

Tobacco Leaf Extract as Denture Cleaning Paste on Transverse Strength of Heat-Cured Acrylic Resin Dentures

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ABSTRACT

Background: Removable dentures are prosthetic devices used to replace missing teeth. Acrylic resin is the most commonly used material for denture base fabrication. Plaque accumulation on improperly cleaned denture bases can lead to denture-associated stomatitis. Tobacco leaves have potential as a denture cleaning paste due to their antibacterial and antifungal properties. However, their phenol content may degrade polymer bonds and reduce the transverse strength of heat-cured acrylic resins. **Objective:** This study aims to investigate the effect of using 25% and 50% tobacco leaf (*Nicotiana tabacum* L.) extract paste as a denture cleaning agent on the transverse strength of heat-cured acrylic resin. **Method:** This study used an experimental laboratory design with a post-test-only control group. Thirty rectangular block-shaped samples (60x12x3 mm) were divided into one control group (K) and two treatment groups (n=10), which were brushed with 25% (T1) and 50% tobacco leaf extract paste (T2), respectively, for 28.2 minutes. Transverse strength was tested using a universal testing machine with the three-point bending test method. **Results:** The transverse strengths of groups K (126.926 MPa), T1 (103.136 MPa), and T2 (83.001 MPa) were determined. The parametric test results indicated significant differences between groups K and T2 ($p=0.001$) and between T1 and T2 ($p<0.001$). However, no significant difference was observed between groups K and T1 ($p=0.052$). **Conclusion:** This study found a decrease in the transverse strength of heat-cured acrylic resin after brushing with tobacco leaf extract paste.

Keywords: Denture cleaning paste, heat-cured acrylic resin, tobacco leaf, transverse strength

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INTRODUCTION

Removable dentures are prosthetic devices used to replace missing teeth on the dental arch, allowing patients to insert and remove them independently. The use of dentures is essential as they play a role in the rehabilitation of masticatory function, speech, and aesthetics.¹ However, its benefits are not widely recognized. According to the 2023 Indonesian Health Survey (SKI), the prevalence of tooth loss in Indonesia was 21% of the total population, yet only 6.8% used dentures. More than 95% of denture users rely on acrylic resin as the base material.²

Acrylic resin is a polymer composed of repeated methyl methacrylate units, polymerized by heating. Its advantages include color harmony with the replaced and surrounding tissues, reparability and reattachment, simplicity in manipulation and polishing techniques, and affordability. However, its drawbacks include susceptibility to fractures, porosity formation, liquid absorption, and allergenicity.^{3,4}

Maintaining denture cleanliness is essential for ensuring oral and dental health. Uncleaned denture bases, particularly in areas in direct contact with the mucosa, can lead to plaque buildup, which can cause denture stomatitis.⁵ However, denture cleaning products remain limited in availability.⁶ Consequently, investigations into natural materials with potential applications as denture cleaning agents continue to be developed.

Tobacco leaves are a natural material with potential as a denture cleaner. They contain saponins, alkaloids, terpenoids, and flavonoids that exhibit antifungal and antibacterial properties.⁷ Tobacco leaves can be utilized as a denture cleaner in the form of tobacco leaf extract paste. Cleaning dentures with paste and a toothbrush (a mechanical method) has the advantage of improving plaque removal efficiency and requiring relatively little time.⁸ Previous studies have shown that 25% and 50%

tobacco leaf extract paste can inhibit the growth of *Candida albicans* on thermoplastic nylon plates.⁹

Phenolic compounds in tobacco leaves may trigger hydrolysis reactions, leading to polymer degradation.¹⁰ The breakdown of polymer chains in acrylic resins has the potential to reduce its mechanical properties, including transverse strength. Transverse strength reflects the durability of the denture base during mastication, as it is subjected to compressive, shear, and tensile forces simultaneously.¹¹ This study aimed to examine the impact of 25% and 50% tobacco leaf extract paste as a denture cleaning agent on the transverse strength of heat-cured acrylic resin.

