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THE EFFECT OF STAR FRUIT JUICE (Averrhoa bilimbi Linn.) ON TOOTH COLOR CHANGES IN THE TOOTH BLEACHING PROCESS

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ABSTRACT
Background: Tooth discoloration is an aesthetic problem that motivates patients to seek treatment. Tooth discoloration can be addressed through dental bleaching treatment. Natural ingredients can be used as an alternative to teeth whitening that is safer, more readily available, and more affordable. Bilimbi fruit juice (*Averrhoa bilimbi Linn.*) contains oxalic acid, which acts as an oxidizing agent capable of breaking down pigments by releasing oxygen in the form of free radicals. The released oxygen then breaks down the complex pigment molecules that cause tooth discoloration into simpler, colorless molecules, resulting in a whitening effect on the teeth. **Objective:** To determine the effect of color of teeth soaked in bilimbi fruit juice (*Averrhoa bilimbi Linn.*) on the bleaching process. **Methods**: This research is an experimental laboratory study with a pre-test post-test design method. The research sample consisted of 27 first and second permanent premolars, both maxillary and mandibular, which were soaked in bilimbi fruit juice (*Averrhoa bilimbi Linn.*) with a duration of 1 hour, 3 hours and 5 hours. The study was conducted by measuring differences in tooth color after soaking using Vita Easyshade V. **Results:** All groups of samples produced changes after soaking bilimbi fruit juice (*Averrhoa bilimbi Linn.*). The value of light, chrome, and hue showed a significant difference in tooth color (sig < 0.05). **Conclusion:** There is an effect of color change on teeth soaked in starfruit juice extract (Averrhoa bilimbi Linn.), there are changes in tooth color after being soaked in starfruit juice (*Averrhoa bilimbi Linn.*) due to its oxalic acid content and influenced by pH, concentration, soaking duration, surface cleanliness of the teeth, shelf life of the material, temperature, sealed environment, and additives.

INTRODUCTION

Tooth discoloration is an aesthetic issue that motivates patients to seek treatment. Teeth are considered discolored when their color does not match their normal tooth color. Tooth discoloration is often considered disturbing because it makes people feel uncomfortable when talking or smiling. (Santoso L et al., 2016).

Tooth discoloration can have a negative impact on those who experience it, especially if it occurs on the front teeth, which are the center of attention when someone speaks or opens their mouth. Factors that cause tooth discoloration can be internal, external, or a combination of both. Internal tooth discoloration can occur systemically or be congenital within the tooth structure. Meanwhile, external tooth discoloration generally forms on the tooth surface or pellicle layer due to the presence of coloring agents (chromogens) from certain food or beverage consumption patterns, such as coffee and tea, smoking habits, or the use of mouthwash containing chlorhexidine. (Chasanah N et al., 2021).

People are increasingly aware that tooth discoloration is a physical aspect that can affect a person's appearance. Meanwhile, dental bleaching that patients can apply independently at home under the supervision of a dentist is called home bleaching. Common chemicals used in teeth whitening procedures include carbamide peroxide in various concentrations in gel or paste forms.[5,6]

The tooth whitening process with carbamide peroxide occurs through an oxidation reaction that converts peroxide compounds into dihydroxy and oxygenase. These compounds then form free radicals that can bind to stain-causing compounds on the tooth surface. Although this ingredient has been proven to whiten teeth, its use still has drawbacks that must be considered, so the bleaching procedure must be carried out correctly. The application of high-concentration teeth whitening agents can actually cause changes in tooth structure. Several studies have suggested that these bleaching agents can cause tooth hypersensitivity and irritation of the soft tissues of the oral cavity.6

This has prompted researchers to seek alternatives using natural ingredients as teeth whitening agents. These natural ingredients are considered to have several advantages, such as being readily available, economical, and having a lower risk of side effects compared to chemical substances. Indonesia is listed as the country with the largest potential for herbal plants after Brazil, with approximately 9,000 plant species suspected of containing phytochemical compounds with potential medicinal uses. One example of a natural ingredient that can be used is starfruit (Averrhoa bilimbi Linn.) because it contains carboxylate compounds in the form of oxalic acid which functions as a teeth whitening agent. (Selvia EY et al., 2021). Starfruit extract gel has been proven to be an alternative natural tooth whitening ingredient. (Natalia G., 2019) A gel preparation made from starfruit extract can be used as a natural alternative in home bleaching methods to improve tooth color brightness(Permata IC, 2021)

METHODS

This study is a laboratory experimental study with a pre-test post-test design. The samples used were 27 permanent premolar teeth (upper and lower jaws) divided into three groups based on the duration of immersion in starfruit juice (1 hour, 3 hours, and 5 hours). The number of samples was determined using the Federer formula to obtain 27 samples, each with 9 samples per treatment group. Data were analyzed univariately (frequency distribution and mean) and bivariately to compare tooth color before and after immersion. Statistical tests used include: Normality test (Shapiro-Wilk), Homogeneity test (Levene's test),

Paired sample t-test to see significant differences between treatment times.

