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The Difference in Effectiveness of Strawberry Juice (Fragaria x Annanasea) and Blueberry Juice (Vaccinium Corybosum) on Tooth Discoloration During Teeth Whitening

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ABSTRACT

Background: Tooth discoloration is a common aesthetic problem and can affect self-confidence. One solution to this problem is a tooth whitening procedure, using either chemical or natural ingredients. Objective: To compare the effectiveness of strawberry juice and blueberry juice on tooth discoloration during the teeth whitening process. Methods: This was a laboratory experimental study using a pre-test and post-test control group design. Twenty-four permanent first and second premolar teeth were immersed in red grape extract and green grape extract for 1, 3, and 5 hours, respectively. Tooth color was measured before and after immersion using a VITA Easyshade V digital spectrophotometer, based on L (lightness), C (chroma), and H (hue) values. Results: The study showed an increase in L values and a decrease in C and H values, indicating a significant difference in tooth color (sig <0.05) across all immersion groups, using both strawberry juice and blueberry juice. The most significant increase in L values occurred in the 5-hour soaking group with strawberry juice. Conclusion: There is a difference in effectiveness between strawberry juice and blueberry juice in the tooth whitening process. Strawberry juice is more effective as a natural external tooth whitening agent, especially with longer soaking times, due to its active ingredients such as malic acid, electic acid, vitamin C, and phenolic compounds. There is also a difference in pH between strawberry and blueberry juices. The pH value of strawberry juice is lower than that of blueberry juice

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INTRODUCTION

Discolored teeth are a significant aesthetic concern, and people often seek to alter their appearance to improve their aesthetics. Appearance is important to everyone, and discolored teeth can be a contributing factor to a decrease in self-confidence. Aesthetic treatments are essential to achieving a better appearance. Tooth discoloration is typically caused by smoking and consuming coffee, tea, or carbonated beverages, leading to tooth decay, a common problem for patients. Bleaching is a treatment used to brighten and improve tooth color, and many patients seek this treatment.

Discoloration can occur due to extrinsic and intrinsic factors. Extrinsic tooth discoloration is influenced by chromogens from foods consumed during dieting, mouthwashes, and plaque on the tooth surface. Intrinsic factors, on the other hand, are caused by the body's metabolism, genetics, and local factors. Bleaching is an effective dental treatment for instantly whitening discolored teeth. The cost of in-clinic teeth whitening treatments is relatively more expensive than at-home teeth whitening treatments. The main active ingredients in teeth whitening products vary depending on the manufacturer, but generally include substances such as hydrogen peroxide, carbamide peroxide, or urea peroxide. Additionally, there are also non-hydrogen peroxide systems containing components such as sodium chloride, oxygen, and sodium fluoride. Some products even include potassium nitrate and fluoride to reduce tooth sensitivity. Carbamide peroxide itself is a combination of hydrogen peroxide and urea. The concentration of this compound in whitening products typically ranges from 10% to 22%, with the most common concentration being 10%, and an average acidity level (pH) between 5.3 and 5.6.

Carbamide peroxide has a distinctive aroma and is formulated with glycerin or propylene glycol, as well as sodium stannate, phosphoric acid, or citric acid. It is unstable and can decompose into urea, ammonia, carbon monoxide, and hydrogen. Carbamide peroxide is widely used in extracoronal bleaching methods and remains under the supervision of a dentist.

Fruits are natural ingredients with the potential to help treat and prevent various diseases.

Various studies have been conducted to explore the health benefits of fruit consumption, particularly regarding the active compounds that play a role in the prevention and treatment of certain diseases. Natural ingredients have been widely used for generations, including strawberries and blueberries, which can be used as natural teeth whitening agents. They theoretically contain the enzyme peroxidase that can convert into hydrogen peroxide, which can function as a teeth whitening agent.

