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Research Article

Effectiveness of Clove *(Syzygium aromaticum)* Decoction Against *Streptococcus mutans* on Heat-Polymerized Acrylic Resin

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KEYWORDS

Clove flower (Syzygium aromaticum), clove leaf, heat-polymerized acrylic resin, Streptococcus mutans.

ABSTRACT

Introduction: Heat-polymerized acrylic resin is the most widely utilized material for removable denture bases. However, its inherent porosity and surface roughness facilitate the accumulation of plaque and bacteria, notably *Streptococcus mutans*. Poor denture hygiene can lead to mucosal inflammation known as denture stomatitis. Clove plants contain bioactive compounds such as alkaloids, flavonoids, terpenoids, phenolics, and essential oils, which possess established antibacterial properties. This study aimed to evaluate the effectiveness of clove flower and leaf decoctions against *Streptococcus mutans* on heat-polymerized acrylic resin.
Materials and Methods: This laboratory experimental study employed a post-test only control group design. Twenty-seven heat-polymerized acrylic resin plates (10 x 10 x 2 mm) were divided into three groups. Group 1 was immersed in 20% clove flower decoction, Group 2 in 20% clove leaf decoction, and Group 3 in distilled water (control), each for 15 minutes.
Results and Discussion: Significant differences in *Streptococcus mutans* counts were observed between the clove flower decoction group compared to the clove leaf decoction group (p = 0.025) and the distilled water group (p = 0.001). No significant difference was found between the clove leaf decoction and distilled water groups (p = 0.415).
Conclusion: Clove flower decoction is significantly more effective in inhibiting the growth of *Streptococcus mutans* compared to clove leaf decoction.

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INTRODUCTION

The demand for dental and oral healthcare continues to increase. Partial or complete tooth loss can have emotional and functional impacts, as well as affect appearance.[1] Tooth loss generally influences masticatory function, aesthetics, and speech. The more missing teeth, the greater the impact.[2] Tooth loss can be managed by the fabrication of dentures, which are prosthetic devices that replace missing teeth and the surrounding tissue structures.[3,4]

Acrylic resin, or polymethyl methacrylate, is used as the base material for denture fabrication. This resin is biocompatible, easy to fabricate, easy to clean, insoluble in oral fluids, and possesses high rigidity and hardness. According to the American Dental Association (ADA), there are two types of acrylic resin: heat-polymerized acrylic resin and self-polymerized acrylic resin. Heat-polymerized acrylic resin is the most commonly used denture base material. Its advantages include good aesthetics, a texture similar to gingival tissue, relatively low water absorption, and minimal dimensional changes.[3]

Porosity and surface roughness are disadvantages of heat-polymerized acrylic resin. These characteristics allow food debris to easily adhere to the denture base surface. If dentures are not properly cleaned, they can become a site for the growth of fungi or bacteria, one of which is Streptococcus mutans.[3,5] Streptococcus mutans can cause inflammation of the mucosa beneath the denture, known as denture stomatitis. Various methods are available for denture cleaning, one of which is immersion.[5,6] Denture cleansers are generally chemical-based; however, herbal-based alternatives have recently begun to be developed.

Clove *(Syzygium aromaticum)* is a plant originating from the Maluku Islands of Indonesia, also known as the "Spice Islands." Clove has significant economic industrial value and is widely used across various industries, including tobacco, food, beverages, pharmaceuticals, and cosmetics. Dried clove flower buds and leaf buds possess a distinctive aroma and strong flavor, making them useful as spices in various dishes, beverages, and other products. In the medical field, clove is well known for its antiseptic properties and its ability to relieve pain. Clove also has potential as an additive in the cosmetic and pharmaceutical industries, making it an important commodity in international trade.[7]

Clove has been shown to possess antibacterial, antifungal, anti-inflammatory, analgesic, and antioxidant properties. Methanolic extract of clove flowers has demonstrated strong inhibitory activity against the growth of Streptococcus mutans, with a minimum inhibitory concentration of 25%.[8] Clove leaf extract has also been shown to inhibit the growth of Streptococcus mutans, with the most effective concentration being 30%.[9]

Based on the description above, there has been no research examining the effectiveness of clove decoction against Streptococcus mutans on acrylic resin. Therefore, it is necessary to conduct a study to determine the effectiveness of clove decoction against Streptococcus mutans on heat-polymerized acrylic resin.

