



GRADUATION PROJECT

Degree in Dentistry

Effectiveness of chlorhexidine in controlling gingivitis in adults compared to other mouthwashes

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RESUMEN

Introducción: Para evitar la gingivitis, se utilizan terapias coadyuvantes como los colutorios (enjuagues bucales) además de la higiene mecánica. Aunque la clorhexidina (CHX) es el estándar de oro, su uso a largo plazo produce efectos secundarios como la tinción dental y la alteración del gusto. Actualmente, se presentan nuevos colutorios como alternativas para la gingivitis con el fin de reducir los efectos secundarios en el uso de mantenimiento.; **Objetivos:** El objetivo principal de este estudio es responder a esta pregunta PICO: En adultos con gingivitis (P), ¿los colutorios de clorhexidina (I), en comparación con otros colutorios (C), dan como resultado una mayor reducción de la placa y la inflamación gingival (O)?; **Metodología:** Esta revisión sintetiza los datos de 16 estudios que fueron seleccionados mediante un proceso de cribado. Se comparó la eficacia de los colutorios alternativos frente a la CHX utilizando índices de placa e índices gingivales.; **Resultados:** Se recopilaron datos de 635 participantes. Los análisis mostraron que varios colutorios presentaron resultados similares a la CHX. Se obtuvieron excelentes resultados con el colutorio polihierbal, Triphala y el aceite de semilla de eneldo. Otros colutorios de extractos naturales demostraron gran eficacia; por ejemplo, la hoja de guayaba presentó una gran protección antioxidante.; **Conclusiones:** Los colutorios naturales representan una excelente alternativa a la CHX como terapia coadyuvante en el tratamiento a largo plazo de enfermedades periodontales como la gingivitis. Presentan pocos o ningún efecto secundario y ofrecen una alternativa biodegradable sin comprometer los resultados clínicos. A pesar de esto, la CHX se sigue considerando el estándar de oro para el control a corto plazo de la placa y la inflamación gingival. Es necesario realizar más estudios para observar la acción de estos colutorios en poblaciones específicas o de alto riesgo.

PALABRAS CLAVE

Odontología, Gingivitis, Colutorio, Clorhexidina, Revisión.

ABSTRACT

Introduction: To avoid gingivitis adjunctive therapies such as mouthwashes are used in addition to mechanical hygiene. While Chlorhexidine (CHX) is the gold standard, its long-term use it produces side effects such as tooth staining and taste alteration. New mouthwashes are nowadays presented as alternatives for gingivitis in order to reduce the side effects for maintenance use.; **Objectives:** The primary objective of this study is to answer this PICO question: In adults with gingivitis (P), do chlorhexidine mouthwashes (I), compared with other mouthwashes (C), result in greater reduction of plaque and gingival inflammation (O)?; **Methods:** This review synthesize data from 16 studies that were selected through a screening process. Effectiveness of alternative mouthwashes were compared to CHX with plaque and gingival indexes.; **Results:** Data was collected from the 635 participants. Analyzed showed that several mouthwashes presented similar results with CHX. Great results were obtained with polyherbal mouthwash, Triphala, Dill seed oil. Other mouthwashes from natural extracts demonstrated great effectiveness as Guava leaf presented great antioxidant protection.; **Conclusions:** Natural mouthwashes represent a great alternative to CHX in the long-term treatment of periodontal disease as gingivitis as an adjunctive therapy. They present low to no side effects and offer a biodegradable alternative without compromising clinical results. Even though CHX is still considered the gold standard for the short-term control of plaque and gingiva inflammation. Further studies need to be conducted to observe the action of these mouthwashes on specific or high-risk populations.

KEYWORDS

Dentistry, Gingivitis, Mouthwash, Chlorhexidine, Review.

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1. INTRODUCTION

1.1. Periodontal disease and gingivitis

Periodontal disease presents a high prevalence in our society nowadays, with dental caries it represent the first cause of tooth loss(1,2).

Gingivitis is a periodontal disease that is caused by dental plaque. It consists of a biofilm that stays on the tooth surfaces. It involves a reversible inflammation of the gums, which is characterized by swelling, redness and bleeding of the gums. Gingivitis can lead to periodontitis if not treated, which is a chronic multifactorial inflammatory disease. This chronic inflammation creates the destruction of the alveolar bone (bone around the tooth) and can lead to tooth mobility and spontaneous tooth loss if not treated. It can be manifested by gingival recession, periodontal pocketing and clinical attachment loss.

To avoid periodontal disease such as gingivitis and periodontitis, removal of the dental plaque on a daily basis is very important to prevent gingivitis and periodontitis (1–3).

1.2. Chlorhexidine

The dental plaque contains pathogenic microorganisms, for some patients the usual mechanical cleaning is not sufficient, and chemical methods such as mouthwashes can be indicated. Studies have shown that Chlorhexidine (CHX) mouthwashes used with mechanical cleaning control reduce dental plaque(1,3).

CHX is a cationic molecule that binds to cells wall, it's active against gram positive, gram negative, facultative anaerobes , aerobes organism and yeast(2). CHX can present bacteriostatic or bactericidal effect depending on the concentration. CHX is also characterized by its substantivity(1). CHX is present in different forms such as gels, mouthwashes and toothpastes.

1.3. Analyze

The efficacy of mouthwashes is determined by several indices. As gingivitis is linked to the presence of dental plaque, the plaque indices are very good indicator. Studies also use other indices such as gingival index and bleeding index.

1.4. Alternatives

Even though CHX is efficient in the prevention of gingivitis, it presents some limitations. Indeed, CHX presents several side effects which can open the discussion to the use of different

mouthwashes. For the past years other mouthwashes have been tested to find an antiplaque agent with minimal side effects(4). A lot of alternatives exist such as essential oils , Cetylpyridinium chloride (CPC), tea, neem and herbal mouthwash(2,4–6). Some of these alternatives are more natural and used for centuries in other countries like tea and neem in India(5). These alternatives can be very interesting considering the development of bacterial resistance to synthetic antimicrobial and the reduction of side effects(3). Several clinical trials compare them with CHX which is the gold standard, new alternatives can be interesting in short term maintenance or long-term used as some of them present similar effectiveness and fewer side effects (3).

1.5. Findings of systematics reviews

In the search for articles about the adjunctive therapy, we referred to systematic review and meta-analysis(1,2,6). The objectives of these reviews were to determine the efficacy of adjunctive therapies in patients with gingivitis.

The *James et al. (2017)* review focused on the CHX mouthwashes , 51 studies were analyze for a total of 5345 participants (1).

38 studies included the gingival inflammation as an outcome using different indexes, 31 used the gingival index of Löe and Silness, 2 the modified gingival index, 4 used Papillary marginal gingival index and one the Papillary bleeding score.

48 studies include the plaque as an outcome. Several indexes were used, 22 used the Plaque index of *Silness and Löe*. 19 used the *Turesky* modification of the *Quigley and Hein* Index. One study used both the Quigley and Hein plaque index and the Modified Proximal Plaque Index. One study used the Quigley and Hein plaque index. One used the Approximal Plaque Index, one used the Full-mouth plaque score. One used the method described by *Greene and Vermilion*. And 3 studies measured the presence of or absence of plaque without specification of the index used(1).

