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Potential of 10% strawberry gel (*fragaria x annanasea*) as an alternative bleaching agent for extrinsic discoloration of composite resin: an in vitro study



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Abstract

Objective: The aim of this study was to examine the potential of 10% strawberry gel in reducing extrinsic discoloration of composite resin.

Material and Methods: This was a laboratory experimental study using 40 composite resins molded in 8-mm diameter and 2-mm thickness. Samples were soaked in coffee solution for 7 days to obtain discoloration and checked by VITAPAN classical shade guide and adobe photoshop CS4 Version 11.0 by CIEL*a*b method. The discolored samples were randomly divided into two groups of 20 samples of each group. Group I was treated with 10% strawberry gel for 8 hours every day in 12 consecutive days and group II as

control group was treated with 10% carbamide peroxide in the same way as group I.

Results: The results showed a significant change of the color in each group according to Friedman test ($p < 0.05$) while no significant color change difference of group I when compared to group II based on the results of Mann-Whitney test. Either 10% strawberry gel or 10% carbamid peroxide could not return the composite resins color into the baseline.

Conclusion: 10% strawberry gel has similar potency as 10% carbamid peroxide in reducing extrinsic discoloration of composite resin.

Keywords: 10% Strawberry gel, Bleaching agent, Composite resin, Extrinsic discoloration

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Introduction

Composite resins have been one of the most popular materials in aesthetic dentistry because of their excellent aesthetic properties and adequate strength. Aesthetic restorative materials should mimic the appearance of the natural tooth in both color match and color stability. However, restorative resin composites have a tendency to discolor in the oral environment due to intrinsic or extrinsic factors.^{1,2} Intrinsic discoloration are defined as change in the resin matrix or at the matrix/filler interface while extrinsic factors include staining due to superficial or deep absorption of colorants because of contamination from external sources.

Degree of external color change varies from patient to patient based on oral hygiene status, nutritional habits, lifestyle and cigarette smoking.³ These discolorations are the primary reason for replacing composite-resin restorations that tend to increase the preparation and restoration size which may eventually lead to destruction of the remaining tooth structures called 'restoration death spiral'.⁴ Thus alternative approaches were developed to minimize the loss of healthy dental tissue (minimal invasive approach).^{5,6}

Bleaching is one of the alternative approaches to reduce discolored composite resin restoration by the application of bleaching agent.⁷ Carbamide peroxide (CP) or hydrogen peroxide (HP) has been commonly used as bleaching agent that is able to

provide tooth color change and at the same time may yield color alterations of composite resin restorations.^{8,9} Pruthi et al.¹⁰ stated a significant color change was observed on composite resin and GIC restorations following application of 10% carbamide peroxide.⁸ Some other studies also reported color change of composite resin restoration following application of natural ingredients including tomatoes, calamandin, and strawberries.

Strawberry (*fragaria x annanasea*) is one of many fruits that can be used as natural bleaching agent. Margaretha et al.¹¹ reported the significant effect of strawberry juice on the brightness of enamel and restoration in composite resin-restored teeth. However high acidity of strawberry juice has become a concern that can affect roughness of the restoration. Addition of carbopol and triethanolamine (TEA) as gelling agent could be proposed to increase the pH.^{11,12} Therefore this study is aimed to examine the potential of strawberry fruits formulated into gel to be used as an alternative bleaching agent for extrinsic discoloration of dental composite resin.^{11,12}

Material and Methods

Collection and preparation of the material

The preparation of the material was done into 2 parts.

First part: strawberry fruits collected from high-

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land region of Malino, South Sulawesi, Indonesia, were rinsed with water, cut in a half, and extracted by maceration method. The extract was mixed with propylene glycol and formulated to prepare 10% strawberry gel.

