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**ORIGINAL ARTICLE**

# Influence of coffee and red wine on tooth color during and after bleaching

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**Abstract**

***Objective.*** The aim of this study was to evaluate the influence of coffee and red wine staining on tooth color during and after bleaching. ***Materials and methods.*** Blocks obtained from human molars were divided into 11 groups ($n = 5$) in accordance with the bleaching treatment—peroxide carbamide 10%, 15% or 20%—and in accordance with the stain therapy—coffee, wine or without staining (control). Color change analysis was performed by photo-reflectance using a spectrophotometer, during (3-times/week) and after (7, 15 and 30 days) the bleaching treatment. During the experiment, the samples were stored in artificial saliva. The results were submitted to statistical analysis with the Dunnet and Tukey tests ($p < 0.05$). ***Results.*** The concentrations of carbamide peroxide (10%, 15% and 20%) did not differ significantly from the control group during bleaching (up to the 22nd day), with (Tukey, $p > 0.05$) or without storage in pigment solution. After the bleaching, there were statistically significant differences between the groups treated with coffee (30th day) and wine (7th and 30th days) relative to the control, which was treated with whitening agents. ***Conclusion.*** During bleaching, remineralization of the enamel with artificial saliva and the subsequent bleaching session were effective in preventing enamel staining. After the whitening procedures, both stain therapies—coffee and wine—caused enamel color changes; however, the wine led to greater staining than did coffee.

**Key Words:** *carbamide peroxide, tooth bleaching, spectrophotometry, pigmentation*

## Introduction

A growing demand for enhanced smile esthetics has led to the increased development of bleaching products [1,2]. However, tooth color is influenced by a combination of intrinsic color and extrinsic stains [2,3]. Therefore, before starting bleaching treatment, it is first necessary to understand the etiology of dental discoloration [4], because the tooth response to bleaching depends on the type, intensity and duration of the discoloration [5].

Several methods and approaches have been described in the literature for bleaching vital teeth, such as the use of different bleaching agents, concentrations, application times and product formats [3]. Bleaching procedures involve either hydrogen peroxide or carbamide peroxide and the mechanism consists of an oxidation reaction with the release of free radicals [2,5]. Although the mechanism of action of hydrogen peroxide is not well understood, it is considered to be an oxidation reaction in which the pigment molecules are broken down and the small compounds diffuse out of the tooth [3,5]. Currently, carbamide peroxide in concentrations of 10%, 15% or 22% is the most commonly used agent for bleaching vital teeth [6,7]. Some studies have indicated that vital tooth-bleaching techniques can cause surface alterations in dental substrates, such as the formation of

