**Camellia Sinensis Mouthwashes in Oral Care: a Systematic Review**

Ali Tafazoli, PhD; Ehsan Tafazoli Moghadam, DDS

1 Dept. Clinical Pharmacy, Faculty of Pharmacy, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2 Dept. of Orthodontics, School of Dentistry, Qazvin University of Medical Sciences, Qazvin, Iran.

**KEY WORDS**
Camellia sinensis; Dental care; Green tea; Mouthwash; Mouth rinse; Oral hygiene; Tea;

**ABSTRACT**
Herbal products are increasingly growing in the oral care market. Some of the related herbal compounds in this field have considerable clinical evidence for use in mouthwashes in their background. Camellia sinensis or tea plant has attracted numerous researchers of dentistry and pharmaceutical sciences, in recent years, for its biologic and medicinal properties. The effects such as anti-septic, anti-oxidative and anti-inflammatory activities have made this plant a suitable candidate for preparation of mouthwashes. In this systematic review we tried to find, evaluate and categorize the sparse evidence in medical literature about Camellia sinensis mouthwashes.

We explored three scientific databases with keywords including tea, dental care, Camellia sinensis and mouthwashes and found 69 relevant studies including 41 randomized controlled trials (RCTs), which are generally proposing anti-microbial, anti-plaque and analgesic indications for these tea formulations.

Considering the main trend in clinical evidence and favorable safety profile, Camellia sinensis products are able to act as antiseptic, anti-plaque and anti-inflammatory agents and can be used as useful mouthwashes in the future clinical studies and practice.

**Corresponding Author:** Tafazoli Moghadam E, Dept. of Orthodontics, Qazvin University of Medical Sciences, Bahonar Ave, Qazvin, Iran. PO.Box: 15315-34199 Tel: +98-283336001, +989155188582 Email: tafazoli.ehsan@yahoo.com, ehsan.tafazolimoghadam@gmail.com

**Cite this article as:**
Neurological studies indicate that green tea polyphenols act as antioxidant compounds which have neuroprotective benefits and modulatory function on intracellular signaling and cell survival/death genes, hence they can be useful in prevention and treatment of neurodegenerative diseases [26-30]. Antimicrobial, anti-inflammatory and anti-nociceptive properties of Camellia sinensis extract have been the subject of many studies, as well [2, 31-36]. Green tea antibacterial function has been related to its EGCG and other compounds, through damaging the bacterial cell membrane [37], inhibitory effect against gyrase enzyme and destroying cytoplasmic membrane of bacterium [38]. Anti-inflammatory function of EGCG is mainly exerted by down-regulation of Cyclooxygenase-2 via inhibition of interleukin-1b-dependent pro-inflammatory signal transduction and interleukin-6, interleukin-8 and tumor necrosis factor-α gene expression at inflammation sites [39-40]. These characteristics have attracted the scientists for substantial evaluations in local application of tea products. Accordingly, dentistry research has also focused on tea-related formulations, as mouthwash forms, for treatment of several oral ailments [41-43].

In this review we tried to collect and categorize the potential applications of Camellia mouthwashes in different dentistry fields to demonstrate the most evidence-based indications with their advantages and disadvantages.

**Search Strategy**

In order to provide a systematic review with the highest accordance to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, besides a comprehensive and acceptably relevant data pool, we searched three highly accredited databases including PubMed, Cochrane library and Google Scholar, while giving the priority to the first one, due to its privileges and scientific characteristics for systematic searching.

**Inclusion criteria**

The inclusion criteria involved journal articles, those with titles including “green tea” or “tea” or “Camellia sinensis” and “mouthwash” or “mouth rinse” or “gargle” in the field of dentistry. Our exclusion criteria was non-English-abstract articles and those focused on adverse effects or staining capabilities of green tea products. We explored PubMed database with MeSH terms, “tea” and “mouthwashes” at the first step. We also tried “Camellia sinensis” and “mouthwashes” for MeSH terms, which yielded different results. Finally, using the search order (((“Tea”[Majr]) OR "Camellia sinensis”[Majr]) AND “Mouthwashes”[Majr]) provided our desired results to establish a basis for our literature review. Then we searched Google Scholar with the same keywords and arranged entries based on “relevance”. All the topics were screened, one by one, to the last and the suitable manuscripts were handpicked. Consequently, the Cochrane library was searched to look for potentially available reviews about this topic.

