ORIGINAL ARTICLE

Effects of 6% vs 9% Carbamide Peroxide Bleaching Agents on Extracted Teeth Stained by Malaysian Black Coffee

Husniyati Roslan[1], Noraidah Othman[2], Fatanah Mohamad Suhaimi[1], Ahmad Fairuz Omar[3]

[1] Craniofacial and Biomaterial Sciences Cluster, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bertam, 13200 Kepala Batas, Penang, Malaysia.
[2] Children Dental Centre & Malaysian Ministry of Health (Dental) Training Institute, No. 3 Jalan Sepoy Lines, 10450 Georgetown, Penang, Malaysia.
[3] School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia.

ABSTRACT

Introduction: Human teeth tend to stain from intrinsic and extrinsic factors with time. The study was aimed to assess colour change of stained enamel after the use of bleaching agents. **Methods:** 63 extracted human teeth were selected and soaked in the coffee solution for 7 days to stain the teeth. Then they were randomly divided into 3 groups (n = 21). The groups were divided as the control group (distilled water), group using 6% carbamide peroxide (CP6) and group using 9% carbamide peroxide (CP9). The groups of CP6 and CP9 were bleached with 0.2 ml of bleaching agent for 5 minutes daily until 14 days. Colour changes were visually recorded by using VITA Toothguide 3D-MASTER and Ocean Optics Spectrometer instrument. **Results:** CP6 started to show shade reduction on Day 3 (score 5), followed by a steady reduction until Day 10. Day 12 to 14 showed another steady reduction of CP6. CP9 had a larger shade reduction (scores of 2-5) from Day 1 to Day 4, followed by a steady reduction until Day 14. Spectrometer analysis shows that CP9 samples had lower absorbance unit compared to CP6 samples for both second-day and sixth-day groups. However, most changes can be observed on the CP9 samples from control to the second-day and sixth-day. **Conclusion:** Bleaching agent with low concentration can approach the efficacy of high concentration of bleaching agent with an extended treatment time.

Keywords: Tooth bleaching, 6% carbamide peroxide, 9% carbamide peroxide, Black coffee, Visual assessment

Corresponding Author:
Husniyati Roslan, MClinDent (Prosthodontics)
Email: husniyati@usm.my
Tel: +604-5622247

INTRODUCTION

Nowadays, many Malaysians have shown their preference towards drinking coffee compared to tea. Worldwide, Malaysia is in the list for the top fifty countries which consume lots of coffee. In 2016, a survey was carried out for the Malaysians and coffee was found to be the most regular beverages consumed. About 60.83% of all respondents in this survey stated that they drink coffee daily (1). Studies have shown that coffee can stain teeth, white fillings (2) and even dentures (3).

In addition, the colour of the teeth especially adult teeth often become darker as the age increases. This is partly due to the extrinsic effects from the intake of dark-coloured foods or beverages (for example coffee, wine and curry), smoking and tooth wear. Other factor causing stained teeth is intrinsic effects such as dental trauma, overexposure to fluoride during childhood, certain medications (for example tetracycline antibiotics) and natural discolouration of the dentine as the tooth ages. As a result of the stained teeth, patient's self-esteem may be affected.

Bleaching has been one of the efficient treatment options to improve discolouration of vital and non-vital teeth. It can be performed either by a dentist (high peroxide concentration is utilised) or patient (home bleaching; low peroxide concentration is utilised). The effect of bleaching has been correlated with the peroxide concentration and bleaching period (4).

Tooth bleaching involves the application of hydrogen peroxide releasing agents. There are two types of hydrogen peroxide releasing agents; one is ready to be applied directly on the teeth and the other may be produced from carbamide peroxide (CP) (5). The bleaching mechanisms appear by peroxide dispersion through enamel surface of the teeth which later cause oxidation and thus lessening of the stained surfaces,

mainly within the dentinal regions. Generally, the bleaching effectiveness is determined by the peroxide's concentration and the time of its application on the teeth. Specifically, a higher peroxide concentration gives a faster effect compared to a lower peroxide concentration. Nevertheless, a lower peroxide concentration can be as effective as a higher peroxide concentration if a prolonged treatment time is performed.

CP is one of the most popular bleaching agents used to whiten the teeth. It is usually used in different concentrations, based on the suitable application. CP gels with a higher concentration can speed up the bleaching effect. Nevertheless, short and long period of clinical trials using higher concentration of CP reveal corresponding results when compared to 10% CP (6,7). Currently, less attention is given to the alternative bleach systems to peroxide. Other causes that may affect tooth whitening result are initial tooth colour, staining type and age of the subject (5).