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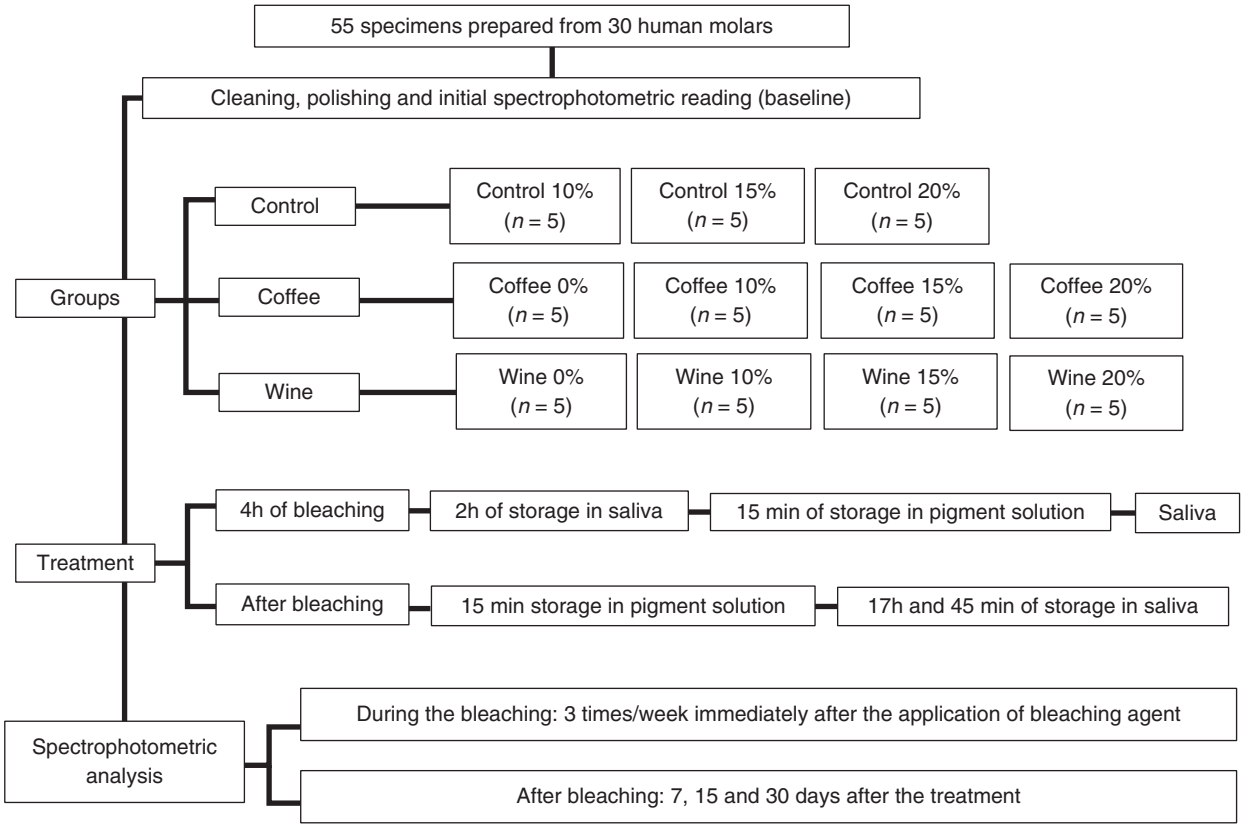


Figure 1. Study design.

pores with increased diameter and enamel erosion or roughness [7–9]. These alterations may facilitate the recurrence of extrinsic staining, often promoted by smoking; by a dietary intake rich in colored foods and drinks, such as tea, red wine and coffee; and by the use of certain cationic agents, such as chlorexidine [3,10,11]. Because the whitening process significantly increases the surface porosity of dental enamel, it is important to evaluate the effects of staining substances during and after bleaching treatment [12].

The literature is not consistent regarding tooth staining during bleaching. Some authors have shown that exposing the tooth to a coffee solution during the bleaching treatment decreases the color stability achieved by the whitening process [12,13]. However, another study [14] demonstrated that coffee did not significantly interfere with bleaching, in contrast to red wine, which caused discoloration of the bleached enamel surface. However, some studies have indicated that staining can be avoided by prolonged contact of the teeth with saliva, which can reverse the loss of minerals and consequent porosity of the enamel caused by bleaching treatment [15,16].

The purpose of this study was to evaluate the influence of coffee and red wine staining on the color of vital teeth during bleaching with carbamide peroxide. The null hypotheses to be tested were as follows: (1) There would be no difference in the photoreflectance results of tooth bleaching with 10%, 15% or 20% carbamide peroxide; and (2) Neither coffee nor red wine would interfere with bleaching effectiveness or color stability.

## Materials and methods

The study design is represented in Figure 1.

### *Preparation and treatment of the specimens*

Thirty human third molars were stored in a saline solution after collection and disinfection. These teeth were examined under a light microscope (4×) to discover any gaps, cracks or caries that might interfere with the bleaching evaluation. If any of these features was found, the tooth was discarded and replaced.