We limited the search results to English language articles. All the harvested articles were pooled together and the repeated ones were deleted. All the articles were meticulously evaluated, analyzed and defragmented to categorize the sub-headings. We added several more academic references from Google to develop our ideas, more clearly.

All the investigation was performed and reexamined with two experts in this field and the whole procedure was conducted according to guidelines of the ethical committee of Qazvin University of Medical Sciences. The systematic search flow-chart is depicted in Figure 1.

**Literature Review Outcome**

Our search protocol in PubMed yielded 26 journal articles. Among them, 25 were in English. Four papers were omitted due to their topic, which focused on green tea products as staining agents, without assessment of potential therapeutic effects. Another article, which was unintentionally included due to the search engine intrinsic malfunction, was also considered irrelevant and omitted. There were two in-vitro studies, one review, two clinical trials without randomization and 15 RCTs. Searching Google scholar added 15 in-vitro studies, one review, four animal studies, three non-randomized trials and 26 RCTs to the reference list. The similar search process in the Cochrane database did not yield any articles.

It could be stated that almost every clinical study, evaluated a different specification of the mouthwash from a different point of view. However, those with common features were gathered together in order to pre-
Discussion
In this part we classified the beneficial effects of different tea-based local oral formulations based on the type of scientific evidence and potential clinical indications. These involve both basic experimental studies with clinical implications and clinical trials.

In vitro and animal studies
Anti-bacterial properties were the major focus of numerous pre-clinical studies on tea products. In a study for evaluation of antibacterial efficacy of an extemporaneous green tea-containing mouth rinse on oral pathogens including Streptococcus mutans (S. mutans), Streptococcus sanguis, Enterococcus faecalis, Pseudomonas aerogenosa and Escherichia coli, the herbal formulation showed considerable inhibitory effects on all microorganisms, although weaker than chlorhexidine (CHX) [44]. A study evaluating antibacterial effect of green tea extract on multi-drug resistant pathogens showed inhibitory effect on Escherichia coli and Streptococcus aureus and also strong synergistic suppression against pathogens in combination of EGCG with gentamycin. This in-vitro observation suggested that green tea has stronger inhibitory effect on gram positive pathogens than gram negative ones [45]. A study conducted in Laval University, Quebec, Canada on inhibitory effect of green tea extract on virulence markers of Fusobacterium nucleatum, a key factor in initiation and progression of periodontal diseases, indicated that treatment of pre-formed Fusobacterium nucleatum biofilm with green tea extract caused a time-dependent decrease in biofilm...
viability and decreased adherence of Fusobacterium nucleatum to oral epithelial cells [46].

Anti-fungal property of green tea has been the subject of many in-vitro studies, as well. Sitheeque et al. [47], showed Candida glabrata is the most sensitive species of Candida to tea polyphenols followed by Candida parapsilosis and Candida albicans (C. albicans). Since being the most common fungal species found in oral cavity, anti-fungal activity of green tea is mostly evaluated against C. albicans [48]. It is suggested that the EGCG found in green tea acts as an antifolate compound, which disturbs metabolism of folic acid in C. albicans [49]. Another study showed that polyphenolic compounds found in green tea extract, caused 75% reduction in viable C. albicans cells during biofilm formation. This research proposed that polyphenols anti-fungal activity is exerted via reduction of proteasomal activity in C. albicans cells [50]. Another study conducted by Yadegari et al. [51], demonstrated that inhibitory effect of EGCG against C. albicans is time dependent. The results also showed that EGCG can be effective on flucconazole-resistant C. albicans. It has also been stated that green tea aqueous extract can be useful against C. albicans colonies growing on acrylic resin and polyvinyl chloride surfaces used in prosthetic dentures and orthodontic appliances [52-53]. In a study conducted by Mollashahi et al. [54], on tooth substrate of extracted pre-molar teeth, it was implied that green tea extract has the potential to be used as an irrigating agent in endodontic treatments, because of its anti-fungal properties however conductors of this research suggested evaluation of its biocompatibility and safety before using it as an irrigating solution in clinical settings. Another study in the department of biotechnology in Graphic Era University, India, investigated synergistic activity of green tea extract and fluconazole, amphotericin B and copper sulphate as a combinational therapy against C. albicans. The results proved a synergic effect that can be efficient against C. albicans and also implied that the combinational therapy does not show cytoxic activity on healthy cells [55].

