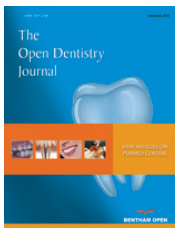

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RESEARCH ARTICLE

Effect on Dental Stains by Potassium Tripolyphosphate Added Chewing Gum

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Abstract:

Background:

Today, people worldwide consider the discoloration of teeth the main concern, therefore, dental stains are an important problem for a lot of patients, especially for smokers, and tea and coffee consumers.

Objective:

This trial was planned to evaluate the effectiveness of a sugar-free chewing gum added with potassium tripolyphosphate, compared to a placebo chewing gum on the development or the removal of dental extrinsic stains preserving regular daily oral hygiene.

Methods:

This was a single-center, double-blind, randomized, 6-week parallel controlled clinical trial. Among those who were eligible for the trial, 162 adult participants were randomly allocated into two groups of 81 each and were instructed to maintain customary oral hygiene. All subjects started the trial period after an in-office dental visit to set the stain index baseline. They chewed one of the two chewing gums for six weeks, five pieces per day, preferably after meals and snacks, for 10 minutes. Both chewing gums were sugar-free, 2g of weight with the same size and shape. The test chewing gum contained potassium tripolyphosphate (24.4 mg per piece), the control chewing gum was identical without potassium tripolyphosphate, therefore, it did not contain any anti-stain agent. The dental extrinsic stain was measured at the first visit and at the end of six weeks by the Modified Lobene Stain Index (MLSI). Comparisons between the groups were performed using ANOVA after adjustment of the baselines, and comparisons between initial and final indexes inside the groups were performed using paired t-tests.

Results:

After the 6 weeks, 154 subjects completed the trial, 77 in each group. The mean difference in stain composite index for all sites after six weeks was 0.04±0.07 in the control group and -0.03±0.07 in the test group. This difference was statistically significant after baseline adjustment ($p<0.001$). Moreover, the differences in stain indexes for both buccal or lingual-palatal sites showed a statistically significant difference ($p<0.001$) for those using the test chewing gum versus the control chewing gum.

Conclusion:

The overall findings of this clinical study suggest that the use of chewing gum containing potassium tripolyphosphate can reduce dental stains versus placebo chewing gum on frontal teeth after six weeks of maintaining regular oral hygiene with normal tooth brushing.

Keywords: Dental stains, Chewing gum, Tooth brushing, Smokers, Drugs, Tripolyphosphate.

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1. INTRODUCTION

Today, most people worldwide consider the yellowish or brownish discoloration of teeth due to intrinsic and extrinsic stains, which is a prime concern. The formation and accumulation of dental stains and later dental calculus is an important problem for many patients, especially smokers and habitual tea and coffee consumers. Stained teeth are unpleasant, both for the cosmetic appearance and socially, as a sign of poor oral hygiene. The deposition of exogenous pigments from colored food such as coffee, red wine, drinks, and smoke and certain drugs into the dental pellicles, corresponds to the formation of the extrinsic dental stain [1]. Therefore, this process is linked to the ingestion of chromogenic foods and beverages; moreover, the use of tobacco and exposure to cationic substances such as

