
Gupta[60]	Mouthwash	CHX, Saline	Mouthwash	30 days	LSGI, TQHPI	No	0

PI=Plaque index, QHPI=Quigley and Hein plaque index, TQHPI=Turesky–Gilmore–Glickman modification of Quigley–Hein plaque index, SLPI=Silness and Löe index, GI=Gingival index, LSGI=Löe and Silness gingival index, GBI=Gingival bleeding index, SBI=Sulcus bleeding index, MOSBI=Mombelli and Ouston modified sulcular bleeding index, BOP=Bleeding sites on probing, PD=Pocket depth, OHI-S=Oral hygiene index– Simplified, CFU counts=Colony-forming unit counts, CHX=Chlorhexidine, NR=Not reported

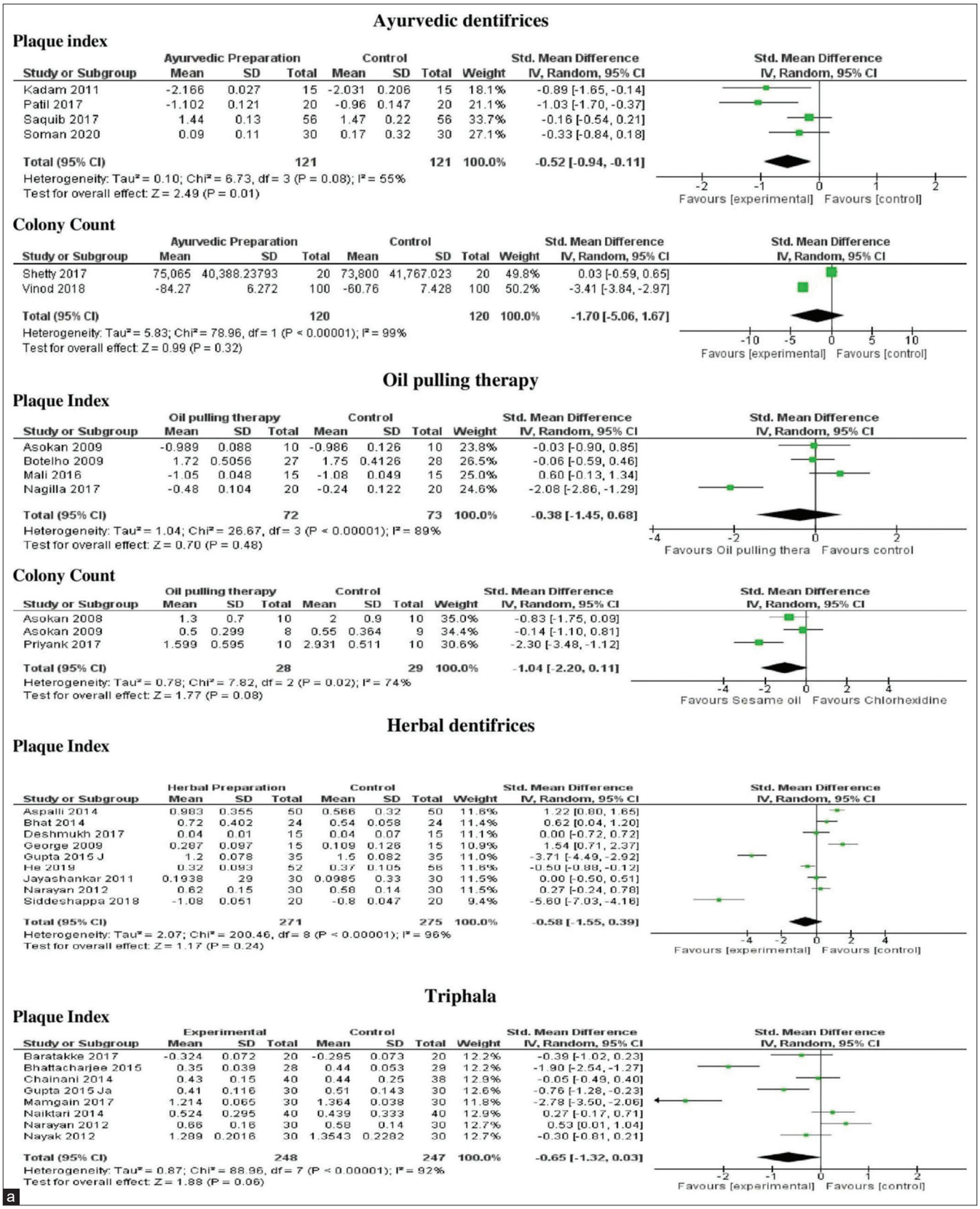

Figure 3: (a and b) Forest plots of included studies

malignant lesions, oral ulcers, periodontitis, and halitosis is recommended.

This is the first meta-analysis of ayurvedic plaque control agents and oil pulling therapy, but subgroup analysis

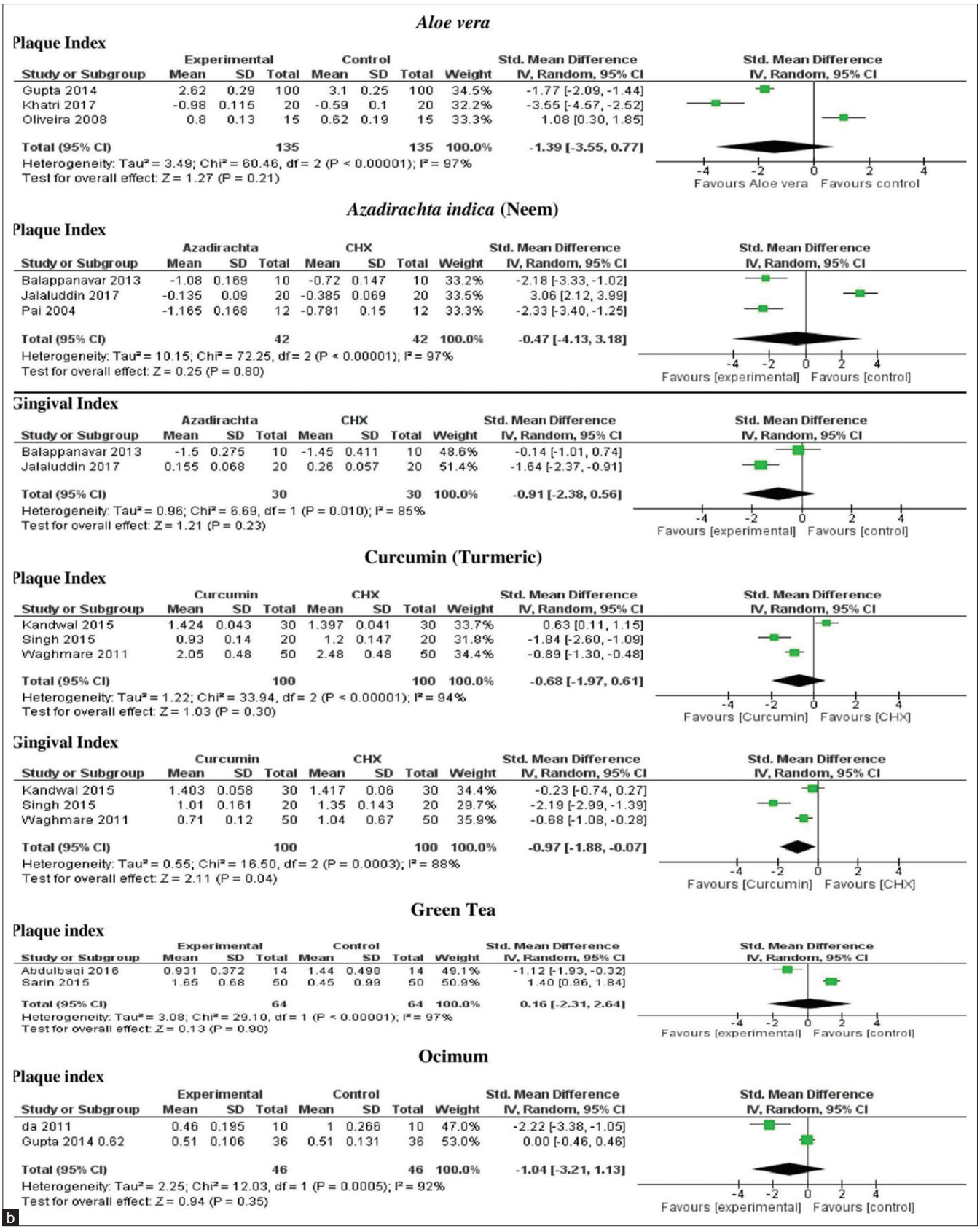

Figure 3: Contd...