Some in-vivo experiments have studied green tea’s anti-inflammatory function. An animal study on type 1 diabetic rats showed green tea extract minimizes expression of receptor activator of nuclear factor kappa-B ligand and tumor necrosis factor-alpha, consequently decelerating alveolar bone resorption compared to placebo group [56]. Another animal observation on albino rats using green tea extract, illustrated a significant reduction in nicotine induced damage, in terms of inflammatory cell infiltrates in buccal mucosa [57]. Such observations proposed the potential benefits of tea mouthwash preparations in clinical application. However there are some controversial findings. Regarding the wound healing, an animal study failed to show a significant effect for green tea formulation [58].

Clinical trials and RCTs
Screening and assessment of clinical trials including RCTs in this review revealed a growing trend for utilization of Camellia products in dentistry clinical practice. Almost every group of authors examined a new and divergent application for such formulations, which are categorized in the following sections. Specifications of the RCTs are summarized in Table 1.

Randomized controlled trials
At first we explored the real-life indications of green tea mouthwashes in RCTs in order to provide a more accurate insight toward clinical applications of these products.

Antiseptic mouthwashes
As mentioned before, microbial regulation is the main purpose of using tea rinses in multiple studies. In a clinical trial on 30 healthy volunteers, gargling with two commercial tea extract solutions for 60 seconds resulted in significant decrease in microbial counts of expectorated oral rinses. Compared to a synthetic antiseptic mouthwash, those herbs showed more durable activity [59]. In addition to teeth and oral cavity, effect of mouthwashes on devices and surgical derbies has also been assessed. In another RCT on 18 patients with unerupted maxillary third molars with extraction indication, researchers tried to evaluate the anti-microbial and anti-adherence activity of different mouthwashes on suture materials after the surgery. Participants were equally divided in three groups of Camellia sinensis, Calendula officinalis or CHX mouthwash users for one week. Compared to no intervention, as a control, all solutions were effective to reduce the number of adhered microorganisms, but the only significant difference was observed for CHX [60]. The same results was found in an RCT done by Prabakar et al. [61], in which they showed that CHX and green tea mouthwashes are significantly
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Indication</th>
<th>Product</th>
<th>Number of Participants</th>
<th>Finding</th>
<th>Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hajahmadi/2019</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 5% / Green tea xylitol 20% mouthwash</td>
<td>64</td>
<td>Higher antibacterial efficacy in green tea xylitol than green tea mouthwash</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Salama/2019</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash</td>
<td>40</td>
<td>Decreased S. mutans colony count compared to control group</td>
<td>NA</td>
</tr>
<tr>
<td>Yaghini/2019</td>
<td>Plaque removal</td>
<td>Green tea- Lee vera extract mouthwash</td>
<td>60</td>
<td>Decreased PI and GI compared to CHX and mastic mouthwash</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Khanchemehri/2019</td>
<td>Oral health parameters and inflammatory markers improvement</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>46</td>
<td>Oral health setting improvement compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Mustafa/2019</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash</td>
<td>45</td>
<td>Improvement in clinical periodontal parameters and inflammatory markers compared to CHX</td>
<td>NA</td>
</tr>
<tr>
<td>Ahmadi/2019</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash %</td>
<td>30</td>
<td>Decreased microbial count compared to green tea gel 0.5%</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Romoozi/2018</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash</td>
<td>10</td>
<td>Decreased PI and GI but less than CHX group</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Nagari/2018</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash 1 mg/dl</td>
<td>30</td>
<td>Decreased PI compared to CHX and white tea extract</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Khanchemehri/2018</td>
<td>Antiseptic (for orally imitated patients)</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>46</td>
<td>Decreased pharyngeal microbial load compared to CHX</td>
<td>NA</td>
</tr>
<tr>
<td>Prabakar/2018</td>
<td>Antiseptic (for orthodontic treatments)</td>
<td>Green tea leaves extract mouthwash</td>
<td>52</td>
<td>Less effective than CHX in decreasing S. mutans colony count</td>
<td>NA</td>
</tr>
<tr>
<td>Elvinia/2018</td>
<td>Analgesic (for orthodontic treatments)</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>40</td>
<td>Less effective compared to paracetamol</td>
<td>NA</td>
</tr>
<tr>
<td>Ghobani/2018</td>
<td>Denture stomatitis treatment</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>22</td>
<td>Decreased size of denture stomatitis lesion compared to nystatin 10000 IU/ml</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Shalimi/2018</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash</td>
<td>32</td>
<td>Decreased PI less than CHX and herbal mouthwash (HiOra)</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Kamalabdarpan/2018</td>
<td>pH modulation</td>
<td>Green tea leaves extract mouthwash 2%</td>
<td>40</td>