The review concluded that there is a high quality evidence of reduction of dental plaque and gingivitis in the groups using CHX mouthwashes with a mechanical control hygiene for 4 to 6 weeks and 6 months(1).

The *Figuro et al. (2019)* review compared several mouthwashes (6). 21 studies were analyzed for the mouthwashes part, 15 studies included one test group, 5 studies included two test groups and 1 study included tree test groups. Placebo was used in 19 arms of trials for a total of

1557 patients and 4218 used mouthwashes. 11 studies used gingival index of *Löe and Silness* and 10 used the modified gingival index.

11 trials studies essential oils (EEOO), 7 trials studies CPC at different concentrations, 5 trials studies CHX.

This review concluded that there is significant differences between placebo and active agents. And the mouthwashes that shown the greatest results on the gingival index score was the mouthwashes with essential oils(6).

The *Windhorst et al. (2025)* is a systematic review and a meta-analyses that compare CHX mouthwash and CPC on scores plaques and gingivitis (2). This study compares CPC and CHX in non-brushing patient and brushing patients. 14 studies were analyzed, presenting 18 comparisons; 12 were on non-brushing patients and 6 on brushing patients. For brushing comparison studies, all evaluated the plaque score. Some of them also evaluated the gingival index and the bleeding index and the staining score. No statistically significant differences were observed between *CHX* and *CPC* except for one study that found that *CHX* mouthwashes present significantly more staining than *CPC*.

For the non-brushing studies, out of 12 comparisons 7 found that CHX mouthwashes were significantly more effective than *CPC*. Only one study found a result in favor of *CPC* compared to *CHX*. The results are heterogenous on this part of the results.

From the 14 studies of the review, it was concluded that *CHX* mouthwashes may present a slight advantage in plaque control for patients that don't brush their teeth and no significant difference for brushing patients.

1.6. Findings of small clinical trials

The *Eshwar et al. (2016)* is a randomized double blind parallel arm clinical study(3); this study compares effectiveness of 0.2% CHX mouthwashes and dill seed oil. This comparison of effectiveness is done by means of plaque level and gingival score. 90 subjects were selected and divided into 2 groups. Group A (45) rinsed with dill seed oil mouth rinse and group B (45) rinsed with 0.2% CHX gluconate. On the first day of the study every subject did an examination of hard and soft tissue and received professional cleaning, every plaque, calculus and extrinsic staining to ensure that all deposits have been removed. All subjects rinsed twice a day with 20ml for 60 seconds. After 45 and 90 days plaque and gingival indices were done. When dill seed oil groups were compared no statistically significant difference was found for the gingival and plaque indices at 45 and 90 days. Dill seed oil mouthwashes and 0.2% CHX mouthwashes have similar plaque and anti-gingival effectiveness. For short terms antiplaque effect, CHX remains the first

choice but in Dill seed oil can be considered as alternatives for short term maintenance considering its effectiveness and the fact that it presents fewer side effects. Dill seed oil must be tested on larger population and at community level.

The *Pradeep et al. (2016)* is a randomized controlled clinical trial that evaluate the efficacy of Triphala (TRP) for the reduction and plaque and gingivitis (4). 90 patients were selected and randomly divided in 3 groups of 30 participants. Composed of 42 males and 48 women aged from 25 to 40 years old with a mean age of 31 years old. The first group received a placebo mouthwash, the group number 2 received the TRP mouthwashes, and the group number 3 received CHX mouthwashes. No patients were lost during the follow up. Examinations and scoring were conducted by a blinded clinician at the baseline, at 7, 30 and 60 days. At the baseline, plaque index, gingival index and oral hygiene index-simplified were measured after the patients received scaling and polishing with fluoride paste. Individuals were instructed to use 15ml of mouthwash twice a day 30 to 45 minutes after brushing. Significant reduction of the plaque index, the gingival index and the oral hygiene index-simplified were observed in group 2 and group 3. TRP plaque index, gingival index and microbial colony counts reduction were close to the ones of CHX group and greater than the placebo (group 1) and present fewer side effects. TRP mouthwash was found to reduce inflammation and can be considered as a potential therapeutic agent in the treatment of gingivitis.

The *Balappanavar et al. (2013)* is a randomized control trial that compare the effectiveness of 0.5% tea, 2% neem and 0.2% CHX mouthwash (5). 30 subjects were selected and divided into 3 groups composed of 10 subjects. Group A uses 0.2% CHX mouthwash, group B uses 2% neem and group C 0.5% tea. Participants were instructed to use 15ml for 30 seconds with the mouthwash assigned after brushing twice a day. Group A used the mouthwash for 14 days; group B and C used it for 21 days. To compare the different groups the trial used plaque index, gingival index, simplified oral hygiene index and salivary pH; those indices and pH were recorded at the baseline, after 1week, after 2 weeks and after 3 weeks (except for group A). Plaque and gingival scores were reduced in every group Anti plaque action was the highest in group C (0.5% tea). Group B (neem) and C (tea) showed better effectiveness on the gingiva compared to group A (CHX). Oral hygiene improvement was better appreciated in group B (neem) and C (tea).

2. OBJECTIVE

The primary objective of this study is to answer this PICO question: In adults with gingivitis, do chlorhexidine mouthwashes, compared with other mouthwashes, result in greater reduction of plaque and gingival inflammation?

3. MATERIAL AND METHODS

3.1. Pico question

Table 1: Table of the pico question

Population	Adults with gingivitis
Intervention	Treatment with chlorhexidine mouthwashes
Comparison	Compared with other mouthwashes
Outcome	Greater reduction of plaque and gingival inflammation

3.2. Eligibility criteria

Studies included participants older than 18 years old with gingivitis as our population is adult with gingivitis. The studies should also compare mouthwash with Chlorhexidine (CHX) using plaque indexes or gingival indexes.

Different study designs were included, randomized clinical trials, cohort studies, case-control studies, case series, case report and systematic reviews.

Only studies in English were included.

3.3. Exclusion criteria

Studies with participant that are younger than 18 years old, studies in other languages than English. Editorial and expert opinions will not be considered.

Articles that did not compare the alternative mouthwash with CHX were excluded.

Articles of more than 10 years (2015) were excluded

3.4. Search strategy

For the search of studies and articles we used several information sources. We used Pubmed, MEDLINE complete and Dentistry & Oral Science Source.

We used different search terms on those information sources with Boolean operators (OR, AND), "Gingivitis", "Chlorhexidine", "CHX", "alternatives", "Comparison", "Effectiveness", "Periodontal disease"

The following search equation was used on Pubmed:

((((((((((gingivitis) OR (gingival inflammation)) OR (dental plaque)) AND (mouthwash)) OR (mouthrinse)) OR (chemical agents)) AND (chlorhexidine)) OR (CPC)) OR (CHX)) OR (essential oils)) OR (cetylpyridinium chloride)) OR (herbal)) OR (triclosan)

4. RESULTS

4.1. Screening process

An age filter was used to remove the studies on participants younger than 18 years old. Reviews (secondary evidence) are removed to include only primary evidence (randomized control trials, cohort studies, case-control studies, case series and case reports). Another filter was added for the articles older than 2015 to eliminate all the articles published more than 10 years ago. We continue with a title screening to do the first selection of articles and eliminate the possible duplicate. We continue with an abstract screening. After eliminating articles from the abstract screening, we proceed to the Full text screening. Once this part is done, a list of the articles is included for the review.

