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EFFECT OF AN EXPERIMENTAL GREEN TEA EXTRACT BLEACHING GEL ON THE COLOR CHANGES OF A COMPOSITE RESIN

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ABSTRACT. The effect of the color change of stained and then bleached composite resins blocks have been evaluated. 28 blocks, made from Admira fusion composite resin and divided in 3 groups, were included in the present study. They were stained in coffee for 3 days and then bleached with Opalescence gel (GO) and experimental bleaching gel based on green tea extract (GE). All color indices were measured in all situations (initially, after staining and after bleaching) with Vita Easy Shade spectrophotometer. It was used the CIE*L*a*b system for the color change parameters. The group bleached with Opalescence presented the most significant color changes. The bleaching effect of the experimental gel is lower that Opalescence bleaching gel.

Keywords: *green tea, composite blocks, staining, bleaching, color change*

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INTRODUCTION

Since the introduction of the bleaching therapeutic procedures by Haywood and Heyman in 1989 [1], teeth whitening has gained significant acceptance among dental practitioners and patients, both through the simplicity of the procedure and its effectiveness [2].

In the treatment of lesions with loss of tooth substance, the light-curing composite resins are the most used materials for restoration, and therefore the requirements of patients include a better adaptation of the restoration color and a greater stability over time [3]. These two properties depend on the chemical composition of the resin and how it is finished after application in the tooth cavity. Intrinsic factors, such as changes in the structure of the filler, the matrix and the silane, but also the extrinsic ones can cause changes in the color of the composite restoration materials [4].

Due to the unlimited possibilities of combinations and the existence of an extensive range of shades and opacities to reproduce as accurately as possible the optical properties of the dental structures, the initial appearance of composite restorations can be excellent [5]. However, a major disadvantage of composite resins is their great color instability [5]. External factors that may induce color changes include food dyes, beverages, UV radiation, temperature differences and water absorption [5].

The most well-known method of treating tooth discolorations is dental bleaching, performed either by the patient at home under the guidance of the dentist, using prefabricated or customized trays, or in the dental office. The most used substances for tooth bleaching are based on hydrogen peroxide (HP) or carbamide peroxide (PC) [6].

Carbamide peroxide is an organic derivative that decomposes during bleaching treatment with hydrogen peroxide (H_2O_2) and urea (CH_4N_2O). Urea decomposes further into ammonia and water, which tends to increase the pH of the solution.

Hydrogen peroxide generates by decomposition (Fenton reaction, Haber-Weiss reaction with metal ions) the hydroxyl radical, a molecule with an even higher oxidative potential [7]. This reaction is catalyzed by metal ions such as Fe^{2+} or Cu^{+}. Cell iron cannot mediate a Fenton reaction in vivo. The release of iron ions from cellular transport and storage proteins can mediate a Fenton reaction with hydroxyl ion formation and this reaction is favored by the chelating agents contained in the bleaching agent and acid pH [9].

The Haber-Weiss reaction steps are [8]:

- reducing the ferric ion to the ferrous ion:

$$Fe^{3+} + \bullet O_2^{-} \rightarrow Fe^{2+} + O_2$$

- Fenton reaction:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{-} + \bullet OH$$

Characteristic of these free radicals of oxygen, respectively hydroxyl ($\bullet OH^-$), superoxide ($\bullet O_2^-$), singlet oxygen ($\bullet O_2$) produced as a result of these reactions is their great chemical instability [7].

Also, the hydroxyl radical reacts very easily and can oxidize any organic substrate, as long as, it is close to it [9]. On the other hand, the oxidative reaction is nonspecific and the hydroxyl radical can also affect the organic matrix of the enamel, dentine [10, 11] and composite resins restorations. The present study aims to evaluate the color change of the composite resins restorations during teeth whitening with carbamide peroxide gels and experimental green tea extract bleaching gel.

RESULTS AND DISCUSSION

Twenty-eight blocks of nanohibrid composite resin, taken in this study, were randomly divided into three groups: GC, which served as control group and two experimental groups: GO bleached with commercial preparation based on 16% carbamide peroxide and GE subjected to bleaching treatment with experimental whitening gel based on 16% carbamide peroxide and green tea extract.

To the test groups were applied processes of staining and then of chemical bleaching. Also, to all composite resin blocks were registered the following color parameters: brightness, L, the color parameter in the red-green axis, a, the color parameter in the yellow-blue axis, b, as well as the total color change ΔE. These parameters were measured in the initial situation (before applying any treatment), after staining and after the bleaching process.

