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ORIGINAL ARTICLE

# The effectiveness of natural tooth whitening using herbal substances on coffee-induced tooth discoloration

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**ABSTRACT**

Tooth discoloration can be caused by many factors, including food and beverages. One of the drinks that can affect tooth color is coffee. Tooth discoloration can be overcome by teeth whitening procedures, which often use chemicals that can cause tooth sensitivity. Therefore, in this study, researchers are looking for safer alternatives, namely using herbal ingredients such as kepok banana peel and pineapple stem. This study used a laboratory experimental method with a pre-test and post-test only research design with control groups. The sample consisted of 27 central and lateral incisor teeth, which were divided into three treatment groups. The samples were then soaked for 14 days in coffee solution, and then group one was soaked in 100% kepok banana peel extract, group two was soaked in 100% pineapple stem extract, and group three as a control group was soaked in 6% hydrogen peroxide. All samples were soaked for two days in an incubator. The results of the one-way ANOVA test showed that there was a significant color difference ($p<0.05$) between the three treatment groups. The Post Hoc LSD test showed there was a significant difference between the 6% hydrogen peroxide group and the two extract groups, and also a significant difference between 100% kepok banana peel and 100% pineapple stem extract. Each group has an effect on tooth discoloration. Hydrogen peroxide is indeed the group with the highest tooth color change but has an effect that can make teeth sensitive. The banana peel and pineapple stem extract groups also had a significant and safer effect on teeth. 100% kepok banana peel extract and 100% pineapple stem extract have an effect on tooth discoloration but are not better than hydrogen peroxide. In addition, 100% pineapple stem extract has a better ability in teeth whitening than 100% kepok banana peel extract.

**Keywords:** insicivus teeth, teeth whitening, pineapple stem, kepok banana peel

## Introduction

The most crucial aspect of human life is health, encompassing both mental and physical well-being. Attention to overall bodily health is equally important to oral health. Facial aesthetics can influence an individual's quality of life and their self-perception. There are two dimensions to facial and dental aesthetics: macro and micro. The face, lips, gingiva, and teeth are considered macro-aesthetics; the shape and colour of the teeth themselves constitute micro-aesthetics.[1]

Patients' demands for aesthetics in dental care have increased, driven by a desire to correct disproportionate facial appearances. One of the most significant aesthetic considerations for individuals is tooth colour. Tooth discolouration is classified into two types: intrinsic and extrinsic. Intrinsic tooth discolouration can arise from systemic diseases, metabolic disorders, hereditary factors, dental surgery,

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fluorosis, and tetracycline medication. Extrinsic factors that can cause tooth discolouration include food and beverages such as red wine, coffee, tea, and tobacco, as well as substances like mouthwash and chemicals such as chlorhexidine. Several international studies indicate that 66% of participants feel their tooth colour contributes to dissatisfaction with their appearance. This demonstrates that patients' overall perception of their appearance is influenced by their tooth colour.[2]

Tooth discolouration can also result from other chemical agents, such as chlorhexidine in mouthwash, or superficial stains from foods like red wine, tea, and coffee.[3]. Individuals may experience a loss of self-confidence when their teeth become yellowed, blackened, or brown, leading to feelings of insecurity when smiling or communicating. Consequently, tooth whitening is a highly popular cosmetic dental procedure.[4]

Several existing studies have shown an association, or causal link, between coffee consumption and tooth staining. One such study by Khasanah et al.[5] employing interview and observation data collection techniques, demonstrated that coffee consumption habits were associated with the occurrence of tooth stains. Similar findings were reported by Aprilina et al. where data analysis revealed a correlation between the quantity and duration of coffee consumption and the development of stains. This study utilised questionnaires to gather data on coffee consumption patterns, while direct examinations were used to collect data on tooth stains. The research by Munadirah and Abdullah[6] also yielded comparable results, indicating a correlation between coffee consumption habits and the presence of tooth stains.

Tooth whitening using chemical agents carries the potential to affect tooth vitality. Inappropriate chemical tooth whitening can also lead to adverse effects, including ulceration, mucosal irritation, and tooth sensitivity. Natural whitening agents have gained popularity recently and are suggested for widespread use to avoid the negative consequences of chemical tooth whitening. Numerous studies have investigated the benefits of various natural substances, yielding positive results.[7] Pineapple, strawberries, tomatoes, banana peels, roselle, apples, lemons, and green pears are among the natural materials that function effectively as bleaching agents. Natural bleaching solutions are more affordable, safer, and readily available.[4]

Bananas are among the most widely consumed fruits due to their versatility in various processed forms and their suitability for raw consumption.[8] Minerals and phytochemicals can be found in banana peels. The minerals identified in banana peels include iron, manganese, calcium, sodium, and potassium. The phytochemical components present in banana peels are alkaloids, flavonoids, phenols, tannins, and saponins.[9] Banana peels contain a bioactive compound called saponin, which has the ability to bind chromogens and whiten teeth.[10] According to Sugianti[11], after being soaked in the extract for three days, the foam present in Roselle (*Hibiscus sabdariffa*), another bioactive chemical substance containing saponins, binds to colouring agents and whitens teeth. Teeth can become whiter due to this colour-binding ability.