A 2022 study by Febriani M, et al., examined the effect of strawberry juice as a teeth whitening agent due to its malic and ellagic acid content, which helps whiten discolored teeth. A 2018 study by Nikla S. et al. examined the potential of strawberry production as a tooth bleaching agent due to its high vitamin C and antioxidant content. A 2023 study by Hamrun N. et al., using strawberry juice (Fragaria x annanasea) at various concentrations (100%), found that strawberry

juice can improve tooth discoloration and brighten teeth due to its content of ellegic and malic acids.

A 2020 study by Afrida F., investigating the potential of strawberries as a tooth whitening agent, showed that the discoloration of teeth soaked in strawberry juice was due to the malic acid (C4H6O5) and ellegic acid (C6H6O8), found in strawberries. Furthermore, strawberries have a low pH, making them more effective at whitening teeth than other fruits.

Of the studies mentioned above, very few have discussed the use of strawberry juice and blueberry juice as natural bleaching agents, prompting the author to investigate further.

Based on the aforementioned background, this study aims to compare the effectiveness of strawberry juice and blueberry juice as teeth whitening agents in the teeth bleaching process. This study aimed to determine the difference in effectiveness of strawberry juice and blueberry juice on tooth discoloration during the teeth whitening process. It is hoped that the results of this study will contribute to the community by providing alternative natural ingredients that are safe, economical, and able to minimize side effects such as tooth sensitivity during the whitening process.

THEORETICAL REVIEW

Bleaching restores the normal color of teeth by removing staining substances with strong oxidants known as bleaching agents, such as hydrogen peroxide, sodium perborate, and carbamide peroxide. The mechanism of action of teeth whitening is based on an oxidation process involving a chemical reaction between the bleaching agent and the molecules that cause tooth discoloration. The most commonly used bleaching agents are hydrogen peroxide (H2O2) and its derivatives, which act as strong oxidizing agents. These compounds produce highly reactive free radicals, which then penetrate the tooth enamel and enter the dentinal tubules.

In the tooth tissue, these free radicals react with large, highly pigmented organic molecules, the primary cause of discoloration. This process converts these molecules into smaller, colorless, and more stable compounds. This chemical process increases the amount of light reflected by the tooth surface, making the teeth appear brighter and whiter. Bleaching can be performed in two ways: in-office bleaching and home bleaching, either directly by a dentist or at home under the supervision of a dentist.

In-office bleaching is the most preferred method due to its rapid results. Dental clinics use this bleaching technique. Between 35 and 40 percent hydrogen peroxide and 35 percent carbamide peroxide are used. The advantage of this technique is faster results and shorter time required. This method can help remove yellow-brown discoloration from teeth. Home bleaching procedures on their vital teeth are performed using a night guard and 10% carbamide peroxide. The advantages of this home bleaching system are that it is easy, inexpensive, safe, and has a high success rate.

Tooth whitening treatments on non-vital teeth are generally performed after root canal (endodontic) procedures, when discoloration occurs in the pulp

chamber. Discoloration in vital teeth can be treated by applying an oxidizing agent directly to the tooth surface. This technique is used for conditions such as mild enamel discoloration, endemic fluorosis, and tooth discoloration due to natural aging.

METHODOLOGY

This study used a laboratory experimental design with a pre-test, post-test, and control group design. Permanent first and second premolar tooth samples were immersed in red grape extract and green grape extract, then tooth color was measured before and after treatment using a digital spectrophotometer (VITA Easyshade V) based on the parameters L (lightness), C (chroma), and H (hue). The research samples consisted of intact upper and lower permanent premolar teeth, free from caries, cracks/fractures, or restorations. A total of 24 samples were divided into 6 treatment groups with 4 samples each. The tools used included: VITA Easyshade V, blender, measuring cup, stopwatch, soaking container, tweezers, and standard laboratory equipment. The materials used included permanent premolar teeth, strawberry juice with a pH of 3.25 before immersion and blueberry juice with a pH of 3.48 before immersion.