After disinfection of the samples with a 0.1% thymol solution, the crowns were separated from their roots by sectioning at the dentinoenamel junction with a double-faced diamond disk (KG Sorensen, Barueri, SP, Brazil) in a low-speed hand piece under constant water irrigation. Afterwards, the crown was sectioned from distal to mesial, which produced two fragments. Each fragment was cut with a precision, slow-speed, water-cooled diamond saw (Imptech PC10, Equilam-Lab Equip., Diadema, SP, Brazil) to obtain blocks with an area of 9 $mm^2$ (3 mm × 3 mm). Fifty-five samples were obtained. The enamel surface was flattened with 600- and 1200-grit silicon carbide papers under

Table I. Mean values of reflectance (%) of the carbamide peroxide (10%, 15% and 20%)-treated and untreated groups, submitted or not, to staining with coffee or wine.

| | | Bleaching agent | | | |
|---|---|---|---|---|---|
| Day | Treatment | 0% | 10% | 15% | 20% |
| 1 | Control | | 66.05[a] | 66.02[a] | 65.36[a] |
| | Coffee | 65.16 | 65.13[a] | 65.77[a] | 66.15[a] |
| | Wine | 64.88 | 65.84[a] | 65.53[a] | 65.41[a] |
| 7 | Control | | 80.63[a] | 80.55[a] | 80.13[a] |
| | Coffee | 63.98 | 76.24[a]* | 81.35[a]* | 81.80[a]* |
| | Wine | 62.53 | 77.93[a]** | 78.26[a]** | 77.61[a]** |
| 15 | Control | | 78.93[a] | 80.47[a] | 79.96[a] |
| | Coffee | 62.45 | 78.23[a]* | 82.59[a]* | 82.55[a]* |
| | Wine | 55.58 | 79.85[a]** | 77.47[a]** | 78.42[a]** |
| 22 | Control | | 81.22[a] | 83.35[a] | 82.06[a] |
| | Coffee | 58.85 | 79.14[a]* | 82.96[a]* | 84.27[a]* |
| | Wine | 48.45 | 80.58[a]** | 81.47[a]** | 82.39[a]** |
| 29 | Control | | 79.31[a] | 82.27[a] | 80.58[a] |
| | Coffee | | 75.27[a] | 77.90[a] | 79.40[a] |
| | Wine | | 67.01[b] | 67.15[b] | 70.54[b] |
| 52 | Control | | 81.19[a] | 84.22[a] | 79.62[a] |
| | Coffee | | 75.42[b] | 75.38[b] | 77.22[b] |
| | Wine | | 56.31[c] | 56.60[c] | 54.22[c] |

*Differ from wine 0% by Dunnet test ($p < 0.05$).
**Differ from wine 0% by Dunnet test ($p < 0.05$).
Means followed by different letters at the vertical in each day are different by Tukey test ($p < 0.05$).

constant irrigation. These specimens were stored in distilled water and divided into 11 groups, in accordance with the bleaching agent ($n = 5$): 10%, 15% and 20% carbamide peroxide (Opalescence Xtra, Ultradent Inc., Salt Lake City, UT); and pigment solution: coffee (Café Pilão, São Paulo, Brazil) and wine (Miolo Gamay, Rio Grande do Sul, Brazil).

For the bleaching procedure, the whitening agent was applied to the specimen with a syringe to form a 1-mm-thick layer. After this treatment, an individual polyacetate tray was placed on the block. After 4 h, the tray was removed and the dental fragment was washed with distilled water and immersed in artificial saliva for 2 h. This step was followed by immersion in staining solution for 15 min and subsequent washing and immersing in artificial saliva for 17 h 45 min, for a cycle of 24 h. The specimens were bleached for 22 days and then stored at 37°C. The staining solutions were composed of 750 mL of wine and 8 g of coffee dissolved in 100 mL of water. The two-phase bleaching process was interrupted by a staining session.

### *Photoreflectance analysis*

The efficacy of bleaching was measured by a spectrophotometer (model 77702, Oriel Instruments, Mountain View, CA) in reflectance mode. For the reflectance analysis, a Teflon sphere in the reflectance configuration was used. Reflectance is the luminous radiation portion that is reflected by the material under study. Before the bleaching procedure, the specimens were placed in the sample carrier, which is part of the spectrometer sphere, and irradiated by fiber-optics at a distance of 2 mm to obtain the initial reading (baseline). The optical signal of the integrating sphere was captured by a 600-nm-diameter optical fiber attached to a white-light source. The optical potency available in the optical fiber tip was 5 mW. This fiber was placed 2 mm from the reference pattern (Teflon diffuser) and maintained at this distance. For each reading, 100 signal accumulations were obtained during 50 s of exposure. The reflectance signal was confined inside the integrating sphere. From this signal, a proportional signal fraction was collected for analysis in the spectrometer, where it underwent spectral dispersion through a diffraction grating. The reflectance analysis data reading was interpreted with a computer and exhibited as the intensity × wavelength signal [1,2,5].