During the screening of the title abstract and full text of the articles the aim was to select the best articles for this review. The focused on the eligibility criteria and made sure that no exclusion criteria were found. The articles without comparison to Chlorhexidine (CHX) were excluded as well as the articles talking about different problematic such as periimplantitis/ effect on patients with implant, orthodontic treatment or general health condition as Asmaa, stress and anxiety.

4.2. Study selection

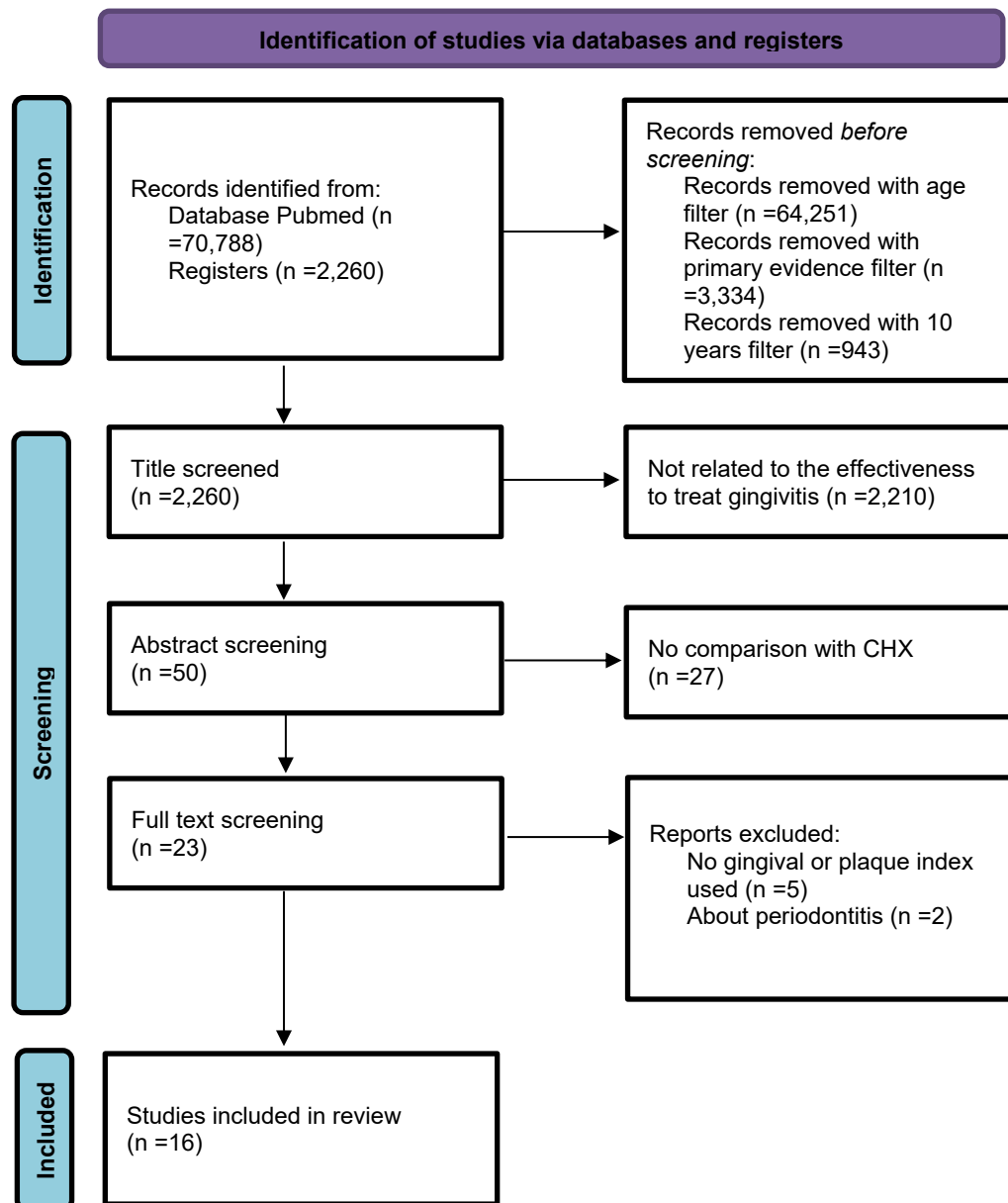


Figure 1: Identification studies diagram.

Prisma 2000 flow diagram Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

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Of the 70,788 articles, 16 were included in this review after different screening. Data from 635 participants were extracted. The minimum participants per group was 14 and the maximum was 90.

Studies were conducted for different time periods. The most common was 1 month, the shortest one was 4 days and the longest one was 3 months (90 days).

Several indexes were measured in different studies, the two most used were PI and GI. Several mouthwashes were tested and compared to CHX which is considered the gold standard and used as a reference for the comparison of effectiveness in the treatment of gingivitis.

Here are the alternative mouthwashes that we compared to CHX: *herbal/essential oil mouthwash, coconut oil, probiotic mouthwash, amide fluoride, povidone iodine, Anacardium occidentale extract, guava leaf extract, Tea, Lycium barbarum (Goji berry), Arimadadi Tailam, Matricaria chamomilla L. extract (miswak)*.

Most of the studies samples were divided into 2 groups, one alternative mouthwash group and one CHX group (7–9).

Other studies have more groups if they tested more than one alternative mouthwash or had a placebo group (4,10–16).

Some studies, all participants went into several cycles (3 cycles) with period of washout between every cycles (17,18).

And some studies divide their sample in groups and perform several cycles with period of washout between the every cycle (3,19,20).

To facilitate the understanding of the data extracted we decided to do 2 tables (Table 2a and Table 2b) in addition to the explanation of the data.

4.3. Effect on the Gingival index

The most studied alternative mouthwash was herbal mouthwash (*Boyapati et al. (2024), Quintas et al. (2015), Marchetti et al. (2017), Senkalvarayan et al. (2023), Eshwar et al. (2016), Pradeep et al. (2016)*) compared in 6 studies (3,4,11,16,18,19). Regarding the Gingival index (GI) several were used Beeding on interdental brushing (BOIB), Gingival index (GI) and Loe and Silness. *Quintas et al. (2015) and Marchetti et al. (2017)* did not measure GI (they only measure plaque index)(18,19). In all the studies using GI an improvement in the indexes was observed. In the 3 studies no statistical was observed differences of the GI between the herbal mouthwash and CHX (3,4,16). On the other hand Boyapati et al. (2024) observed better results with CHX than Herbal mouth wash (Aloe vera) (11).

