



The Comparison of Antimicrobial Effect of New Herbal with Standard Toothpaste with Their Influence on Gingival Health Indexes: A Randomized Clinical Trial

Narjes Akbari ¹, Hamid Ahmadi ², Ebrahim Shafaie ³, Omid Rajabi ⁴, Gholamreza Sharifzadeh ⁵ and Zoya Tahergorabi ^{6,*}

¹Department of Oral & Maxillofacial Diseases, School of Dentistry, Infectious Diseases Research Center, Birjand University of Medical Sciences, Birjand, Iran

²Student Research Committee, School of Medicine, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran

³Department of Medical Microbiology, School of Medicine, Infectious Diseases Research Center, Birjand University of Medical Sciences, Birjand, Iran

⁴Department of Drug Control, School of Pharmacy, Targeted Drug Delivery Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

⁵Department of Epidemiology and Biostatistics, School of Health, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran

⁶Medical Toxicology and Drug Abuse Research Center, Department of Physiology, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran

*Corresponding author: Associate Professor of Physiology, Medical Toxicology and Drug Abuse Research Center, Department of Physiology, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran. Email: z.tahergorabi@yahoo.com

Received 2022 September 07; Revised 2022 October 31; Accepted 2022 November 20.

Abstract

Background: Dental caries, gingivitis, and periodontitis are considered the most common oral and dental health problems in different parts of the world.

Objectives: The present study aimed to evaluate the antibacterial activity, plaque index, and gingival index determination of herbal toothpaste compared with standard toothpaste.

Methods: The present study is a randomized clinical trial on 60 participants of 18 - 28 years and a minimum of 24 healthy teeth at Birjand Dental School that were randomly divided into two groups, herbal and standard toothpaste (n = 30 each group); only participants were blind. All subjects brushed their teeth for 3 minutes 2 times a day for seven months. The plaque index (PI) and gingival index (GI) for each participant also, saliva samples were taken from the subjects for *Streptococcus mutans* and *Lactobacillus* spp., colony count at the onset of the study, and 3, 5, and 7 months after toothpaste usage.

Results: This study was conducted on 60 patients in two study groups. No significant statistical difference was observed between age and gender in the two studied groups. Our study showed that the mean number of *S. mutans* in the two groups was not significantly different ($P > 0.05$), but the mean number of *Lactobacillus* spp. in the group of herbal toothpaste at three months ($P = 0.02$) and seven months ($P = 0.002$) was significantly less than standard toothpaste. Also, the mean PI and the GI indices in the herbal toothpaste group after use for five months ($P = 0.02$) ($P = 0.03$) and seven months ($P < 0.001$) ($P = 0.03$), respectively, were significantly lower than standard toothpaste.

Conclusions: Throughout the 7-month trial, herbal toothpaste showed higher antimicrobial activity against *Lactobacillus* spp. than standard toothpaste, effectively reducing dental plaque and gingivitis. Furthermore, no undesirable reactions to toothpaste were reported during the trial. Therefore, it was concluded that possibly novel herbal toothpaste could be an alternative for controlling dental plaque and gingivitis. Further studies are needed.

Keywords: Periodontal index, Herbal, Toothpaste, *Lactobacillus* spp., *Streptococcus mutans*

1. Background

Oral and dental diseases is considered one of the most common health problems in the world (1). Accordingly, poor oral hygiene is associated with various problems, such as periodontitis, tooth decay, tooth or gum pain and discomfort, infection, and even loss of teeth; (2) also increases the probability of chronic diseases such as diabetes, cardiovascular diseases, stroke, and respiratory dis-

ease (3).

Dental caries is still high in many developing countries, and almost half of the world's population, or 3.5 billion people, suffers from tooth decay (4). Current evidence shows that risk factors for developing dental caries, including plaque formation, fermentable carbohydrates, cariogenic bacteria, the quantity and quality of saliva, host susceptibility, poor oral hygiene, and duration, play a role in

the onset and progression of dental caries (5).