The values of the indices measured for the control group GC are presented in **Table 1.**

Table 1. The average values measured in the three situations for the GC.

	Initial evaluation	**Evaluation after staining**		**Evaluation after bleaching**	
Block	**L**	**L**	**ΔE**	**L**	**ΔE**
10	71.2(0.7)	65.7(0.4)	10.1	65.7(0.1)	0
12	74.2(0.1)	57.4(1)	5.39	57.4(0.1)	0
17	77.9(6.9)	58.7(0.1)	21.8	58.7(0.1)	0
19	81.3(0.7)	79.3(1.6)	3.61	79.3(0.1)	0
21	74.3(0.5)	72.4(0.3)	2.74		0
22	81.6(0.5)	76.3(0.3)	6.84	76.3(0.1)	0
23	73.9(0.1)	79.9(0.6)	6.5	79.9(0.1)	0
24	81.5(0.6)	74.2(0.2)	8.44	74.2(0.1)	0
25	80.7(2.1)	72.7(1.3)	9.64	72.7(0.1)	0

L, a and b were described using the mean (standard deviation).

The values of the indices measured for GO, group bleached with commercial whitening gel are presented in **Table 2.**

Table 2. The average values of the indices measured in the three situations for GO.

Block	Initial evaluation	Evaluation after staining		Evaluation after bleaching	
	L	L	ΔE	L	ΔE
1	79.3(3.8)	71.2(0.1)	8.78	82(0)	11.9
5	70.6(0.5)	65.3(0.2)	8.38	76.3(0.2)	17
6	70.9(0.9)	67.5(0)	7.04	82.2(0.1)	20.3
7	77(0.1)	72.8(0.3)	5.93	76.4(0.2)	11.2
8	68.2(1.8)	60.2(0)	11.35	74.1(0.1)	17.7
13	71.6(0.1)	63.9(0.6)	11.34	72.6(0.1)	12.5
16	74(1)	63.1(0.9)	11.44	76.5(0.3)	13.9
20	81(2.1)	74.6(3.2)	6.96	73.2(0)	1.86

The values of the indices measured for the group GE group bleached with experimental gel are presented in **Table 3.**

Table 3. Mean values of the indices measured in the three situations for GE.

Block	Initial evaluation	Evaluation after staining		Evaluation after bleaching	
	L	L	ΔE	L	ΔE
4	65.6(0.3)	64.9(3.7)	5.23	75.3(0.4)	16.52
2	79.5(4.2)	69.8(0.1)	10.31	71(1.3)	3.32
11	77.7(5.3)	59.8(0.5)	18.1	68.2(0.3)	14.12
15	74.4(0.3)	59.7(0.2)	16.87	68.1(0.1)	11.4
18	73.5(0.3)	62.3(0.1)	13.02	67.9(0.2)	8.43
3	73.8(0.1)	61.7(0.1)	15.53	63.3(1.5)	10.69
9	79.9(3.4)	57.5(1.1)	87.14	66.5(0.1)	10.37
14	79.1(4.8)	57.5(1.42)	24.21	68(0.2)	11.09

Regarding the brightness parameter L, after staining (L_2), this differs statistically and significantly between the three groups tested ($p < 0.001$, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between the GO and GC groups there were no significant differences in brightness ($p = 0.053$, Mann-Whitney U test), but between GE and GO and GE and GC the differences were significant ($p < 0.001$, Mann-Whitney U test).

The brightness parameter L, after whitening (L_3), it differed statistically between the three groups tested ($p < 0.001$, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between the GE and GC

groups there were no significant differences in brightness (p = 0.193, Mann-Whitney U test), but between GE and GO and GE and GC the differences were significant (p <0.05, Mann-Whitney U test).

In the GO group there are statistically significant differences between L_1-L_2 (p <0.001), L_1-L_3 (p = 0.022) and L_3-L_2 (p <0.001) pairs. In the GE group there are statistically significant differences between L_1-L_2 (p <0.001), L_1-L_3 (p = 0.002) and L_3-L_2 (p <0.001) pairs.