Another alternative mouthwash studied is the coconut oils rinse in 2 studies (*Pardiñas López et al. (2025) and Shamini et al. (2023)*)(10,15). GI was measured in the *Shamini et al. (2023)* and Inflammatory markers (Interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- α)) and Bacterial

DNA in *Pardiñas López et al. (2025)*. They both observed reduction of the inflammation and lower GI, no statistical difference was observed compared to *CHX*.

Other studies compare mouthwash from natural extracts. *Anacardium occidentale extract* in *Gomes et al. (2016) (12)*. *Guava leaf extract* in *Nayak et al. (2019) (13)*. *Lycium barbarum (Goji berry) ethanolic extract* in *Sanghavi et al. (2023)(9)*. And *Matricaria chamomilla L. extract* mouthwash in *Goes et al. (2016)(14)*. Several indexes were used, Gingival bleeding index (GBI), Gingival index (GI) Loe & Silness and Bleeding on probing (BOP). All mouthwashes showed reduction of the inflammation in different indexes used comparable to *CHX* in all the studies.

Other articles compared other mouthwashes, *Miswak* mouthwash *Al-Mahmood & Sabea (2021) (7)*. Gingival index and BOP (bleeding on probing) index were scored from the Bucco-lingual and Bucco-mesial site of the tooth. Improvement was observed in the BOP, although *CHX* showed superior results in both BOP and GI. Miswak was also seen in a test formulation with *green tea and Salavadora persica L. extracts (miswak)* in *Abdulbaqi et al. (2016) (17)*. Only the plaque index was measured on this study.

Amine Fluoride (AmF) mouthwash was also tested in *Priya & Galgali (2015)(8)*. gingival index (Löe and Silness), bleeding index (Ainamo and Bay) were measured. A reduction was observed in the GI and bleeding index. No significant differences were observed compared to *CHX*.

In the study of *Casarin et al. (2019)*, *Melaleuca alternifolia (Tea Tree oil) nanoparticles mouthwash (MEL-NP)* was tested(20). Gingival bleeding index and Interleukin-1 β was measured. Similar results were obtained compared to *CHX* group.

A probiotic (*Darolac*) and *Povidone iodine* mouthwashes were tested alongside with Herbal mouthwash and *CHX* in *Boyapati et al. (2024) (11)*. Bleeding on interdental brushing (BOIB) was measured. Improvements were observed in all the groups but better were observed in groups using *CHX* and Probiotic mouthwash compared to *Povidone iodine*.

4.4. Effect on the plaque index

Now let's look at the plaque index and the effect of the different mouthwashes. Herbal mouthwash (*Boyapati et al. (2024)*, *Quintas et al. (2015)*, *Marchetti et al. (2017)*, *Senkalvarayan et al. (2023)*, *Eshwar et al. (2016)*, *Pradeep et al. (2016)*) compared in 6 studies (3,4,11,16,18,19). Plaque was measured with different indexes: Marginal plaque index (MPI), Biofilm thickness, *Turesky* modification of the *Quigley–Hein* Plaque Index, Plaque index (PI) and Plaque index *Silness and Loe*. All studies showed a significant reduction in the plaque indexes. No statistical

difference with CHX was observed (3,4,16). CHX showed a better inhibitory effect on the plaque regrowth compared to Listerine Zero and Alcohol based essential oils(19). CHX was more effective in the reduction of the thickness of plaque than Listerine and Mentol mouthwashes (18). CHX showed better result on the MPI than Aloe vera mouthwash (11).

Another alternative mouthwash studied is the coconut oils rinse in 2 studies (*Pardiñas López et al. (2025)* and *Shamini et al. (2023)*) (7,18). Plaque index (PI) was measured in *Shamini et al.(2023)* (15). No plaque index was measured in *Pardiñas López et al. (2025)*, only bacterial DNA was collected (10). Reduction of the PI was observed, similar results to the CHX groups. No statistical difference was observed between the Coconut oil and CHX (15).

Some articles compare mouthwash from natural extracts. *Anacardium occidentale* extract in *Gomes et al. (2016)* (12). *Guava leaf* extract in *Nayak et al. (2019)* (13). *Lycium barbarum* (*Goji berry*) *ethanolic* extract in *Sanghavi et al. (2023)*(9). And *Matricaria chamomilla* L. extract mouthwash in *Goes et al. (2016)*(14). Several indexes have been used to measure the effectiveness on the plaque, Plaque index (PI), *Turesky–Gilmore Glickman* modification of *Quigley Hein* Plaque Index and Visible plaque index (VPI). Reduction of the plaque has been observed in every study. No significant differences with CHX has been observed (9,12,14). In the study of *Nayak et al. (2019)* CHX was more effective for the PI than *Guava leaf* extract mouthwash (13).

Other articles compared other mouthwashes, *Miswak* mouthwash *Al-Mahmood & Sabea (2021)* (7). Plaque index scored from the buccal and lingual sides of the tooth. Results showed an improvement of the PI but the CHX showed better results. *Miswak* was also observed on a test formulation of *green tea* and *Salavadora persica* L. extracts (*Miswak*) in *Abdulbaqi et al. (2016)* (17). The Modified *Quigley Hein* plaque index was used. A significant reduction of the plaque was observed for the group using the test formulation of *green tea* and *Salvadora persica* L. compared to the groups using CHX and placebo groups with distilled water.

Amine Fluoride (AmF) mouthwash was also tested in *Priya & Galgali (2015)*(8). *Turesky* modification of the *Quigley-Hein* plaque index was used in this study. Significant reduction of the plaque index was observed and results from the AmF group were similar to the one using CHX.

In the study of *Casarin et al. (2019)*, *Melaleuca alternifolia* (Tea Tree oil) nanoparticles mouthwash (MEL-NP) was tested(20). *Quigley-Hein* Plaque Index was measured. In both group CHX and MEL-NP reduction of the plaque was achieved but more effective for the CHX groups.

A probiotic (*Darolac*) and *Povidone iodine* mouthwashes were tested alongside with Herbal mouthwash and CHX in *Boyapati et al. (2024)* (11). Marginal plaque index (MPI) was used in this study. Reduction of the plaque index was observed in both *Darolac* group and *Povidone iodine* group and CHX. Better results were obtained with CHX and *Darolac* groups.

4.5. Table of results

Table 2a: Sample and study design of the studies reviewed.