The most significant sources of primary staining include certain types of drinks, artificial food colourings, and also smoking habit (8). After bleaching treatment, dentists usually will advise patients to reduce tea and coffee consumption to avoid new stain on the teeth again. This is supported by findings which revealed that bleaching agents may modify the enamel's morphology and texture (9).

There are many different methods available to determine the colour changes after tooth whitening. Most commonly used method is by using a standard dental shade guide (10). This method is usually used in the clinical setting. However, this method is subjective and can be influenced by the clinician's age and experience. Besides, lighting of the dental clinic can also influence the colour assessment. Spectrophotometric shade analysis appears more consistent compared to visual shade determination. However, visual assessment results in more variations (i.e. primarily darker colour) in the recordings (11).

Thus, the objective of this study was to determine the effects of 6% and 9% CP home bleaching agents on extracted teeth which were stained with one of the Malaysians mostly consumed black coffee.

MATERIALS AND METHODS

Teeth Preparation

Sixty-three extracted human molar teeth without enamel cracks, defects, and restorations were utilised in the study. The tooth surface was scratched with the tip of a sharp explorer to determine any presence of crack. All the selected teeth were then soaked in 10% formalin for one week before starting the experiment.

Then three teeth were randomly picked and arranged in a mould made of dental Plaster of Paris (Shiva products, India) in a dimension of 2.5 cm width x 2.0 cm height x 7.5 cm length (Fig. 1). This would make the handling of the samples much easier.

Figure 1: The arrangement of teeth in a stone block

Teeth Staining Process

Artificial staining of the samples was performed according to the established method (1) to standardise the tooth colour. The standardised coffee solution was prepared by boiling 12 g of coffee (Tupai Special Coffee, Malaysia) in a container of 200 ml of distilled water for 5 minutes. The solution was then filtered using a gauze. The blocks of samples were immersed daily for seven days in the daily renewed coffee solution. This was performed at room temperature (28±2°C). After the immersion into the coffee solution, the blocks of samples were cleaned and kept in distilled water.

Teeth Shade Assessment

The baseline colour was recorded after the immersion in coffee solution for seven days. In this study, two methods of shade assessment were utilised: visually by using VITA Toothguide 3D-MASTER (VITA Zahnfabrik, Germany), and the visible backscatter spectrum of the samples assessment by Ocean Optics QE65000 spectrometer (illumination light source of tungsten halogen) (Ocean Optics, Inc., Dunedin, FL, USA). The visual colour differences were assessed on Day 1 until Day 14, based on VITA Toothguide 3D-MASTER scores ranging from the lighter to the darker shades (Table I). Meanwhile, the spectrometer analysis was performed on Day 1 until Day 7 only. The changes in backscatter intensity indicated changes in the colour of the samples. The higher the absorbance unit means, the darker the samples. On the other hand, a lower absorbance unit means the brighter the samples. For both of these assessments, the principal investigator was trained and calibrated by more experienced researchers before the actual study started.

Bleaching Procedure

The stained samples (three teeth in a block) were then randomly divided into three groups (n=21; seven blocks): distilled water (control), 6% carbamide peroxide (CP6) or 9% carbamide peroxide (CP9). The enamel surface

Table I: Colour scores by sequence of colours in VITA Toothguide 3D-MASTER (from lighter to darker colours)

VITA Toothguide 3D-MASTER	Scores
0M1	1
0M2	2
0M3	3
1M1	4
1M2	5
2M1	6
2L1.5	7
2M2	8
2R1.5	9
2L2.5	10
2M3	11
2R2.5	12
3M1	13
3L1.5	14
3M2	15
3R1.5	16
3L2.5	17
3M3	18
3R2.5	19
4M1	20
4L1.5	21
4M2	22
4R1.5	23
4L2.5	24
4M3	25
4R2.5	26
5M1	27
5M2	28
5M3	29

for bleaching procedure was marked as round (5 mm x 5 mm) with a permanent marker for each tooth, either on the buccal or lingual surface (i.e. flat surface). Meanwhile, the rest of the tooth surface was painted with a clear nail polish to avoid the bleaching agent from penetrating the non-intended surface.

Table II shows the manufacturers and chemical composition for the bleaching agents used in the current study. For the control group, the samples were stored in the daily renewed distilled water for fourteen days. About 0.2 ml bleaching gels were applied on samples of CP6 and CP9 for 5 minutes (i.e. following the manufacturer's recommendation) each day for fourteen days consecutively. After 5 minutes, the gels were wiped using a sterile gauze and then washed using tap water. Following this treatment, the samples were then kept again in distilled water until the next application on the following day.