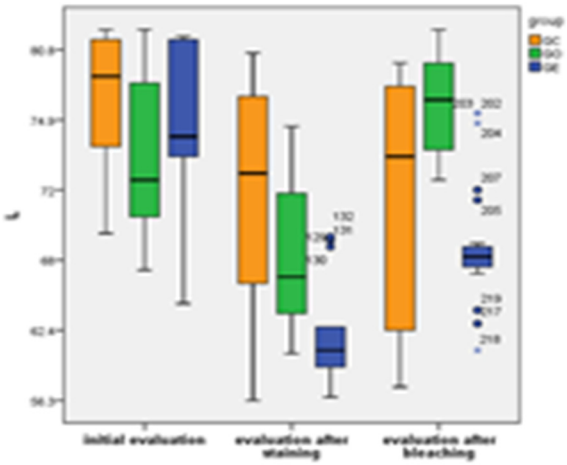

Figure 1. Modifications of the L parameter.

Regarding parameter Δa, after staining (a2), it differs statistically significantly between the three groups tested (p <0.001, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between GE and GO there were no significant differences (p = 0.074, Mann-Whitney U test), but between GE vs GC (p <0.001) and GO vs GC (p = 0.016) the differences are significant.

Parameter Δa after bleaching (a_3) differed statistically between the three groups tested (p <0.001, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between the GE and GO groups there were no significant differences in brightness (p = 0.131, Mann-Whitney U test), but between GE vs GC (p = 0.004) and GO vs GC (p <0.001), the differences are significant.

In the GO group, there are statistically significant differences between a_1-a_2 pairs (p <0.001) and a_3-a_2 pairs (p <0.001), but between a_1-a_3 there are no significant differences (p = 0.1).

In the GE group there are statistically significant differences between a_1-a_2 pairs (p <0.001), a_1-a_3 (p <0.001) and a_3-a_2 pairs (p <0.001).

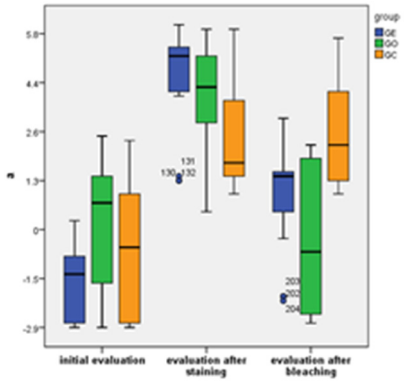

Figure 2. Modifications of ∆a parameter.

Regarding the parameter Δb, after staining (b2), it differs significantly between the three groups tested (p <0.001, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between GE and GO there were no significant differences (p = 0.19, Mann-Whitney U test), but between GE vs GC (p <0.001) and GO vs GC (p <0.001), the differences are significant.

The parameter Δb after bleaching (b_3) did not differ statistically between the three groups tested (p = 0.161, Kruskal-Wallis test). Continuing the post-hoc comparisons, we determined that between the GE and GO groups there were significant differences in brightness (p = 0.049, Mann-Whitney U test), but between GE vs GC (p = 0.193) and GO vs GC (p = 0.975), the differences are not significant. In the GO group there are statistically significant differences between the pairs b_1-b_2 (p <0.001), b_3-b_2 (p<0.001), and b_1-b_3 (p<0.001). In the GE group there are statistically significant differences between the pairs b_1-b_2 (p<0.001), b_1-b_3 (p = 0.028) and b_3-b_2 (p <0.001).

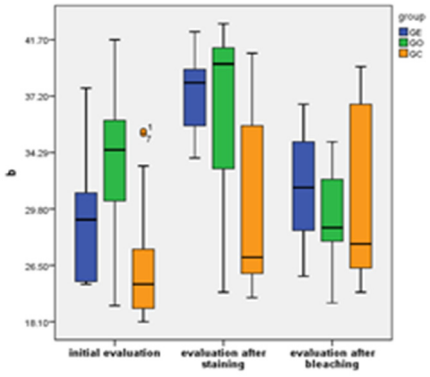

Figure 3. Modifications of ∆b parameter.

Color change, ΔE, after staining (E_2) differs statistically significantly between the three groups tested (p <0.001). Continuing the post-hoc comparisons, we found statistically significant differences between all groups of two groups taken: GE vs GO, GE vs GC and GO vs GC (p <0.001). Regarding the parameter ΔE, after staining (E_2) between the groups GE and GO there are significant differences (p <0.001). The ΔE parameter after bleaching (E_3) between the GE and GO groups did not show significant differences (p <0.001).

In the GO group there are statistically significant differences between E_3-E_2 (p = 0.001). In the GE group there are statistically significant differences between E_3-E_2 (p = 0.005).