The research procedures include examining the ascorbic acid content in both types of juice using spectrophotometry, measuring the initial tooth color using VITA Easyshade V, soaking the teeth in each solution for 1 hour, 3 hours, and 5 hours, and measuring the tooth color after treatment to assess changes in L, C, and H values. Data were analyzed univariately and bivariately. Normality tests were performed using Shapiro-Wilk. If the data were normally distributed and homogeneous, a Paired Sample T-Test was used to compare differences in tooth color before and after treatment.

Table 1. Sample Measurement Strawberry juice in immersion for 1 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	19.4	20.5	17.3	16.2	-5.1	-4.7
2	19.6	20.7	17.8	16.4	-5.3	-4.8
3	19.5	20.3	17.5	16.7	-5.7	-4.2
4	19.2	20.8	17.4	16.1	-5.2	-4.3
average	19.38	20.58	17.50	16.35	-5.33	-4.50

pH before immersion 3.25
pH after immersion for 1 hour 3.19

Table 2. Sample Measurement Strawberry juice in immersion for 3 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	20.4	22.7	18.9	17.2	-5.7	-4.2
2	20.6	22.1	18.7	17.5	-5.9	-4.4
3	20.8	22.5	18.4	17.6	-5.4	-4.3
4	20.1	22.4	18.1	17.8	-5.3	-4.1
average	20.48	22.43	18.53	17.53	-5.56	-4.25

pH before immersion 3.25
pH after immersion for 3 hour 3.14

Table 3. Sample Measurement Strawberry juice in immersion for 5 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	25.9	26.4	19.1	18.9	-4.7	-3.2
2	25.7	26.8	19.0	18.6	-4.3	-3.6
3	25.4	26.7	19.7	18.4	-4.6	-3.1
4	25.2	26.6	19.7	18.5	-4.2	-3.0
average	25.55	26.63	19.40	18.60	-4.48	-3.23

pH before immersion 3.25
pH after immersion for 5 hour 3.09
Tooth color before immersion is shade B3, after immersion shade is A3.5

Table 4. Sample Measurement Blueberry juice in immersion for 1 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	14.8	15.2	16.2	9.6	-4.3	-2.9
2	14.6	15.1	16.4	9.5	-4,7	-2.7
3	14.5	15.9	16.5	9.2	-4.6	-2.4
4	14.3	15.7	16.9	9.9	-4.2	-2.6
average	14.55	15.48	16.5	9.55	-4.45	-2.65

pH before immersion 3.48
pH after immersion for 1 hour 3.38

Table 5. Sample Measurement Blueberry juice in immersion for 3 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	16.4	19.	17.6	12.1	-2.3	-1.9
2	16.1	19.2	17.2	12.2	-2.6	-1.9
3	16.7	19.5	17.7	11.9	-2.4	-1.8
4	16.3	19.7	17.1	11.8	-2.5	-2.0
average	16.38	19.43	17.40	12.00	-2.45	-1.90

pH before immersion 3.38
pH after immersion for 3 hour 3.32

Table 6. Sample Measurement Blueberry juice in immersion for 5 hour

No	L value before immersion	L value after immersion	C value before immersion	C value after immersion	H value before immersion	H value after immersion
1	16.9	19.9	17.9	14.2	-2.0	-1.5
2	17.1	20.1	18.3	14.9	-2.1	-1.2
3	17.2	20.2	18.5	14.4	-2.3	-1.6
4	17.6	20.4	18.1	14.2	-2.0	-1.3
average	17.20	20.15	18.20	14.43	-2.10	-1.40

pH before immersion 3.38
pH after immersion for 5 hour 3.20
Tooth color before immersion is shade B3, after immersion shade is A3
Noted:
L: Light or Value
C: Chroma
H: Hue

There was an increase in the Light (L) value before and after immersion in strawberry juice, indicating a change in color before and after immersion to a lighter shade. An increase in the Chroma (C) value before and after immersion in strawberry juice indicates a change in color before and after immersion to a stronger or clearer shade. An increase in the Hue (H) value before and after immersion in strawberry juice indicates a change in color before and after immersion, shifting to a different shade.