Sample preparation

Twenty samples were fabricated from nanofilled composite resin (Filtek TM Z350 XT shade 3, 3M ESPE, USA) using a plastic mold of 8-mm diameter and 2-mm thickness. Samples were light-cured for 20 seconds on each side at 1 mm distance using LED light curing unit with light intensity 1500mW/cm² (Liang Ya Dental Equipment Co. Ltd LY-B200, Guangzhou). The samples were placed in distilled water at 37°C for 24 hours to ensure complete polymerization, and then were randomly divided into two groups of 20 samples each, soaked in coffee solution for 7 days. Group I was applied with 10% strawberry gel for 3 minutes and group II as control group was applied with 10% carbamide peroxide for 3 minutes (Opalescence PF®, Ultradent Products Inc, USA). Samples of both groups were kept for 8 hours, rinsed with water, dried and put them into a plastic container. The procedures were repeated in 12 consecutive days.

Color assessment

The color of all samples were analysed using VITAPAN Classical® Shade Guide (Vita Zahnfabrik H.Rauter GmbH & Co KG, Bad Sckingen, Germany) and Adobe Photoshop CS4 version 11.0 (Adobe Systems, USA) by CIEL*a*b* (Commission Internationale de l'Éclairage L*, a*, b*) method. Color was observed and determined at baseline (before treatment), after soaking in coffee solution for 7 days, and after treating with 10% strawberry gel and bleaching agent on day 3, 6, 9 and 12. Color change (E) was calculated by the equation below

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \text{ or } \Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

The color space consists of three coordinates L*, a* and b*. The L* refers to the lightness coordinate and its value ranges from 0 for perfect black to 100 for perfect white. The a* and b* are the chromaticity coordinates in the green-red axis and the blue-yellow axis, respectively. Negative a* values cover the green color range and negative values indicate red color range. Similarly, negative b* values indicate blue color range while positive values indicate yellow color range.

ΔE shows difference in color value of samples before treatment (L₁^{*}, a₁^{*}, b₁^{*}) in comparison with L₂^{*}, a₂^{*}, b₂^{*} value of samples after treatment. Thus six E were obtained from this method: a. ΔE1 (after soaking in coffee solution - baseline); b. ΔE2 (day 3 after treatment - after soaking in coffee solution); c. ΔE3 (day 6 - day 3 after treatment); d. ΔE4 (day 9 - day 6 after treatment); e. ΔE5 (day 12 - day 9 after treatment); f. ΔE6 (day 12 after treatment - baseline).

ΔE value <1 is considered not visible to the naked eye. A perceptible discoloration, that is ΔE >1.0 is acceptable up to the value of ΔE = 3.3 in subjective visual evaluation under optimal lighting conditions. A value E 3.3 is considered clinically acceptable in the study.

Statistical analysis

The results of color difference of each observation time of each group were analyzed by Friedman tests. The comparison of color change evaluation of both groups at each observation time was analyzed by Mann-Whitney test. For both tests, the level of significance was 5%.

Results

Table 1 showed E1 mean value in samples of group I was higher than 3.3 after soaking in coffee solution for 7 days (ΔE1: 9.91 ± 1.65). Following treatment with 10% strawberry gel, the value lower than 3.3 was observed on day 6 (ΔE3: 3.18 ± 1.82) and on day 12 (ΔE5: 0.37 ± 0.18).

Color change difference on day 12 after treatment with 10% strawberry gel compared with baseline color was also lower than 3.3 as seen in table 1 for group I (ΔE6 2.79 ± 1.60). In group II E1 mean value was also higher than 3.3 after soaking in coffee solution for 7 days (ΔE1: 10.48 ± 1.41). Following bleaching with 10% carbamide peroxide, the value lower than 3.3 was observed on day 6 (ΔE3: 2.47 ± 1.24) and on day 12 (ΔE5: 0.29 ± 0.12).

Comparison of color change difference on day 12 after bleaching and baseline was also lower than 3.3 as seen in table 1 for group II (ΔE6 2.39 ± 1.92). A significant change to lighter color was observed in each group after 12 days observation (p:0.000).