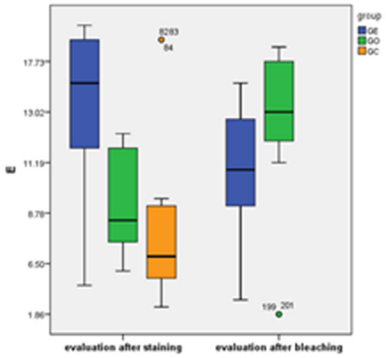

Figure 4. Modification of ΔE parameter.

It is well known that using CIEL*a*b system is the best option to measure the color change parameters [12]. Various research demonstrated that ΔE values between 1 and 3 are detectable to the eyes and values over 3,3 are clinically undesirable [13, 14]. At the end of the bleaching process, the most significant color change is represented by the lot bleached with 16% Opalescence, followed by the lot bleached with experimental green tea extract.

Tooth bleaching is a dynamic process, which involves diffusion of the bleaching material, which interacts with the chromophore molecules, but also acts on the surfaces on which they are applied, producing surface micromorphological changes and also changes in the depth of the tooth or restoration, modifying the optical properties [15].

Chromophore molecules fall into two categories: large organic compounds, which have conjugated double bonds in their structure and metal-containing compounds. The bleaching of the organic compounds with hydrogen peroxide implies the oxidation of the double bonds, after which they break. This causes the chromophore substance to become a lighter colored compound [16].

New studies have shown that during tooth bleaching process can result increased tooth sensitivity, changes in the microstructure of teeth and in the same time whitening gels can react chemically with composite restorations, glass ionomer cements, sealing materials and ceramic crowns, thus reducing their durability [16].

Other studies have shown that composite resin restorations are susceptible to unacceptable color changes, even when using OTC home systems [17].

Admira fusion is a nano-hybrid restoration material based on Ormocer technology (organically modified ceramics), which has been used instead of the classical matrix consisting of large and pre condensed molecules from an inorganic matrix with a high degree of crosslinking with the property of low shrinkage during light curing [18]. For this reason, the Admira fusion composite does not contain classical monomers, such as bisphenol A-glycidyl methacrylate, triethylene glycol dimethacrylate or hydroxyethyl methacrylate, thus eliminating the possibility of their release after polymerization and making the material more biocompatible. Recent study has proven that small dimensions of nano-filled composite resins may present low staining awareness [19, 20]. Also, Ayad has proven in a study that Ormocer based composite resins have undoubtedly a lower color sensitivity [21].

In literature, numerous studies [22],[13] have shown that the structure of the composite resin and its particle characteristics have a direct impact on the susceptibility to extrinsic staining. Furthermore, it has been shown that composite resins can undergo superficial and structural alterations, caused by mastication or various finishing and polishing processes [23-25]. The conclusion of the study was that carbamide peroxide was responsible for removing the dyes on the surfaces of the study specimens. It is known that during the tooth bleaching process, the active agents can penetrate the enamel and dentine, oxidizing the chromophore molecules. Some studies have indicated that surface bleaching of composite resins after bleaching was probably due to superficial cleaning of the samples, not necessarily to the intrinsic color change [26]. Therefore, after bleaching, the color of the composite resin restoration does not always match the color of the neighboring dental structures.

Recent research concerns raise the attention on the effects of natural herbal extracts. Numerous studies have indicated the anticancer, antibacterial and antioxidant effects of different plant extracts [27-29]. In addition, herbal products are non-cytotoxic, easily accessible, with a long shelf life [30].

It is known that the application of antioxidants after bleaching has beneficial effects on the adverse reactions following this therapeutic procedure. One such oxidant is green tea extract, due to its flavonoid content

[31, 32]. Thus a lot of studies have shown that green tea extract has the ability to neutralize free radicals and through this, it balance the oxidative stress from some diseases [31-33].

In a research, Khamverdi et al have proven that using green tea extract on teeth after bleaching with carbamide peroxide gels, might counterbalance the oxygen free radicals, responsible for altering the adhesion of composite resin restorations [30].

Some studies have demonstrated that alcoholic green tea extract has the most important antioxidant effect from some previously studied leafy herbal extracts [34,35].

Weber et al. have confirmed in analyze that due to their antioxidant power some herbal extracts can offer an innovative path to the prophylaxis of tooth erosions [36].