There was an increase in the Light (L) value before and after immersion in blueberry juice, indicating a change in color before and after immersion to a lighter shade. An increase in the Chroma (C) value before and after immersion in blueberry juice indicates a change in color before and after immersion to a stronger or clearer shade. An increase in the Hue (H) value before and after immersion in blueberry juice indicates a change in color before and after immersion, shifting to a different shade.

The results of the Shapiro-Wilk test show that all groups of immersion time at L, C and H values have a p value > 0.05, meaning that the data of this study are normally distributed and the results of the homogeneity test obtained a p value > 0.05, so it can be stated that the data of this study are homogeneous. The results of the paired T-test calculation show that immersion of teeth in strawberry juice for 1 hour, 3 hours and 5 hours results in a very significant color change with a p value < 0.05. This can be seen from the increase in the Light value as well as changes in the Chroma value and Hue value in the premolar teeth used as research samples.

Soaking teeth in blueberry juice also showed significant color changes with a p-value <0.05 at 1 hour, 3 hours, and 5 hours. However, compared to strawberry juice, the magnitude of changes in L, C, and H values in blueberry juice tended to be lower, indicating slightly different levels of whitening effectiveness between the two types of fruit juice. The pH value of strawberry (Fragaria x ananasea) juice was lower than that of blueberry (Vaccinium corybosum) juice both before and after immersion.

The pH values before and after immersion in strawberry (Fragaria x ananasea) juice decreased, as shown in the following table:

Immersion hour	pH before immersion	pH after immersion
1 hour	3.25	3.19
3 hours	3.25	3.14
5 hours	3.25	3.09

The pH values before and after immersion in blueberry (Vaccinium corybosum) juice decreased, as shown in the following table:

Immersion hour	pH before immersion	pH after immersion
1 hour	3.48	3.38
3 hours	3.48	3.32
5 hours	3.48	3.20

RESEARCH RESULTS AND DISCUSSION

Strawberry juice (Fragaria x annanasea) contains malic acid, which is often claimed to help remove surface stains on teeth. It can help clean light extrinsic stains (e.g., from coffee or tea) and also provides a "temporary whitening" effect due to a cleaner surface. There are several limitations: strawberry juice does not actually whiten teeth intrinsically (does not change the color of dentin), and its effects are minimal and temporary. However, due to the malic acid content, strawberry juice can cause enamel erosion, and repeated, uncontrolled use can make teeth more sensitive and dull. The main active ingredients are malic acid and vitamin C (ascorbic acid, in smaller amounts).

The literature indicates that discoloration of teeth soaked in strawberry juice begins with a mild demineralization process in the enamel layer. Malic acid lowers the pH, softens the outermost enamel layer, and helps remove extrinsic stains (coffee, tea, and cigarettes). The next step is the stain-cleaning effect, making stains adhering to the pellicle or outer enamel easier to remove. It can also be combined with a mild abrasive to enhance the mechanical effect. The enamel surface becomes cleaner so it reflects light better and teeth appear brighter.

Blueberry juice (Vaccinium corybosum) contains the powerful color pigment anthocyanin. Its primary effect tends to be tooth staining, not whitening, and it is often used in research as a staining agent. It risks increasing enamel stains, and if consumed frequently without rinsing or brushing, it can cause teeth to appear darker. The main components of blueberries are anthocyanins (strong blue-purple pigments) and organic acids.

The discoloration mechanism begins with the adsorption of pigments onto the enamel. Anthocyanins bind to the pellicle and the enamel surface, causing discoloration. Micro-penetration into the enamel pores; slightly degraded or rough enamel allows pigments to penetrate more easily and form more persistent stains. The acidic pH helps open the enamel surface and enhance pigment penetration. A combination of acid and pigment can also intensify the staining effect on teeth.