Number of articles	Author and Year and study type	Sample	Study design	Sample weight in the review
1	<i>Boyapati et al. (2024) (11)</i> A randomized controlled trial	N=40 randomized Divides into 4 groups: probiotic mouthwash, Herbal mouthwash (Aloe vera), Povidone iodine mouthwash, CHX mouthwash	Participants brushed their teeth 2 times a day with the same toothbrush and dentifrice during the whole observation. Assigned mouthwash for each group were used twice a day. MPI and BOIB indexes were measured at the beginning of the study (baseline), on the 14 th and 28 th day.	40 out of 635 participants. 6.3%
2	<i>Quintas et al. (2015)(18)</i> A Randomized Clinical Trial	15 participants were selected to do 3 cycles with a period of 14 days between every cycle. One cycle with CHX mouthwash, one with EO mouthwash and one with distilled water.	All participants receive SRP the day before starting the cycle. Each participant wore splints with glass disk only removed to eat and perform hygiene without toothpaste or mouthwash (only mechanical). Then participants start the protocol (A, B or C): 20 ml of mouth rinse for 30seconds for EO and water / 10ml for CHX. Mouthwashes were used. Mouthwashes were used for 4 days followed by sample collection and a break of 14 days before the next cycle.	15 out of 635 participants. 2.4%
3	<i>Marchetti et al. (2017)(19)</i> A randomized crossover clinical trial	N=21 participants divided into 4 groups (LZ, EO+, CHX and Saline solution placebo)	Participants receive a professional profilaxis. Participants are then instructed to suspend all mechanical cleaning for 3 days and rinse twice a day with 15ml of mouthwash. 7 days washout between cycles.	21 out of 635 participants. 3.3%
4	<i>Senkalvarayan et al.(2023)(16)</i> Randomized Controlled Trial	N=45 Participants divided into 3 equals groups Group A: Himalaya complete care Group B: CHX mouthwash Group C: Distilled water	All participants received complete profilaxis at the beginning of the experiment. Participants were instructed to use 10ml of mouthwash twice a day. Indexes were measured at baseline, 7 th day and 14 th day	45 out of 635 participants. 7.1%
5	<i>Eshwar et al.(2016)(3)</i> A double blind randomized clinical trial	N=30 Divided into 3 equal groups. Herbal mouthwash group CHX group Normal saline group (Placebo)	All participants received a profilaxis at the beginning of the experiment. Subject were instructed to use 10ml of mouthwash for 30 secondes twice a day for 30 days. During the test periode no mechanical or other chemical hygiene mesure were used. A 15 days washout period was used before trying the other mouthwash. Indexes were measured at 15 th days and 30 th days.	30 out of 635 participants. 4.7%
6	<i>Pradeep et al.(2016)(4)</i> A randomized controlled clinical trial	N=90 with chronic generalized gingivitis divided into 3 groups: Placebo mouthwash, TRP mouthwash, CHX mouthwash	SRP or profilaxis were not performed at the beginning of the experiment. Participants were instructed to rinse with 15 ml of their assigned mouthwash for 1 minute twice daily (after breakfast and before bed). Indices were measured at 7 th days,30 th days and 60 th days	90 out of 635 participants. 14.2%

7	<i>Pardiñas López et al.(2025)(10)</i> triple-blinded randomized controlled trial	N=30 (15 male and 15 female) With an age range from 33 to 72 Divided into 3 groups. <u>Group 1</u> use coconut oil rinse <u>Group 2</u> 0.12% CHX and <u>Group 3</u> used coconut flavored water (Placebo)	Saliva and crevicular fluid were collected before the treatment, one month after the treatment and one month post non-surgical periodontal treatment.	30 out of 635 participants. 4.7%
8	<i>Shamini et al.(2023).(15)</i> Parallel, double-blinded, randomized controlled pilot study	N=60 Participants were divided into 3 groups. One for CEC, AT and CHX	Participants were instructed to rinse in the morning with 10ml of mouthwash for 1 minute. PI and GI were measured at baseline, at 15 days and 30 days	60 out of 635 participants. 9.4%
9	<i>Gomes et al. (2016)(12)</i> A randomized controlled trial	N=30 Divided into 3 groups of 10 participants Group CHX, Group AO and Group PB (Placebo)	All participants were instructed to brush their teeth 2 times a day with fluoridated toothpaste and use their assigned mouthwash for 1minute 30minutes after brushing. Index were measured at the beginning (baseline)and at the end of the study (1 month)	30 out of 635 participants. 4.7%
10	<i>Nayak et al. (2019)(13)</i> A randomized placebo-controlled clinical trial	N=60 with chronic generalized gingivitis divided into 3 groups of 20 participants. <u>Group A:</u> 0.15% Guava mouth rinse <u>Group B:</u> 0.2% Chlorhexidine (CHX) <u>Group C:</u> Distilled water (placebo)	All the participants received a professional profilaxis. The indexes were measured at the base. Participants were instructed to use twice a day 10ml of mouthwash for one minute, half an hour after toothbrushing for 30 days. Measure of indexes were taken at 1month and 3 months.	60 out of 635 participants. 9.4%
11	<i>Sanghavi et al. (2024)(9)</i> Randomized, double-blind, parallel-arm clinical trial	N=60 adults participants. Divided into 2 groups. Group 1: L.Barbarum mouthwash Group 2: CHX mouthwash	All participants were educated to brush with the modified bass and stillman technique. They all receive a SRP at baseline. Participants were then instructed to use 10ml of mouthwash for 30-45 seconds twice a day for one month. Indexes were measured at baseline, 15 days and 1 month.	60 out of 635 participants. 9.4%
12	<i>Goes et al. (2016)(14)</i> Randomized Controlled Trial	N=30 Group 1: rinse with water (placebo) Group 2: rinse with 0.12% CHX Group 3: rinse with 1% MTC	Participants were instructed to rinse twice a day (morning and evening) immediately after toothbrushing for 15 days. Indexes were measured at day 1 and day 15.	30 out of 635 participants. 4.7%
13	<i>Al-Mahmood & Sabea (2024)(7)</i> A Blinded, Randomized Clinical Trial	N=60 Divided into 2 groups: 40% miswak mouthwash and 0.12% CHX mouthwash	The mouthwashes (CHX and Miswak) were used twice a day for 2 months. Indexes were measured at the beginning (baseline) and at the end (2months). All indexes were recorded according to Loe and Sinless.	60 out of 635 participants. 9.4%
14	<i>Priya & Galgali (2015)(8)</i> A randomized controlled clinical trial	N=30 Divided into 2 groups of 15 participants. Group 1: receive Amf mouthwash Group 2: receive CHX mouthwash.	Participants were told to use a modified bass and stillman technique and to use their mouth rinse 10ml 2 times a day during 1 minute. Indexes were measured at the baseline, at 15 days and at 4 weeks. Perception of the taste and odor or any discomfort was also recorded.	30 out of 635 participants. 4.7%
15	<i>Abdulbaqi et al. (2016)(17)</i> A randomized controlled crossover clinical trial	N=14 participants. That tried 3 formulations:CHX, the test formulation with green tea, Salvadora	Participants receive a profilaxis 7 days before the beginning of the protocol. Then they rinse twice a day with 15ml of the different mouthwash for 30 seconds. 24h later the plaque regrowth of plaque is followed by a 6days washout before doing the next formulation.	14 out of 635 participants. 2.2%

		persica L. extracts and a placebo with distilled water.		
16	Casarin et al. (2019)(20) A randomized crossover trial	N=20 Separated in 2 groups randomly between MEL-NP and CHX.	Participants received a professional profilaxis. They then stopped every mechanical cleaning for 3 days and only used twice a day 15ml of mouthwash. On the 4 th day indexes were measured PI, GBI and GCF. A 7 days washout period before repeating it.	20 out of 635 participants. 3.1%

Table 2b: Mouthwashes evaluated, and outcomes of the studies reviewed.