<td>Increased salivary pH compared to prohitic</td>
<td>NA</td>
</tr>
<tr>
<td>Thomas/2017</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>45</td>
<td>Decreased microbial count compared to garlic- lime and NaF 0.05%</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Heidari/2017</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>75</td>
<td>Decreased S. mutans and lactobacilli spp. colony count but less than CHX group</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Goyal/2017</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash</td>
<td>30</td>
<td>Decreased S. mutans colony count compared to saliva</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Raja/2017</td>
<td>Plaque removal in orthodontic patients</td>
<td>Green tea leaves extract mouthwash</td>
<td>30</td>
<td>More effective in decreasing plaque score than CHX and Listerine</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Ido/2017</td>
<td>Antibiotic prophylaxis</td>
<td>Bottled green tea solution with catchen concentration of 37 mg/dl.</td>
<td>747</td>
<td>Minimal positive effect on fu incidence</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Abdullaqi/2016</td>
<td>Plaque removal</td>
<td>Green tea-Salvadora persica extract mouthwash 0.25mg-7.32mg/ml</td>
<td>14</td>
<td>Decreased PI compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Thomas/2016</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>30</td>
<td>Decreased S. mutans and lactobacilli spp. colony count compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Nandani/2016</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash</td>
<td>60</td>
<td>Significant analgesic effect compared to placebo</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Tafazoli Moghadame/2016</td>
<td>Analgesic (after periodontal surgery)</td>
<td>Green tea- Aloe vera mouthwash</td>
<td>45</td>
<td>Decreased PI compared to CHX</td>
<td>NA</td>
</tr>
<tr>
<td>Sargolzari/2016</td>
<td>Plaque removal</td>
<td>Green tea- Aloe vera mouthwash</td>
<td>60</td>
<td>Decreased PI compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Sarai/2015</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 2%</td>
<td>110</td>
<td>Decreased PI and GI compared to placebo</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Lamba/2015</td>
<td>Anti-inflammation</td>
<td>Commercially available preformulated Colgate plax Green Tea mouthwash</td>
<td>60</td>
<td>Decreased total leukocyte count and PI compared to saline mouthwash</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Biswas/2015</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>48</td>
<td>Decreased PI compared to CHX</td>
<td>NA</td>
</tr>
<tr>
<td>Hambri/2015</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash 0.5%</td>
<td>60</td>
<td>Decreased PI and GI compared to CHX and NaF 0.05%</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Shahani/2015</td>
<td>Alveolar osteitis prevention after surgery</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>57</td>
<td>No effect on Alveolar osteitis compared to placebo mouthwash</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Radafsar/2015</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash with 1% tannin</td>
<td>40</td>
<td>Decreased PI and GI compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Priya/2015</td>
<td>Plaque removal</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>30</td>
<td>Decreased PI and GI compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Netari/2014</td>
<td>Antiseptic (for oral cavity)</td>
<td>Green tea leaves extract mouthwash 2%</td>
<td>30</td>
<td>Decreased microbial count compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Shahakoli/2014</td>
<td>Analgesia (perioral)</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>97</td>
<td>Decreased pain score and painkuller use compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Ido/2014</td>
<td>Antibiotic prophylaxis</td>
<td>Bottled green tea solution with catchen concentration of 37 mg/dl.</td>
<td>747</td>
<td>Decreased pain score and painkuller use compared to placebo</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Eshghpoor/2013</td>
<td>Analgesia (post-surgical)</td>
<td>Green tea leaves extract mouthwash 5%</td>
<td>43</td>
<td>Decreased PI and GI compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Balapanavar/2013</td>
<td>Plaque removal</td>
<td>Green tea solution mouthwash 0.5%</td>
<td>30</td>
<td>Decreased VSCs level compared to placebo mouthwash</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Rassameermuang/2012</td>
<td>halitosis</td>
<td>Green tea solution mouthwash</td>
<td>60</td>
<td>Decreased plaque and BOP compared to placebo</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Forouzanfar/2012</td>
<td>Plaque removal</td>
<td>green tea aqueous extract can</td>
<td>34</td>
<td>Decreased microbial count compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Farzad/2011</td>
<td>Antiseptic (for suture materials)</td>
<td>Green tea leaves water-ethanol extract mouthwash 25%</td>
<td>18</td>
<td>Decreased microbial count compared to CHX</td>
<td>No adverse effects reported</td>
</tr>
<tr>
<td>Esimone/2001</td>
<td>Antiseptic (for commercially available brands)</td>
<td>Tea leaves extract 8% of two commercially available brands</td>
<td>30</td>
<td>Decreased microbial count with longer effect compared to Minty Brett</td>
<td>NA</td>
</tr>
<tr>
<td>Atta/1995</td>
<td>Plaque removal</td>
<td>Darjeeling first flush tea infusion</td>
<td>30</td>
<td>No difference from tap water</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Abbreviations:** CHX: Chlorhexidine; GI: Gingival Index; NA: Not Available; PL: Plaque Index

