

Effect Of Gambir Toothpaste on Tooth Remineralization

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Abstract

Enamel is the outermost and hardest tissue of the tooth crown, composed of approximately 96% inorganic and 4% organic material. A reduction in the mineral content leads to demineralization, a process that can be reversed through remineralization, which can be enhanced by using toothpaste formulated with natural ingredients, such as gambir. This study aims to determine the effect of gambir toothpaste on tooth remineralization. Ten premolar crowns were divided into two groups: Group A (gambir toothpaste) and Group B (control). Initial hardness was measured using a Vickers Hardness Tester. Each sample was treated for 30 minutes daily for 14 days, then soaked in artificial saliva and incubated at 37°C. Hardness was measured again after remineralization using the same method. Statistical analysis was performed using the Paired t-test and the independent t-test. Results showed a significant increase in enamel hardness within each group; however, the independent t-test indicated no significant difference between the two groups. Gambir toothpaste did not demonstrate a significantly different remineralization effect compared to the placebo.

Keywords: enamel hardness, remineralization, gambir toothpaste

Abstrak

Efek Pasta Gigi Gambir Terhadap Remineralisasi Gigi. Email gigi merupakan lapisan terluar sekaligus jaringan terkeras yang melapisi mahkota gigi, tersusun atas 96% komponen anorganik dan 4% komponen organik. Kehilangan komponen mineral ini menyebabkan terjadinya demineralisasi. Proses tersebut dapat diperbaiki melalui remineralisasi, yang dapat ditingkatkan salah satunya dengan penggunaan pasta gigi berbahan alami seperti ekstrak gambir. Penelitian ini bertujuan mengevaluasi pengaruh pasta gigi gambir terhadap proses remineralisasi email gigi. Sebanyak sepuluh mahkota gigi premolar dibagi menjadi dua kelompok: Kelompok A (pasta gigi gambir) dan Kelompok B (kontrol). Kekerasan awal email diukur menggunakan Vickers Hardness Tester. Sampel kemudian diberi perlakuan selama 30 menit setiap hari selama 14 hari, direndam dalam saliva artifisial, dan diinkubasi pada suhu 37°C. Setelah periode remineralisasi, kekerasan email kembali diukur menggunakan alat dan metode yang sama. Analisis statistik dilakukan menggunakan *paired t-test* dan *independent t-test*. *Paired t-test* menunjukkan adanya peningkatan signifikan pada kekerasan email dalam masing-masing kelompok. Namun, hasil *independent t-test* menunjukkan bahwa perbedaan kekerasan awal dan pascaremineralisasi antara kedua kelompok tidak signifikan. Dapat disimpulkan bahwa pasta gigi gambir tidak menunjukkan perbedaan efek remineralisasi yang signifikan dibandingkan pasta gigi plasebo.

Kata kunci: kekerasan email, remineralisasi, pasta gigi gambir

Introduction

Dental enamel is the outermost layer covering the crown of the tooth. It is composed primarily of inorganic materials, mainly calcium and phosphate, with the remaining portion consisting of organic components. The loss of these mineral constituents is known as demineralization.¹⁻⁴ This reversible process involves the removal of mineral ions from hydroxyapatite crystals within the enamel. Demineralization occurs when the oral environment reaches a critical pH and is typically triggered by acids derived from dietary intake or produced by oral bacteria. If it continues, it may lead to progressive tooth damage. However, this process can be reversed when demineralization and remineralization are maintained in a dynamic balance.^{4,6}

Remineralization is a natural repair process driven by the supersaturation of calcium, phosphate, and fluoride ions.⁶ It occurs when the oral pH returns to a neutral state. This process can be further enhanced through the use of remineralizing agents, such as CPP-ACP (casein phosphopeptide–amorphous calcium phosphate), and most commonly, fluoride, which is widely incorporated into toothpaste formulations.⁷

Toothpaste is an essential product for maintaining oral hygiene, eliminating bacteria, and promoting enamel remineralization. It also helps remove stains and freshen breath.⁸ Toothpaste formulations may exhibit antibacterial, anti-inflammatory, and desensitizing properties. Fluoridated toothpaste is considered the most effective approach for maintaining oral health and enhancing enamel remineralization.⁹ However, excessive fluoride exposure can lead to adverse effects. These potential side effects may be reduced by incorporating herbal-based agents as alternative or adjunctive active ingredients.

