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Research Paper: Effects of three different whitening mouth rinses on the color recovery of stained teeth

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ABSTRACT

Introduction: Tooth color is an important factor in smile esthetics. The present study aimed to evaluate the efficacy of three different whitening mouth rinses on color recovery of teeth with surface staining.

Materials and Methods: Thirty-two bovine incisors were used in this invitro study. First, the teeth were stained by being immersed in a tea solution for 14 days and then randomly assigned to four groups based on the type of mouth rinse used (n=8): C: control (distilled water); ZSW: Zenon Smart White (containing pyrophosphate and triphosphate); PCW: Pasta del Capitano Whitening (containing Plasdone); SWN: Signal White Now (containing Blue Covarine). Colorimetry was carried out using a spectrophotometer at baseline, after staining, and 2, 4, 8, and 12 weeks after immersion in mouth rinses. The data were analyzed with CIELab parameters and ANOVA, repeated measures ANOVA, and Tukey tests (α=0.05).

Results: The mouth rinses decreased tooth staining. The mouth rinses resulted in significant color changes compared to the controls (Ppcw=0.028 and Pzsw=0.002), except for the SWN mouth rinse. The color recovery of the teeth by ZSW mouth rinse, compared to the baseline, was in the clinically acceptable range ($\Delta E<3.3$), and the difference from the control group was borderline (P=0.05).

Conclusion: A relative recovery of tooth colors was only achieved using the ZSW mouth rinse, which contains pyrophosphate and triphosphate compounds.

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Introduction

Currently, there is an ever-increasing demand for sound teeth and an esthetic smile. The color and esthetic appearance of teeth are highly important for patients. Tooth staining is due to external pigments that affect the external surfaces of teeth or might penetrate the teeth. Food stains, tobacco, and some mouth rinses are the etiologic agents responsible for color changes in teeth (1).

Professional prophylactic procedures remove the available stains from tooth surfaces; however, if the pigments are out of reach, tooth bleaching techniques might be useful. Tooth bleaching in modern dentistry is a common, reliable, simple, and non-invasive technique compared to other treatments, such as veneers and crowns (2).

Vital tooth bleaching might be implemented at home (at-home technique) under the supervision of a dentist or carried out in the office (in-office technique) by the dentist. The procedure is implemented chemically by the chemical interactions of bleaching agents, mainly hydrogen peroxide, with the tooth structure (3). In addition, patients can bleach their teeth with the products they buy, which are available as over-the-counter (OTC) products. OTC products are low-cost alternatives for bleaching teeth without a dentist's supervision. Different OTC products are available in supermarkets, pharmacies, and websites. They usually contain low concentrations of bleaching agents applied on tooth surfaces. Toothpastes, mouth rinses, bleaching strips, dental flosses, and paint-on brushes are some OTC products (4).

Mouth rinses sold in stores based on bleaching claims might contain different kinds of active gents, including hydrogen peroxide, hexametaphosphate, tripolyphosphate, pyrophosphate, and recently Plasdone. In addition, the use of the blue light technology (Blue Covarine) with a color change from yellow to blue, is another claim for bleaching by some mouth rinses (4).

A few studies are available on the efficacy of whitening mouth rinses, with contradictory results concerning decreasing or removing stains from tooth surfaces (5-9). Although the efficacy of some of these mouth rinses has been shown in some studies (10), but Rodrigues et al. reported that color changes induced by whitening mouth rinses are similar to conventional mouth rinses, and most of them cannot bleach teeth (3). These contradictions might be attributed to the diversities in the composition of these materials and their method of application. One important consideration in the efficacy of these products is the nature of their active agent and the duration of contact with the tooth compared to the professional bleaching technique (11). Unlike professional bleaching techniques, no proper guide is available for prescribing these products.

Therefore, studies are necessary to evaluate and compare the efficacy of these diverse products. As a result, the present study was undertaken to compare the efficacy of three whitening mouth rinses that are available on the market concerning their effect on the color recovery of tooth enamel with surface stains.

Materials and Methods

The protocol of the present study was approved by the Research Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1401.184).