**Notes:**
- The table shows findings and adverse effects reported in various randomized controlled trials of camellia sinensis mouthwashes.
- The indicated effects compared to green tea mouthwash include:
  - Decreased S. mutans colony count
  - Decreased VSCs level
  - Decreased PI and GI
  - Decreased microbial count
  - Improved clinical periodontal parameters
- Adverse effects such as tooth staining, tannins, and paresthesia are also reported.
- **Effectiveness:**
  - Green tea was effective against S. mutans, although the antibacterial effect was superior for CHX.
  - Another RCT compared the efficacy of green tea and CHX mouthwashes against S. mutans, Lactobacilli spp., and C. albicans in...
children with severe early childhood caries. Thirty children aged 4-6 years were randomly divided into green tea and CHX groups and were asked to use the prescribed mouthwashes once daily, for two weeks. The results showed significant decrease in S. mutans and Lactobacillus spp. colonies but no decrease was detected in C. albicans in both groups. This study revealed that green tea mouthwash was more efficient against S. mutans, whilst CHX had higher efficiency against Lactobacillus spp. Regarding tolerability and acceptability, this research proved green tea mouthwash, to be more tolerable than CHX in children [62]. The same results for efficacy of green tea against S. mutans were reported in five other similar RCTs [63-67]. However this privilege was not a fixed rule in all clinical trials [68]. Another clinical study showed green tea mouthwash can be as effective as nystatin in reducing candidal denture stomatitis symptoms [69].