Herbal ingredients traditionally used to treat various diseases, including oral conditions, include *Uncaria gambir* Roxb., or gambir, a plant belonging to the *Rubiaceae* family.¹⁰ Gambir contains several major bioactive components, notably catechu tannic acid (20–50%), catechin (7–33%), and pyrocatechol (20–30%). Catechin and tannins exhibit antioxidant and antibacterial properties.^{11,12} Catechin helps inhibit the formation of extracellular glucans that enable *Streptococcus mutans* to adhere to the tooth surface, and it also contributes to increasing salivary pH, thereby supporting the tooth remineralization process.^{13,14}

Studies have demonstrated the potential of herbal-based toothpaste formulations to exert antibacterial and remineralizing effects. Dewanti et al. (2022) reported that herbal toothpaste containing catechins derived from gambir extract exhibits antibacterial activity by disrupting bacterial cell walls.¹⁵ Herdiani et al. (2023) observed growth-inhibitory effects of betel leaf and gambir extracts against *Streptococcus mutans* at concentrations of 10%, 15%, and 20%.¹⁶ Celik et al. (2021) found that herbal toothpaste formulated with ginger, honey, bitter chocolate, and their combinations enhanced enamel surface hardness and produced anticaries effects comparable to fluoride toothpaste, including remineralization potential.¹⁷ Similarly, Febrian et al. (2017) demonstrated that toothpaste containing 15% green tea extract, rich in catechins, significantly increased enamel remineralization and yielded substantially higher microhardness values.^{18,19} The evidence above highlights the potential of gambir-derived catechins to enhance dental remineralization. Therefore, this study aims to evaluate the remineralization effects of gambir-based toothpaste on enamel.

Experimental Section

Materials and Apparatus

This is an in vitro experimental laboratory design using a pretest–posttest control group. The sample consisted of 15 extracted maxillary and mandibular premolars with intact crowns, free of caries, and without restorations. Following extraction, the teeth were cleaned, placed in sealed plastic containers filled with distilled water, and stored in a freezer.

Each tooth crown was separated from its root at the cementoenamel junction (CEJ) using a separating disc. The crowns were then sectioned vertically in a mesiodistal direction to obtain two halves.¹⁰ Subsequently, each crown segment was embedded in self-cure acrylic resin using a cylindrical mold measuring 1 cm in diameter and 1 cm in height (Figure 1).¹⁰

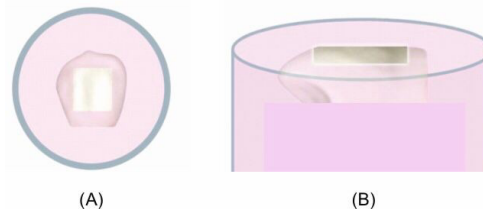


Figure 1. Specimen embedded in self-cured acrylic. (A) superior view; (B) lateral view.

The enamel surface was prepared by sequential polishing using 400-, 1000-, and 1500-grit abrasive papers. Enamel microhardness was then measured using a Vickers hardness tester with a 5-kg load applied for 15 seconds, and two indentation points were recorded for each specimen.²⁰ For the remineralization procedure, samples in Group A were treated by applying gambir toothpaste to the enamel surface, after which the specimens were immersed in artificial saliva and stored at 37°C. Samples in Group B (control) received placebo toothpaste and were similarly immersed in artificial saliva at 37°C. Following the 14-day remineralization period, enamel hardness was measured again using the same Vickers Hardness Tester protocol. Data collection consisted of comparing enamel surface hardness at baseline and after the remineralization treatment for each sample.

Results and Discussion

Figure 2 illustrates the mean enamel hardness values before and after the application of the remineralizing agents. The Shapiro–Wilk test confirmed that the data were normally distributed, while Levene’s test showed that the data were homogeneous.