Thirty-two extracted bovine incisors were used in the present in vitro study. A scaler was used to remove all the soft tissues from the tooth surfaces, and the teeth were cleaned with pumice and a rubber cup. Teeth with stains, cracks, or fractures were excluded. The tooth samples were stored in 0.5% chloramine solution for one week, followed by storage in distilled water at 4ºC in a refrigerator until being tested. First, the samples were immersed in a solution of black tea at 37ºC for 14 days. The solution was prepared by adding 3.5 gr of black tea (Golestan, Iran) to 100 mL of boiling distilled water for 10 minutes. At the end of the period, each sample was rinsed with distilled water for 60 seconds (12).

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The whitening process

The teeth were randomly assigned to four groups (n=8) for the whitening process based on the whitening mouth rinse used:

1) Control (immersion in distilled water) (C)

2) Zenon Smart White mouth rinse (containing phosphate compounds) (ZSW)

3) Pasta del Capitano Whitening mouth rinse (containing Plasdone) (PCW)

4) Signal White NOW mouth rinse (containing blue Covarine) (SWN)

Table 1 presents the composition of mouth rinses used in the present study. The tooth samples were numbered within the study groups so that the changes for each tooth could be compared at different time intervals. The control group samples were stored in distilled water at room temperature. In groups 2 to 4, the samples were immersed in the relevant mouth rinses twice daily, 30 seconds each time (based on the manufacturer's instruction) for 12 weeks, and then rinsed with distilled water for 10 seconds. The samples in each group were stored in distilled water at room temperature after the whitening procedures every day. The distilled water was changed every day (11).

Table 1. The composition of the mouth rinse tested

Mouthrinse	Manufacturer	Composition
Zenon Smatrt-White	Silanesabz Company, Karaj, Iran	Ethanol(10%), Glycerin, Pentasodium Triphosphate, Potassium Citrate, Tetrasodium Pyrophosphate, Cocamidopropyl Betain, Sodium Lauryl Sulfate, Benzoic acid, Cetylpyridinium Chloride, Sodium Benzoate, Fragrance, Sodium Fluoride(1000ppm), Menthol, Color, Water
Pasta del Capitano (Whitening)	Ciccarelli Company,Via Clemente Prodenzio, 20138 Milano MI, Italy	Aqua, Glycerin, Alcohol Denat, Polysorbate 20, PVP, PEG-40 Hydrogenated Castor Oil, Betaine, Sodium Benzoate, Aroma, Lactic Acid, Sodium Lactate, Sodium Bicarbonate, Sodium Fluoride, 2-Bromo-2-Nitropropane-1,3-Diol, Sodium Monofluorophosphate, Sodium Saccharin, Eugenol, Limonene, Zinc Coco-Sulfate, Geraniol, Cl 47005, Cl 42051
Signal White Now	Unilever Company, Rueil-Malmaison, France	Aqua, Hydrogenated Starch Hydrolysate, PEG-40 Hydrogenated Castor Oil, PVM/MA Copolymer, Sodium Lauryl Sulfate, Aroma, Benzyl Alcohol, Phenoxyethanol, Trisodium Phosphate, Sodium Saccharin, Sodium Fluoride, Lecithin, Glycerin, Sodium Laureth Sulfate, Limonene, Cl 74160

Colorimetry

For the colorimetry procedure, first, the samples were dried with absorbent paper. Then a trained operator performed the procedure on a white background in the same environment using a spectrophotometer (VITA Easy shade, Vita Zahnfabrik, Germany).

The procedure was carried out one day after the last round of immersion in the mouth rinse at that time interval (11). Before each procedure, the spectrophotometer was calibrated using its special screen according to the manufacturer's instructions. In each tooth, the spectrophotometer's tip was placed at a specific distance from the incisal edge at the center of the tooth.

This location was the same during several measurement procedures. The colorimetry procedures were carried out at baseline (T0), after staining (TS), and two weeks (T2W), four weeks (T4W), eight weeks (T8W), and twelve weeks (T12W) after using the whitening mouth rinse.