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chlorhexidine can further enhance the deposition of food-derived stains [1]. That unpleasant discoloration can be reduced by good oral hygiene and by dentifrices containing stain-removing agents. Studies of chemical agents to reduce dental stains were focused on chelants, surfactants, and enzymes [2, 3]. Researchers tested various ingredients that could assist in the stain removal process, but almost all of them were not indicated as an addition to foods due to their toxicity. Pyrophosphate and polyphosphates are safe and approved additives for chewing gum, therefore, in the past years, clinical studies examined their efficacy in reducing the occurrence of calculus and stain development [4 - 8]. This activity is achieved through desorbing portions of adsorbed proteins, including those containing trapped stain components, resulting in an overall effect on the tooth surface pellicle, which favors the reduction of stain deposits, thus enhancing whitening [9 - 12]. Chewing gum is a well-accepted, enjoyable, and frequent activity in both adults and children, and, therefore, could be a useful means for local drug administration into the oral cavity [13]. Moreover, recent papers suggested, among the oral health benefits of chewing gum, the removal of food debris and tooth surface stains [14]. Past clinical trials reported a statistically significant efficacy in preventing chlorhexidine-associated stains in a six-week clinical study with sugar-free chewing gum versus no gum control [15]. Other researchers confirmed these results but showed a higher reduction with polyphosphate added chewing gum and a statistically significant difference between that gum and a placebo sugar-free chewing gum in a forced stain model [16]. Porciani *et al*. studied the efficacy of sugar-free chewing gum containing sodium tripolyphosphate (1%) on dental stain occurrence versus placebo sugar-free chewing gum for six weeks and found that STP-added chewing gum was more effective in preventing and reducing dental stains compared to a sugar-free placebo even without a stain promoting agent like chlorhexidine [17]. It is to be noted that in this study and all previously cited ones, polyphosphates were employed as sodium salts. However, even chewing gums without active ingredients were found to decrease natural stains compared to baseline or no-gum control [18, 19]. Milleman *et al*., in a recent cross-over study, reported a significant reduction in dental stain accumulation for plain sugar-free chewing gum in a 12-week trial versus a control group without any chewing gum, together with once-daily oral hygiene with a soft toothbrush in a population selected for stain forming habits [20]. ADA suggested planning six weeks or longer trials with a validated stain index, such as Lobene, to assess the ability of a product to reduce dental stain. WHO advised that recent data on sodium intake show that populations around the world are consuming much more sodium than is physiologically necessary, with a potential health risk. In food, potassium may substitute sodium, therefore, in this study, the chewing gum was added with potassium tripolyphosphate. This controlled clinical double-blinded study was designed and conducted to evaluate the efficacy of sugar-free chewing gum added with tripolyphosphate, which is employed for the first time as a salt of potassium, versus a control chewing gum in preventing dental stain accumulation in six weeks, preserving customary daily oral hygiene with dentifrice and regular tooth brushing in a sample of the adult population with normal eating habits. The Null Hypothesis tested is that there are no significant differences between the chewing gum added with potassium tripolyphosphate and the control chewing gum after six weeks.

2. MATERIALS AND METHODS

This controlled clinical study was a single-site, randomized, double-blind, 6-week, parallel design evaluating the reduction in an extrinsic dental stain on the anterior teeth with one chewing gum added with potassium tripolyphosphate compared to one control chewing gum without any proven antistain agents with daily oral hygiene with dentifrice and regular tooth brushing.

2.1. Participants

All potential participants in this study were questioned about their medical/dental history and required to read carefully and sign an informed consent reporting the proceedings of the trial, the technical sheet of chewing gum administrated, which was made with food-grade ingredients and additives, and their acceptance to be visited and to share their data for the objective of the trial. They were also advised to maintain their habits regarding smoking, tea, and coffee use, and their habitual oral hygiene with regular tooth brushing and to use only the dentifrice they received, which was devoid of any known whitening agent (Elmex®, Gaba, Colgate Palmolive, PL-58-100 Świdnica) and to avoid professional dental cleaning and any procedure or active agent marketed as whitening. After, they were screened to determine if they entered the inclusion criteria. Participants were required to be at least 18 years old, be in good general health based on medical and dental history, have all anterior teeth with scoreable buccal and lingual surfaces, have no partial dentures or orthodontic appliances, read, and sign the Informed Consent and other necessary paperwork before initiation of the study procedures. Moreover, they did not present advanced periodontal disease, five or more grossly decayed, untreated dental sites (cavities), pathologic lesions of the oral cavity (suspicious or confirmed), diagnosis of xerostomia or impaired/decreased salivary function (female) or a medical history indicating that the subject is pregnant or currently breastfeeding, a history of a true allergy or intolerance to gum ingredients, including (but not limited to) soy, phenylalanine, low-calorie artificial sweeteners, artificial colors or flavors, mint, peppermint, spearmint, milk proteins, or other ingredients, a serious medical illness or disorder, *e.g.*, immune-compromised, AIDS, *etc*., that would be unduly affected by participation in this study, a history of the temporomandibular joint disorder (TMJ). All participants were instructed to promptly report any adverse effects to their examiner. At the first visit, their habits of smoking and habitual consumption of coffee or tea were screened and recorded. Participants who reported smoking more than 5 cigarettes per day were classified as smokers, and those who drank two or more cups of coffee or one or more cups of tea per day were signed as habitual consumers of coffee and tea, respectively. Subjects were randomly assigned to test or control groups with a random table considering an equity distribution of subgroups generated by the statistical department of the University of Siena.