Table 2 showed color change difference value of group I was significantly lower than group II on day 3 (ΔE2) (p=0.017) and day 9 (ΔE4) (p=0.015). However the color difference value was still in clinically acceptable value, which is lower than 3.3.

The changes in the mean lightness and chromaticity coordinate (ΔL*, Δa*, Δb*) are presented

Table 1 Mean of color change difference value (ΔE) of each observation time of each group

Group	n	ΔE						p-value
		$\Delta E1$ Mean \pm SD	$\Delta E2$ Mean \pm SD	$\Delta E3$ Mean \pm SD	$\Delta E4$ Mean \pm SD	$\Delta E5$ Mean \pm SD	$\Delta E6$ Mean \pm SD	
I	20	9.91 \pm 1.65	4.73 \pm 1.33	3.18 \pm 1.82	3.78 \pm 1.50	0.37 \pm 1.50	2.79 \pm 1.60	0.000*
II	20	10.48 \pm 1.41	6.25 \pm 1.77	2.47 \pm 1.24	4.86 \pm 1.22	0.29 \pm 0.12	2.39 \pm 1.92	0.000*

aNormality test, Shapiro-Wilk test; p<0.05; data distribution not normal
*Friedman test; p<0.05, Significant

Table 2 Color change difference value (ΔE) between groups at each observation time

Group	n	ΔE						p-value
		$\Delta E1$ Mean \pm SD	$\Delta E2$ Mean \pm SD	$\Delta E3$ Mean \pm SD	$\Delta E4$ Mean \pm SD	$\Delta E5$ Mean \pm SD	$\Delta E6$ Mean \pm SD	
I	20	9.91 \pm 1.65	4.73 \pm 1.33	3.18 \pm 1.82	3.78 \pm 1.50	0.37 \pm 1.50	2.79 \pm 1.60	
II	20	10.48 \pm 1.41	6.25 \pm 1.77	2.47 \pm 1.24	4.86 \pm 1.22	0.29 \pm 0.12	2.39 \pm 1.92	
		0.234	0.017*	0.394	0.013*	0.261	0.957	

aNormality test, Shapiro-Wilk test; p<0.05; data distribution not normal
*Mann-Whitney test; p<0.05; significant

Table 3 Mean of ΔL^* , Δa^* , Δb^* value of each observation time of each group

Mean	ΔL	Group I		Group II		
		Δa	Δb	ΔL	Δa	Δb
$\Delta E1$	10.445	-0.0695	0.31475	9.185	0.0075	0.348
$\Delta E2$	5.4925	0.715	-2.804	-4.1365	0.716	-1.3517
$\Delta E3$	-2.179	-0.3485	0.0185	2.106	-0.2502	-1.0964
$\Delta E4$	-1.2745	0.0102	3.9305	-2.099	0.2648	1.9835
$\Delta E5$	-0.0885	-0.0167	-0.0405	-0.0012	-0.0468	-0.001

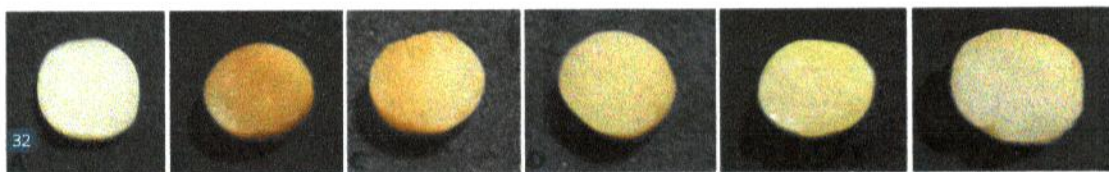


Figure 1 Visual composite resin's color: A. Baseline, B. After soaking in coffee solution, C-F. After treatment with 10% strawberry gel on day 3, day 6, day 9, and day 12. It was observed that 10% strawberry gel could lighten the composite resins color although it could not return the color lightness into baseline.

in table 3 and figure 3-5. The lightness values ΔL^* showed an increase for both groups, while the mean Δa^* values were relatively unstable and no observable change in the red-green chromaticity coordinate as seen in figure 4 although both groups almost return

to baseline despite fluctuation of Δa^* values. It was also observed for Δb^* values in figure 3. Data from our study indicates that changes in ΔE values were primarily due to changes in ΔL^* values.