MATERIALS AND METHODS

This study was an experimental laboratory with a post-test-only control group design. The samples were rectangular in shape with dimensions (60×12×3) mm, based on the specifications of the American Standards for Testing and Materials.¹² The sample criteria included conformity in shape and size, non-porosity, and smooth, shiny, and flat surfaces. Thirty samples were divided into three groups: control group (K), which was not subjected to brushing treatment; (T1), which used 25% tobacco leaf extract paste; and (T2), which used 50% tobacco leaf extract paste (n=10).

Tobacco Leaf Extract Preparation

The preparation of the tobacco leaf extract began by drying the tobacco leaves in an oven at 50°C until dry. The dried tobacco leaves were then blended and sieved to ensure uniform sample fineness. Next, the tobacco leaf simplicia was extracted using the maceration method, with a mass-to-solvent ratio of 1:4 (96% ethanol). This process was carried out at room temperature for three days in a sealed inert container. Subsequently, the extract was filtered and evaporated using a rotary evaporator to obtain a 100% tobacco leaf extract.¹³



Paste Preparation

Tobacco leaf extract paste was prepared by mixing the placebo with powdered tobacco leaf extract. The placebo consisted of calcium carbonate (29%), magnesium carbonate (26%), sterile distilled water (25%), *propylene glycol* (8%), *glycerin* (6%), TEA (*triethanolamine*) (4%), and *Oleum Menthae Piperithae* (2%).¹⁴ The powder was prepared by drying the extract mixed with *maltodextrin* in an oven at 40°C until dry. The 25% tobacco leaf extract paste was prepared by mixing 25 grams of tobacco leaf extract powder with 75 grams of placebo, the 50% tobacco leaf extract paste was prepared by mixing 50 grams of tobacco leaf extract powder with 50 grams of placebo (Fig. 1). The mixture was blended using a mortar and pestle until homogeneous and stored in a sealed container.



Figure 1. Tobacco leaf extract paste

Heat-Cured Acrylic Resin Plates Preparation

The preparation of the heat-cured acrylic resin plate involved creating a mold space from red wax with dimensions of 60 × 12 × 3 mm. The cuvette was coated with vaseline and filled with gypsum at the bottom. The pattern wax sheet was placed horizontally on wet gypsum. After the gypsum hardened, its surface was coated with vaseline, and the upper cuvette was filled with gypsum and pressed with a beagle press. Once the gypsum hardened completely, the beagle press was placed in a pot of boiling water to form the mold space.



Figure 2. Heat-cured acrylic resin plate

Acrylic resin powder and liquid (ADM brand, America) were mixed (at a 3:1 ratio) until the dough stage, then placed into the mold space lined with Cold Mould Seal (CMS) and covered with cellophane plastic. The mixture was pressed slowly using a hydraulic bench press (1500 psi), followed by final pressing after removing the cellophane. The curing process was carried out by immersing the cuvette in boiling water at 100°C. Once the water reached a boil, the cuvette was immersed for approximately 20 minutes, then the sample was allowed to cool to room temperature. The final steps included deflasking, finishing, and polishing (Fig. 2).¹³

Brushing Treatment of Heat-Cured Acrylic Resin Plates

The samples were immersed in distilled water for 24 hours before treatment. Heat-cured acrylic resin plates were brushed onto the polished surface using an electric toothbrush with soft, thin bristles measuring 0.15 mm. Brushing was conducted at a 20.000 strokes per minute for 28.2 minutes for groups T1 (25% paste) and T2 (50% paste). After brushing, the samples were rinsed and dried (Fig. 3).