Measurements of each sample were made to obtain the area (%) given by the graph. Readings were taken 3-times a week, from immediately after applying the bleaching agent until the end of treatment (22 days). After the bleaching procedure was completed, the blocks continued to receive only the pigmentation treatment. New readings were performed 7, 15 and 30 days after the end of the bleaching. These readings were intended to check the stability of the obtained color.

### *Statistical analysis*

The data obtained were submitted to statistical analysis. After exploratory data analysis, a Tukey test was applied to compare different treatments of the blocks with bleaching and dye solutions. The control group was compared with the other groups by the Dunnet test, by considering the time of evaluation. The significance level was 5%.

## Results

Statistical differences were not observed between the groups treated with 10%, 15% or 20% carbamide peroxide during the bleaching treatment up to the 22nd day with or without concomitant pigment solution storage (control, coffee and wine) (Table I; $p > 0.05$ by Tukey test). After application of the whitening agent, the control group was stable until the end of the study, whereas the group treated with the wine solution was characterized by lower values for the reflectance spectrophotometry after 7 days (29th day; $p < 0.05$ vs control). After storage in the pigment solution for 30 days (52nd day), lower mean values for reflectance were evident for the groups

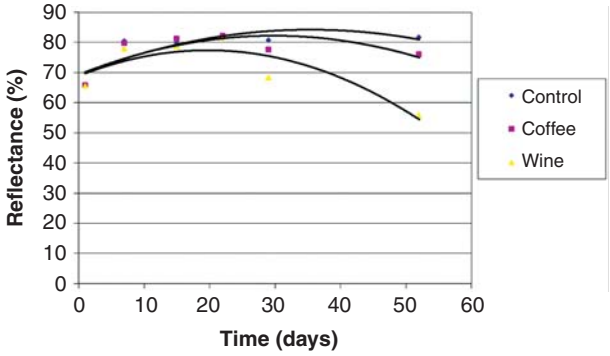


Figure 2. Lines of reflectance relative to Table I (control, $R^2 = 0.6801$; coffee, $R^2 = 0.2883$; wine, $R^2 = 0777$).

treated with coffee and wine. The group treated with wine had the least reflectance (i.e. most staining) of all of the groups. From the 7th day, the bleached, control, coffee and wine groups were characterized by values that were greater than those of the groups submitted only to staining with coffee or wine without bleaching ($p < 0.05$, Dunnet test).

Figure 2 shows that staining with coffee or wine did not affect the results of bleaching. The reference lines of the control, coffee and wine groups were similar, with a gradual increase until the 22nd day, when treatment with carbamide peroxide was concluded. After the 22nd day, the control group was maintained in artificial saliva, whereas the others continued to be subjected to coffee or wine staining. The reflectance of the control was constant, whereas the group treated with coffee underwent a smaller reduction in values. The group treated with wine showed a mean reflectance that was significantly less than that of the control group or the group treated with coffee.

## Discussion

The results of the present study indicate that the tested concentrations of carbamide peroxide were all effective for bleaching and statistically similar in terms of the bleaching treatment; therefore, the first null hypothesis was rejected. The second null hypothesis was also rejected because the pigments, coffee and wine, caused staining, negatively interfering with color stability after bleaching.

Spectrophotometers differ from colorimeters in that they measure reflected light within the entire visible spectrum, whereas colorimeters measure reflected light at only three wavelengths [17]. Although colorimeters provide reproducible results, such results can be affected by tooth translucency, contour and texture [18]. Some conditions interfere with the measurement of tooth color, such as a rough surface and non-uniform surface geometry. The spectrophotometer in a diffuse reflectance mode minimizes edge losses at the side of the sample tooth and maximizes the collection of reflected light in all directions, all of which minimize the disadvantages of sample characteristics [17–19].