Growing evidence suggests that oral pathogens are identified as a key element in the formation of dental caries (6). *Streptococcus mutans* is one of the most effective cariogenic bacteria, which has a key role in dental caries by adhesion to oral and dental tissues; herein, carbohydrate fermentation results in lactic acid production and demineralization of enamel (7). Since Mechanical plaque removal is one of the most accepted methods of controlling plaque, there are many mechanical aids to remove or control dental plaque, including toothbrushes, dental floss, mouth rinses, and dentifrices (8). Brushing with toothpaste containing various chemical formulations by reducing the number and activity of dental plaque is considered the most common form of dental disease prevention worldwide (9).

Toothpaste is classified as a drug and, according to American Dental Association (ADA), pastes gels or powders are used with a toothbrush for cleaning dental plaque and improving of oral health (10). Commonly, a wide range of chemical agents, such as fluoride in toothpaste, is used for inhibitory effects by destroying the cell wall and disrupting enzymatic activity in plaque formation (11). However, it can be associated with adverse outcomes, including chemical resistance to the antibacterial agents also lead to local toxic effects such as irritation and desquamation of the oral mucosa (stomatitis, glossitis, gingivitis) or systemic side effects such as allergic toxic reactions (acute or chronic) and even dental staining (12).

Considering that the phytochemicals isolated from the plants have a large number of active biological components, they may be a good alternative to Barberry and *Zizyphus jujuba*, which are found in Birjand (a sunny city in eastern Iran, the capital of South Khorasan province). Berberine is the main compound of berberis, an isoquinoline alkaloid produced by *Berberis vulgaris* L. cultivated in Asia and Europe with different pharmacological effects such as anti-inflammatory, antimicrobial, antifungal, and antiviral effects in both in vitro and in vivo studies (13). Also, *Z. jujuba* Mill, which is cultivated mainly in Europe and most of Asia with many biologically active components, especially alkaloids and Saponin, which have antioxidant, anti-inflammatory, and antiviral properties and also improve immune function (14).

2. Objectives

Since chemical agents such as fluoride in toothpaste are associated with adverse outcomes, including chemical resistance to the antibacterial agents, the phytochemicals isolated from the plants as herbal toothpaste seem to be

a good alternative. Thus, the present study aimed to evaluate the antibacterial activity, plaque, and gingival index determination of herbal in comparison with standard toothpaste against *S. mutans* and *Lactobacillus* spp.

3. Methods

3.1. Study Setting

The present study is a randomized control clinical trial conducted at Birjand Dental School, Birjand, Iran, on 60 participants aged 18 - 28 years who were simply randomly divided into two groups of herbal and standard toothpaste (n = 30 each group).

3.2. Sample Collection

According to the results obtained from the study of Esfahanizadeh et al. (15) and using the formula for comparing two averages and considering 90% power and 99% confidence $S1 = 0.2$, $S2 = 0.23$, $d = 0.2$ and taking into account the 10% drop in the number of samples about 30 people in each group was calculated.

Participants were admitted to the study if meeting the following criteria: Age 18 - 30 years and a minimum of 24 healthy teeth. Exclusion criteria included systemic disease, using drugs, periodontal disease, pregnancy, breastfeeding, smoking, and a history of allergies to toothpaste or herbal medicine.

3.3. Toothpaste Preparation

A non-Iranian toothpaste (crest cavity protection) and herbal toothpaste prepared from *Berberine* and *Saponin* (main compounds of Barberry and *Z. jujuba*) respectively in the department of Pharmacology, Mashhad University of medical sciences were used in this study. All toothpaste was prepared in the lab section of the department of Pharmacology and separately packaged in label-free tubes with the same color of herbal toothpaste for two groups as those participants were completely blind. All subjects brushed their teeth for 3 min 2 times a day with the Bass method.

3.4. Gingival Health Assessment

GI and PI index: To determination of the GI at the onset of the study and 3, 5, and 7 months after toothpaste usage, each of the four areas of the facial, mesial, distal, and lingual teeth is examined and received a score from zero to 3 as normal gum and without inflammation: Zero; mild inflammation: Slight color change and very little edema without bleeding during the probe: 1; moderate inflammation: Edema and inflammation with bleeding during the probe: 2; and severe inflammation: Severe

and marked edema and inflammation, ulceration and tendency to bleed spontaneously: 3.