Number of articles	Author and Year and study type	Mouthrinse evaluated	Index used to measure	Outcome
1	Boyapati et al. (2024) (11) A randomized controlled trial	Probiotic (Darolac), Herbal (Aloe vera), Povidone iodine and CHX	Marginal plaque index (MPI) and Bleeding on interdental brushing (BOIB)	Reduction in plaque index and gingival bleeding were observed in the 4 groups. Probiotic mouthwash achieved comparable results to CHX. Better results were observed in CHX and probiotic rinses compared to herbal and Povidone iodine rinses.
2	Quintas et al. (2015)(18) A Randomised Clinical Trial	Essential oils (EO) mouthwash Listerine Mentol 0.2% CHX mouthwash	Confocal laser scanning microscopy (CLSM), Bacterial vitality, Biofilm thickness, Covering grade	EO and CHX were more effective than the water mouthwash. CHX was more effective than EO in reducing the thickness and covering grade of the plaque. No significant difference has been found for the bacterial vitality.
3	Marchetti et al. (2017)(19) A randomized crossover clinical trial	Alcohol-free essential oils. Listerine Zero (LZ) Alcohol-based essential oils (EO+) 0.20% CHX	Turesky modification of the Quigley–Hein Plaque Index (PI)	LZ and EO+ showed similar results on plaque regrowth. CHX presents a better inhibitory effect on plaque regrowth than LZ and EO+
4	Senkalvarayan et al.(2023)(16) Randomized Controlled Trial	Herbal mouth wash (Himalaya complete care mouthwash) CHX mouthwash	Gingival index (GI), Plaque index (PI) Simplified oral hygiene index (OHI-s) Ainamo and Bay index (gingival bleeding)	Herbal and CHX mouthwash were more effective to keep the gingival health compared to the distilled water. No significant difference has been measured between the Herbal and CHX mouthwash groups
5	Eshwar et al.(2016)(3)	Herbal mouthwash (100% aloe vera juice) 0.12% CHX mouthwash	Plaque index (PI) Silness and Loe Gingival index (GI) Loe and Silness	PI and GI were lower in CHX and Herbal mouthwash groups compared to the placebo group. No significant difference was observed between the 2

	A double blind randomized clinical trial			groups. CHX groups presented some side effects such as tooth staining, taste alterations.
6	<i>Pradeep et al. (2016)(4)</i> A randomized controlled clinical trial	<i>Herbal mouthwash: Triphala (TRP) 0.12% CHX</i>	Plaque index (PI), Gingival index (GI), Oral hygiene index-simplified (OHI-S) Microbial colony count	TRP and CHX groups showed a significant reduction of PI, GI and OHI-S compared to placebo. No statistical difference has been established between TRP and CHX. TRP presented no side effect in contrary to CHX.
7	<i>Pardiñas López et al. (2025)(10)</i> triple-blinded randomized controlled trial	<i>Coconut oils rinse (CO) and 0.12% CHX (with 3 drops of coconut concentrated flavoring)</i>	Inflammatory markers (Interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α)) and Bacterial DNA	Reduction of the inflammatory factors and reduction of the pathogenic bacteria. Promotion of balance microbiome and improvement in periodontal health.
8	<i>Shamini et al. (2023)(15)</i> Parallel, double-blinded, randomized controlled pilot study	<i>Customised Enriched coconut (CEC) oil, Arimadadi Tailam (AT), 0.2% CHX</i>	Plaque index (PI), Gingival index (GI) Oratest (evaluate the biofilm and antitartar effect) DMFT	CEC had the highest score at the Oratest followed by CHX and AT. However, no statistical difference was observed between the groups PI and GI remained at 0 during the study
9	<i>Gomes et al. (2016)(12)</i> A randomized controlled trial	<i>10% Anacardium occidentale extract (AO) and 0.12% CHX</i>	Plaque index (PLI) Gingival bleeding index (BLI)	AO and CHX groups showed significant reduction in PLI and BLI. CHX was the most effective but no statistically significant difference was established between the AO and CHX groups.
10	<i>Nayak et al. (2019)(13)</i> A randomized placebo-controlled clinical trial	<i>0.15% Guava leaf extract mouthwash 0.2% CHX mouthwash</i>	Gingival index (GI) proposed by Loe and Silness, Turesky–Gillmore Glickman modification of Quigley Hein Plaque Index (PI), Antioxidant activity and Microbial count	Guava and CHX groups showed significant reduction in PI and GI. CHX was slightly more effective for the PI. Guava showed high antioxidant activity.
11	<i>Sanghavi et al. (2024)(9)</i> Randomized, double-blind, parallel-arm clinical trial	<i>0.2% CHX mouthwash Lycium barbarum (Goji berry) ethanolic extract (50 \mu g/ml) mouthwash</i>	Plaque index (PI) Gingival index (GI) Loe & Silness, Bleeding on probing (BOP)	Both groups showed significant reduction on PI, BOP, PPD and GI from baseline to one month. No statistically significant difference has been observed on the following parameter.
12	<i>Goes et al. (2016)(14)</i> Randomized Controlled Trial	<i>1% Matricaria chamomilla L. extract mouthwash (MTC) and 0.12% CHX</i>	Visible plaque index (VPI) Gingival bleeding index (GBI)	Reduction of the VPI and GBI was observed for both CHX and MTC groups. No significant efficacy difference between the 2 groups has been observed
13	<i>Al-Mahmood & Sabea (2024)(7)</i> A Blinded, Randomized Clinical Trial	<i>Miswak mouthwash and 0.12% CHX mouthwash</i>	Gingival and Plaque index, BOP (bleeding on probing) index were scored from the Bucco-lingual and Bucco-mesial site of the tooth.	Both groups achieved significant improvement in gingival health. CHX showed superior effectiveness (on the gingival, plaque and bleeding indexes) compared to Miswak. It remains a good alternative for long-term use.
14	<i>Priya & Galgali (2015)(8)</i> A randomized controlled clinical trial	<i>Amine Fluoride (AmF) mouth rinse 0.12% CHX mouth rinse</i>	Plaque index (Turesky modification of the Quigley-Hein plaque index), gingival index (Löe and Silness), bleeding index (Ainamo and Bay), tooth stain (TS).	Both groups showed a significant reduction in plaque index, gingival index, and bleeding index at both 15 days and 1 month. No significant differences were observed between the 2 groups except TS and tongue staining that were higher in the CHX group.