Colorimetry was carried out based on the three-parameter model of CIELab, consisting of the parameters L, a, and b. The L parameter has a range of 0–100 and indicates the degree of brightness, with 0 indicating completely dark and 100 indicating completely white. The parameter a indicates the color variation between green (-a) and red (+a), and parameter b indicates the color variation between blue (-b) and yellow (+b). At each time interval, Δ was calculated for each parameter to reveal color changes. ΔE for the overall color change of each sample was calculated using the following formula (13):

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

Data analysis

The means and standard deviations of parameters L, a, b, and ΔE were used to describe tooth colors. After analyzing the normal distribution of data with the Shapiro-Wilk test and the homogeneity of variables with Levene's test, ANOVA was used to compare color changes in terms of the mouth rinses. In addition, repeated measures two-way ANOVA was used to compare color changes between colorimetry intervals. A partial Eta square was used to determine the effect of mouth rinses over time: A partial Eta value >0.13 was considered a significant effect. Tukey test was used for the two-by-two comparisons of the group concerning ΔE. SPSS 26 was used for all the statistical analyses. Statistical significance was set at P<0.05.

Results

Table 2 presents L, a, b, and ΔE value changes in all the groups after immersion in the tea solution compared to the baseline. Immersion in tea resulted in staining in all the groups, with a decrease in the L parameter and increases in the a and b parameters. The differences between the groups were not significant (P>0.05).

Table 2. Means and standard deviations of tooth enamel color changes after immersion in the tea solution

	Δa					Δb				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
Ts -T0	1.19 ±1.00	1.64 ±1.32	1.28 ±0.66	1.25 ±0.94	0.807	4.30 ±1.87	6.38 ±2.93	6.54 ±2.35	6.68 ±2.08	0.163

	ΔL					ΔE				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
Ts -T0	-3.44 ±1.10	-2.85 ±2.29	-3.60 ±2.41	-3.13 ±1.58	0.867	5.78 ±1.96	7.49 ±3.20	7.74 ±2.98	7.58 ±2.43	0.437

T0 = baseline

Ts = after staining

P = P value

The mouth rinses led to distinct ΔE (ΔE>3.3), with an increase in the L parameter and decreases in the a and b parameters at all the time intervals after staining, indicating decreased tooth darkness. However, ΔE in the control group was slight and was associated with increased L (darkness).

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Changes in the parameters and tooth colors were perceptible only in the ZSW group over time (P<0.05), and this mouth rinse had the highest effect on ΔE at all the intervals in stained teeth (PEta S=0.462) (Table 3).

Table 3. Means and standard deviations of tooth enamel color changes after using mouth rinses compared to the time after staining

	Δa					Δb				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
T2w -Ts	-0.28 ±0.47	-1.02 ±0.69	-0.79 ±0.55	-0.54 ±0.32	0.047	-1.30 ±1.66	-4.64 ±3.19	-5.44 ±2.25	-4.37 ±1.73	0.007
T4w -Ts	-0.56 ±0.80	-1.01 ±0.82	-0.86 ±0.54	-0.65 ±0.54	0.560	-1.59 ±1.66	-2.31 ±1.56	-3.54 ±2.20	-3.91 ±2.24	0.082
T8w -Ts	-0.50 ±0.45	-1.00 ±0.36	-1.14 ±0.56	-1.00 ±0.67	0.098	-2.00 ±1.33	-3.76 ±3.21	-3.97 ±1.82	-3.87 ±2.00	0.247
T8w -Ts	-0.46 ±0.41	-1.04 ±0.46	-1.34 ±0.52	-0.87 ±0.32	0.004	-1.45 ±1.39	-2.45 ±1.63	-4.84 ±1.73	-3.21 ±2.22	0.005
Ptime	0.206	0.980	<0.001	0.136		0.404	0.148	0.028	0.317	
Eta S	0.212	0.001	0.721	0.227		0.127	0.260	0.371	0.148	
	ΔL					ΔE				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
T2w -Ts	-1.25 ±1.23	0.89 ±0.76	2.09 ±1.43	2.04 ±1.47	0.001	2.33 ±1.45	5.05 ±2.97	6.03 ±2.31	4.99 ±1.93	0.016
T4w -Ts	-1.23 ±0.94	0.88 ±0.99	2.65 ±1.69	1.93 ±2.16	0.001	2.49 ±1.47	2.94 ±1.55	4.59 ±2.66	4.54 ±2.93	0.158
T8w -Ts	-0.61 ±0.65	1.59 ±1.50	3.93 ±1.69	3.68 ±1.64	0.001	2.36 ±1.15	4.78 ±2.60	5.88 ±2.04	5.55 ±2.37	0.010
T8w -Ts	-0.78 ±0.44	2.76 ±3.79	4.35 ±1.57	2.80 ±1.43	0.001	1.84 ±1.33	4.52 ±3.26	6.87 ±1.47	4.61 ±2.10	0.001
Ptime	0.252	0.217	0.001	0.009		0.392	0.250	0.004	0.449	
Eta S	0.140	0.187	0.709	0.416		0.130	0.174	0.462	0.116	