PI for each tooth was determined as the average score of 4 tooth levels (buccal/labial and distal and lingual surfaces of teeth) and was scored as without plaque: Zero, a very thin plaque clinging to the edge of the free gum and adjacent teeth: 1; medium accumulation of plaque on the edge of the gums visible to the naked eye: 2; and excessive plaque buildup between the gingival pockets or on the teeth and gingival margins: 3 (16). Then, oral cavity was examined for any allergic or adverse reaction on hard and soft tissues.

3.5. Sampling and Microbial Assay

Saliva sampling: Saliva samples were taken from the participants 4 times onset of the study, 3, 5, and 7 months after using toothpaste. The participants were educated not to eat or drink except water and not perform physical exercise for at least two h before the saliva collection. Participants were asked to swallow their saliva and at least 1 mL of their non-induced saliva collection in a sterile container for 5 minutes (17). The saliva sample was then transferred to the laboratory in less than 30 minutes for *S. mutans* and *Lactobacillus* spp. culture.

3.5.1. Bacteria Culture

The collected saliva was diluted ten-fold as serial dilution by sterile normal saline. Diluted saliva was cultured in duplicate on Mitis salivarius bacitracin (MSB) agar (Himedia, India) supplemented by potassium tellurite and MRS agar (Merck, Germany) for isolation of *S. mutans* and *Lactobacillus* spp., respectively. The plates were incubated in a candle jar with a microaerophilic atmosphere at 37° for 48 h. Colonies of *S. mutans* identified with morphologic characteristics (0.5 mm convex undulated colonies of light blue color). Colonies of *Lactobacillus* spp. were characterized by small grayish-white. Colony-forming units (CFUs) per mL of saliva were calculated based on the mean of the counted colonies and saliva dilution rates (18).

3.6. Statistical Analysis

Obtained data were analyzed using SPSS 19 software. The normality of the data was evaluated using Kolmogorov-Smirnov statistical test. Mann-Whitney test was used to compare the two groups with each other, and Friedman and Wilcoxon's tests were to analyze the changes during the onset of the study and three, five, and seven months after toothpaste usage. The criterion for the significant difference was $P < 0.05$.

4. Results

This study was conducted on 60 patients in two study groups. The mean age in the herbal toothpaste group was 23.5 ± 2.1 years, and in the standard toothpaste group was 23.3 ± 2.01 years ($P = 0.56$). In the herbal and standard toothpaste groups, 60% and 50% of subjects were male, respectively ($P = 0.43$). So no significant statistical difference was observed in terms of age and gender in the two studied groups.

The levels of *S. mutans* and *Lactobacillus* spp. in saliva at the onset of the study and 3, 5, and 7 months after toothpaste usage are shown in Tables 1 and 2. Most participants had high levels of salivary *S. mutans* and *Lactobacillus* spp. at baseline. The results showed that the mean number of *S. mutans* and *Lactobacillus* spp. significantly decreased in both herbal and standard toothpaste groups compared to baseline after seven months of follow-up. There was no statistically significant difference between *S. mutans* levels in the three follow-up times between the herbal and standard toothpaste groups. In the case of *Lactobacillus* spp., the results show a significant decrease in the number of *Lactobacillus* spp. in the group using herbal toothpaste compared to the standard in 3 months ($P = 0.02$) and seven months ($P = 0.002$) of follow-up.

The mean of PI and GI at the baseline and 3, 5, and 7 months after herbal and standard toothpaste usage was shown in Tables 3 and 4. The results showed that the PI and GI significantly decreased in both herbal and standard toothpaste groups compared to baseline after seven months of follow-up. The PI significantly decreased in the herbal toothpaste group compared to the standard in the 5-month ($P = 0.02$) and 7-month ($P < 0.001$) follow-ups. Also, the GI significantly decreased in the herbal toothpaste group compared to the standard in the 5-month and 7-month follow-ups ($P = 0.03$).