In 2019, a crossover clinical trial was conducted on 46 patients admitted in the intensive care unit of Kerman hospital, Iran, using green tea and CHX mouthwashes for the test subjects on different days with a randomized order. No significant difference in oral health settings at the end of the study between those mouthwashes were observed [70]. In another experiment, the same treatment protocol was implemented on intubated patients admitted to intensive care unit, this time evaluating bacterial colonies in their throat culture. Results of this study showed green tea and CHX have the same efficacy in reducing pharyngeal bacterial load [71]. A crossover RCT in Mashhad University of Medical Sciences evaluated incidence of alveolar osteitis after using green tea mouthwash following third molar surgery. The intervention resulted in no clinically significant difference for the mouthwash users compared to control group [72].

Besides local cleansing effects, green tea gargle has also been evaluated for prevention of airborne systemic infections. Ide et al. [73] randomized 757 high school children into green tea and tap water gargle three times daily during the influenza epidemic season. Despite the fact that no significant advantage was observed for green tea for flu prevention, authors stated that modification of the non-blinded design, control for better adherence rates, and utilization of better placebos or diagnostic tools may reveal more promising results in the future studies. In a secondary analysis of these results using Bayesian estimation, the authors found that green tea gargling has a slight superiority over water gargling for that indication [74]. A clinical comparative evaluation between green tea mouthwash and green tea gel showed no significant difference in their antibacterial potency [75]. Considering CHX as an old and well-known oral disinfectant, tea mouthwashes have shown relatively acceptable anti-microbial effects without any of the complications associated with synthetic chemicals, including the adverse effects.

**Anti-plaque mouthwashes**

Dental hygiene has also been evaluated in tea mouthwash trials. Potential anti-plaque effects have been investigated following the observations for effective anti-microbial properties of these compounds. A randomized, blinded and controlled trial compared anti-plaque potency and gingival protective effects of tea mouthwash solution with CHX and neem extract mouthwashes. By assigning 30 healthy participants to three groups, results showed that use of tea mouthwash was more effective in terms of plaque-score. Also it improved gingival and oral hygiene status. There was no placebo group in this trial [76]. In a larger RCT on 110 industrial male workers with mean plaque index (PI) of 1.5 and gingival index (GI) of 1, participants were divided into green tea extract and placebo mouthwash groups. They were instructed to use the rinses twice daily, 30 seconds each time for 28 days. Results revealed that the PI and GI were significantly decreased in the green tea group [77]. Another comparative RCT conducted by Romoozi et al. [78], demonstrated that besides being as effective as CHX mouthwash in improving PI and GI in patients with plaque-induced gingivitis, tea mouthwash has the privilege of no dental staining which is a common side effect of CHX. There are four other RCTs with similar protocols that have also confirmed effectiveness of green tea mouthwash at the levels of CHX in improving plaque and gingival indices in patients with plaque-induced gingivitis [79-82]. On the other hand, in an RCT conducted in 2018 by Nagar et al. [83], 30 dental students whom were divided into CHX, green tea and white tea groups were asked to use the prescribed mouthwashes for 10 days. According to the results, in spite of significant improvements in gingival and plaque indices by herbal formulations, they were less effective.
compared to CHX. In addition, in a single-blind, one-operator, three-period, three-treatment clinical study with a randomized Latin square cross-over design on 30 volunteers, no significant reduction in plaque surface area was detected for tea mouthwash compared to a synthetic commercial product [84].

Regarding the saliva acidity, an RCT showed green tea mouthwash to be more effective in increasing salivary pH than CHX and sodium fluoride mouthwashes [85]. In comparison with probiotics, green tea mouth rinse demonstrated similar success in increasing salivary pH, which can be beneficial in prevention of enamel demineralization [86].

Plaque control and oral hygiene maintenance has always been a major concern in orthodontic patients. In an RCT on 30 orthodontic patients with fixed orthodontic appliances, anti-plaque efficacy of CHX (as a routine prescribed mouth rinse in orthodontic treatments) and green tea mouthwash was compared. This study showed superiority in plaque reduction for green tea over CHX and Listerine mouthwash [87]. Contrarily, in another RCT, during fixed orthodontic treatment green tea exerted significant plaque reduction, while it was not as efficient as CHX [88].