RESULTS AND DISCUSSION

Table 1 Average sample results

Time	Average	Warna		
		L	C	H
1 hour	Before soaking	19.233	14.678	0.888
	After soaking	20.189	12.856	-0.944
3 hours	Before soaking	18.822	14.922	0.944
	After soaking	21.144	12.911	-0.544
5 hours	Before soaking	18.867	15.067	0.878
	After soaking	23.311	12.456	-0.122

Based on the average results in Table 5.3 above, there was an increase in light values in each group after immersion for 1 hour, 3 hours, and 5 hours. The 5-hour immersion showed a higher increase compared to the 1-hour and 3-hour immersions.

The chromium value decreased most significantly in the 5-hour immersion group compared to the other groups. The 1-hour immersion group experienced the greatest decrease in hue values.

Table 2 Paired T-test

Time	Color	Mean ± SD		*p-value*
		Before	after	
1 hour	*Light*	19.23 ± 0.74	20.189 ± 1.05	0.001*
	Chrome	14.68 ± 1.05	12.86 ± 0.78	0.000*
	Hue	0.79 ± 0.59	-0.94 ± 0.53	0.001*
3 hours	*Light*	18.82 ± 1.22	21.14 ±1.27	0.000*
	Chrome	14.92 ± 2.20	12.91 ± 1.98	0.000*
	Hue	0.94 ± 0.70	-0.54 ± 0.34	0.001*
5 hours	*Light*	18.87 ± 2.03	23.31 ± 2.24	0.000*
	Chrome	15.07 ± 2.18	12.46 ± 1.72	0.000*
	Hue	0.88 ± 0.54	-0.12 ± 0.57	0.001*

* Significant p-value <0.05

Based on the t-test results in Table 5.6, it can be seen that during immersion for 1 hour, 3 hours, and 5 hours, there were significant changes in the color of the first and second permanent premolars of both the upper and lower jaws before and after immersion in starfruit juice, as indicated by a p-value <0.05. This concludes that before and after immersion, there were significant changes in the color of the teeth (L, C, and H). Therefore, the hypothesis stating that starfruit juice has an effect on tooth color changes during 1 hour, 3 hours, and 5 hours is accepted. Tooth discoloration is an aesthetic issue that can motivate patients to seek treatment. A 2017 study by Marheni in Bali, Indonesia, showed that 80% of people were dissatisfied with their tooth color. This dissatisfaction can potentially lower self-confidence, especially when speaking or smiling. This is in line with the results of a study by Da Costa et al. (2017) in Brazil, which showed that 50% of people have a positive perception of dental aesthetics, including tooth color. This is supported by a study by Isiekwe and Aikins (2019), which stated that 90% of people agree that healthy tooth color affects physical appearance and quality of life. Teeth are considered discolored when their color does not match their normal tooth color. There are two factors that can cause tooth discoloration: extrinsic and intrinsic factors. Extrinsic discoloration is common and can be caused by many factors, such as poor oral hygiene, restorations, gingival bleeding, plaque buildup, dietary habits, or the presence of chromogenic microorganisms. Intrinsic tooth discoloration includes the use of certain medications such as tetracycline, excess fluoride, and other types of trauma.

Teeth bleaching is the process of lightening discolored teeth by applying chemicals to them to bring them closer to their natural color. Bleaching can lighten teeth by using chemicals to oxidize organic pigmentation in teeth. However, the use of chemicals in dental bleaching procedures can cause side effects, including decreased enamel surface hardness, gingival irritation, tooth sensitivity, and higher costs. Therefore, researchers are looking for natural ingredients as teeth whitening agents that are more readily available, economical, and have fewer side effects than chemical ones. According to research by Prastiwi CD & Wijayanti N, (2016), star fruit is one natural ingredient proven effective as a teeth whitening agent. This is in line with research by Niswatun et al. (2021), which states that star fruit extract plays a role in whitening teeth.

This study used starfruit juice (Averrhoa bilimbi Linn.), which is commonly used as a spice or cooking ingredient and traditional food preservative. Starfruit is often found in markets. The whitening process was carried out by immersing the teeth in starfruit juice at a concentration of 100% for 1 hour, 3 hours, and 5 hours. Before immersion, the pH was checked to determine the acidity level of the starfruit. Color measurements of the first or second permanent premolar tooth samples were carried out before and after immersion in starfruit juice using VITA Easyshade V. This difference in immersion time was chosen based on previous research by Tsaniya (2022), with the results of the study showing color differences in all treatment groups after immersion for 1 hour, 3 hours, and 5 hours in starfruit juice. These results are in line with the research of Niswatun et al. (2021), which showed an increase in tooth color brightness after soaking with starfruit extract gel. This study is also supported by research by Asih et al. (2021), which stated that starfruit extract gel has an effect on increasing tooth color brightness. In addition, these results are consistent with research by Permata (2021), which stated that starfruit extract gel is effective as an alternative

natural bleaching agent, with tooth brightness increasing with increasing natural soaking time. Meanwhile, according to I Gusti Agung Ayu Hartini (2024), 100% starfruit juice (Averrhoa bilimbi Linn.) can be used as an alternative ingredient to brighten teeth but is not more effective than 10% carbamide peroxide gel.[3,6,7,11,12]