5. Discussion

Since plaque is considered the main etiological factor for several oral diseases, optimal plaque control, including mechanical control, is important for preventing gingivitis, periodontitis, and dental caries (19). Hence, various chemical substances have been developed to control periodontal diseases that may lead to harmful local and systemic side effects when used for a long time (11, 12). Therefore, research has recently been done on alternative products to synthetic chemicals.

The results of our study showed that the mean of PI and GI was significantly reduced in herbal and standard toothpaste groups after seven months of follow-up examination as compared to baseline. Our study is in line with

Table 1. Comparison of *Streptococcus mutans* Count Between Herbal Toothpaste and Standard Toothpaste^a

Group/Time	Standard Toothpaste	Herbal Toothpaste	Mann-Whitney (P Value)
Baseline	81.1 ± 60.3 [50 (35 - 126)]	75.9 ± 62.4 [72 (19.5 - 125)]	0.56
Three months after	60.7 ± 43.8 [48 (24-98.5)]	51.9 ± 35.8 [49 (16 - 80)]	0.46
Five months after	42.3 ± 25.8 [40 (20 - 57)]	48.3 ± 70.3 [36 (12 - 59)]	0.56
Seven months after	26.2 ± 10 [19 (12 - 40)]	25.5 ± 22.9 [19 (7.5 - 40)]	0.54
Friedman test (P value)	< 0.001	< 0.001	
Wilcoxon's test (P value)	< 0.001; All times together are significant	< 0.001; All times together are significant	

^a Values are expressed as mean ± SD [median (Q1 - Q3)].

Table 2. Comparison of *Lactobacillus* spp. Count Between Herbal Toothpaste and Standard Toothpaste^a

Group/Time	Standard Toothpaste	Herbal Toothpaste	Mann-Whitney (P Value)
Baseline	52.8 ± 18.03 [15 [(6 - 24)]]	22.4 ± 30.1 [11 (3.9 - 30.5)]	0.77
Three months after	7.7 ± 11.3 [4.5 (1.1 - 8.3)]	2.96 ± 4.03 [1.6 (0.6 - 4.2)]	0.02*
Five months after	3.5 ± 5.9 [1 (0.4 - 3.5)]	0.944 ± 0.758 [0.6 (0.1 - 4.3)]	0.26
Seven months after	1.9 ± 2.27 [1 (0.6 - 2)]	0.705 ± 1.08 [0.4 (0.2 - 0.8)]	0.002*
Friedman test (P value)	0.001	0.001	
Wilcoxon's test (P value)	0.001; All times together are significant	0.001; All times except 5 with seven months are significant	

^a Values are expressed as mean ± SD [median (Q1 - Q3)].

Table 3. Comparison of Plaque Index Between Herbal Toothpaste and Standard Toothpaste

Group/Time	Standard Toothpaste	Herbal Toothpaste	Mann-Whitney (P Value)
Baseline	0.83 ± 0.65 [1 (0 - 1)]	0.7 ± 0.59 [1 (0 - 1)]	0.43
Three months after	0.73 ± 0.58 [1 (0 - 1)]	0.47 ± 0.51 [0 (0 - 1)]	0.08
Five months after	0.53 ± 0.51 [1 (0 - 1)]	0.23 ± 0.43 [0 (0 - 0.25)]	0.02 ^b
Seven months after	0.47 ± 0.51 [0 (0 - 1)]	0 ± 0 [0 (0 - 0)]	< 0.001 ^a
Friedman test (P value)	0.003	0.001	
Wilcoxon's test (P value)	0.005 ^b ; 0.029 ^c ; 0.034 ^d ; 0.021 ^e	< 0.001; All times except onset with three months is significant	

^a Values are expressed as mean ± SD [median (Q1 - Q3)].

^b Onset with seven months.

^c onset with five months.

^d Three months with five months.

^e Three months with seven months.