C-reactive protein and alkaline phosphatase are considered two nonspecific inflammatory markers which rise in peripheral blood circulation and gingival crevicular fluid as a sign of active periodontitis [89-90]. An RCT on 45 patients with mild to moderate localized chronic periodontitis showed that administration of green tea 5% mouthwash for two weeks significantly reduced these biomarkers in blood circulation in chronic periodontitis [91]. Lamba et al. [92], have also proposed that using green tea mouthwash after the phase I of periodontal treatments (Oral hygiene education, scaling and root planing) had significantly higher effect in reducing the total leukocyte count, especially neutrophil count, compared to placebo.

Anti-plaque effect of tea rinses is mainly related to its anti-microbial effect but presence of other mechanisms cannot be ruled out. It is almost a proven fact that these products can be efficiently used for the purpose of plaque fighting.

**Pain-killer mouthwashes**

Oral lesions and surgical wounds are on the top rank etiologies. Healing properties have been detected for tea ingredients. Accordingly, some studies evaluated relieving effects of such rinses. In a clinical trial with split-mouth double blind design, on 44 candidates for impacted third molar removal, the efficacy of green tea mouthwash was evaluated for post-operative pain management. Findings showed that daily application of this mouthwash significantly decreased the pain severity and number of required pain-killer pills during the first 7 days after the surgery. No considerable adverse effect reported by herbal mouthwash users [93]. Also the analgesic effect of green tea has been evaluated on pericoronitis pain. Randomization of 97 patients with acute pericoronitis of mandibular third molar to green tea and chlorhexidine mouthwashes, revealed a significant decrease in pain score and number of pain-killer uses and a non-significant improvement in trismus with herbal rinse [94]. Contrarily, in a clinical trial on orthodontic patients, green tea mouthwash was not as capable as acetaminophen in pain reduction during orthodontic tooth movements [95].

Generally, it could be stated that tea preparations are moderate pain-killers. They have acceptable anti-nociceptive effects. These characteristics are sometimes inferior compared to common pain-killers but bypassing numerous adverse effects is a considerable advantage.

**Combination mouthwashes**

There are several RCTs that assessed the synergistic efficacy of Camellia products in combination with other herbal or chemical ingredients in mouthwash formulations. These studies provide the chance for designing formulations with higher effectiveness associated with acceptable safety. Based on in vitro findings about synergistic anti-bacterial and anti-adherence effects of green tea and Salvadora persica extracts on plaque and gingivitis producing bacteria, in a double-blinded, randomized crossover trial with 14 participants, efficacy of this combination was evaluated, clinically. Comparison of the test mouthwash with placebo and CHX mouthwashes showed that lowest plaque score was yielded by herbal product followed by CHX and then the placebo was ranked, with statistically significant differences [96]. In another clinical study, combination of tea extract with sodium lauryl sulfate in a mouthwash, produced a greater anti-bacterial potency than the extract
alone [59]. A randomized clinical evaluation between “green tea” and “green tea with xylitol” mouthwashes, regarding their efficacy against salivary S. mutans and Lactobacillus colonies, findings demonstrated that addition of xylitol to green tea extract has better antibacterial efficacy compared to green tea extract alone [97]. Some studies have indicated that combining green tea and Aloe vera extracts creates a more potent antimicrobial herbal mouthwash. An RCT on patients suffering from periodontitis showed combination of Camellia sinensis and Aloe vera extract is highly effective in improvement of gingival indices [98]. Another comparative clinical trial between green tea-Aloe vera, CHX and matrica mouthwashes displayed that green tea-Aloe vera mouthwash is as effective as CHX in reducing PI, GI, and bleeding on probing index and exerts more anti-plaque potency than matrica mouthwash [99].