2.2. Chewing Gums

The test chewing gum contained potassium tripolyphosphate, equal to 24.4 mg per piece, and the control chewing gum was identical in taste, shape, weight (2g each piece), color, and packaging but without this ingredient. All chewing gums investigated were sugar-free, and they were provided by the manufacturer (Perfetti Van Melle S.p.A., Lainate, MI, Italy).

2.3. Protocol

After the enrollment procedure, all subjects were examined for oral tissue health and scored by a single independent experienced examiner for baseline dental extrinsic stains by the Modified Lobene Stain Index (MLSI) for the anterior teeth [21]. Then, each participant joined randomly the chewing gum group or the control chewing gum group. Subjects of both groups agreed to chew one chewing gum five times a day, preferably after meals or snacks, for ten minutes over six weeks. All groups received the chewing gums assigned and a supply of a commercial dentifrice with no whitening agents (Elmex®, Gaba, Colgate-Palmolive, PL-58-100 Świdnica) containing ammonium fluoride (1400ppm F) as the only active ingredient for caries prevention and were instructed to maintain their regular oral hygiene with normal tooth brushing. Subjects were provided with written treatment instructions on the procedure and compliance, and they were blinded and instructed not to discuss their treatment products with any clinical personnel to maintain examiner blindness, too. After using the chewing gums for 6 weeks (±3 days), they were again examined for oral health and assessed for extrinsic stain by the same examiner who evaluated the MLSI index again. Participants were required to get back the empty packages of chewing gum and dentifrices to control their administration by the operator. Subjects who did not meet the compliance request of 95% of chewing gum assumed and 67% of dentifrice consumed were excluded. Measurements were obtained for each tooth and the composite index was calculated as the product of the extent and intensity scores. The mean for each subject was calculated from all frontal teeth (six upper and six lower), each divided into two surfaces (buccal and palatal/lingual). Data were scored and recorded by the same blinded operator for all measurements. To help the operator to be more accurate in index evaluation, he examined by eye each subject and he took a set of digital pictures of all examined teeth.

2.3.1. Oral Soft and Hard Tissue Health

To assess trial safety, a visual and tactile inspection of the oral soft and hard tissues was performed at each examination in all subjects. Oral hard tissue examinations were performed with a dental mirror to examine teeth and bony structures. Oral soft tissue examination was performed by examining each subject's mouth and pharynx, including lips, tongue, floor of the mouth, palate, gingiva, alveolar, and buccal mucosa, oropharynx, tonsils, uvula, and salivary glands using palpation techniques and visualization. Extraoral examination of the head and neck regions has also been done by visualization and bimanual palpation. Any abnormalities were recorded, assessed for severity, and a judgment was made for those absent at baseline as to whether they were potentially attributable to the test products and they may constitute a reason for exclusion or dismissal from the study.

2.4. Evaluation Procedure

Before scoring, the patient cleaned his teeth with a soft toothbrush and water to remove any plaque and food debris. Then, the anterior teeth were dried using a chair-side air syringe and kept dry throughout the examination. Stain assessment was made with the aid of a magnifying glass and digital images. The same blinded examiner evaluated clinically all subjects, checked the digital images taken at both visits, and scored the indexes.

2.5. Statistical Analysis

The raw data were analyzed by an independent statistical consultant blinded to the objective of the trial. Clinical stain scores were summed and averaged to provide mean per-subject scores at each clinical exam. The parameter analyzed in this study was the stain product calculated from the site products of the area and intensity scores (composite index). Subject whole mouth scores were evaluated by taking the mean score overall sites measured in the mouth. Additionally, subject mean scores were also calculated for the buccal and lingual subsets of the mouth. All data were statistically analyzed with SPSS software SPSS (IBM, Armonk, NY, USA) for descriptive tests (average and standard deviation) and comparisons between groups and intragroup (paired t-test). The composite indexes of buccal, lingual-palatal, and total surfaces were analyzed and compared between the test and the control group using ANOVA after the baseline adjustment. All statistical tests of the hypothesis were performed with α=0.05 level of significance.

