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Effect of Small Starfruit (*Averrhoa bilimbi L.*) Extract Gel On Tooth Enamel Color Changes

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Abstract. This study aimed to analyze the color change effect of the application of small starfruit extract gel on tooth enamel. Thirty specimens of bovine teeth were divided into 6 groups that would receive applications of gels with different concentrations of Aceh's small starfruit extracts (70%, 80%, 90%) and of Bogor's small starfruit extracts (70%, 80%, 90%). The application of the gel was performed 4 hours per day for 14 days. The measurement of the color changes was performed before application and after 7 and 14 days of application by using a VITA Easyshade®. The changes were calculated according to the CIEL*a*b* formula. Dependent t-tests showed that there were significant color changes after application of the gels containing 70% and 80% of small starfruit extracts for 7 and 14 days, but the gels caused discoloration instead of whitening of the enamel surface of bovine teeth.

1. Introduction

Tooth whitening or dental bleaching has become one of the most demanded dental aesthetic treatments. Initially, tooth whitening treatment aimed at treating non-vital teeth that had been discolored by trauma or after endodontic treatment. However, modern trends have led to an increased demand for the whitening of vital teeth. In addition, Tooth whitening techniques have been developed continually. In the 1800s, tooth whitening could only be performed by a dentist at his practice location and was called in-office bleaching. In the late 1980s, tooth whitening techniques that could be performed by patients at home, referred to as home bleaching, became available. Both types of tooth whitening techniques have advantages and disadvantages [1–3].

The common ingredients used in tooth whitening include hydrogen peroxide and carbamide peroxide in the form of a gel or toothpaste with varying concentrations. In addition to the benefit of whitening teeth, these materials also have disadvantages; therefore, whitening must be performed properly and carefully. Some reports have mentioned tooth hypersensitivity and irritation of soft tissue as the most frequent side effects of tooth whitening treatments using both types of whitening materials. The use of a high-concentration tooth whitener to increase efficiency is believed to have an adverse effect on the state of the tooth structure [4,5]. It has been reported that some patients experienced side effects after dental treatment; 62.2% noted sensitive teeth, 45.9% had soft tissue irritation, 2.1% experienced systemic effects, and 18.8% had no side effects [6]. Research on natural bleaching ingredients continues because of the magnitude of the harm that can result from the use of tooth whitening. The use of natural ingredients as tooth whiteners is expected to restore the white color of teeth with minimal side effects.



Several studies have been conducted on natural tooth whitening agents, such as tomatoes, strawberries, and apples. These fruits have been shown to contain compounds capable of returning white color to discolored teeth. Tomatoes contain peroxide compounds, and strawberries and apples contain malic acid. In addition to these fruits, recent research has shown that small starfruit also can provide tooth whitening. Small starfruit contains carboxylic compounds, specifically oxalic acid, that can be used as a tooth whitening agent. Small starfruit has also been shown to contain peroxide compounds that can restore the white color of teeth [2,7].

A study conducted by Fauziah et al. showed that there was an increase in color values in teeth treated with small starfruit solution [8]. The study found that there were significant mean color changes in the teeth after application of small starfruit solution every 2 hours for 14 days. The study used visual observation to detect color changes, which resulted in significant variation in the assessments of color increase values that led to the conclusion that the changes were not homogeneous. There has been no research on whether the extract of small starfruit in the form of gels with different concentrations can change the color of teeth. Therefore, the aim of the study was to determine if gels containing small starfruit extract of different concentrations cause color changes sufficient for use as a natural bleaching agent for tooth whitening treatment.

2. Methods

2.1. Samples

This laboratory experimental research study was conducted at the Faculty of Dentistry, Universitas Indonesia from July to December 2014. The samples used were bovine incisive teeth obtained from slaughter houses in the Darussalam area, Banda Aceh. The samples used were 30 bovine incisors that met the inclusion criteria; i.e., no caries, no anomalies, and had a good buccal surface. Small starfruit from Aceh and Bogor, carboxymethyl cellulose, and saline were also used. The tools used were brushes, plastic pots, incubators, and the VITA Easyshade® clinical spectrophotometer (Vita Zahnfabrik, Bad Säckingen, Germany).

