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Review Article

Effect of *Camellia sinensis* plant on decreasing the level of halitosis: A systematic review

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ABSTRACT

Tea is the second most consumed beverage. Polyphenolic catechins of green tea have a number of beneficial effects in oral cavity. This study aims to evaluate the clinical effects of green tea on halitosis through a systematic review of available literature. All available randomized, clinical trials – with a relevant subject that met the inclusion criteria – were included by searching PubMed, Cochrane, ProQuest, and Google Scholar, and Scopus databases. To score the selected articles, 27 items of CONSORT 2010 checklist were considered. Each article was reviewed by all the authors. Searching the PubMed database yielded 42 articles, 2 of which met the inclusion criteria. None of the 12 articles were obtained through Cochrane library, and 85 articles retrieved from ProQuest database met the inclusion criteria. Three hundred and five articles were obtained from Google Scholar, three of which fulfilled the inclusion criteria. Two articles were omitted because they were duplicated, and the rest were excluded. Searching the Scopus database yielded 270 articles, 2 of which met the inclusion criteria, but they were also duplicated. Finally, two studies were selected according to the inclusion criteria of the study. In both of the included articles, the early effect of green tea use was statistically significant in comparison with baseline. One of the studies showed the long-term effect of green tea mouthwash. Green tea can reduce halitosis through rinsing and antimicrobial effect.

Key Words: *Camellia sinensis*, green tea, halitosis, mouthwash

INTRODUCTION

Tea is the second most widely consumed beverage after water globally, with 3 billion kilograms of annual production and consumption; it is gained by some processes on *Camellia sinensis* plant.[1,2] Black tea, oolong tea, and green tea are three types of tea[3] categorized according to the fermentation rate. Black tea is the final product when *C. sinensis* leaves are fermented, oolong tea is gained by partial fermentation, and green tea is produced without fermentation.[4] Green tea production starts with steaming fresh *C. sinensis* leaves to prevent fermentation. This step deactivates the enzymes decomposing the color pigments of leaves, leading to preservation of green color of tea during the next steps as well as retention of natural polyphenols.[5] Polyphenolic catechins of green tea – a group of its active compounds – include epicatechin gallate, epicatechin, epigallocatechin, and epigallocatechin gallate (EGCG). Different oral health-related effects have been reported for the active components of green tea. Oral cancer chemoprevention

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has been attributed to EGCG, which has the highest concentration and activity among the other catechins of green tea.[6-8] Green tea has also other beneficial effects in the oral cavity including reducing the bleeding time after tooth extraction,[9] antibacterial activity against the bacteria responsible for periodontal disease and dental caries,[10] reducing periodontal disease,[11] anticariogenic activity,[12] and reducing halitosis.[13] Halitosis is the condition of unpleasant odor due to complex odorous substances in the breath.[14] Up to 50% of the people around the world find themselves with oral malodor steadily or in recurrent episodes.[15] Halitosis is divided into intraoral and extraoral types. Intraoral halitosis is more common than extraoral type; however, extraoral treatment is more complicated, and patients should be referred to medical specialists (physicians).[16,17] Probable contribution of several bacterial species (mainly Gram-negative anaerobes) to intraoral halitosis instead of a single specific species has been reported.[18] Volatile sulfur compounds (VSCs), diamines, and short-chain fatty acids (agents mainly causing oral malodor) are products of methionine, cystine, and cysteine metabolism as precursors of bacterial metabolism.[15,19] Some of the studies have suggested the effective role of green tea extracts in halitosis. The potential mechanisms of this product in reduction of halitosis might be attributed to the possibly suppressive role of EGCG in production of methyl mercapthane[20] as well as antibacterial activity of tannin.[20,21] In case of acceptable effects on halitosis, this medicament can be a good suggestion for halitosis treatment, which can enhance the patients' acceptance, motivation, and cooperation. In addition to its reputation for other therapeutic effects, it is available, easy, and cheap to prepare and has good taste. Patients can prepare and use it at home daily. Therefore, the aim of this study is to evaluate the clinical effect of green tea on halitosis through a systematic review of available literature.