All of the concentrations of carbamide peroxide were effective and similar for the bleaching result, in terms of the photoreflectance color analysis. There were no statistically significant differences in reflectance between the various concentrations of the whitening agent. According to Braun et al. [20], different concentrations of carbamide peroxide (10% and 17%) did not result in differences in color stability 1 week after the end of the whitening treatment. Therefore, we advise the use of a low concentration of bleaching agent to avoid side-effects, such as tooth sensitivity [21].

Susceptibility to enamel staining is related not only to surface roughness, but also to enamel composition, such as the water absorption rate due to changes in permeability. The accumulation of pigments and dyes can be exacerbated by irregularities left on bleached enamel surfaces [22]. Because vital bleaching involves direct contact between the tooth surface and the bleaching agent for a long time, several investigators have evaluated the effects of 10% carbamide peroxide on the composition and micromorphology of the enamel surface. Some researchers have reported that there is neither significant loss of calcium or phosphate in bleached teeth [9,23] nor a reduction in microhardness [23,24]. Nevertheless, others have suggested that these effects may occur [14,25–29]. Thus, it is important to consider the role of saliva in the process of enamel mineral exchange.

In this study, it was observed that, during bleaching treatment, the different concentrations of carbamide peroxide did not increase enamel susceptibility to staining with coffee or wine. Considering the previous reports, we conclude that storing the specimens in artificial saliva during bleaching (22 days) contributed to the maintenance of the color reached during treatment. The ability of artificial saliva to remineralize bleached enamel contributes to the color stability of the enamel and is associated with the duration of salivary immersion. Attia et al. [12] reported that storing bleached specimens in artificial saliva for only 5 min was insufficient to make the enamel resistant to superficial staining with coffee. In this study, the specimens were stored in artificial saliva for 2 h after bleaching and for 17 h 45 min after staining, simulating oral conditions. In addition, the bleaching agent was found to oxidize molecules of coffee or wine deposited on the enamel surface, producing results similar to those in groups not exposed to pigment solutions during bleaching.

Coffee, tea, juices, wines and cola-based soft drinks are beverages with the potential to darken, discolor or stain bleached enamel surfaces. Some of these beverages are acidic solutions that can increase demineralization and others contain ethanol or pigments [13,22]. Certain beverages, artificial food colorations

and frequent smoking are responsible for primary staining, darkening and discoloration of teeth. The reflectance values reported in Table I suggest that bleached teeth are more susceptible to staining, particularly by red wine, which is an acidic, colored and alcoholic beverage. Moreover, even the unbleached specimens were characterized by a decrease in reflectance, mainly for wine, although both pigments were effective in staining. Thus, red wine had a greater capacity for staining than did coffee [22].

These results are consistent with those of Liporoni et al. [14], who reported that coffee and wine effectively interfered with the reflectance values on the bleached enamel surface. However, they also concluded that coffee did not significantly interfere with the bleaching, whereas wine discolored the enamel compared to that of the control group. Although some authors have observed that bleached enamel is not susceptible to staining by other pigments, such as tea, after saliva storage [13], the predisposition of enamel to stain after whitening was previously observed, and this tendency was even greater with wine storage [12,14,22].

In accordance with the results of this study, remineralization of enamel with artificial saliva during bleaching and subsequent bleaching sessions were effective in preventing enamel staining. However, the values of reflectance decreased even after the end of the bleaching period (7 days and 30 days, respectively) for the stained specimens. Therefore, it is important to instruct patients to avoid certain beverages, artificial food colors and acidic fruits to maintain the clinical results of the whitening sessions.

## Conclusion

Based on the experimental conditions of this study and within the limitations of an *in vitro* investigation, it can be concluded that the whitening agents were effective in preventing tooth staining during treatment. After the bleaching, the pigment solution caused a loss of stability in the results obtained with the whitening procedure, the wine stains more so than the coffee.

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