Tw = after mouthwash treatment

Ts = after staining

P<0.05 : significant difference

P = P value

Eta S = Patial Eta Square

The final ΔE under the effects of ZSW and PCW mouth rinses was significant compared to the control group (P=0.002 and P=0.028, respectively);

however, other two-by-two comparisons did not reveal any significant differences (P>0.05) (Table 4).

Table 4. Comparison of ΔE in the study groups after using mouth rinse compared to the time after staining

Groups	C	ZSW	SWN	PCW
C	-	0.002	0.120	0.028
ZSW	-	-	0.343	0.736
SWN	-	-	-	0.906

P<0.05 : significant difference

Table 5 presents the color recovery values of the teeth compared to the baseline. Based on the ΔE values at the end of treatment, only in the ZSW group ΔE was >3.3 (ΔE=3.09), with an increased L value. The effect of this mouth rinse on color recovery over time was higher than the other mouth rinses (PEta S=0.711).

Two-by-two comparisons of color recovery between the groups showed that only the ZSW mouth rinse group had a borderline difference from the control group (P=0.05), while the other comparisons did not reveal significant differences (Table 6).

Table 5. Means and standard deviations of the recovery of tooth enamel color after using the mouth rinses compared to the baseline

	Δa					Δb				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
T2w -Ts	-0.28 ±0.47	-1.02 ±0.69	-0.79 ±0.55	-0.54 ±0.32	0.047	-1.30 ±1.66	-4.64 ±3.19	-5.44 ±2.25	-4.37 ±1.73	0.007
T4w -Ts	-0.56 ±0.80	-1.01 ±0.82	-0.86 ±0.54	-0.65 ±0.54	0.560	-1.59 ±1.66	-2.31 ±1.56	-3.54 ±2.20	-3.91 ±2.24	0.082
T8w -Ts	-0.50 ±0.45	-1.00 ±0.36	-1.14 ±0.56	-1.00 ±0.67	0.098	-2.00 ±1.33	-3.76 ±3.21	-3.97 ±1.82	-3.87 ±2.00	0.247
T8w -Ts	-0.46 ±0.41	-1.04 ±0.46	-1.34 ±0.52	-0.87 ±0.32	0.004	-1.45 ±1.39	-2.45 ±1.63	-4.84 ±1.73	-3.21 ±2.22	0.005
Ptime	0.206	0.980	<0.001	0.136		0.404	0.148	0.028	0.317	
Eta S	0.212	0.001	0.721	0.227		0.127	0.260	0.371	0.148	

	ΔL					ΔE				
Groups	C	SWN	ZSW	PCW	P	C	SWN	ZSW	PCW	P
T2w -Ts	-1.25 ±1.23	0.89 ±0.76	2.09 ±1.43	2.04 ±1.47	0.001	2.33 ±1.45	5.05 ±2.97	6.03 ±2.31	4.99 ±1.93	0.016
T4w -Ts	-1.23 ±0.94	0.88 ±0.99	2.65 ±1.69	1.93 ±2.16	0.001	2.49 ±1.47	2.94 ±1.55	4.59 ±2.66	4.54 ±2.93	0.158
T8w -Ts	-0.61 ±0.65	1.59 ±1.50	3.93 ±1.69	3.68 ±1.64	0.001	2.36 ±1.15	4.78 ±2.60	5.88 ±2.04	5.55 ±2.37	0.010
T8w -Ts	-0.78 ±0.44	2.76 ±3.79	4.35 ±1.57	2.80 ±1.43	0.001	1.84 ±1.33	4.52 ±3.26	6.87 ±1.47	4.61 ±2.10	0.001
Ptime	0.252	0.217	0.001	0.009		0.392	0.250	0.004	0.449	
Eta S	0.140	0.187	0.709	0.416		0.130	0.174	0.462	0.116	

