ORIGINAL ARTICLE

Transversal strength of heat-cured acrylic resin after immersion in *Annona muricata* L. effervescent extract

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ABSTRACT

Introduction: Heat-cured acrylic resin is one of the most widely used denture bases. Patients need to keep the removable dentures clean in order for them to have no adverse impacts. Natural ingredients, such as *Anonna muricata* L., are known for their benefits and can be used as a denture cleanser, but their effect towards mechanical properties needs to be studied. The objective of this study is to analyze the role of *Anonna muricata* L. effervescent extract with various concentrations (25, 35, and 45%) on the transversal strength of heat-cured acrylic resin. **Methods:** The samples were twenty eight heat-cured acrylic resin plates with a size of 65x10x2.5 mm randomly divided into four groups. The control group (immersed in distilled water), the 25, 35, and 45%, were immersed for fifteen minutes three times a day for ten days. The transversal strength was measured by the Universal Testing Machine (Shimadzu) loaded at 1kN with a constant control rate of 1 mm/min and analyzed by Kruskal-Wallis. **Results:** The average transversal strength of the control group was 118.59 MPa, followed by 25% with 114.35 MPa, 35% with 117.28 MPa, and 45% with 111.32 MPa. Based on Kruskal-Wallis, there were no significant differences with a significant value $p>0.05$ ($p=0.886$). **Conclusion:** The immersion of heat-cured acrylic resin in the extract of *Anonna muricata* L. effervescent does not affect the transversal strength of the material.

KEYWORDS
transverse strength; acrylic resins; *Annona muricata* L.

INTRODUCTION

The national percentage of tooth loss in Indonesia, based on the RISKESDAS report (2018), stated that the largest proportion of dental problems in Indonesia was tooth loss, at 14%, after tooth decay.[1] This condition can be overcome by dentures, which are expected to improve mastication, phonation, and aesthetics, as well as maintain oral tissue health and prevent further damage of intraoral surroundings.[2]

According to the *American Dental Association* (ADA), there are two types of acrylic resins: heat cured and self-cured polymers. Heat-cured polymer is the most commonly used type of acrylic resin. This type of acrylic resin had more advantages than self-cured polymers, including smaller porosity, less monomer residue, stronger material, lower distortion and deformation, and better color stability.[3] Denture base material required good physical strength, aesthetics, stiffness, high resistance, and surface hardness.[4] Surface hardness is necessary to protect the denture base from erosion and scratches caused by the denture cleaning processes.[5]

Patients wearing removable dental prostheses are required to maintain the hygiene of the prostheses to avoid any negative impact on patients. Dental prostheses can be cleaned by two methods: mechanical and chemical techniques. The mechanical technique consists of several methods using brushes, pastes, powders, and ultrasonic cleaners.[6] As for the chemical technique, the method of immersing dental prostheses in chemical solutions is to use a solution of disinfectant, alkaline peroxide, and alkali hypochlorite.[7]

Dental cleansers have utilized the content of various herbal ingredients, which are believed to be effective as cleaning materials for dental prostheses. One of these herbal ingredients is the soursop leaf (*Anonna muricata* L.). *Anonna muricata* L. is believed to have various health benefits, including antibacterial, antiviral, antioxidant, antifungal, antiparasitic, antihypertensive, antistress, and a healthy nervous system.[8,9]

Anonna muricata L. is used as a herbal medicine by boiling it and then drinking the decoction to treat cancer. This only kills abnormal cells (cancer), while normal cells remain alive.[10] *Anonna*

muricata L. leaves contain *Annonaceous acetogenin,* which acts as an anti-cancer substance by damaging cancer cells by attaching to cell wall receptors and then damaging ATP in the mitochondrial wall so that cancer cells die because their energy production stops. Not only as an anti-cancer substance, acetogenin has one group, namely phenol, which acts as an antibacterial.[11]

Thalib .[12], used *Anonna muricata* L. extract as a denture cleanser by immersing a heat-cured acrylic resin plate that had been soaked in the *C. albicans* suspension with concentrations of 5, 15, 25, 35, and 45% for eight hours. In 45% concentration, no *C. albicans* colonies grew in the *Sabourroud Dextrose Agar*. Research on the effect of *Anonna muricata* L. extract was also carried out by Pai [13] *who* concluded that higher concentrations of A*nnona muricata* L. resulted in a higher microbial effect on the growth of *C. albicans*.