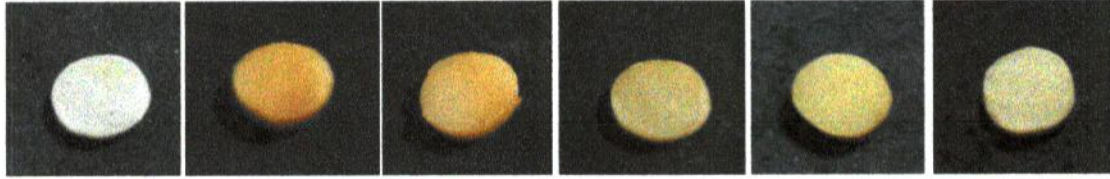


Figure 2 Visual composite resin's shade: a) baseline; b) after soaking in coffee solution; c-f) after bleaching with 10% carbamide peroxide on day 3, day 6, day 9, and day 12. It was observed that 10% carbamide peroxide could lighten the composite resins color although it could not return the color brightness into baseline.

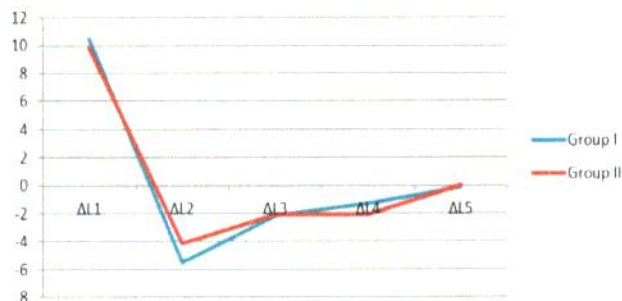


Figure 3 Changing of ΔL^* value during each observation time of each group

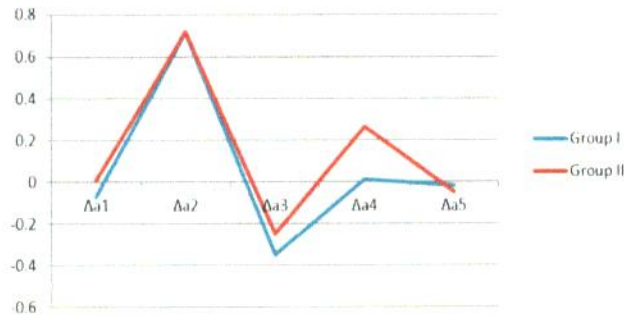


Figure 4 Changing of Δa^* value during each observation time of each group

Discussion

Color is a complex phenomenon and its perception is influenced by lighting conditions, translucency, opacity, light scattering, and the human eye, therefore it may be reported differently on different occasions.^{1,7,8} Two methods are usually used to evaluate color: vitapan for visual color assessment and CIE $L^*a^*b^*$ method (ΔE) which is also well

suited for determination of slightly color differences.

Excellent aesthetics is of utmost importance for tooth-colored materials to maintain their intrinsic color stability and resistance to surface staining. However, composite restorations acquire external stains when exposed to saliva, stains, food components, and beverages in the oral environment that can affect the esthetic quality of composite restorations.⁹ Drinking coffee is a trending lifestyle nowadays and studies showed coffee discolors composite restorations much more than tea and cola.^{15,16} Therefore coffee solution was chosen to discolor the samples in this study which showed perceptible color changes ($\Delta E_{ab}^* \geq 3.3$) following 7 days immersion. Yellow colorants contained in coffee are assumed to induce visible discoloration of composite resin.