The bromelain enzyme content in pineapple can help to whiten darkened tooth surfaces caused by external factors.[12] Malic acid, which belongs to the dicarboxylic acid group, is another substance found in pineapples. Malic acid can be used for tooth whitening by oxidising the tooth surface.[13] Malic acid can penetrate the tooth structure to reach trapped stains.[14] The citric acid in pineapple also possesses a similar tooth-whitening ability to the ellagic acid in strawberries, as it can be converted into oxidants such as hydrogen peroxide and ellagic acid.[15] Given the negative effects of chemical bleaching agents and the effectiveness of banana peels and pineapple in tooth whitening, the researchers are interested in analysing the effectiveness of banana peel and pineapple extracts as natural tooth whitening agents.

## Method

The research methodology employed in this study was a laboratory experiment utilising a pre-test and post-test only control group design. The sample was selected using purposive sampling, based on pre-defined criteria. The sample size was determined using the Frederer formula, resulting in a total of 27 teeth. The inclusion criteria were that samples consisted of extracted central and lateral incisor teeth. The samples were subsequently divided into three treatment groups: the first group comprised teeth immersed in 100% Kepok banana peel extract, the second group consisted of teeth immersed in pineapple core extract, and the third group served as a control and comprised teeth immersed in 6% hydrogen peroxide.

The stages of this research were as follows: the samples were immersed in a coffee solution for 14 days, with the coffee solution being refreshed daily. Following immersion in the coffee solution, the colour of the samples was measured using a colorimeter. These initial measurements were labelled as L0, a0, and b0. After the initial measurements, the samples were immersed in the prepared extracts. Prior to immersion, the pH of each extract was measured. Sample immersion in the extracts was conducted for 2 days and the

samples were placed in an incubator. Upon completion of the immersion in the extracts, a second set of measurements was taken using the same colorimeter. These subsequent measurements were labelled as L1, a1, and b1. Finally, all the collected data were processed and analysed.

## Results

Based on the Shapiro-Wilk normality test results and a common significance level of 0.05, we do not have sufficient evidence to conclude that the "Colour change" data in any of the three groups (Group I, Group II, and Group III) significantly deviates from a normal distribution.

Table 1. Normality test results using the Shapiro-Wilk test

| | Group | *P-Value* |
|---|---|---|
| Colour change (ΔE) | Group I | 0,82 |
| | Group II | 0.83 |
| | Group III | 0,28 |

The paired t-test results presented in Table 2 consistently demonstrate a statistically significant decrease from L0 to L1 across all three groups (Group I, Group II, and Group III). The negative mean differences indicate the direction of this change, with L1 values being lower than L0 values in each group. The p-values of 0.000 for all three comparisons provide strong statistical evidence to support the conclusion that these observed decreases are not due to random variation but represent a real and significant effect within each group. The magnitude of the decrease varies across the groups, with Group III exhibiting the largest average reduction from L0 to L1.

Table 2. Paired T-test results for L0 and L1 between groups

| Comparison | Mean Difference | *P-Value* |
|---|---|---|
| $L_0$ vs $L_1$ (Group I) | -2,62 | 0,000 |
| $L_0$ vs $L_1$ (Group II) | -3,60 | 0,000 |
| $L_0$ vs $L_1$ (Group III) | -4,25 | 0,000 |

Following a two-day immersion in 6% hydrogen peroxide, 100% *Musa paradisiaca* peel extract, and 100% *Ananas comosus* stem extract, an ANOVA was conducted to determine whether there were significant differences in colour change between the groups. The ANOVA yielded a p-value of 0.000, which is less than 0.05, indicating a statistically significant difference in colour change.

Table 3. ANOVA test results for colour change in each group

| | Group | n | *Mean* | *P-Value*) |
|---|---|---|---|---|
| Colour change (ΔE) | Group I | 9 | 5,05 | 0,000 |
| | Group II | 9 | 6,68 | |
| | Group III | 9 | 7,69 | |

Following a statistical analysis that indicated an overall significant difference between the groups, a post hoc Least Significant Difference (LSD) test was performed to determine which specific pairs of groups differed significantly from each other. The results of these pairwise comparisons are presented in Table 4.

Table 4. Post Hoc LSD test results between groups

| Post Hoc LSD Test | *Mean Difference* | *P-Value* |
|---|---|---|
| Group I vs. Group II | -1,62 | 0,000 |
| Group I vs. Group III | -2,64 | 0,000 |
| Group II vs. Group III | -1,01 | 0,000 |

The comparison between Group I and Group II revealed a statistically significant difference ($p<0.001$). The mean of Group II was found to be 1.62 units higher than the mean of Group I. Similarly, the comparison between Group I and Group III showed a statistically significant difference ($p<0.001$). The mean of Group III was significantly higher than the mean of Group I, with a mean difference of 2.64 units. Finally, the comparison between Group II and Group III also demonstrated a statistically significant difference ($p<0.001$). The mean of Group III was found to be 1.01 units higher than the mean of Group II. In summary, the post hoc LSD test indicates that all pairwise comparisons between the three groups (Group I, Group II,

and Group III) yielded statistically significant differences. Furthermore, the negative mean difference values consistently show that Group III had the highest mean, followed by Group II, and then Group I had the lowest mean among the three groups.