2.6. Power and Sample Size

In the literature, we found only one previous trial with similar chewing gum and protocol [17]. Researchers globally enrolled 108 subjects divided into two groups. Based on the statistical data published in the results of that study and setting the power to 0.9 with α=0.05, it was calculated a minimum sample size of 148 participants to allocate in two groups of 74 each. Following the drop-out rate of previous studies of about 5%, the minimum number of subjects to enroll was 156.

2.7. Ethical Issue

The study was conducted following ethical principles that have their origin in the Declaration of Helsinki and approximate Good Clinical Practice guidelines [22]. The chewing gums used in the trial were without chemical active agents and made with food-grade ingredients and additives; therefore, they were considered a common aliment and they were administrated in a common dosage. The dentifrice used in the trial is available on the counter and participants were requested to maintain their regular oral hygiene procedures. The protocol of this study could reflect the normal conduct of everyday life. This trial was approved by Ethical Committee US Investigational Review Board Inc. with the IRB number U.S IRB2021PVM/01. This trial was conducted according to the local guidelines for COVID prevention.

3. RESULTS

180 subjects were enrolled and signed the informed consent, but 10 made a no-show at the screening and 8 were excluded at this stage from the trial. Therefore, this trial was joined by 162 subjects, and it was completed by 154, 77 in each group (mean age 34.86±11.32; 66 males and 88 females) who met the minimum compliance requested (95% of the chewing gum used and 67% of the dentifrice) therefore we incurred in 4.9% of drop-out. In the control group, they were 35.1±11.32 years old (32 males and 45 females), and in the test group, 34.62±10.79 years old (34 males and 43 females). Participants not completing the study were lost to follow-up for no-show dental treatment, or incorrect procedures, thus, no adverse effects related to chewing gums were reported or screened at oral visits. Among those who completed the trial, 64 were smokers (33 in the test group and 31 in the control group), 126 coffee consumers (64 in the test group and 62 in the control group), and 56 tea consumers (29 in the test group and 27 in the control group), therefore habits correlated to stain buildup were balanced among groups (Table **1**). The MLSI composite score (stain extension multiplied by intensity) for all sites showed a statistically significant reduction of 2.76% ($p<0.005$) in the chewing gum group, instead, it showed a statistically significant increase of 4.16% ($p<0.001$) in control chewing gum group. At baseline, before adjustment, the buccal stain composite MLSI index was in the test group 0.33±0.4 and the control group 0.29±0.32, and the lingual-palatal index was 1.68±0.94 and 1.73±0.94, respectively, and the all-sites index was 1.01±0.6 and 1.01±0.57, respectively. After 6 weeks, the buccal stain composite MLSI index was in the test group 0.32±0.4 and the control group 0.31±0.34, the lingual-palatal index was 1.63±0.94 and 1.79±0.94 respectively and the all-sites index was 0.98±0.6 and 1.05±0.57 respectively. No statistical difference was found at baseline between the test and control group for all indexes examined (for all sites, the p was 0.97). The differences from baseline in average MLSI composite scores for the buccal, lingual-palatal, and all sites of the anterior teeth after 6 weeks of the trial were summarized in Table **2**. The mean differences between test and control chewing gum for stain composite index in all sites after six weeks and the differences for buccal or lingual palatal sites were statistically significant after baseline adjustment ($p<0.001$). The same findings and levels of significance were found for the subgroup of nonsmokers as suggested by ADA guidelines. During this trial, there were no observed or reported adverse events that were attributable to the test products or procedures.