Tw = after mouthwash treatment

T0 = baseline

P<0.05 : significant difference

P = P value

Eta S = Patial Eta Square

Table 6. Comparison of ΔE in the study groups after using the mouth rinses compared to the baseline

Groups	C	ZSW	SWN	PCW
C	-	0.057	0.843	0.122
ZSW	-	-	0.273	0.982
SWN	-	-	-	0.464

P<0.05 : significant difference

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Discussion

Patients' dissatisfaction with their tooth color has resulted in the introduction of OTC products with tooth-bleaching claims. Among these products, mouth rinses are more popular due to their low cost, availability on the market, and ease of use. These products have a wide variety on the market, and people consider them proper products for improving the esthetic appearance of teeth due to their ready availability (4). Therefore, the production of these products has increased in recent years (14), and more diverse and novel products are expected in the near future (15). Bleaching mouth rinses have diverse formulations and efficacy. The concentrations (percentages) of bleaching agents in their structure are lower than in bleaching toothpastes; in addition, they have no abrasive agents. On the other hand, their efficacy has not been dealt with adequately in previous studies (16,17).

The present study evaluated the efficacy of three bleaching mouth rinses—Zenon Smart White, Pasta del Capitano, and Signal White Now—to compare their efficacy in removing enamel surface stains and improving tooth color. The mouth rinses used in the present study were selected due to their availability on the market and differences in their formulations.

Bovine incisors were used for standardization and proper collection of the samples. Bovine incisors have an adequately smooth surface and improve and standardize the colorimetry conditions. On the other hand, the chemical composition and structure of these teeth are similar to human teeth; therefore, they are considered proper alternatives to human teeth in studies (18). The tooth surfaces were thoroughly cleaned, but they were not smoothened to simulate the natural situation. Although such a situation might lead to greater diversity in terms of absorbing pigments and colorimetry procedures, removing the surface layer of enamel makes it more susceptible to pigment and stain absorption (19).

Several dietary factors can cause tooth discoloration. Many studies have used black tea to produce tooth-discoloring pigments (20). For this reason, the tooth samples were immersed in black tea for 14 days in the present study to compare the efficacy of bleaching mouth rinses in eliminating stains and pigments.

A digital spectrophotometer was used to evaluate tooth colors. A spectrophotometer shows the light spectrum in different values and parameters, including the CIELab systems. The Easy Shade spectrophotometer used in the present study could reliably evaluate changes in tooth color (20).

In the present study, the L parameter decreased after immersing the tooth samples in the tea solution, and the a and b parameters increased, indicating decreased brightness and increased color saturation of the teeth. Li et al. (21) reported that tooth darkening is mostly related to decreased L parameter (a negative ΔL value) and increased b parameter (a positive Δb value). The susceptibility of the teeth in different groups to overall staining was different; however, generally, there were no significant differences in changes in the parameters between the groups ($P>0.05$). In all the groups, color changes were $\Delta E>3.3$ and significant, indicating that the tea solution had resulted in color changes in the clinically unacceptable range. According to previous studies, $\Delta E>3.3$ is unacceptable clinically (22,23); therefore, the color recovery process in the present study was adequate, reliable, and consistent with previous studies (21).

In the present study, the bleaching efficacy of the oral rinses was evaluated for 30 seconds in every round, according to the manufacturer's instructions. Although there were no recommendations concerning the number of daily rounds, twice daily is routine and applicable clinically. Concerning the duration of treatment, a study showed that a period of four weeks is adequate to confirm the efficacy of bleaching mouth rinses (11). However, since no specialty prescriptions are available for such products, and individuals might use these mouth rinses for a long time, a 12-week interval was selected based on a number of previous studies (6,7,24).