In the study of Shivani Kohli, et all 2023, which conducted an in vitro evaluation of strawberry fruit extract used as a dental bleaching agent, stated that strawberry fruit extract can increase the □E value of tooth discoloration and a whitening effect on mild and superficial teeth. Another study by Neha R. et all 2022, regarding the effect of strawberry fruit extract on teeth that experience discoloration and enamel morphology, obtained results stating that there is a tooth whitening effect without any significant changes in enamel morphology and tooth discoloration only occurs on the enamel surface.

Furthermore, research by Wowor.CM. et al. (2023), which examined the effect of strawberry extract on denture discoloration, found that strawberry extract can reduce tea-induced discoloration and remove extrinsic stains on dentures. Research by Putri RA. et al. (2022), on strawberries as a natural dental bleaching agent, showed the presence of ellagic acid and malic acid, which aid in tooth whitening. It also stated that the bleaching effect of strawberries is quite limited compared to chemical bleaching agents.

According to Basha SR. et al. (2022), research on the potential of strawberry extract as a whitening agent found that strawberry extract can lower the pH and remove stains on the tooth surface. In a 2006 article by Joiner J, a literature review on tooth bleaching, findings suggest that tooth discoloration can be caused by chromogens from colored foods and drinks, including berries. In the article by Watts. A, Addy. M 2001, regarding a review of tooth discoloration and staining, it was stated that pigments such as anthocyanins in blueberries can cause extrinsic stains on tooth enamel. In the research of Febriani M, Rachmawaty E 2022 on the potential of strawberry fruit extract as a whitening agent for discolored teeth, it was found that strawberry fruit extract containing malic acid and ellagic acid can help whiten discolored teeth and can cause teeth to become sensitive.

A study by Pramesti A, Jasrin, TA, et al. (2013) on the whitening effect of strawberry juice on coffee-stained teeth found that strawberry juice can whiten teeth discolored by drinking coffee, and the mechanism involved is related to the removal of extrinsic stains on the enamel. This contrasts with a study by Asmawati, Rieuwpassa, IE (2018), which compared enamel hardness after applying strawberry gel and 10% carbamide peroxide to dental bleaching. The strawberry gel resulted in superficial demineralization, while the carbamide peroxide experienced deep penetration, accompanied by changes in enamel structure.

A study by Sukarno EA, Katu H (2022), on an in vitro study of an alternative natural dental bleaching ingredient, strawberry fruit extract, found that strawberries have potential as a natural bleaching agent, with their ellagic acid content and a whitening mechanism resulting from the oxidation of chromogens, which causes enamel discoloration after 2-3 weeks of strawberry extract use.

The mechanism of action of teeth whitening (bleaching) is based on an oxidation process involving a chemical reaction between the bleaching agent and the molecules that cause tooth discoloration. Commonly used bleaching agents are hydrogen peroxide (H2O2) and its derivatives, which act as powerful oxidizing agents. These compounds produce highly reactive free radicals, which then penetrate the tooth enamel and enter the dentinal tubules.

Within tooth tissue, these free radicals react with large, highly pigmented organic molecules, the primary cause of discoloration. This process converts these molecules into smaller, colorless, and more stable compounds. This chemical reaction increases the amount of light reflected by the tooth surface, making the teeth appear brighter and whiter.

Based on research and data obtained, a comparison of chemical and natural bleaching agents reveals advantages and disadvantages for each, but neither is as effective as carbamide peroxide in changing the ΔE value of tooth color. Chemicals such as hydrogen peroxide and carbamide peroxide have been shown to be more effective in whitening, both in the short and long term. Chemicals can produce significant whitening results in a relatively short time. However, the use of chemicals also has significant side effects, such as increased

tooth sensitivity, soft tissue irritation, and the risk of damage to tooth enamel if used excessively or without professional supervision.

In contrast, the use of natural ingredients such as strawberries and blueberries tends to be safer and has fewer side effects on the hard tissue structure of teeth. However, the effectiveness of natural ingredients in the bleaching process is relatively lower and requires a longer time to show significant color changes.