4. DISCUSSION

The results showed that the chewing gum significantly reduced the dental stain on the anterior teeth versus the control chewing gum, allowing some dental stains to accumulate. Analysis of the tooth surfaces showed that the chewing gum was remarkably effective on the more visible buccal surfaces of the front teeth. In the design of the present study, no attempt to change the oral hygiene habits of the volunteers was implemented, while a dentifrice devoid of any whitening agent was distributed to prevent any confounding effect on extrinsic stains due to it. Subject compliance and appropriate usage of the products were monitored in this study, and it was reported as excellent during the 6-week trial period. Subjects were very receptive to the organoleptic properties of the chewing gums, and they did not express any objections to using the product, thus, comparisons between treatments for the clinical parameters were not influenced by compliance issues. In previous studies, it was reported that all kinds of chewing gums could have a light mechanical removal action of food debris even without any anti-stain agent [23]. Anti-stain and anticalculus effects of pyrophosphates and polyphosphates administered as sodium salts were described in many past published studies. In 1996, White DJ *et al*. showed the clinical benefits of pyrophosphate on reductions in cosmetically objectionable supragingival calculus [24]. Researchers generally agreed about the effect of Calcium Phosphate Surface Active Binders like pyrophosphates in reducing dental stain formation, however, they reported different results in efficacy for various dosages, time of observation, agents, or different vehicles of administration [17, 24 - 27]. In the literature, there are a few studies on the administration of Calcium Phosphate Surface Active Binders by chewing gum with different formulations and regimens, therefore there is no information about saliva levels of phosphates after chewing a gum containing them and their preferable and acceptable concentration to be used. In a similar published trial with one chewing gum added with sodium tripolyphosphate versus one control chewing gum for six weeks, the authors reported that the mean reduction in stain index in the test group was 0.05 instead of the control group was observed with an increment of 0.09 and this difference of effect between the two groups was significant ($p<0.001$) [17]. Moreover, inside the groups, this trial showed a statistically significant reduction by 6% in the stain for the test group ($p<0.05$) and a statistically significant increment by 10% for the control group ($p<0.01$) [17]. These results reported with chewing gum containing sodium tripolyphosphate (20mg per piece), which was administered with two gums together three times per day, are like those presented in this trial, where subjects chewed one gum containing potassium tripolyphosphate (24.4 mg per piece) five times per day. Noticeably, the net amount of tripolyphosphate anion moiety per piece is the same (13.8 mg/piece) in the current and previous trials, while the net amount of sodium and potassium salt per piece is different to stoichiometrically accommodate the different atomic weights of sodium and potassium ions [17]. Therefore, they suggest that sugar-free chewing gum added with potassium or sodium tripolyphosphate can prevent dental stain accumulation and reduce it over six weeks, following the recommendations of the WHO to reduce sodium daily intake.

Table 1. Demographic distribution between groups.

Group	Subjects	Age	Sex	Smokers	Tea Consumers	Coffee Consumers
Test	77	34.6±10.8	F = 43 M = 34	33	29	64
Control	77	35.1±11.3	F = 45 M = 32	31	27	62

Table 2. MLSI differences in composite indexes in test and control groups after 6 weeks from baseline.

Chewing Gum	Buccal Sites	Lingual-Palatal Sites	All Sites
Test	-0.01±0.04	-0.05±0.13	-0.03±0.07
Control	0.02±0.06	0.06±0.10	0.04±0.07

Data before baseline adjustment expressed in mean ± SD.

CONCLUSION

In this trial, the sugar-free chewing gum added with potassium tripolyphosphate was found to decrease the extrinsic dental stains on the anterior teeth of subjects who chewed this gum over 6 weeks, and this reduction in extrinsic dental stain was statistically significant compared to the control chewing gum ($p<0.001$) for all dental sites examined. Further studies are suggested to confirm this observation, especially over a longer time.

LIST OF ABBREVIATIONS

MLSI = Modified Lobene Stain Index

TMJ = Temporomandibular Joint Disorder

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This trial was approved by Ethical Committee US Investigational Review Board Inc. with the IRB number U.S IRB2021PVM/01. This trial was conducted according to the local guidelines for COVID prevention.

HUMAN AND ANIMAL RIGHTS

The study was conducted following ethical principles that have their origin in the Declaration of Helsinki and approximate Good Clinical Practice guidelines.

CONSENT FOR PUBLICATION

All potential participants in this study were questioned about their medical/dental history and required to read carefully and sign an informed consent reporting the proceedings of the trial.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

This work was funded by Perfetti Van Melle S.p.A.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

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