The results of using the bleaching mouth

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rinses in the present study indicated an increase in brightness (positive ΔL), a decrease in yellowness (negative Δb), and a decrease in redness (negative Δa) in teeth stained with tea. According to previous studies, increased brightness and decreased yellowness are the main factors for tooth whitening, and decreased redness has a minor role in tooth bleaching (1). It should be pointed out that all the mouth rinses used in the present study decreased tooth stains. ΔE at the end of treatment was >3.3 with all the mouth rinses, compared to the period after staining (ZSW=6.87, PCW=4.61, SWN=4.52), indicating significant changes concerning tooth bleaching. The tooth samples in the control group (distilled water), too, exhibited slight color changes associated with decreased yellowness and redness; however, the ΔE values were lower (ΔE=1.84), possibly indicating that some stains were dissolved in water, decreasing pigmentation over time. Of the three mouth rinses, the highest color recovery was induced by ZSW, followed by PCW, which was statistically significant compared to the control group. However, the Signal mouth rinse increase was not much more effective than the control group.

In the present study, despite the effect of mouth rinses on increasing tooth discoloration, only the ZSW mouth rinse removed the tea pigments over the study period at a clinically acceptable level (ΔE<3.3), resulting in color improvement relative to the baseline (ΔE=3.09). In addition, only this mouth rinse increased brightness compared to the baseline and improved color compared to the distilled water group at a statistically borderline level (P=0.05). However, PCW and SWN mouth rinses did not improve the color of the teeth with tea pigments, and the teeth had a ΔE at a clinically unacceptable level (ΔE>3.3) compared to their baseline color (PCW=3.93 SWN=5.43).

Bleaching mouth rinses have low concentrations of materials with bleaching properties, including pentasodium triphosphate, sodium hexametaphosphate, potassium pyrophosphate, sodium citrate, hydrogen peroxide, and recently, Plasdone and Blue Covarine. These agents remove or manage stains during bleaching (25). In the present study, each bleaching mouth rinse had its unique composition, with a claim of bleaching with a specific technology. Zenon Smart White contains pyrophosphate and pentasodium triphosphate ingredients, which exhibited a proper function in removing pigments and improving tooth color. These active ingredients have a bleaching potential and decrease pigments on teeth. Pyrophosphates have a strong affinity for creating strong bonds with pigments and removing stains from root surfaces by displacing anions. In addition, pentasodium triphosphate has enzymatic activity and breaks the bond between the stain and the tooth surface to clean and bleach the tooth (25,26).

Some studies have evaluated the efficacy of bleaching mouth rinses in eliminating stains and improving the colors of teeth and composite resins. In a study by Jaime et al. (8), using a hydrogen peroxide-containing mouth rinse increased the brightness of the tooth enamel containing pigments. Kazemi Yazdi et al. (27) reported that bleaching mouth rinses could recover the color of composite resins with surface stains. On the other hand, a study showed that hydrogen peroxide-containing mouth rinses did not affect the brightness of teeth with surface stains (9). In a study by Al-Shahrani et al. (28), pyrophosphate- and triphosphate-containing mouth rinses and hydrogen peroxide-containing mouth rinses were not more effective clinically than distilled water in eliminating stains. The differences between the present study and that by Al-Shahrani might be attributed to a shorter period of the study, concomitant tooth brushing, and using various enamel with stains instead of sound enamel in that study. In the present study, none of the mouth rinses had indications for use before brushing. Therefore, their effect, concomitant with brushing, was not evaluated. On the other hand, the brand diversities of the mouth rises used in these two studies (albeit a similar composition) might have affected their efficacy (7).