Table II: Description of manusfacturers and bleaching agents used in this study

Product	Manufacturer	Chemical composition
White Glo 6%	White Glo House, Sydney, Australia	6% Carbamide Peroxide, Propylene Glycol, Glycerine, Carbomer 940, Triethanolamine, Peppermint Oil
White Glo 9%	White Glo House, Sydney, Australia	9% Carbamide Peroxide, Propylene Glycol, Glycerine, Carbomer 940, Triethanolamine, Peppermint Oil

RESULTS

The Visual Shade Assessment

Table III presents the average colour measurements based on VITA Toothguide 3D-MASTER for all experimental groups. The colour of the teeth was maintained in the control group throughout the experimental period. On Day 1, the CP6 group showed no shade reduction at all while CP9 group had a 2-score shade reduction. CP6 still maintained its shade on Day 2 while CP9 showed a mean of 3-score shade reduction. On Day 3, both CP6 and CP9 showed a mean of 5-score shade reduction. On Day 7, CP9 showed a lighter shade than CP6 by a mean of 4-score.

After that, CP6 showed an average mean shade reduction of about 1-2 scores until Day 10. It had a mean 3 scores shade reduction on Day 11, followed by an average mean reduction of 1-2 scores until Day 14. On the contrary, CP9 had a larger mean shade reduction

Table III. The tooth shade mean scores and standard deviations (± SD) for different groups based on VITA Toothguide 3D-MASTER

Days	Groups		
	Control (± SD)	CP6 (± SD)	CP9 (± SD)
Baseline record	22.86 (± 1.07)	23.14 (± 1.46)	24.57 (± 1.13)
1	22.86 (± 1.07)	23.14 (± 1.46)	22.57 (± 0.98)
2	22.86 (± 1.07)	23.14 (± 1.46)	19.14 (± 1.95)
3	22.86 (± 1.07)	18.72 (± 2.06)	14.43 (± 0.98)
4	22.86 (± 1.07)	17.71 (± 1.25)	12.86 (± 0.38)
5	22.86 (± 1.07)	16.29 (± 1.25)	11.57 (± 2.44)
6	22.86 (± 1.07)	14.57 (± 1.13)	11.29 (± 2.29)
7	22.86 (± 1.07)	14.29 (± 0.95)	10.57 (± 1.9)
8	22.86 (± 1.07)	14.14 (± 0.9)	9.0 (± 2.52)
9	22.86 (± 1.07)	13.43 (± 1.51)	8.86 (± 2.27)
10	22.86 (± 1.07)	13.14 (± 1.51)	8.43 (± 1.62)
11	22.86 (± 1.07)	10.14 (± 1.46)	7.71 (± 1.25)
12	22.86 (± 1.07)	7.43 (± 0.98)	6.86 (± 1.07)
13	22.86 (± 1.07)	6.86 (± 1.07)	6.57 (± 0.79)
14	22.86 (± 1.07)	5.71 (± 0.49)	6.14 (± 1.07)

*SD = standard deviation
CP6 = 6% carbamide peroxide
CP9 = 9% carbamide peroxide

(scores of 2-5) from Day 1 to Day 4. This was followed by a steady mean shade reduction until Day 14 (average score of 1 shade reduction per day). Overall, the total means shade reduction for CP6 was 17.43 while for CP9 was 18.43.

Statistical Package for the Social Science (SPSS) software Version 20 (SPSS, IBM, NY, USA) was used in this study. One-way analysis of variance (ANOVA) was performed for the analysis. The results revealed a significant difference in the means shade reduction among all groups ($p<0.001$). Significant differences between the control group and CP6 group, and control group and CP9 group ($p<0.001$) were also seen. However, the means shade reduction between CP6 and CP9 groups were not statistically significant.

The Visible Spectroscopy Analysis

In this study, the discolouration of the tooth samples by the bleaching agents, CP6 and CP9 was represented by the visible absorbance spectra (λ: 400–700 nm). Fig. 2 shows the spectral response between control samples and the tooth spectra for second and sixth days after bleaching treatment by CP6 and CP9. The Y-axis of the graph is represented by the uncalibrated and raw backscatter signal retrieved by the spectrometer. Hence, visually, the spectra are dominated by the tungsten halogen spectral features. In order to obtain a comparable response between the effect of each bleaching agent, spectral response at 500 nm was extracted from the whole data set and normalised to the response obtained by the control sample as shown in Fig. 3.

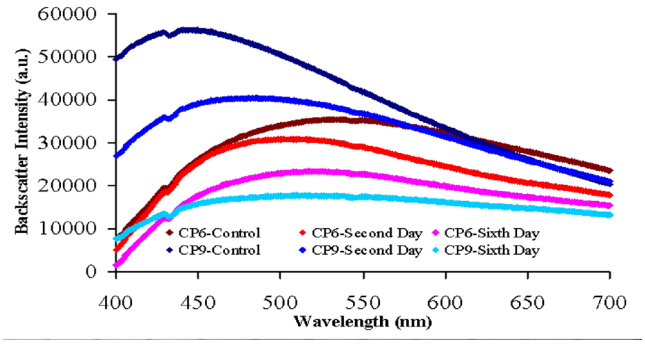

Figure 2: Visible spectral response of tooth after two and six days of bleaching treatment.