Table 4. Comparison of Gingival Index Between Herbal Toothpaste and Standard Toothpaste

Group/Time	Standard Toothpaste	Herbal Toothpaste	Mann-Whitney (P Value)
Baseline	1.07 ± 0.64 [1 (1 - 1.25)]	1.07 ± 0.69 [1 (1 - 2)]	0.99
Three months after	1.03 ± 0.49 [1 (1 - 1)]	0.87 ± 0.51 [1 (1 - 1)]	0.19
Five months after	0.87 ± 0.35 [1 (1 - 1)]	0.63 ± 0.49 [1 (0 - 1)]	0.03 ^b
Seven months after	0.8 ± 0.41 [1 (1 - 1)]	0.53 ± 0.51 [1 (0 - 1)]	0.03 ^b
Friedman test (P value)	0.013	< 0.001	
Wilcoxon's test (P value)	0.033 ^b ; 0.008 ^c	0.003 ^d ; 0.002 ^b ; 0.008 ^c	

^a Values are expressed as mean ± SD [median (Q1 - Q3)].

^b Onset with seven months.

^c Three months with seven months.

^d Onset with five months.

a randomized clinical trial study by Taghavi et al., in which PI and GI scores had significant differences between baseline and follow-up examinations (20). Also, the comparison between the two groups in our study showed that the PI and GI were significantly reduced at five months and seven months after using herbal toothpaste compared to standard toothpaste. Our study is in line with a double-blind clinical trial study by Makarem and Asodeh (21) that showed *berberine* gel significantly reduced microbial plaque and gingivitis in school-aged children compared with placebo.

Several studies have shown the effect of herbal toothpaste on plaque control compared to standard types. Similar results were observed by de Oliveira et al. that the *Aloe vera* plant product was effective in reducing plaque but showed less effectiveness of the plant product on gingivitis and gingival bleeding compared to standard types (22). Also, the study by Amoian et al. on 40 participants over four weeks in 2 groups of control and Calendula flower extract toothpaste that was found significant reductions in PI, GI, and bleeding on probing (BoP) in *Calendula* toothpaste than control toothpaste in weeks 2,3 and 4 (23). The reducing effects of PI and GI scores can be attributed to the anti-inflammatory effects of *berberine* and *Saponin* (22, 23). Several mechanisms have been mentioned for the antimicrobial effects of *berberine*, such as inhibition of cell division, disrupting of protein synthesis, inhibiting of enzyme activity, and destroying the surface structures of bacteria (24-26). Two mechanisms exert the effect of saponins on the biofilm system: First, surfactant properties by surface tension reduction in an aqueous solution can form micelles, and this, in critical point concentration, can structurally change biological macromolecules. Second, perforation and rupture of the cell membrane of bacteria by binding to surface sterols in eukaryotic cell membranes (27). Considering that the chemicals used in toothpaste, mouthwashes, etc., when used regularly, may cause undesirable side effects such as changes in mouth taste, tooth discoloration, and ulceration of the oral mucosa (22) however, there was no adverse reaction with herbal toothpaste in our study during follow-up.

Our study showed that the mean number of *S. mutans* and *Lactobacillus* spp. significantly decreased in both groups of using herbal and standard toothpaste compared to baseline after seven months of follow-up, but there was no statistically significant difference between *S. mutans* levels in the three follow-up times between the herbal and standard toothpaste groups. Our result is in line with Patil et al.'s (28) study on 100 students of 4 - 6-year-old children using Himalaya herbal dental cream or cheerio gel containing fluoride (n = 50), despite the 90% reduction of saliva *S. mutans* after a 5-month follow-up period in two

groups, no statistically significant difference observed between the groups (26). Our study showed that the herbal toothpaste was more effective than the standard in reducing *Lactobacillus* spp., especially after seven months of use. Many studies have been conducted on reducing *S. mutans* and *Lactobacillus* spp. using commercial and herbal toothpaste. Our result is in line with the Biria et al.'s study (29) that using herbal toothpaste containing bamboo salt and non-herbal conventional toothpaste leads to a significant reduction of *S. mutans* and *Lactobacillus* spp., after a 4-week follow-up; however, unlike our study, it is not statistically different between the two groups in the case of *Lactobacillus* spp. It seems that the duration of using herbal toothpaste is an effective factor in reducing the amount of *Lactobacillus* spp. Mehta et al. study (30) on 55 children aged 8-14 years showed herbal (Freshol) mouthwash and chlorhexidine can significantly reduce the amount of *S. mutans* saliva, PI, and GI score during periods of 10 days. Our study is in line with Ferrazzano et al. (31) on 66 healthy individuals of 12 - 18 years in two groups of green tea extract, or placebo mouth rinse exhibited a statistically significant reduction in colony counts of *Lactobacilli* saliva sample relative to the control group.