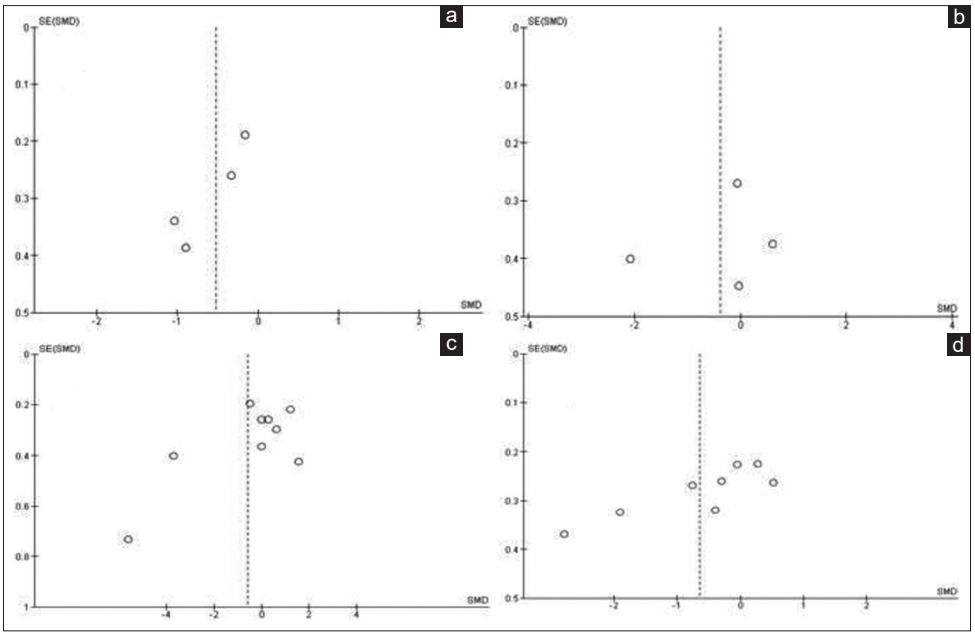

Figure 4: Funnel plot of comparison: (a) Ayurvedic preparation, (b) Oil pulling therapy, (c) Herbal preparations and (d) Triphala vs. Control, Outcome: Plaque index.

was not conducted, and the study included all types of populations. The generalizability of the results is limited as most studies were conducted in India and were only undertaken for a short period. Adverse events were rarely reported. Future RCTs in herbal and ayurvedic dentistry should use uniform methods and outcomes reporting and adequate randomization, sample size, allocation concealment, and blinding of outcome assessors to improve evidence quality (e.g. CONSORT).

Conclusion

Ayurvedic and herbal formulations show promise in controlling plaque in patients with gingivitis, but further rigorous studies are needed to establish their efficacy and safety. Integrating these formulations as a complementary treatment option should be considered by health policymakers, but evidence-based guidelines and regulations are necessary for safe and effective use, ultimately improving oral health outcomes and providing alternative treatment options.

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Abbreviations

CFU	Colony-forming unit
CHX	Chlorhexidine
CI	Confidence intervals
CONSORT	Consolidated Standards of Reporting trials
LSGI	Löe and Silness gingival index
MD	Mean differences
PICOS	Participants-Interventions-Comparators- Outcomes-Study design
QHPI	Quigley and Hein plaque index
RCT	Randomized clinical trial
SD	Standard deviations
SLPI	Silness and Löe index
SMD	Standard mean difference
TQHPI	Turesky–Gilmore–Glickman modification of Quigley–Hein plaque index

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Conflicts of interest

There are no conflicts of interest.

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