## Discussion

In dentistry, tooth whitening, also known as bleaching, is a process employed to lighten the shade of teeth or to remove stains and other materials that cause discolouration.[7] Given the side effects associated with chemical bleaching treatments, there is a need to explore natural alternatives that are safe for oral health. Pineapple contains bromelain, an enzyme that may assist in tooth whitening, while banana contains bioactive chemical compounds called saponins, which can bind to chromogenic substances and whiten teeth.[10,16]

This study found a discernible increase in colour change following the application of *Musa paradisiaca var. kepok* peel extract to all samples. The smallest colour change observed was 4.38 units, and the largest was 5.82 units. This effect is attributed to the saponin content of banana peels. Saponins are a complex group of compounds characterised by their foaming properties. The foam produced can act as a cleansing agent and bind to staining molecules, thereby contributing to tooth whitening. Furthermore, saponins contain antioxidant compounds that may slow down the formation of free radicals in the hard tissues of teeth. This can also contribute to whitening as free radicals achieve stability by accepting electrons from antioxidants.[17]

These findings are supported by the research of Kadek et al.[18] which investigated the effectiveness of 50% and 100% concentrations of *Musa paradisiaca var. kapok* peel extract on tooth colour change. Their results indicated that both concentrations led to the whitening of discoloured teeth, with the 100% concentration group exhibiting the most significant colour change. Similarly, Dinar et al.'s study on the effectiveness of *Musa paradisiaca* L. peel extract on discoloured teeth also found that immersion in the extract tended to lighten tooth colour.[19]

Another natural element that can contribute to a brighter tooth colour is pineapple. Januarizqi et al. reported that soaking teeth in pineapple juice could lead to whitening. Pineapple contains amino acids, the enzyme bromelain, and nitrogen. Bromelain in pineapple may aid in whitening the tooth surface. In the present study, colour changes were observed after the application of pineapple fruit extract in all treatment groups. This change in colour is likely due to the presence of the bromelain enzyme in pineapple. Research on the inclusion of pineapple fruit extract in toothpaste has shown that bromelain, containing proteolytic enzymes, can dissolve stains attached to the protein component of the pellicle/plaque that gradually forms on the tooth surface.[14,20] This is further supported by the work of Ribero et al[21]., who compared the colour change, hardness alteration, roughness, and biocompatibility of bromelain with chemical tooth whitening agents. Their findings indicated no significant difference in tooth colour change between teeth treated with bromelain and those treated with commercial bleaching agents.

The group treated with 6% hydrogen peroxide also exhibited colour changes in all samples. Hydrogen and oxygen form the highly reactive chemical substance hydrogen peroxide. This agent can whiten teeth by penetrating the enamel and breaking down the complex molecules of chemical substances that cause tooth discolouration. Statistical analysis using ANOVA revealed a significant difference in the colour change values between each group ($p=0.000<0.05$). The most substantial colour change occurred in the 6% hydrogen peroxide group, which was significantly different from the banana peel and pineapple extract groups. The superior whitening effect of 6% hydrogen peroxide is consistent with its established efficacy as a tooth whitening agent.[22]

The tooth colour change in the samples treated with banana peel extract also showed a significant difference compared to the samples treated with pineapple fruit extract. Banana peel extract resulted in the least colour change among the groups. This may be attributed to the lower pH of pineapple fruit extract compared to banana peel extract. Excessive or insufficient acidity (pH) can alter the activity of the bromelain enzyme, potentially leading to protein denaturation or slowed catalysis. According to the research by Kevinda et al., pineapple has a low pH and can whiten teeth because a lower pH facilitates the erosion of the enamel surface, making teeth appear whiter. This is further elucidated by Irawati's study comparing tooth colour changes after immersion in pineapple core and banana peel extracts. The mean difference in colour change for the pineapple core extract group was 1.13 units, while for the banana peel extract group, it was 0.56 units.[23]

In conclusion, this study demonstrates that *Musa paradisiaca var. kepok* peel extract and pineapple fruit extract have the potential to lighten the colour of teeth discoloured by coffee. While 6% hydrogen peroxide exhibited a greater colour change compared to the natural extracts, suggesting superior efficacy in terms of colour alteration, further research is needed to evaluate other aspects and definitively determine the overall superiority of hydrogen peroxide.

## Conclusion

Based on the research conducted, it can be concluded that 100% pineapple core extract and 100% Kepok banana peel extract are effective natural whitening agents. Furthermore, this research indicates that neither extract performed better than 6% hydrogen peroxide. The 100% pineapple core extract demonstrated a greater average change in tooth colour, suggesting that it is more effective at whitening teeth than the 100% Kepok banana peel extract.

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