MATERIALS AND METHODS

This study is approving by research and ethics committee of University of Medical Sciences (No: 296030).

Inclusion criteria

Type of study

We included randomized controlled trials (RCTs) and quasi-RCTs which investigated the effect of green tea on oral malodor. They had to have a green tea intervention group and a control group in their study groups. We just included research articles written in English language.

Type of Participants

The participants of studies suffered from physiologic intraoral malodor (halitosis not associated with respiratory or gastrointestinal problems or periodontal disease and xerostomia) and were of any age groups and of both genders.

Type of intervention

Green tea was used as mouth rinse or just as pure extract.

Outcome

VSCs were measured by gas chromatography machine or portable sulfide monitors.

Exclusion criteria

The studies excluded from the review in which green tea was not used in oral environment and was just utilized in patient's specimens such as saliva.

Search methods for identification and selection of studies

Electronic search was conducted in PubMed (July 11, 2016), Cochrane (July 11, 2016), ProQuest (Full Text Dissertations and Theses: Health and Medicine, Nursing, and Allied Health Source) (2000–July 2016), and Google Scholar (July 2016) databases. Details of search strategy are presented in Table 1. The studies were selected according to their titles and abstracts; if some criteria could not be evaluated by abstracts, the full texts of articles were checked.

Data extraction

Details of each selected article were presented in the table including author's name, publication year, study design, study method, participants' characteristics, outcome, and main results.

To score the selected articles, 27 items of CONSORT 2010 checklist were considered. Each article was reviewed by all authors to investigate whether the item was accomplished in the study or not. If the item was accomplished, one point was given to the article; if it was not done or mentioned, zero point was given to the article. Finally, the scores of each article were summed, and according to the final score, they were classified as high quality (19–27 score), average quality (10–18 score), and low quality (0-9 score). The low, average, and high-quality articles were included in the study.

Safety outcomes

Possible oral side effects including xerostomia, burning sensation, changes in taste perception,

Table 1: Search strategy to find the relevant articles in databases

Database	Keywords	Results
PubMed July 11	((((((((((“unfermented tea”) OR “green tea”) OR “plant products”) OR tea) OR “plant extracts”) OR “camellia sinensis”) OR “green tea extract”) OR “tea oil”))) AND (((((((((halitosis) OR malodor) OR “fetor ex ore”) OR “bad breath”) OR “breath malodor”) OR “oral malodor”) OR “fetor oris”) OR “foul breath”))	42
Cochrane	((((((((((“unfermented tea”) OR “green tea”) OR “plants product”) OR tea) OR “plant extracts”) OR “camellia sinensis”) OR “green tea extract”) OR “tea oil”))) AND (((((((((halitosis) OR malodor) OR “fetor ex ore”) OR “bad breath”) OR “breath malodor”) OR “oral malodor”) OR “fetor oris”) OR “foul breath”))	12
ProQuest (full text dissertations and theses: health and medicine, nursing and allied health source)	((((((((((“unfermented tea”) OR “green tea”) OR “plants product”) OR tea) OR “plant extracts”) OR “camellia sinensis”) OR “green tea extract”) OR “tea oil”))) AND (((((((((halitosis) OR malodor) OR “fetor ex ore”) OR “bad breath”) OR “breath malodor”) OR “oral malodor”) OR “fetor oris”) OR “foul breath”))) AND stype. exact(“Scholarly Journals” OR “Dissertations & Theses”) AND at. exact(“Article”) AND la. exact(“English”)	85
Google scholar	(“green tea” OR “camellia sinensis” OR “unfermented tea”) AND (“halitosis” OR “malodor” OR “bad breath”) AND “clinical trial”	305
Scopus	((((((((((“unfermented tea”) OR “green tea”) OR “plant products”) OR tea) OR “plant extracts”) OR “camellia sinensis”) OR “green tea extract”) OR “tea oil”))) AND(((((((((halitosis) OR malodor) OR “fetor ex ore”) OR “bad breath”) OR “breath malodor”) OR “oral malodor”) OR “fetor oris”) OR “foul breath”)) AND (EXCLUDE (DOCTYPE,”re”) OREXCLUDE (DOCTYPE,”ch”) OREXCLUDE (DOCTYPE,”bk”)) AND (EXCLUDE (SUBJAREA,”ENGI”) OREXCLUDE (SUBJAREA,”PHYS”))	270