The oxalic acid in starfruit functions as an oxidizing agent that can be used in teeth whitening. According to Selvia EY et al. (2021), oxalic acid, as an oxidizing agent, can break down pigments by releasing oxygen in the form of free radicals. This oxygen then breaks down the complex pigment molecules that cause tooth discoloration into simpler, colorless molecules, resulting in whiter teeth.[5]

From the results of the research that has been conducted, it was found that there were differences in tooth color that occurred after soaking using starfruit juice (Averrhoa bilimbi Linn.) for 1 hour, 3 hours, and 5 hours. This indicates that starfruit juice contains oxalic acid which is a strong oxidizer. In line with research conducted by Hartini IGAA et al., (2023), which stated that the oxalic acid content in starfruit is effective for whitening teeth by oxidizing the surface of tooth enamel. Supported by the results of research by Cahyarani (2025), which stated that the oxalic acid content in starfruit with various concentrations, namely 20%, 40%, and 60%, the results obtained starfruit extract with various concentrations are effective in whitening teeth.[6,13,14]

Based on the results of this study, there were changes in the L, C, and H values in each sample group. An increase in the L value in samples soaked in starfruit juice indicates that the tooth color became brighter. This is in accordance with the theory proposed by Aschheim KW, (2015) which states that the L value is used to describe the level of brightness or darkness of tooth color, where the higher the L value, the brighter the tooth color, while a lower L value indicates a darker tooth color. This is also in line with the theory of Craig's Restorative Dental Materials (2019), which explains that the L value describes lightness, with a range from 0 (black) to 100 (white). An increasing L value indicates an increase in tooth color brightness.[15,16]

Based on the average L graph (Figure 5.1), it can be seen that the color change with the highest average increase in value was found in the 5-hour group. Therefore, the samples that had been soaked in starfruit juice for 5 hours experienced a brighter color change compared to the other immersion groups. The difference seen in the 5-hour immersion in starfruit juice can be interpreted as meaning that the group with a longer immersion time will likely produce whiter tooth color changes. This is in line with research by Permata (2021), which stated that starfruit extract gel is effective as an alternative natural tooth bleaching agent, with the level of tooth brightness increasing with increasing immersion time. This statement is also supported by the theory of Craig's Restorative Dental Materials (2019) and Grossman (2021), which explains that tooth color changes during the bleaching process can be influenced by several factors, such as tooth surface cleanliness, material concentration, temperature, pH, immersion duration, and patient age.[7,16,17]

Based on phytochemical tests conducted at the Department of Food Science and Technology Laboratory of Bogor Agricultural University (IPB), starfruit juice (Averrhoa bilimbi Linn.) was found to contain saponins and steroids. These saponins and steroids play a role in tooth discoloration, as saponins have surfactant properties that help clean tooth surfaces, while steroids can undergo oxidation reactions, producing chromophore groups (conjugated unsaturated carbons).[18,19,20]

The results of data analysis using a paired t-test in this study showed that there were significant differences ($p < 0.05$) in the measurement of L, C, and H values in each sample time group, both before and after being soaked in starfruit juice. However, this is different from Natalia Grace (2019), who conducted a study on the effect of starfruit extract gel (Averrhoa bilimbi Linn.) as an alternative home bleaching agent on tooth discoloration, with the results obtained showing no significant differences. The insignificant measurement values were explained because the cleanliness of the tooth surface was still considered inadequate and the success of bleaching was also determined by the soaking time. However, this study is supported by research conducted by Niswatun et al. (2021), Asih et al. (2021), Permata (2021), Hartini IGAA & Primadana AARA, (2024), and Cahyarani SF, (2025) which also stated that there were significant differences in tooth color before and after being given starfruit treatment. Thus, the results of this study support the theory that the acid content in star fruit has the potential to be a natural whitening agent that can affect the brightness of tooth color.

CONCLUSION

This study shows that there is an effect of color change on teeth soaked in starfruit juice extract (Averrhoa bilimbi Linn.), significantly affects tooth discoloration during the bleaching process. Soaking teeth in starfruit juice for 1, 3, and 5 hours increased lightness (L) values and decreased chroma (C) and hue (H) values. The most optimal whitening effect was achieved in the 5-hour soaking group.

Thus, the oxalic acid content in starfruit juice acts as a natural oxidizing agent capable of breaking down discoloration-causing pigments, resulting in brighter teeth. These results support the potential of starfruit juice as a safer and more affordable natural alternative for tooth bleaching procedures.

SUGGESTIONS

After conducting the research, there are several suggestions that the author can convey regarding the need for further research using other natural bleaching materials to see the effects on the teeth that occur.

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