In another research, it was shown that noni juice can be a good alternative to sodium hypochlorite for endodontic irrigation and that it can successfully remove the root canal smear layer [37].

A recent study, regarding the bone loss in peri-implantitis, has demonstrated that this process can be the consequence of an oxidative stress and treating peri-implantitis with antioxidant herbal extract therapy can be a good choice [38].

Previous investigations have proven that triphala, a mix of equal proportion of three herbs has chelating action, removing the root canal smear layer [39 - 43].

Nowadays, it is a huge tendency of using plant extracts medicines due to their numerous, concomitant actions and very limited negative side effects and they can provide a good alternative to chemically synthetic therapy [44].

CONCLUSIONS

The results of the total color modification ΔE, after staining show values greater than 3 for all the groups studied, so the staining process was efficient in the whole study group.

After the bleaching process, the most significant color change was recorded by the group GO, bleached with Opalescence, while the GE experimental group recorded lower ΔE values, proving the antioxidant capacity of the green tea extract. However, in both cases $\Delta E_3 > 3$, so the color change was detectable with the naked eye.

EXPERIMENTAL SECTION

Specimen's preparation

The twenty-eight composite blocks with the size of 5mmx5mmx5mm were prepared from Admira fusion, a nano-hybrid composite resin (VocoGmBH, Cuxhaven, Germany). Silicone conformers (Elite HD putty, Zhemack SpA, Badia Polesine, Italy) were made, in which the composite blocks were constructed according to manufacturer's protocol.

Staining protocol

The entire group of composite blocks was subjected to a staining process, being immersed in coffee solution for 8 hours / day, for 3 consecutive days. The coffee solution was prepared in the Saeco Pico Baristo machine in espresso mode, using 5 grams of Lavazza coffee (Luigi Lavazza SpA, Turin, Italy) in 100 ml of water. Freshly prepared coffee solution was used at each session. During this procedure, the blocks were kept immersed in artificial saliva at 37ºC.

Bleaching protocol

The bleaching protocol aimed to simulate a home-use bleaching treatment, using individualized trays. Thus, 16% carbamide peroxide bleaching gel (Opalescence, Ultradent Products, South Jordan, UT, USA) was applied to the GO group 6 hours/day for 7 consecutive days. Study group GE was bleached with the experimental gel for 6 hours / day for 7 consecutive days. At the end of each bleaching step, the blocks were rinsed for 60 seconds in water and then stored in artificial saliva at 37ºC.

Experimental bleaching gel preparation

The green tea based experimental extract was prepared at the "Raluca Ripan" Chemistry Institute of Babes-Bolyai University, Cluj-Napoca as follows: 20 g of green tea leaves were added to 200 ml of boiled distilled water (R.Twining and Company Limited, London, UK). The extract solution was left to infuse for 10 minutes. The obtained product was filtered to remove possible impurities and was stored in sterile containers at 4ºC for later use. To obtain the experimental bleaching gel, the extract solution was used, to which carbamide peroxide, polyethylene glycol and silicon dioxide were added according to the formula: 100 g experimental bleaching gel contains: 22.2 g polyethylene glycol, 7.7 g silicon dioxide, 16 g carbamide peroxide and 54,1 g green tea extract.

Color measurement

Measurement of color parameters was performed using the Vita EasyShade Advance 4.0 spectrophotometer (Vita zahnfabrik, Bad Säckingen, Germany). The measurements were made in the CIE L*a*b* global mode and aimed to determine the color parameters L_1 (brightness), a_1 (the chromatic parameter in the red-green axis) and b_1 (the chromatic parameter in the yellow-blue axis) for the initial situation, L_2, a_2, b_2 and ΔE_1 after the staining process and parameters L_3, a_3, b_3 and ΔE_2 after bleaching procedure. For each unit and each situation, three measurements were made, among which an arithmetic mean was calculated.

The measurements were used to calculate the color difference, according to the formula:

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

The SPSS software package version 21.0 (SPSS Inc., Chicago, USA) was used for statistical analysis and graphical representations. The acceptable error threshold was α=0.05. In order to describe the continuous quantitative data with, we used the arithmetic mean and the standard deviation (SD). The Kruskal-Wallis ANOVA was used to test the differences in the investigated independent groups. The Mann-Whitney test was used in post-hoc analysis when significant differences were identified by Kruskal-Wallis ANOVA test. The Wilcoxon Signed Rank test was used to test the differences in the paired groups.

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