5.1. Conclusions

Our study showed considering the new herbal toothpaste for seven months in vivo that relatively well-controlled gingivitis and dental plaque also, there were no adverse effects it can be used effectively. Of course, more studies are needed to evaluate its effectiveness.

5.2. Limitations

First, in this study, only two of the important cariogenic bacteria in dental biofilm formation were examined so that it can study other cariogenic bacteria and at the molecular level. Second, the effect of new toothpaste in this study was not examined on special groups, including elderly subjects also pregnant and breastfeeding women.

Acknowledgments

The authors of this manuscript appreciate the Birjand University of Medical Sciences Research Council (Grant number 456293).

Footnotes

Authors' Contribution: Conception or design of the work, N. A, H. A, E. Sh, Z. T.; Analysis or interpretation of data

for the work, Gh. R. Sh.; Drafting the work or revising it critically for important intellectual content, ZT, E. Sh, H. A.; Final approval of the version to be published, N. A, H. A, E. Sh, O. R, Gh.R. Sh, Z. T.; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved, N. A, H. A, E. Sh, O. R, Gh. R. Sh, Z. T.

Clinical Trial Registration Code: IRCT20170316033099N13

Conflict of Interests: The authors have no conflict of interests to declare.

Data Reproducibility: All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

Ethical Approval: Permission to conduct obtained with ethical code IR.BUMS.REC.1399.543 from the ethics committee of Birjand University of medical sciences (link: ethics.research.ac.ir/ProposalCertificate.php?id=187678).

Funding/Support: The present study was partially supported with Grant number 456293 by Birjand University of Medical Sciences Research Council.

Informed Consent: Informed consent was obtained from all participants in the study before sampling.