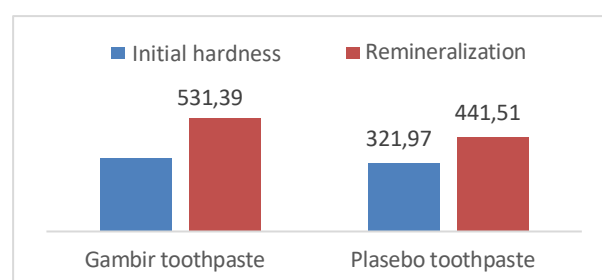


Figure 2. Mean of enamel hardness before and after remineralization.

The Paired t-test, conducted to evaluate the change in enamel hardness before and after treatment with gambir toothpaste and placebo toothpaste, revealed a significant increase in mean enamel hardness in both groups following application of the respective agents (Table 1). The Independent t-test results presented in Table 2 show that the difference in enamel hardness before and after treatment with gambir toothpaste and placebo toothpaste yielded a p-value of 0.166 ($p > 0.05$), indicating no statistically significant difference between the groups.

Table 1. Paired t-test

Kelompok Perlakuan	n	Rata-Rata $\pm$ SD		p-value
		Kekerasan Awal	Sesudah Remineralisasi	
Pasta Gigi Gambir	5	346.48 $\pm$ 60.50	531.39 $\pm$ 67.27	0,002
Pasta Gigi Plasebo	5	321.97 $\pm$ 84.80	441.51 $\pm$ 79.19	0,024

p < 0,0 significant

Table. 2 Independent t-test

Kelompok Perlakuan	n	Selisih Sebelum dan sesudah diberi bahan remineralisasi	p-value
Pasta Gigi Gambir	5	184.90 $\pm$ 58.71	0.166
Pasta Gigi Plasebo	5	119.54 $\pm$ 75.69	

The results of the Paired t-test presented in Table 1 indicate that gambir toothpaste effectively enhances enamel microhardness. Gambir toothpaste contains catechin, which possesses antibacterial properties and can increase salivary pH levels, thereby reducing the number of *Streptococcus mutans* colonies.²¹ A decline in bacterial colonies subsequently reduces sucrose metabolism and lactic acid production, ultimately promoting the remineralization process.²² These findings align with the study by Dewi S. et al. (2012), which reported that 10% gambir toothpaste containing catechin significantly decreased the colony counts of *Streptococcus mutans*.²³ The mechanism by which catechin acts includes inhibiting glucosyltransferase activity and the formation of extracellular glucan polysaccharides, preventing the adherence of *S. mutans* to the tooth surface.²²

Additional factors contributing to the increase in enamel hardness in this study include the neutral pH (7) of the artificial saliva and the storage of samples at 37°C. Artificial saliva contains adequate mineral components, such as calcium and phosphate, which support the remineralization process.^{24,25} The placebo toothpaste also demonstrated an increase in enamel hardness, likely because it contained an abrasive agent. The abrasive used, calcium carbonate, can clean the tooth surface and promote remineralization.²⁶

The results of the independent t-test presented in Table 2 indicate that the change in enamel hardness before and after the application of gambir toothpaste was greater than that of the placebo group. However, no statistically significant difference was observed between the two groups. This lack of significance may be attributed to the drying process of the gambir leaves, which were sun-dried for only four hours under intense sunlight. According to Santoso (2022), sun-drying process typically requires 2 to 3 days, depending on weather conditions, and excessive heat diminishes the active compounds in the leaves.^{27,28} Furthermore, variations in human enamel hardness may also affect the results. Factors such as the age of the teeth, the histological structure, the chemical composition, sample preparation, and potential errors in indentation measurements can all contribute to inconsistencies.²⁹ Overall, the findings suggest that gambir toothpaste has the potential to enhance enamel remineralization.

Conclusions

There was an increase in enamel hardness both before and after the application of gambir toothpaste and the placebo toothpaste. However, the increase in hardness was not significantly different between the two groups. This indicates that gambir toothpaste did not show a greater remineralization effect compared to the placebo. It is advisable to control the condition of teeth after extraction to ensure that all samples maintain comparable baseline enamel hardness.

Conflict of Interest

The authors declare no conflict of interest related to this study.

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