Figure 3. Brushing treatment of heat-cured acrylic resin plates

Transverse Strength Test

The transverse strength test was conducted using a Tarno Grocki Universal Testing Machine with a 100 kN capacity, employing the three-point bending method with a support span of 30 mm and a load speed of 5 mm/min (Fig 4). The results were calculated using the transverse strength formula, expressed in MPa. One-way ANOVA test was conducted to analyze the data, followed by the Games-Howell post-hoc test



Figure 4. Transverse strength testing

Statistical Analysis

A one-way ANOVA was conducted to analyze the data, followed by the Games-Howell post hoc test ($p < 0.05$).

RESULTS

Based on the data (Fig. 4), the highest mean transverse strength was observed in group K at 126.926 ± 26.582 MPa, while the lowest mean transverse strength was found in group T2 at 83.001 ± 6.010 MPa. Group T1 had a mean transverse strength of 103.136 ± 9.394 MPa (Table 1). Subsequently, a parametric test, One-Way ANOVA, was conducted to identify

differences in mean values between groups (Fig. 5).

Table 1. Mean and standard deviation values of the transverse strength of heat-cured acrylic resin

Group	N	Mean (MPa)	Standard deviation
Control (K)	10	126.926	26.582
Concentrated tobacco leaf extract denture cleaning paste 25% (T1)	10	103.136	9.394
Concentrated tobacco leaf extract denture cleaning paste 50% (T2)	10	83.001	6.010

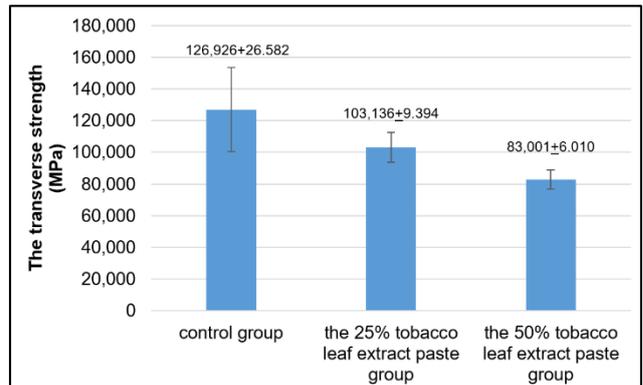


Figure 5. The transverse strength of heat-cured acrylic resin.

The results of the one-way ANOVA test showed significant differences among the groups, followed by the Games-Howell post hoc test. The results of this test indicated no significant difference between the K and T1 groups ($p = 0.052$). However, significant differences were observed between the K and T2 groups, as well as between the T1 and T2 groups ($p < 0.05$).

DISCUSSION

Transverse strength is a mechanical property of heat-cured acrylic resins that describes its ability to withstand masticatory



forces without experiencing permanent deformation. This property arises from the concurrent actions of compressive, tensile, and shear forces. Inadequate transverse strength in a denture base limits its ability to resist excessive masticatory load, resulting in an elevated risk of fracture.^{11,15} According to the American Dental Association Specification No. 12, the minimum transverse strength required for denture bases made of heat-cured acrylic resin is 65 MPa.¹⁶

The K group exhibited the highest average transverse strength compared to the other groups, with a value of 126.926 ± 26.582 MPa, followed by the T1 group at 103.136 ± 9.394 MPa and the T2 group at 83.001 ± 6.010 MPa. The decrease in tobacco leaf extract paste concentration is linked to a reduction in denture base strength, as the content of active ingredients diminishes at lower concentrations.⁷

The results indicated a significant difference between the K and T2 groups, as well as between the T1 and T2 groups. This difference is attributed to the phenolic compound content in tobacco leaf extract paste, which can reduce the strength of heat-cured acrylic resin. This finding aligns with previous research on denture cleansers, such as soaking in black tea (*Camellia sinensis*), which showed that the phenolic compounds therein can decrease the surface strength of heat-cured acrylic denture bases.¹⁷ In this study, the Games–Howell test was used because the homogeneity-of-variance test indicated that the data did not meet the homogeneity of variance assumption. Further analysis (post-hoc) was conducted using the Games–Howell test. This test was chosen because it does not assume equal variances across groups and is more appropriate for data with heterogeneous variance.