2.2. Specimen preparation

Thirty incisor crowns of a bovine mandibular were separated from their roots, and the pulp tissue was removed. Then, to prevent penetration of the gel into the crown, the cervical part of the crown was covered with a clear nail color. Next, the middle and lower third labial surfaces were covered with insulation to mark the area of gel application. Then, the 30 specimens were divided randomly into 6 treatment groups with each group consisting of 5 specimens. Each specimen was mounted on clear wax with the labial surface facing upwards. After the specimen preparation was complete, the VITA Easyshade color measuring tool (clinical spectrophotometer) was used to perform the color measurement on each specimen.

A total of 2 kg of small starfruit (*Averrhoa bilimbi* L.) originating from the Aceh and Bogor areas were subjected to a maceration extraction method to extract chemical substances. The extraction product was mixed with carboxymethyl cellulose gel material to make gels from each kind of small starfruit at 3 concentrations: 70%, 80%, and 90%. Then, the Aceh's and Bogor's small starfruit extract gels were each applied to the teeth in 3 of the 6 treatment groups ($n = 5$ teeth each group) at 70%, 80%, and 90% concentrations.

Each gel-treated specimen was inserted into an incubator set at a temperature of 37°C for 4 hours. The specimen was cleaned by using absorbent paper and Aqua Bidest after incubation. Then, the specimen was put back into the plastic pot. This procedure was repeated for up to 7 days and 14 days of application. Color change measurements were performed after 7 days and 14 days of application by using the VITA Easyshade color measuring tool. The VITA Easyshade provided the values of L^* , a^* , and b^* , which were then used in the formula $\Delta f_{ab}(L^*a^*b) = [(\Delta L^*)^2 + (\Delta a^*_{ab})^2 + (\Delta b^*_{ab})^2]^{1/2}$ to calculate the color change value (ΔE_{ab}).

After obtaining the results, the SPSS program and the dependent t-test were used to perform the data analysis to determine the significance of differences in the color change values based on the

application duration. The independent t-test was used to determine the significance of differences in the color change values based on the varying gel concentrations.

3. Results

The color change values were obtained according to the following formula: $\Delta E^*_{ab}(L^*a^*b) = [(\Delta L^*)^2 + (\Delta a^*_{ab})^2 + (\Delta b^*_{ab})^2]^{1/2}$. These values show the color changes that occur in the specimens from initial until after the application of the gel. ΔE^*_{0-7} and ΔE^*_{0-14} are the differences in ΔE^* between the initial value and the after 7 days and after 14 days of application values, respectively. The color changes (ΔE^*) are presented in Table 1.

Table 1. Mean Values of Tooth Enamel Color Changes (ΔE^*) Before, After 7 days, and After 14 days of Small Starfruit Extract Gel Application

Groups	Concentration (%)	ΔE^* Mean Values				
		Initial ΔE^*	7 Days ΔE^*	ΔE^*_{0-7}	14 Days ΔE^*	ΔE^*_{0-14}
ASS	70%	84.75	91.02	6.67	92.04	7.55
	80%	88.22	92.83	4.61	93.92	5.70
	90%	84.75	89.14	4.39	90.99	6.24
BSS	70%	81.97	91.02	9.04	92.04	10.07
	80%	79.20	88.34	9.13	88.81	9.61
	90%	88.85	91.49	2.63	93.00	4.15

ASS: Aceh's Small Starfruit

BSS: Bogor's Small Starfruit

Table 1 shows the ΔE^* mean values in each group before and after application of small starfruit extract gels for 7 days and 14 days. The normality test results showed normally distributed data ($p > 0.05$). The values represent the color changes in all groups after application of Aceh and Bogor small starfruit extract gels at various concentrations.