External bleaching is one of many approaches to improve dental esthetics by reducing such discoloration and lead restoration to lighter color.⁵ That 10% carbamide peroxide can remove stain on the surface of composite resins and hybrid ionomer, however tooth sensitivity and gingival irritation can occur in some patients, although in most cases they are mild to moderate and transient. Natural bleaching materials were reported to have whitening potentials including tomatoes, strawberries, and calamondin.

Strawberry juice effectively lightens tooth enamel color after soaking it for 3 hours. It is proposed that high acidity of strawberry juice with pH value 3-4 is one of the factors in whitening the teeth. However this low pH tends to increase the surface roughness of the restorations causing them to pick-up stains more readily after bleaching. Therefore the pH in this study was increased by formulating a strawberry gel, and color change was also observed following treatment with 10% strawberry gel. This could be explained by the presence of ellagic acid and malic acid contained in strawberry (*Fragaria x annanasea*). The acids penetrate the organic matrix and release electrons by oxidation process that cause chromo-

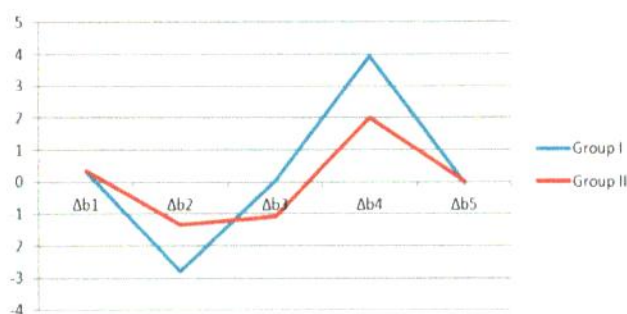


Figure 5 Changing of Δb^* value during each observation time of each group

gen degradation on the surface of composite resin which lead the composite resin into a lighter color.^{16,11} In addition, high level of ellagic acid produces more potential OH clusters which break and produce H⁺ radical as a powerful oxidizer thus make bleaching process more effective. In this study treatment with 10% strawberry gel showed similar significant color change with 10% carbamide peroxide for each observation time ($p < 0.05$). On the other hand, color change difference between groups was not significantly different at each observation time. This result was in line with the results reported by Margaretha et al.¹² that no significant of color change difference on teeth following immersion in strawberry juice and 10% carbamide peroxide for 2 weeks time.¹²

Both 10% strawberry gel and 10% carbamide peroxide could not return the samples' color into baseline color. This may be explained by the presence of bisphenol A diglycidyl methacrylate (Bis-GMA), and triethylene glycol dimethacrylate (TEGDMA) a hydrophilic monomer in composite resin that may be more susceptible to water sorption and discoloration over time. When each component of CIE L*a*b* method was analyzed, it was shown that the color of all samples became lighter (ΔL) following treatment with both 10% strawberry gel and 10% carbamide peroxide (diagram I). In contrast, both Δa (represent green-red color) and Δb (represent yellow-blue color) showed lack of changes (diagram II and III). This might be assumed that bleaching agent is only able to lighten the color of the samples. That 15% hydrogen peroxide could only lighten the discolored of composite resin into resemble baseline color. This could be related to camphorquinone (CQ) used as photo initiator in dental composite resin. Camphorquinone is a solid yellow compound with an unbleachable chromophore group, which might explain all samples' color could not

return into baseline color. 45% hydrogen peroxide could reduce discoloration into baseline color in 14 days. Further studies need to be carried out to evaluate the potency of strawberry gel in higher concentration.

Conclusion

Under the limitation of this study, it can be concluded that 10% strawberry gel has similar potency as 10% carbamide peroxide to reduce extrinsic discoloration of composite resin.

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Conflict of Interest

The authors report no conflict of interest.

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