MATERIAL AND METHODS

This laboratory experimental study utilized a post-test only control group design. Antibacterial testing was conducted at the Biotechnology Laboratory – BRIN PUSPIPTEK, South Tangerang.

Twenty-seven heat-polymerized acrylic resin plates (10 x 10 x 2 mm) were fabricated. The samples were soaked in distilled water for 24 hours, sterilized in an autoclave for 15 minutes, and then immersed in sterile saliva for one hour. Subsequently, the samples were incubated in a *Streptococcus mutans* suspension for 24 hours.

The decoctions were prepared by boiling 20 grams of flowers or leaves in 100 ml of water for 15 minutes, followed by cooling and filtration. The samples were divided into three groups (n=9 per group): 20% clove flower decoction, 20% clove leaf decoction, and distilled water. After a 15-minute immersion, samples were vibrated in sterile distilled water for 10 minutes and subjected to serial dilution. Microbial plating was performed using the pour plate method on Tryptic Soy Agar (TSA) and incubated for 24 hours. Bacterial colonies were quantified using a colony counter[10,11].

RESULTS AND DISCUSSIONS

This study investigated the effectiveness of clove flower decoction and clove leaf decoction against Streptococcus mutans on heat-polymerized acrylic resin plates. The results of the immersion of the heat-polymerized acrylic resin plates are shown in Table 2 and Figures 1, 2, and 3.

Table 1. Descriptive data on the number of Streptococcus mutans after immersion in 20% clove flower decoction, 20% clove leaf decoction, and distilled water.

Group	Mean ± SD	Range
Clove Flower	949.39 ± 804.67	5–2,500
Clove Leaf	33,944.44 ± 30,856.97	2,500–110,000
Distilled Water	49,000.00 ± 29,853.81	13,000–94,000

Notes:

1. Data are presented as mean ± standard deviation (SD) and minimum–maximum range.
2. Each group consisted of nine samples (n = 9).
3. Clove flower and clove leaf preparations were tested at a concentration of 20%.
4. Distilled water was used as the control group.

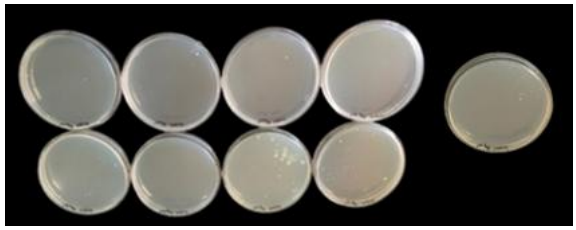

Figure 1. Results of immersion in 20% clove flower decoction

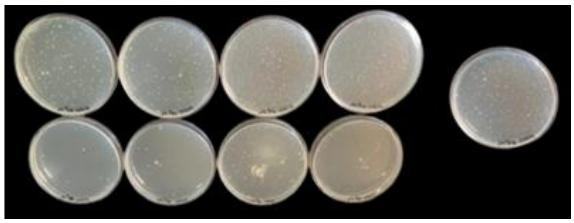

Figure 2. Results of immersion in 20% clove leaf decoction

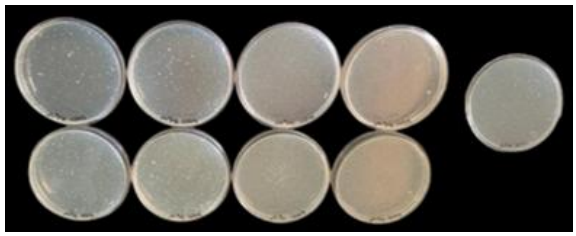

Figure 3. Results of immersion in distilled water

Based on Table 1, the average number of *Streptococcus mutans* after immersion in clove flower decoction is the lowest, followed by immersion in clove leaf decoction, while the highest count is observed after immersion in distilled water. The collected data were then analyzed.