Tobacco leaves contain flavonoids from the phenol group, nicotine from the alkaloid group, steroids from the saponin group, and terpenoids from essential oils. Phenol has a lower molecular weight than heat-cured acrylic resin, enabling it to penetrate the acrylic resin

matrix and break its polymer bonds.¹⁸ When phenol is absorbed into the acrylic resin matrix, an ion-exchange reaction may occur. Phenol, being acidic, is more prone to oxidation because it releases H⁺ ions, as the carbon (C) atom in the phenol benzene ring (C₆H₅OH) has a stronger ability to attract electrons from oxygen (O) atoms than hydrogen (H) atoms. The release of H⁺ ions leads to the breakage of phenol into phenoxide ions (C₆H₅OH⁻) as an anion and H⁺ ions as a cation. Additionally, acyl groups (RCO⁺) and methoxide ions (CH₃O⁻) are released from esters. In the presence of phenol compounds, the phenoxide ions will react with acyl groups, while the H⁺ ions will interact with methoxide ions. This process alters the chemical structure of the acrylic resin, leading to cavities.^{13,19–22} Besides ion exchange reactions, hydrolysis reactions may also occur.

Heat-cured acrylic resin is a polymer composed of repeating methyl methacrylate units that form Polymethyl Methacrylate (PMMA) with the chemical formula (C₅O₂H₈)_n through free radical addition polymerization. This resin has low polarity. In contrast, phenol is a highly polar compound with acidic characteristics. Polyester undergoes hydrolysis in acidic conditions, producing carboxylic acids and alcohols. The degradation of polyester disrupts the chemical bonds within heat-cured acrylic resin.¹⁰

Heat-cured acrylic resin is generally insoluble in water or other liquids present in the mouth, but can dissolve in aromatic hydrocarbon solvents. Phenol is an aromatic hydrocarbon compound that consists of a hydroxyl group (-OH) and an aromatic hydrocarbon ring. This dissolution reduces hardness and affects mechanical properties. Based on the standards set by the International Organization for Standardization (ISO), the solubility of heat-cured acrylic resin must not exceed 1.6 µg/mm.^{3,23,24}

The significant difference in transverse strength values may also be due to the abrasive materials in the paste (calcium carbonate and

magnesium carbonate). The paste contains abrasive substances that may cause surface abrasion of the acrylic resin. This condition can increase surface roughness and ultimately damage the physical properties of acrylic resin.²¹

Porosity is a physical characteristic of acrylic resins. Porosity allows heat-cured acrylic resin to absorb liquids.⁷ Heat-cured acrylic resin can absorb liquid up to 0.69 mg/cm². The resin can absorb liquids because its base material, Polymethyl Methacrylate (PMMA), is polar due to ester groups in its structure. These polar groups are hydrophilic, allowing the resin to absorb liquids.^{18,25}

Water absorption occurs through diffusion, where solution particles penetrate the polymer-based material. Water molecules slowly diffuse into the polymer matrix until saturation is reached.¹³ Diffusion is the process of transferring molecules from areas of high concentration to areas of low concentration.²⁶

According to the matrix degradation theory, acrylic resins absorb water molecules, which then enter the intermolecular spaces between the polymer chains. These water molecules disrupt the polar interactions between the chain. The ester groups in heat-cured acrylic resins create polar interactions; however, when water molecules enter the spaces between polymer chains, these interactions are disrupted. This weakens the attractive forces between the polar molecules of the polymer, causing the polymer chains to separate, increasing the distance between them, and making the matrix looser or swollen, a process known as matrix expansion. This expansion is followed by matrix softening, which is a decrease in polymer strength.²⁸

The tobacco leaf extract-paste at concentrations of 25% and 50% reduced the transverse strength of heat-cured acrylic resin. However, the decrease remained above the minimum transverse strength required for denture bases made of heat-cured acrylic resins.

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