tooth staining, mucosal irritation,[13] and its systemic adverse effects including irritability, tachycardia, and insomnia[22] were also reported.

RESULTS

Searching in PubMed database resulted in 42 articles, 2 of which met the inclusion criteria.[13,23]

None of the 12 articles were obtained through Cochrane library, and 85 articles obtained through ProQuest (Full-Text Dissertations and Theses: Health and Medicine, Nursing, and Allied Health Source) met the inclusion criteria. Three hundred and five articles were obtained by searching Google Scholar, three of which fulfilled the inclusion criteria. Two of the articles were omitted because they were duplicated. The third article was excluded because the green tea mouthwash was used on saliva specimens instead of oral environment.[21] Searching in Scopus database yielded 270 articles, only two of which met the inclusion criteria, but these two articles were duplicated too. Details of database searching are presented in Table 1.

The study design, participants’ characteristics, outcome, main results of the two eligible articles, and score given to each article according to CONSORT 2010 checklist are summarized in Table 2.

The first article was performed by Farina *et al*.[23] They evaluated the effect of the medicinal plants *Curcuma zedoaria* and *C. sinensis* on halitosis in thirty volunteer adults of both sexes, aged 19–43 years. Green tea was administered as 10 mL mouthwash for 30 s. VSC was measured by a halimeter before, 1 min, 90 min, and 180 min after consumption of green tea mouthwash, and the outcome was compared with the placebo group (water). Details of the study method of articles are presented in Table 1. One minute after the mouthwash was used, a reduction occurred in VSC level, which was similar to water and green tea mouthwash. After 90 and 180 min, VSC level similarly increased in both groups.

The second article was carried out by Rassameemasmaung *et al*.[13] Sixty participants recruited in this study were stratified according to their VSC levels. Participants in each stratum were randomly divided into green tea mouthwash and placebo group. VSC level was measured by portable sulfide monitor, and then 15 ml of green tea mouthwash was used for 1 min. VSC level was measured 30 min and 3 h later. The assigned mouthwashes were used twice daily with a specific protocol for 4 weeks. In 30 min and 3 h periods, the result showed that green tea significantly reduced VSC compared to baseline, and it was more effective than placebo; however, it was not statistically significant. However, after 28 days, differences were significant for green tea group in comparison with baseline and control group.

DISCUSSION

In addition to the importance of halitosis control for its bad effect on social communications,[24] the causative VSCs in halitosis are important to be reduced because