**Other clinical trials**

There are some clinical trials in scientific literature about Camellia mouthwashes which devoid of the straight forward RCT design. We evaluated these studies separately in this part. A clinical study conducted in 2019 tried to evaluate green tea mouthwash antibacterial efficiency by comparing organic acids found in saliva of 15 healthy adults before and 4 weeks after using the mouthwash. Researchers announced that green tea mouthwash has the potential to reduce bacterial activities in oral cavity via reduction of lactate concentration in saliva [100]. In a highly cited article by Ooshima et al. [101], the anti-plaque disposition effect of oolong tea was evaluated in 35 volunteers. Participants were instructed to rinse their mouth with tea extract ethanolic solution before and after each meal and at bedtime. The findings were recorded and controlled with the use of an ethanol-only solution after one week. Results showed a significant inhibition of plaque disposition with the herbal tea solution.

In a quasi-experimental study, 81 orally intubated patients hospitalized in intensive care unit of a medical center in Taiwan were divided into three oral care protocol groups: green tea, boiled water and control group. This study revealed irrigation with green tea extract in orally intubated patients minimizes mucosal changes and dental plaque accumulation and is beneficial in improving their oral health status [102].

The efficacy of green tea mouthwash has also been evaluated for management of halitosis. In a clinical trial (without any statement about randomization) on 30 volunteers free of natural halitosis, participants were tested with four different mouthwashes including Camellia sinensis and Curcuma zedoaria aqueous solutions, CHX and water as a placebo, concomitant with episodes of cysteine challenge tests. All mouthwashes demonstrated acute inhibitory effects on volatile sulphur compounds but a lasting effect was only presented after use of CHX [103]. Another RCT concerning halitosis showed that in patients with more than 80 parts per billion volatile sulphur compounds in their morning breath, green tea mouthwash can reduce them by 36.8 % [104].

**Conclusion**

Camellia sinensis mouthwashes have shown acceptable efficacy for management of various oral pathologies. To our knowledge this is the first review in medical literature which involves all potential applications of green tea formulations in the form oral rinses, as an industrially standard medication in the setting of dentistry. Although there are several review articles about use of green tea in dentistry fields [105-106] none of them has the same comprehensiveness. Regarding our investigations, advantages of this herbal product has been demonstrated in the majority of studies. Therefore, some indications can be proposed for the tea mouthwashes with higher level of evidence including oral disinfection, dental plaque removal and oral analgesia. An important and interesting issue in this context is the noticeable safety profile of these formulations which is an outstanding advantage for this herbal mouthwash over synthetic chemical ones.

**Acknowledgments**

The authors have no conflicts of interest to disclose. There was no source of support or fund for preparation of this manuscript. All authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

**Conflicts of Interest**

None

**References**


[65] Salama MT, Alsughier ZA. Effect of Green Tea Extract Mouthwash on Salivary Streptococcus mutans Counts in


[68] Hegde RJ, Kamath S. Comparison of the Streptococcus mutans and Lactobacillus colony count changes in saliva following chlorhexidine (0.12%) mouth rinse, combination mouth rinse, and green tea extract (0.5%) mouth rinse in children. J Indian Soc Pedod Prev Dent. 2017; 35: 150-155.


[76] Balappanavar AY, Sardana V, Singh M. Comparison of the effectiveness of 0.5% tea, 2% neem and 0.2% chlorhexidine mouthwashes on oral health: a randomized controlled trial. Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research. 2013; 24: 26-34.


[85] Hambire CU, Jawade R, Patil A, Wani VR, Kulkarni AA, Nehete PB. Comparing the antiplaque efficacy of 0.5% Camellia sinensis extract, 0.05% sodium fluoride, and 0.2% chlorhexidine gluconate mouthwash in children. Journal of International Society of Preventive & Community Dentistry. 2015; 5: 218.


[103] Farina VH, Lima AP, Balducci I, Brandao AA. Effects of the medicinal plants curcuma zedoaria and camellia
Camellia Sinensis Mouthwashes in Oral Care

This in press article needs final revision

Tafazoli A, et al.