References

- Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol.* 2003;**31** Suppl 1:3-23. [PubMed ID: 15015736]. <https://doi.org/10.1046/j.2003.com122.x>.
- Jahangiry L, Bagheri R, Darabi F, Sarbakhsh P, Sistani MMN, Ponnet K. Oral health status and associated lifestyle behaviors in a sample of Iranian adults: an exploratory household survey. *BMC Oral Health.* 2020;**20**(1):82. [PubMed ID: 32192497]. [PubMed Central ID: PMC7082917]. <https://doi.org/10.1186/s12903-020-01072-z>.
- Chapple IL, Bouchard P, Cagetti MG, Campus G, Carra MC, Cocco F, et al. Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. *J Clin Periodontol.* 2017;**44** Suppl 18:S39–S51. [PubMed ID: 28266114]. <https://doi.org/10.1111/jcpe.12685>.
- World Health Organization. *Oral health.* Geneva, Switzerland: World Health Organization; 2018, [cited 21 Aug 2018]. Available from: https://www.who.int/health-topics/oral-health#tab=tab_1.
- Butten K, Johnson NW, Hall KK, Anderson J, Toombs M, King N, et al. Risk factors for oral health in young, urban, Aboriginal and Torres Strait Islander children. *Aust Dent J.* 2019;**64**(1):72–81. [PubMed ID: 30375649]. [PubMed Central ID: PMC6392135]. <https://doi.org/10.1111/adj.12662>.
- Razi MA, Qamar S, Singhal A, Mahajan A, Siddiqui S, Mohina Minz RS. Role of natural salivary defenses in the maintenance of healthy oral microbiota in children and adolescents. *J Family Med Prim Care.* 2020;**9**(3):1603–7. [PubMed ID: 32509658]. [PubMed Central ID: PMC7266239]. https://doi.org/10.4103/jfmpc.jfmpc_1134_19.
- Garcia SS, Blackledge MS, Michalek S, Su L, Ptacek T, Eipers P, et al. Targeting of *Streptococcus mutans* Biofilms by a Novel Small Molecule Prevents Dental Caries and Preserves the Oral Microbiome. *J Dent Res.* 2017;**96**(7):807–14. [PubMed ID: 28571487]. [PubMed Central ID: PMC5480807]. <https://doi.org/10.1177/0022034517698096>.
- Barnes VM, Richter R, DeVizio W. Comparison of the short-term antiplaque/antibacterial efficacy of two commercial dentifrices. *J Clin Dent.* 2010;**21**(4):101–4. [PubMed ID: 21269038].
- Rajendiran M, Trivedi HM, Chen D, Gajendrareddy P, Chen L. Recent Development of Active Ingredients in Mouthwashes and Toothpastes for Periodontal Diseases. *Molecules.* 2021;**26**(7). [PubMed ID: 33916013]. [PubMed Central ID: PMC8037529]. <https://doi.org/10.3390/molecules26072001>.
- Oranusi SU, Akhigbe E. Antimicrobial activity and Micro-flora quality evaluation of commonly used toothpastes. *Int J Biol Pharm Allied Sci.* 2013;**2**(7):1388–99.
- Nóbrega DF, Fernández CE, Del Bel Cury AA, Tenuta LM, Cury JA. Frequency of Fluoride Dentifrice Use and Caries Lesions Inhibition and Repair. *Caries Res.* 2016;**50**(2):133–40. [PubMed ID: 26992247]. <https://doi.org/10.1159/000444223>.
- Tadin A, Gavic L, Govic T, Galic N, Zorica Vladislavic N, Zeljezic D. In vivo evaluation of fluoride and sodium lauryl sulphate in toothpaste on buccal epithelial cells toxicity. *Acta Odontol Scand.* 2019;**77**(5):386–93. [PubMed ID: 30784350]. <https://doi.org/10.1080/00016357.2019.1577988>.
- Mohammadzadeh N, Mehri S, Hosseinzadeh H. Berberis vulgaris and its constituent berberine as antidotes and protective agents against natural or chemical toxicities. *Iran J Basic Med Sci.* 2017;**20**(5):538–51. [PubMed ID: 28656089]. [PubMed Central ID: PMC5478782]. <https://doi.org/10.22038/ijbms.2017.8678>.
- Lu Y, Bao T, Mo J, Ni J, Chen W. Research advances in bioactive components and health benefits of jujube (*Ziziphus jujuba* Mill.) fruit. *J Zhejiang Univ Sci B.* 2021;**22**(6):431–49. [PubMed ID: 34128368]. [PubMed Central ID: PMC8214949]. <https://doi.org/10.1631/jzus.B2000594>.
- Esfahanizadeh N, Mortezaee F, Sodeif F, Valaai N. [Comparison the effects of SILCA herbal and Crest7 Complete toothpastes on reduction of microbial plaque]. *J Res Dent Sci.* 2018;**15**(3):145–50. Persian. <https://doi.org/10.29252/jrds.15.3.4>.
- Esfahanian V, Mahabadi M, Soleimani M, Dehdarian A. [Association between keratinized tissue width and periodontal indices around implant supported fixed prosthesis]. *J Mashhad Dent Sch.* 2016;**40**(1):1–8. Persian.
- 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**(2):150–5. [PubMed ID: 28492194]. https://doi.org/10.4103/jisppd.jisppd_13_17.
- Prabakar J, John J, Arumugham IM, Kumar RP, Sakthi DS. Comparing the Effectiveness of Probiotic, Green Tea, and Chlorhexidine- and Fluoride-containing Dentifrices on Oral Microbial Flora: A Double-blind, Randomized Clinical Trial. *Contemp Clin Dent.* 2018;**9**(4):560–9. [PubMed ID: 31772463]. [PubMed Central ID: PMC6868625]. https://doi.org/10.4103/ccd.ccd_659_18.
- Pentapati KC, Kukkamalla MA, Siddiq H, Sabnis N. Effectiveness of novel herbal dentifrice in control of plaque, gingivitis, and halitosis - Randomized controlled trial. *J Tradit Complement Med.* 2020;**10**(6):565–9. [PubMed ID: 33134132]. [PubMed Central ID: PMC7588330]. <https://doi.org/10.1016/j.jtcm.2019.06.006>.
- Taghavi AM, Shabzendedar M, Parissay I, Makarem A, Orafaei H, Hosseinzadeh M. Effect of Berberine gel on periodontal inflammation: clinical and histological. *J Periodontol.* 2012;**4**(1):7–11.
- Makarem A, Asodeh NKR. Efficacy of barberry aqueous extracts dental gel on control of plaque and gingivitis. *Acta Medica Iranica.* 2007;**45**(2):91–4.