Table 2: Summary of the studies included in the study

Authors	Farina *et al.*	Rassameemasmaung *et al.*
Publication year	2012	2013
Study design	RCT (sequential) with two groups of *Camellia sinensis* (green tea), and placebo (water) The green tea mouthwash was prepared and each subject rinsed with 10-Ml acetylcysteine for 30 seconds, expectorated and then kept his/her mouth closed for 60 seconds. Breath was monitored by halimeter 1 min later, the above protocol was repeated To test the residual effect 90 min and 3 hours after using the tested solution, the participants repeated rinsing with acetylcysteine solution (1, 90, 180 min)	RCT (parallel) with two groups in each strata (according to their VSC level): The green tea mouthwash group (mouthwash containing *Camellia sinensis* extracts) or the placebo mouthwash group using sealed envelopes Baseline parameters: VSC level (measured by portable sulfide monitor (Rh-17, halimeter, inter scan Corp, CA, USA), PI and PBI The participants were thoroughly rinsed with 15 mL of the assigned mouthwash for 1 min, VSC level was re-measured at the following 30 min and 3 h Also, after a four-week use, the participants were asked to rinse with the assigned mouthwash twice daily after tooth brushing and were asked to refrain from drinking or water rinsing for at least 30 min after mouthwash use At day 28, VSC, PI, and PBI were recorded again
Participants' characteristics	The absence of natural halitosis (VSC below 110 ppb) before the subjects rinsed with acetylcysteine, were in good general and periodontal health, had at least 20 natural teeth, were nonsmokers, did not wear orthodontia, were not undergoing any medical treatment, were taking no medication and were not using oral mouthwashes	had at least 20 teeth, had over 80 ppb of VSC in the mouth air, had no systemic complicating factors or oral mucosal lesions, were not smokers and denture wearers, or took an antibiotic 1 month before the study
Participants	Thirty volunteer adults of both sexes, between 19 and 43 years of age	The green tea mouthwash group: 30 participants (27 women and 3 men) with an age range of 18-55 years (mean age of 27.2±9.1 years) The placebo mouthwash group: 30 participants (27 women and 3 men) with an age range of 19-42 years (mean age of 25.8±7.6 years).
Outcome	VSC measurement by halimeter	VSC measurement by portable sulfide monitor
Main results	1 min after intervention: There was a reduction in the concentration of VSC (with little variation among the groups). The results with water and *Camellia sinensis* were similar Ninety and 180 min after intervention: there was an increase in VSC in the remaining groups except one group (Chlorhexidine group) (VSC data (%) obtained from breath tests in 30 patients) (P=0.0001<0.05) VSC level in the water group After one min: 42.53±17.46 After 90 min: 8.94±24.27 After 180 min: 22.08±33.68 VSC level in the green tea group After one min: 49.98±16.61 After 90 min: 15.45±26.61 After 180 min: 31.09±33.68 VSC level in chlorohexidine group After one min: 58.91±20.09 After 90 min: 63.53±25.48 After 180 min: 68.80±23.80	After one-time use, VSC level in the green tea group: At 30 min 116.6±63.6 ppb (95% CI: 93.8-139.4 ppb), At 3 h 119.6±65.4 ppb (95% CI: 96.2-143 ppb), At day 28 105.5±66.6 ppb In the placebo group: at 30 min 146.2±99.6 ppb (95% CI: 110.6-181.9 ppb), at 3 h 164.6±109.3 ppb (95% CI: 125.5-203.7 ppb), At day 28 162.4±115.7 ppb The reduction levels of VSC at 30 min and 3 hours after -rinsing were 36.76%±22.00% and 33.18%±32.29% in the green tea group and 19.83%±25.25% and 9.17%±27.81% in the placebo group, respectively(green tea mouthwash could reduce VSC level more effectively). Compared to baseline, VSC level was significantly different in the green tea group at 30 min (P<0.0005) and 3 h <0.0005) after rinsing. However, no significant difference was found between groups in any time periods (P=0.175)
Score	18 (low evidence)	25 (high level evidence)

CI: Confidence interval; VSC: Volatile Sulfur Compound; PI: Plaque Index; PBI: Papillary Bleeding Index; ppb: Parts per billion

of their ability to initiate and accelerate periodontal disease.[25] These active agents harm the gingival fibroblast DNA and cause cellular apoptosis; they also prevent osteoblastic activity and osteoclastic activity.[26]

Green tea has been used widely as a medical herb since ancient time. In some cultures such as Chinese, it is believed that green tea has some paregoric effects on headache and general aches. The positive impacts of green tea on periodontal disease and halitosis have been shown in some studies.[4,27,28] To find the clinical effect of green tea on halitosis, the current study systematically reviewed the available

papers on the ability of green tea in overcoming halitosis.