In the present study, the Pasta del Capitano

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mouth rinse with the Plasdone technology effectively removed the stains; however, it could not recover the original color. Polyvinylpyrrolidone or Plasdone K-29-32 is a water-soluble polymer that can form a complex with catechins and other coloring agents and remove them from the tooth surface with its high solubility, decreasing tooth stains (6). Laydon et al. (29), too, showed the efficacy of a toothpaste containing Plasdone in removing surface stains from teeth. Unlike the study above, Torres et al. (6) reported no beneficial effect concerning the elimination of stains from tooth surfaces by a mouth rinse containing Plasdone. No data are available on the concentrations and compositions of some products. In addition, the product type, mechanism of its use, and duration of use might be factors that affect their efficacy. According to the present study results, Plasdone in the form of a mouth rinse appears to have a lower activity than pyrophosphate and pentasodium triphosphate compounds.

In the present study, the signal White Now mouth rinse, with a claimed blue ray (Blue Covarine) technology, exhibited the least efficacy in removing stains and was not more effective than distilled water (control group) in removing stains and recovering the original color of the teeth. According to previous research, Blue Covarine is precipitated on the tooth surface and forms a semi-translucent layer, changing the optical properties of the tooth from yellow to blue and improving its whiteness immediately after use (30).

Consistent with the present study, Meireles et al. (31) compared Blue Covarine-containing toothpastes with conventional products and reported no advantages for Blue Covarine concerning color recovery. The authors reported that although Blue Covarine could decrease the yellow color, as indicated by decreased b parameter, the decrease was temporary and did not last long. In the study above, most patients were not satisfied with the whitening capacity of the product containing Blue Covarine and did not report any improvement in the appearance of their teeth. Demir et al. (32) reported that a Blue Covarine-containing toothpaste removed surface stains to some extent but did not improve color to a clinically acceptable level. Therefore, according to these evaluations, in recovering the color of teeth with pigments, products with the ability to remove stains are more effective, and Blue Covarine is not effective in recovering the color of teeth with the dark stains of tea.

No previous studies with similar methods or any similar products were available to compare the results of the present study with these studies. In general, studies on the efficacy of bleaching mouth rinses are not consistent. Differences in tooth type, the presence and type of stains and pigments, the protocol of using mouth rinses, the duration of the study, and the brands and diverse compositions of mouth rinses might be the factors affecting the results.

Previous studies have shown that increasing the duration of contact with the tooth and the frequency of using bleaching agents affects the efficacy of tooth bleaching procedures (33,34). In this respect, a study reported no bleaching effect of bleaching mouth rinses after 21 days of use (9). However, Hasturk et al. (5) reported the efficacy of the same mouth rinse after six months of use. The present study showed the efficacy of Zenon Smart White mouth rinse in removing stains and recovering the color of teeth with pigmentation, and its efficacy increased over time, consistent with studies by Rodrigues et al. (11) and Karadas et al. (7), indicating the cumulative effect of chemical bleaching agents.

According to the present study, it appears that the Zenon smart white mouth rinse with phosphate compounds is effective on stains to some extent and might be useful in patients with high susceptibility to the extrinsic staining of teeth due to tea. In general, using such products is advisable after examination and proper diagnosis of the etiologic factors for staining, considering the patient's dietary habits, and evaluating the product's composition by the dentist.

The present study was carried out in vitro. Such studies cannot completely simulate oral conditions; however, the data collected from such studies might help design clinical studies

and use these products. It is advisable to carry out studies close to clinical conditions to better understand the mechanisms and efficacy of bleaching mouth rinses. Another limitation of the present stud was a lack of evaluation of the efficacy of mouth rinses in preventing tooth staining, which might be the focus of further studies.

Conclusion

Under the limitations of the present study, it was concluded that:

1. The three bleaching mouth rinses decreased the enamel stains of teeth with tea staining. Furthermore, of the three mouth rinses, Zenon Smart White and Pasta del Capitano resulted in more color recovery than distilled water.

2. Only the Zenon Smart White mouth rinse (containing pyrophosphate and pentasodium triphosphate) recovered the original color of the teeth ($\Delta E<3.3$).

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None

Authors' contributions

Fereshteh Naser Alavi: Conceptualization, Methodology, Writing - Review & Editing **Ashkan Salari:** Writing - Original Draft, Data Curation, Supervision **Zahra Farzi:** Resources, Investigation, Visualization

Conflict of Interests

The authors declare no conflict of interest.

Ethical declarations

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Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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