22. de Oliveira SM, Torres TC, Pereira SL, Mota OM, Carlos MX. Effect of a dentifrice containing Aloe vera on plaque and gingivitis control. A double-blind clinical study in humans. *J Appl Oral Sci.* 2008;**16**(4):293-6. [PubMed ID: 19089263]. [PubMed Central ID: PMC4327540]. <https://doi.org/10.1590/s1678-77572008000400012>.
23. Amoian B, Moghadamni AA, Mazandaran M, Amoian MM, Mehrmanesh S. The Effect of Calendula Extract Toothpaste on the Plaque Index and Bleeding in Gingivitis. *Res J Med Plant.* 2010;**4**(3):132-40. <https://doi.org/10.3923/rjmp.2010.132.140>.
24. Peng L, Kang S, Yin Z, Jia R, Song X, Li L, et al. Antibacterial activity and mechanism of berberine against *Streptococcus agalactiae*. *Int J Clin Exp Pathol.* 2015;**8**(5):5217-23. [PubMed ID: 26191220]. [PubMed Central ID: PMC4503092].
25. Boberek JM, Stach J, Good L. Genetic evidence for inhibition of bacterial division protein FtsZ by berberine. *PLoS One.* 2010;**5**(10):e13745. [PubMed ID: 21060782]. [PubMed Central ID: PMC2966414]. <https://doi.org/10.1371/journal.pone.0013745>.
26. Sun H, Ansari MF, Fang B, Zhou CH. Natural Berberine-Hybridized Benzimidazoles as Novel Unique Bactericides against *Staphylococcus aureus*. *J Agric Food Chem.* 2021;**69**(28):7831-40. [PubMed ID: 34228443]. <https://doi.org/10.1021/acs.jafc.1c02545>.
27. Dong S, Yang X, Zhao L, Zhang F, Hou Z, Xue P. Antibacterial activity and mechanism of action saponins from *Chenopodium quinoa* Willd. husks against foodborne pathogenic bacteria. *Ind Crops Prod.* 2020;**149**:112350. <https://doi.org/10.1016/j.indcrop.2020.112350>.
28. Patil S, Venkataraghavan K, Anantharaj A, Patil S. Comparison of two commercially available toothpastes on the salivary streptococcus mutans count in urban preschool children-an in vivo study. *Int Dent S Afr.* 2010;**12**(4).
29. Biria M, Rezvani Y, Roodgarian R, Rabbani A, Iranparvar P. Antibacterial effect of an herbal toothpaste containing Bamboo salt: a randomized double-blinded controlled clinical trial. *BMC Oral Health.* 2022;**22**(1):193. [PubMed ID: 35590307]. [PubMed Central ID: PMC9121567]. <https://doi.org/10.1186/s12903-022-02224-z>.
30. Mehta S, Pesapathy S, Joseph M, Tiwari PK, Chawla S. Comparative evaluation of a herbal mouthwash (Freshol) with chlorhexidine on plaque accumulation, gingival inflammation, and salivary *Streptococcus mutans* growth. *J Int Soc Prev Community Dent.* 2013;**3**(1):25-8. [PubMed ID: 24478976]. [PubMed Central ID: PMC3894093]. <https://doi.org/10.4103/2231-0762.115717>.
31. Ferrazzano GF, Roberto L, Amato I, Cantile T, Sangianantoni G, Ingenito A. Antimicrobial properties of green tea extract against cariogenic microflora: an in vivo study. *J Med Food.* 2011;**14**(9):907-11. [PubMed ID: 21612452]. <https://doi.org/10.1089/jmf.2010.0196>.