Based on the online databases, 714 articles related to green tea and halitosis were found in the primary search, only two of which met the inclusion criteria.

The study conducted by Rassameemasmaung *et al*.[13] was ranked a high-quality study; whereas the study by Farina *et al*.[23] gained an average quality. This ranking (according to CONSORT 2010 checklist) shows that the study method employed by Rassameemasmaung S was closer to the standards of clinical trials.

As shown in the included articles, the early effect of green tea mouthwash, in comparison with baseline, was statistically significant. There are some other *in vivo* and *in vitro* studies that support the effectiveness of green tea on reducing halitosis. Zeng *et al*. in their *in vitro* study showed the ability of green tea to remove odorant sulfurs. They showed the intensifying effect of adding herbal acetone powder to green tea in reducing halitosis (Zeng *et al*., 2010). The results of Lodhia *et al*. support the adverse effect of green tea on oral malodor. According to this *in vivo* study, green tea reduced hydrogen sulfide (H2S) and methyl mercaptan (CH3SH) concentration specifically after consumption.[28] It is important because CH3SH is related more to halitosis rather than H2S.[29]

The deodorizing mechanism of EGCG is based on reaction with CH3SH, in which methylthio and/or a methylsulfinyl group reacts with the B ring of EGCG. In this process, a methylthio group is added to the orthoquinone form of catechin (oxidated with atmospheric oxygen) and results in a reduction of bad odor (Yasuda *et al*., 1995).

Furthermore, green tea contains zinc,[30] which can be considered one of the possible ingredients contributing to its antihalitosis effects. It affects VSCss and converts them to nonmalodorous compounds.[31,32] It has been reported that the mouthwash-containing zinc can reduce VSCs by about 80% for 3 h.[33] However, the zinc content of green tea varies in different green teas species.[30] Therefore, considering the green tea with a high concentration of zinc may result in more antihalitosis effects.

It should be noted that, although the first study showed early reduction in halitosis in the green tea group, it was similar to the control group. This finding can be justified by the rinsing effect of mouthwashes regardless of their components.

In both included studies, green tea has been used as mouthwash that can potentially rinse VSCs and reduce their amount in oral cavity. In the second article, the long-term effect of green tea mouthwash was shown, which could be explained by the antimicrobial activity of green tea and its inhibitory effect on the growth of VSC-producing bacteria.[34,35] The study of Morin *et al*. showed the inhibitory effect of EGCG and green tea extract on *Solobacterium moorei* bacterium by interrupting the bacterial cell membrane integrity.[36] *S. moorei* is a Gram-positive, anaerobic bacterium that is highly prevalent in halitosis patients.[37,38]

It has also been reported that EGCG and green tea can decrease adhesion of *S. moorei* and *Porphyromonas gingivalis* to oral epithelial cells.[36,39] The tannin content of green tea is considered a biosynthetic antimicrobial agent. In the study conducted by Moghbel *et al*., green tea mouthwashes with a higher amount of tannin showed more powerful bacterial colonies.

Generally, according to the two included articles, it seems that green tea has the ability to reduce VSCs. Based on the high CONSORT score reported by Rassameemasmaung *et al*., green tea can be suggested to have possibly long-term effect on oral malodor. Although considering green tea mouthwash as a certain medicament for halitosis control needs more randomized clinical trials with sufficient volunteers, it can be suggested to patients as an auxiliary treatment beside other treatments.

CONCLUSION

Green tea mouthwash can reduce halitosis. This effect can be attributed to its rinsing activity as a mouthwash as well as the antimicrobial mechanisms of green tea itself. This study does not support the clinical prescription of green tea for certain treatments due to lack of enough randomized clinical studies, but green tea mouthwash can be a good treatment of choice beside other halitosis treatments to achieve better clinical results.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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