15	Abdulbaqi et al. (2016)(17) A randomized controlled crossover clinical trial	0.12% CHX mouthwash Test formulation: 0.25 mg/ml green tea + 7.82 mg/ml Salvadora persica L. extracts. (Miswak)	Modified Quigley Hein plaque index (PI).	We observe a significant reduction of the plaque accumulation for the test formulation compared to CHX and placebo.
16	Casarin et al. (2019)(20) A randomized crossover trial	<i>Melaleuca alternifolia</i> (Tea Tree oil) nanoparticles mouthwash (MEL-NP) 0.12% CHX mouthwash	Quigley-Hein Plaque Index (PI) Gingival Bleeding Index (GBI). Gingival Crevicular Fluid (GCF) Interleukin-1 β (IL-1β)	Both mouthwash reduced plaque accumulation compared to baseline. CHX was more effective in the reduction of plaque accumulation Similar results were obtained for the (IL-1β)

5. DISCUSION

The aim of this review is to compare the effectiveness of new mouthwashes to Chlorhexidine (CHX) in the control of gingivitis in adult population. During the extraction of the results, the focus was on several information such as the indexes used (usually plaque and gingival index), the mouthwash tested, and their results compared to CHX. This comparison allows us to have a great notion of the effectiveness of the mouth wash as CHX is considered a gold standard in the treatment of gingivitis. Several mouthwashes were compared to *CHX, herbal/essential oil mouthwash, coconut oil, probiotic mouthwash, amide fluoride, Caria papaya leaf extract, povidone iodine, Anacardium occidental extract, guava leaf extract, Tea, Lycium barbarum (Goji berry), Arimedadi Tailam, Matricaria chamomilla L. extract (miswak)*. Figure 2 is bar chart that illustrates the efficacy of the different mouthwashes of this review (in the annexes).

5.1. Herbal and essential oil mouthwash

The results of the different herbal mouthwash suggest a reduction of the gingival index. In all the 6 studies that compared herbal mouthwash and CHX, no statistical difference was observed with CHX in 5 of them. Only one study found better results with CHX (11). On the other hand, results are more mixed when it comes to the effects on the plaque. Despite all the studies, found a reduction of plaque indexes. Out of the 6 studies, 3 observed better results with CHX groups (11,18,19). And 3 found no statistical differences with CHX groups (3,4,16).

This discrepancy might be explained by the duration of the studies and the sample size. Indeed studies where no statistical differences used greater sample size and larger study duration (3,4,16). Moreover, on the studies with larger study period, we observed that herbal mouthwash required 15 to 30 days to reach the same effectiveness as CHX which explain the discrepancy in the results with studies of short duration (3,4,16).

The difference of results can also be explained by the difference between the mouthwashes used. Some of them present polyherbal solution where other are simple extract. Better results were observed with poly herbal solution suggesting a synergy between the different component was observed (4).

Overall herbal mouthwashes showed effectiveness in the reduction of gingival index and plaque index. Polyherbal are more effective and must be used on the long-term to see an effectiveness comparable to CHX.

5.2. Other alternative mouthwash

Other alternative mouthwashes were studied in this review.

Two studies were about coconut oils rinse (10,15). In both studies, a similar reduction to CHX of PI and GI was observed suggesting a good effectiveness of this mouthwash. Although better results were observed with the use of Customized enriched *coconut oil* (CEC) (15). This discrepancy shows the importance of the purity and enrichment of the oil extracted.

Several mouthwashes made from natural extract were also studied. *Anacardium occidentale* extract in Gomes et al. (2016) (12). *Guava leaf* extract in Nayak et al. (2019) (13). *Lycium barbarum* (Goji berry) ethanolic extract in Sanghavi et al. (2023)(9). And *Matricaria chamomilla* L. extract mouthwash in Goes et al. (2016)(14). Reduction of the GI and PI were observed in all the studies. GI was comparable to CHX results but PI on the other hand was less effective for *Guava leaf* extract mouthwash (13). Most of the natural extracts showed great effectiveness comparable to the results of the CHX. They present very interesting strengths such as antioxidant action for the *guava leaf* extract, anti-inflammatory action for the *Chamomile*, immune support for the *goji berry* and high speed of action for the *Astringency*.

Miswak mouthwash was tested in the study of Al-Mahmood & Sabea (2021) (7). Reduction of the GI and PI was observed but CHX present better results for both indexes. *Miswak* presents low effectiveness compared to CHX and other mouthwashes tested in this review. It's the only mouthwash that present significantly lower effectiveness compared to CHX and may be explained by a lack of sustainability (7). *Miswak* was also observed on A test formulation of *green tea* and *Salavadora persica* L. extracts (*Miswak*) in Abdulbaqi et al. (2016) (17). Better results were obtain than with *miswak* alone which suggest synergy with *green tea*. Efficacy depend on the concentration of *miswak* and its association with other compound as *green tea* here.

Amine Fluoride (AmF) mouthwash was also tested in Priya & Galgali (2015)(8). PI and GI results were similar to CHX group. Great effectiveness in treating gingivitis.

In the study of Casarin et al. (2019), *Melaleuca alternifolia* (Tea Tree oil) nanoparticles mouthwash (MEL-NP) was tested(20). The reduction of the GI was similar to CHX but PI better results were obtained by CHX group.

A probiotic (*Darolac*) and *Povidone iodine* mouthwashes were tested alongside with Herbal mouthwash and CHX in Boyapati et al. (2024) (11). For both mouthwash PI and GI were comparable to CHX. Better results were observed for the *Darolac* mouthwash. Great effectiveness for the treatment of gingivitis.

5.3. Comparison with systematic review and meta-analyses

Let's compare the results obtained and the conclusion of the metanalysis and other systematic reviews. Results from this review were compared to 3 systematic review by Javed et al. (2023), Tidke et al. (2022), Figuero et al. (2019) (6,21,22).

Most of the studies of this review are small to moderate cohort. One difference with the meta-analyses is the sample size. Indeed, systematic reviews use very important sample and data from thousands of participants (6,21). This led to some discrepancy, for meta-analysis and systematic review CHX is statistically superior especially in the short-term use. Another difference can be observed between the participants and the environment of the studies selected in this review. Participants in the studies selected are usually either young, healthy or motivated. Better results can also be observed in this kind of study since the participants improve their hygiene because they are being watched. On the other hand, systematic reviews and meta-analysis include studies with diverse population (Diabetics, smokers, elderly) and represent the real population including high risk population.

This review includes crossover and parallel design studies that can lead to discrepancy in the results. Meta analysis and systematic reviews usually categorize the studies by design to avoid this bias.

Most of the articles of this review found that the tested mouthwash had comparable effectiveness to CHX. *Javed et al. (2023)*, *Tidke et al. (2022)* reviews support the results of our review and report a significant reduction of PI and GI (21,22).

The *Figuro et al. (2019)* meta-analysis on the other hand, found that CHX still provide the largest magnitude of effect for PI among all the alternative therapies (6). CHX mouthwash outperformed the alternative mouthwash in the short term for the plaque inhibition.

Another point is the side effects, *Javed et al. (2023)*, *Tidke et al. (2022)* reviews highlighted the limits of CHX on the long term and the advantages of the herbal mouthwashes on the long term for maintenance (21,22).

The meta-analysis support the finding of this review even if the CHX remains the gold standard for short term plaque control (6). Alternative mouthwashes are confirmed as clinically equivalent for long-term maintenance.

5.4. Limitations of this review

Some of the limitations come from the methodology of the articles used in this review. For example, studies didn't use the same plaque and gingival indexes which can lead to discrepancy when comparing the different studies.

Another limitation that we witness is the sample size of some studies. Even if most of the studies selected have a sample between 30 and 60 participants. Some studies had fewer. *Abdulbaqi et al. (2016)* had only 14 participants even if they did 3 cycles with period of washout in between

it's still a small sample (17). *Quintas et al. (2015)* had a similar problem with a sample of 15 participants also with 3 cycles and washout period in between (18).