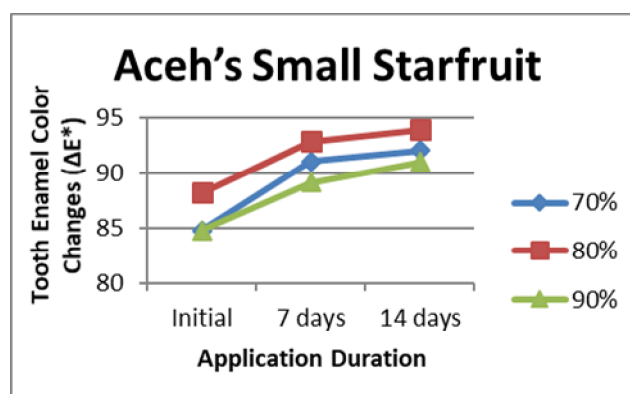


Figure 1. Mean Change in Tooth Color (ΔE^*) Values Versus Gel Application Duration in the ASS Group

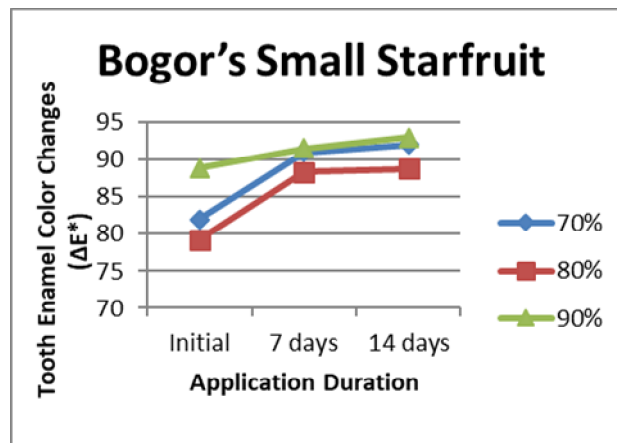


Figure 2. Mean Change in Tooth Color (ΔE^*) Values Versus Gel Application Duration in the BSS Group

In the Aceh's small starfruit extract treatment group, the mean value of ΔE^* increased with increasing application duration (Figure 1). The dependent t-tests showed that significant color changes occurred at concentrations of 70% and 80% but not at 90%. At 80% concentration, significant color changes occurred from initial up to 7 days, from 7 days to 14 days, and from initial to 14 days of application. At 70% concentrations, significant color changes occurred only from initial to 7 days and 14 days of application.

The ΔE^* mean values also increased in the Bogor's small starfruit extract gel treatment group after 7 days and 14 days of application (Figure 2). The dependent t-tests showed that significant color changes also occurred at concentrations of 70% and 80%, but not at 90%, from initial up to 7 days and 14 days of application.

In addition to the duration of the application of the gel, color changes were also seen with varying concentrations of each type of small starfruit. In the Aceh and Bogor small starfruit groups, the most significant color changes after 7 days and 14 days application occurred at 70% concentration. Independent t-tests were used to determine the significance of mean color changes versus concentrations (ΔE^*_{0-7} and ΔE^*_{0-14}). The color changes versus concentration in the Aceh's small starfruit gel group were not significant after either 7 days or after 14 days of application. In contrast, the color changes versus concentration in the Bogor's small starfruit gel group were significant between 70% and 90% concentrations and between 80% and 90% concentrations after 7 days of application and between 70% and 90% concentrations after 14 days of application.

4. Discussion

In this study, color changes were represented by ΔE^* , which was influenced strongly by the color forming elements ΔL^* , Δa^* , and Δb^* . The whitening effect was observed when significant changes in ΔE^* were followed by an increase in ΔL^* combined with a significant decrease in Δa^* and Δb^* . The data showed that color changes were observed for each specimen after application with the Aceh and Bogor small starfruit extract gels. The increase in ΔE^* values indicated that the longer the enamel was exposed to the small starfruit extract gels, the greater the color change.