Table 2. Kruskal-Wallis Test Results

Kruskal Wallis	
Chi Square	17,779
p value	0.000

The results of the Kruskal–Wallis test indicate that there are differences in the effects of clove flower decoction, clove leaf decoction, and distilled water on the growth of *Streptococcus mutans* ($p < 0.05$). The next step was to perform a post hoc

Mann–Whitney test to determine which treatment groups differed significantly.

Post-hoc analysis using the Mann-Whitney test revealed significant differences between the clove flower decoction and both the clove leaf decoction (p = 0.025) and distilled water (p = 0.001). However, no significant difference was found between clove leaf decoction and distilled water (p = 0.415).

This study aimed to analyze the effect of immersing heat-polymerized acrylic resin plates in 20% clove flower decoction and 20% clove leaf decoction on Streptococcus mutans. Distilled water was used as a negative control. The study began with the preparation of clove flower and clove leaf decoctions to extract their bioactive compounds, namely alkaloids, flavonoids, terpenoids, phenolics, and essential oils. These compounds are known to inhibit bacterial growth.[8]

The samples in this study used Streptococcus mutans because it is a normal microbial flora of humans commonly found in the oral cavity, but it can become pathogenic when environmental conditions are favorable, and its population increases. This bacterium can adhere to denture bases and cause complications in users. One of the effects is inflammation of the mucosal tissue beneath the denture, known as denture stomatitis.[12]

This study demonstrated that clove flower decoction is effective in inhibiting the growth of Streptococcus mutans. These findings are consistent with previous research on the antibacterial effects of clove oil extract derived from the flower against Streptococcus mutans, which showed that clove oil extract can inhibit bacterial growth.[13] Previous studies also demonstrated that the methanol extract of clove flowers has strong inhibitory activity against Streptococcus mutans, with a minimum inhibitory concentration of 25%.[8] These studies also confirmed that clove flowers contain alkaloids, flavonoids, terpenoids, phenolics, and essential oils.[8]

Alkaloid compounds in cloves can interfere with the attachment of sortase enzymes to the bacterial cell wall surface. This enzyme functions as a signal-carrying protein for bacteria. When its attachment is inhibited, the sortase enzyme cannot perform its function. Subsequently, alkaloids inhibit virulence gene regulation and bacterial secretion systems. Disruption of these processes can lead to bacterial cell lysis.[14]

Flavonoids have the ability to form complexes with bacterial proteins through hydrogen bonding. Their antibacterial mechanism involves inhibiting nucleic acid synthesis and energy metabolism. This condition destabilizes the bacterial cell wall and cytoplasmic membrane structure, which contain proteins, leading to loss of biological activity. Eventually, bacterial cells undergo lysis and die.[15,16]

Phenolic compounds in clove flowers are thought to inhibit bacterial growth through membrane interactions. Their antibacterial activity works by denaturing cellular proteins. Hydrogen bonds formed between phenols and proteins result in protein structure damage.[8]

The antibacterial mechanism of essential oils in cloves is likely due to their hydrophobic properties. Essential oil components have been shown to affect the lipid bilayer of the cell membrane, increasing membrane permeability. This mechanism can reduce bacterial enzyme activity.[10]

Leaves, stems, and flowers of cloves all exhibit antibacterial activity. Studies have shown that clove flowers have the highest average inhibition zone.[17,18] Research also indicates that clove

flowers, stems, and leaves contain flavonoids, saponins, tannins, and terpenoids, but in different concentrations: flowers (91.18%), stems (88.93%), and leaves (36.43%).[17,19]

Previous research has shown that clove leaf extract can inhibit the growth of Streptococcus mutans, with an optimal concentration of 30%.[9] This differs from the findings of the present study. Although the average number of Streptococcus mutans after immersion in clove leaf decoction was lower than in distilled water, statistically, there was no significant difference (p = 0.415).

CONCLUSION

Clove flower decoction is effective in inhibiting the growth of *Streptococcus mutans* on heat-polymerized acrylic resin. Limitations of this study include the small sample size and the use of only a 20% concentration. Further research is encouraged to explore various concentrations for potential use as a natural denture disinfectant.

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