Another discrepancy observed between studies is that some studies had a placebo group using distilled water or saline solution in addition to the group with the alternative mouthwash (can be several) and the CHX group. Other studies only included 2 groups, the one of the alternative mouthwashes tested and the CHX one.

Another limitation of this review is the duration of the studies. Most studies, indexes were measured for 1 month. Two studies had longer study periods *Nayak et al. (2019)* had a 3 months duration (13). *Pradeep et al.(2016)* had a 60 days duration (4). Other studies have a duration of 1 month or less. Some are extremely short, especially the one focus on the plaque regrowth that includes protocol without brushing/mechanical plaque removal during the duration of the study. In the study of *Casarin et al. (2019)* the duration of the study was 4 days to measure plaque accumulation (20). In the study of *Marchetti et al. (2017)* the protocol had a duration of 3 days to measure plaque regrowth (19).

Although our review includes several studies for the herbal mouthwash, other mouthwashes would need more studies to have a better understanding of their effectiveness *Miswak, Amine Fluoride, Tea based mouthwash, probiotic mouthwash* and *Povidone iodine* mouthwashes.

5.5. Future research

Further research is needed for alternative mouthwash and to study their actions in the long term. Some of the mouthwashes present only a few articles and need to be studied more.

As cited previously most of the study only focus on short duration effectiveness. It would be interesting to study the long terms effect of alternative mouthwashes and compare with the side effects of CHX.

Only 3 studies talked about the differences of side effects between alternative mouthwashes and CHX (*Priya & Galgali (2015)*, *Eshwar et al.(2016)* and *Pradeep et al.(2016)*) (3,4,8).

It would be interesting to use the same GI and PI between studies to ensure an easier comparison and more precise comparison of the data collected.

6. CONCLUSIONS

Based on the literature used for this review alternative mouthwash demonstrates evidence of effectiveness in treating gingivitis.

1.A lot of alternative mouthwash showed effectiveness comparable to CHX for the gingival index and plaque index. While CHX remains the gold standard for short term plaque and gingival

control, natural alternatives provide a great alternative on the long term / maintenance by presenting similar efficacy and fewer side effects.

Within the limitations of this review, alternative mouthwashes proved to be great adjunctive therapy for patients with gingivitis and safe to use.

2.Great results were obtained with polyherbal mouthwashes such as Triphala, Dill seed oil, enriched coconut oil and Guava leaf extract.

Further studies are needed on this subject to improve the knowledge of alternatives mouthwash and evaluate their action on specific or high-risk population. Further research focused on the long-term is also needed to observe advantages that alternatives mouthwash can have over CHX considering the sides effects.

7. SUSTAINABILITY

The integration of natural products in the periodontal treatment is also a strategic alignment with global sustainability goals. Dentistry increasingly transition toward “Green dentistry” but switching from systematic use of chemicals products to plant based or more natural products (23).

This review align with several United Nations Sustainability Development goals (SDG)(24).

SDG 3: Good health and well-being. By validating effective and non-toxic alternatives to CHX. This study promotes accessible preventive care while reducing reliance on synthetic compounds (24). Natural extracts like Triphala, Dill Seed oil, Coconut oil offer antimicrobial efficacy without the side effects that often hinder long-term patient compliance (3,4).

SDG 12: Responsible Consumption and production. Chemical mouthwashes involve important industrial energy for their manufacture and the use of alcohol and dyes (23). In contrast to plant based mouthwashes that present biodegradable formulation and biological resources (23,24). Plant base mouthwashes provide a minimal environmental footprint (23). They are biodegradable unlike synthetic mouthwashes and present no risk of bioaccumulation (23). The use of indigenous plants (*Anacardium occidentale* in Brazil or *Miswak* in the Middle East) encourages the preservation of local biodiversity and supports sustainable agricultural practices over industrial chemical manufacturing (7,12,23).

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Source: Page MJ, et al. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71.

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9. ANNEXES

9.1. Efficacy chart

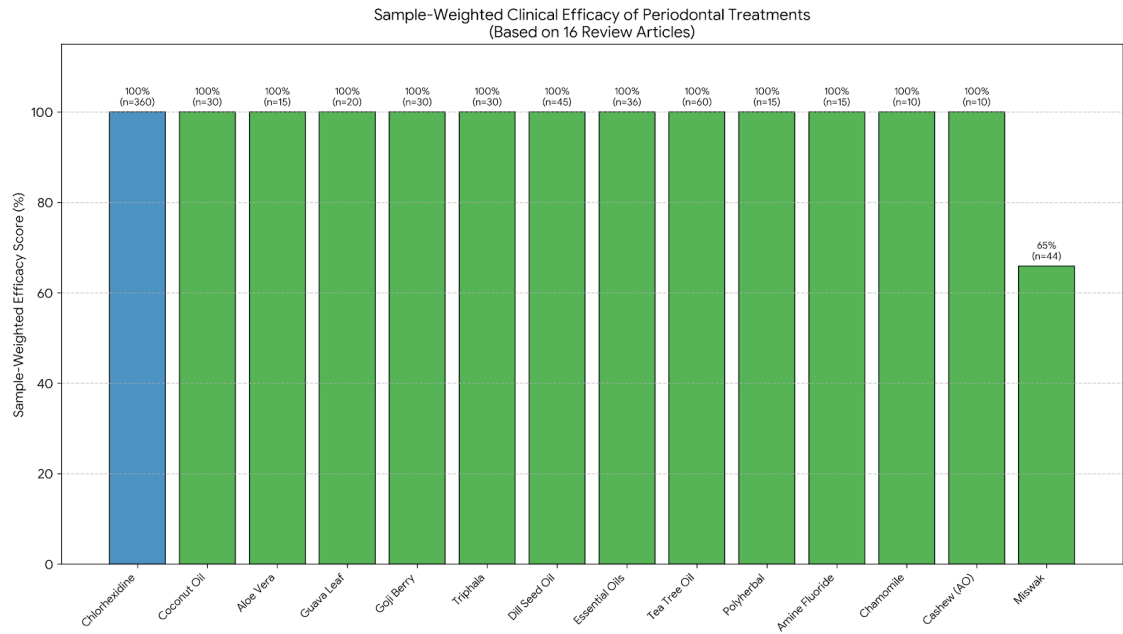


Figure 2: Sample-Weighted Clinical Efficacy of the mouthwashes tested in this review.

Figure 2 illustrates the clinical efficacy of the different mouthwash included in this review. 100% indicate that the mouthwash demonstrates similar or superior results in the reduction of PI and GI, compared to the gold standard CHX.

Weighting system was used to ensure that results from studies with bigger samples carry greater statistical significance.

The final percentage on the bar was obtained by using this formula:

$$\text{Weighted Efficacy \%} = \left(\frac{\sum N \sum (\text{Score} \times N)}{\sum N} \right) \times 100.$$

Miswak have a 66% because efficacy was lower than CHX used alone but demonstrate similar results to CHX when matched with green tea (synergy) (7,17).