This study used strawberry (Fragaria x annanasea) and blueberry (Vaccinium corybosum) juice, which are natural sources rich in biologically active compounds beneficial for health, including in dentistry. The main components contained in these juices include ellagic acid, malic acid, antioxidants, potassium, manganese, vitamin K, phenolic compounds, and vitamin C. Malic acid and ellagic acid are the most abundant organic acids in strawberries. Blueberries, on the other hand, contain anthocyanins, vitamin C, vitamin K, manganese, and fiber. Vitamin C can reduce tooth discoloration, allowing these compounds to help remove stains on the surface of tooth enamel.

Malic acid, ellagic acid, and vitamin C are believed to be factors that enhance the effectiveness of tooth whitening, in addition to malic acid, which is known to brighten teeth through mild oxidation. Research has shown significant differences in tooth color after immersion in strawberry (Fragaria x ananasea) and blueberry (Vaccinium corybosum) juice for 1, 3, and 5 hours. The highest color change occurred in the groups immersed in strawberry juice and blueberry juice for 5 hours. This indicates that strawberry juice contains bioactive compounds such as malic acid, vitamin C, and phenolic compounds that act as natural whitening agents through oxidation.

The results of this study showed changes in tooth color values, measured using the parameters L (lightness), C (chroma), and H (hue), in all treatment groups, including samples immersed in strawberry juice and blueberry juice. The increase in L values was consistent across all groups, indicating a brighter tooth color after the immersion process. Based on Aschheim's 2015, color theory in dentistry, the L value represents the level of color brightness, where a higher L value indicates a lighter tooth appearance, while a lower L value indicates a darker tooth color.

This finding aligns with research by Shivani Kohli (2023), Neha R (2022), Wowor CM (2023), Putri RA (2022), Basha SR (2022), Watts A and Addy M (2001), Febriani M (2022), Pramesti A (2013), Asmati (2018), and Sukarno EA (2022), which states that natural ingredients such as strawberry (Fragaria X annanasea) extract or juice can produce progressive color changes, especially when used over several days or weeks.

The results of the paired t-test showed a significant difference ($p < 0.05$) between the L, C, and H values before and after soaking in both the strawberry and blueberry juice groups. This proves that both ingredients have a whitening effect and are quite effective as natural whitening agents. Differences in the content of active compounds such as malic acid, elagic acid, vitamin C, and phenolic compounds are theoretically higher in strawberry juice than in blueberry juice.

Furthermore, this study also found that the pH of the strawberry juice before soaking was 3.25, after soaking for 1 hour: pH 3.19, after 3 hours: pH 3.14, and after 5 hours: pH 3.09. The pH of the blueberry juice before soaking was 3.48, after soaking for 1 hour: pH 3.38, after 3 hours: pH 3.32, and after 5 hours: pH 3.20. This data also shows that the low pH value of strawberry juice (Fragaria x ananasea) plays a more significant role in the tooth whitening process. The malic and ellagic acids present in strawberry juice help break down stains on the enamel surface, and the whitening effect is more effective than blueberry juice (Vaccinium corybosum). Furthermore, strawberry juice is more acidic.

These results suggest that the choice of bleaching agent for teeth whitening should consider effectiveness, long-term safety, and the individual's dental condition. While chemical products offer instant results and require professional supervision, natural ingredients from fruits can be a safe alternative for long-term use, although their results are only superficial in removing stains and whitening teeth on the enamel surface.

CONCLUSIONS AND RECOMMENDATIONS

The most significant tooth discoloration was observed in the 5-hour immersion group in strawberry (Fragaria x ananasea) and blueberry (Vaccinium corybosum) juice. The duration of immersion affected the intensity of the tooth whitening process, with the longer the immersion, the greater the whitening effect. Tooth discoloration was influenced by pH, the concentration of the immersion agent, the duration of immersion, the cleanliness of the tooth surface, the shelf life of the agent, temperature, the enclosed environment, and additives. Strawberry juice had a lower pH than blueberry juice, and strawberry juice was more acidic due to its content of malic acid, ellagic acid, vitamin C, and phenolic compounds.

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