Independent t-tests were performed on each type of Aceh and Bogor small starfruit to determine the effect of different concentrations on tooth color changes. No significant differences in the color change component (ΔE^*) between 70%, 80%, and 90% concentrations were observed in the Aceh's small starfruit extract gel group. However, in contrast to the Aceh's small starfruit extract gel, the Bogor's small starfruit extract gel showed significant changes in the color change component (ΔE^*) between 70% and 90% days after 14 days of application. Significantly different color changes also occurred between the 80% and 90% concentration groups but only after 7 days of application. The

non-significant color changes (ΔE^*) in the Aceh and Bogor small starfruit extracts were thought to be due to differences in the color component values before the application of the gel in each specimen.

In addition to the comparisons among different concentration groups, the color change ratio versus gel application duration was also calculated. The color changes in each group between application durations were compared by performing dependent t-tests. In the Aceh's small starfruit extract gel group, a significant increase in ΔE^* values occurred from initial up to 7 days and 14 days of application at the 70% concentration. At the 80% concentration, ΔE^* continued to increase significantly from initial to 7 days and 14 days of application and from 7 days to 14 days of application. In contrast to the 90% concentration group, the increases in ΔE^* values from initial up to 7 days and 14 days of application were not statistically significant.

Similar to the Aceh's small starfruit extract gel group, the Bogor's small starfruit extract gel group showed increased values of ΔE^* after 7 days and 14 days of application at some concentrations. The 70% and 80% concentrations, but not the 90% concentration, showed similar improvement patterns; i.e., increases in ΔE^* values were significant from initial up to 7 days and 14 days of the application of the gel.

Significant changes in the ΔE^* value components after 7 days and 14 days of application indicated a greater change in color due to the longer exposure in the groups applied with small starfruit extract gel. According to CIELAB theory, tooth color changes (ΔE^*) above 3.3 after application are relatively large and clinically unacceptable. Significant color changes before and after the application of the gel is strongly influenced by the changes in the color components; i.e., changes in brightness, red–green, and yellow–blue. In this study, the color changes on the enamel surface of the specimens that were originally gray translucent became brownish yellow after application of small starfruit extract gels. The color changes in the surface discoloration of enamel were assumed to be influenced by the tannins contained in the small starfruit extract gels. The yellowish-brown color of the gel is derived from the small starfruit extract. The small starfruit component test results have shown the presence of various kinds of color pigment agents, including tannin that exhibited a yellowish-brown pigment.

According to Nordbo H., tannin is one of the chromogenic agents that can cause tooth discoloration to become darker. In addition to chromogenic agents, tooth discoloration can also be affected by tooth enamel roughness caused by the low pH (high acidity) of compounds exposed to tooth enamel. Research conducted by Fujii et al. showed that at a pH of approximately 6.3, the roughness of tooth enamel did not change, so this pH can be considered to be neutral [9]. In the present study, the small starfruit extract gels were highly acidic; analysis showed that the small starfruit extracts had pH values ranging from 1.75 to 2.09. The low pH values of the small starfruit extracts, which were below the critical enamel pH damage threshold value (<5.5), indicate the possibility of increased tooth enamel roughness after application that could result in further penetration of pigment color into the tooth structure. In addition, a very acidic pH gel also erodes the surface of the enamel, which causes the dentine color to become more pronounced because of the transparent nature of the enamel.

5. Conclusion

The study results indicated that color changes occurred in the specimens after application of Aceh and Bogor small starfruit extract gels at concentrations of 70%, 80%, and 90%. The color changes that occurred caused discoloration of the teeth that could be seen clinically. The surface discoloration of the enamel was caused by tannin in the gel, which turned the originally gray translucent specimens to brownish yellow after the application of the gel.

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