DISCUSSION

This *in vitro* study shows that teeth immersion in coffee solution produces a change in the colour of the enamel surface. Thus, this confirms that teeth are vulnerable to staining by common beverages.

In dentistry, correctly interpreting tooth colour is very important in the aesthetic treatment needs. In addition, assessing the colour changes during the bleaching treatment is also crucial. Over the years, VITA shade guide has been the most commonly utilised method is

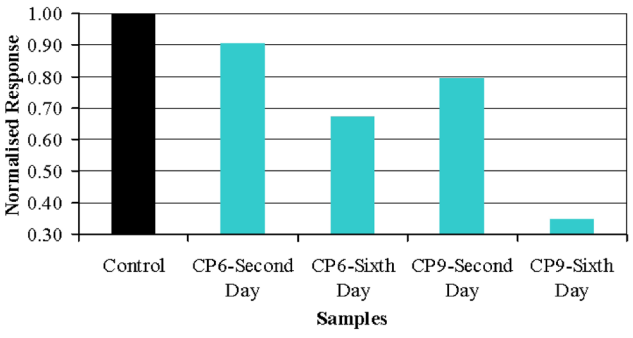

Figure 3: Normalised response at 500 nm for CP6 and CP9 bleaching agents after 2 and 6 days of treatment.

the shade assessment (12) among other methods, which supports its usage in the current study.

Matis et al. mentioned that the percentage of the bleaching material and bleaching time can affect the effectiveness of bleaching treatment (4). In this study, the trend shows that CP6 had a slightly better shade than CP9 on Day 14 despite a slow shade reduction during the experimental period. This result was in agreement with Sulieman et al. (13). Another study also found that using a lower percentage of bleaching agent was more effective in reducing the teeth colour (1). Furthermore, randomised clinical trials have shown that the increase of the carbamide peroxide concentration for home-use did not increase the efficacy and longevity of the tooth whitening effect (6,14).

The current study revealed that stains were minimised after three days by CP6 (low concentration of bleaching agent). On the other hand, CP9 showed a faster mean shade reduction since Day 1. The result of a study by Farawati et al. (15) found that 20% CP minimised the stained teeth after five days of application compared to the 35% and 44% CP concentrations. They concluded that the effectiveness of bleaching agents with lower concentrations were about the same as bleaching agents with higher concentrations. Hence, this will also help to minimise tooth sensitivity occurrence.

Fig. 2 compares the spectral response of the control samples with the samples after two and six days of bleaching treatment. Both control samples of CP6 and CP9 had the highest absorbance unit within their likelihood. Considering the peak of CP9 group at 450 nm, the backscatter intensity was decreased from 55000 (control) to 38000 (CP9-second day) and further reduced to 18000 (CP9-sixth day). This indicates that CP9-normal has high absorption, followed by CP9-second day, and CP9-sixth day.

Similarly, for sample CP6, the peak of backscatter intensity was observed at the wavelength of 500 nm. The reflectance of the control sample was the highest (32000), followed by the second-day sample (30000), and sixth-day sample (21000). Therefore, CP6-normal

has the highest absorption compared to the CP6-second day and CP6-sixth day.

Interestingly, the changes of CP9 bleaching agent from control to the second day to the sixth day were more pronounced compared to the changes occurs in CP6 bleaching agent, observed based on the difference in backscatter intensity at the corresponding wavelength. Fig. 3 shows the normalised response of CP6 and CP9 bleaching agents after 2 and 6 days of treatment, observed at the wavelength of 500 nm of the spectral response. For the CP6 group, the normalised response was reduced from 0.90 to 0.68 for second-day and sixth-day, respectively. However, the most significant changes can be observed on the CP9-sixth day sample, with a response of 0.35 compared to 0.79 on the second day.

Comparing the day basis, CP9 samples had lower absorbance unit compared to CP6 samples. Overall, CP9 showed the most changes of absorbance compared to CP6 from the control samples.

CONCLUSION

The present study showed that both 6% and 9% carbamide peroxides effectively reduced the stained teeth. Lower absorbance unit of CP9 compared to CP6 samples suggest that CP9 samples were brighter than CP6 samples for both second day and sixth day groups. More importantly, samples of CP9-sixth day had the brightest colour and the most changes compared to other samples.

Even though CP9 showed a bigger and faster means shade reduction in the earlier experimental period, however, both bleaching agents did not show much difference shade on Day 14. Thus, a bleaching agent with lower concentration can approach the efficacy of higher concentration of bleaching agent with an extended treatment time.

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