Along with the use of dental prostheses, the immersion method can affect the mechanical properties of heat-cured acrylic resin, which can reduce patient comfort when wearing dental prostheses. Therefore, knowing the mechanical strength of heat-cured acrylic resin is important because it can affect patients' comfort in the use of dental prostheses. One of the important mechanical properties is transverse strength. Transverse strength represents the combination of tensile and shear strength that occurs during the mastication process.[14] Good transverse strength, according to ADA specification No.12, is a minimum of 65 MPa.[15] The objective of this study is to analyze the role of *Anonna muricata* L. effervescent extract with various concentrations (25, 35, and 45%) on the transversal strength of heat-cured acrylic resin.

METHODS

This was an experimental laboratory study with a posttest-only group design. This study used 28 samples of heat-cured acrylic resin plates, which were divided into four groups: the control group was heat-cured acrylic resin that was soaked in distilled water; treatment 1 (P1) was soaked in 25% *extract Anonna muricata* L. effervescent; treatment 2 (P2) was soaked in 35% extract *Anonna muricata* L. effervescent; and treatment 3 (P3) was soaked in 45% extract *Anonna muricata* L. effervescent for 15 minutes, three times a day for ten days, which is equivalent to using a denture cleanser for 30 days.[12] Concentrations of 25, 35, and 45% were chosen based on a recent study by Thalib and Hasan,[12] which concluded that 35% was the minimum concentration, while 45% was the most effective concentration in inhibiting the growth of *candida albicans*. Then a concentration of 25% was chosen as the lower border. Heat-cured acrylic resin samples were made by making a mold as the master model in a plate shape with a size of 65x10x2.5mm. Molds were then packed with heat-cured acrylic, and polymerization of the heat-cured acrylic was carried out using a water bath (74°C for 2 hours followed by 100°C for 1 hour). Each sample group consists of seveb samples, as shown in Figure 1.

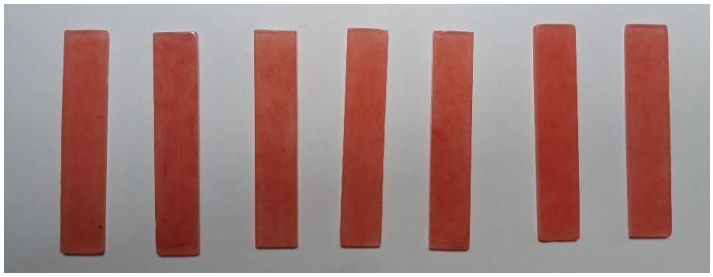

Figure 1. Heat-cured acrylic samples

Extract of *Anonna muricata* L. effervescent was made by 19.300 gr of fresh, clean, dark green leaves that were dried in the oven at 45°C. Then it was crushed until it became powder, and then it was weighed. The *Anonna muricata* L. powder was then mixed with 3.5 L of 96% ethanol. The maceration was then covered for 2 days and stirred once a day. It was filtered to obtain a thick liquid extract of soursop leaves. Following that, the thick extract was evaporated to separate it from the solvent. A concentration of 25% was made by diluting 25 gr *Anonna muricata* L. extract with aquades until it became 100 ml. Concentrations of 35 and 45% were made by the same method as mentioned. The effervescent powder results are shown in Figure 2.

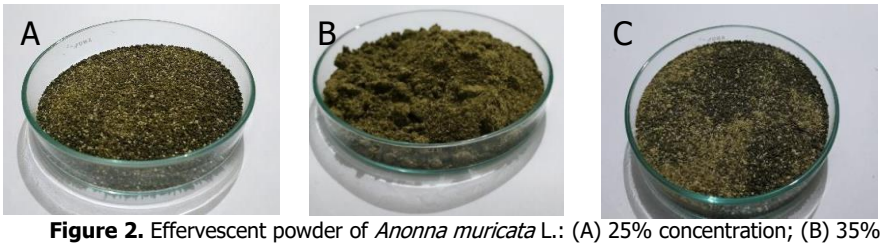

Figure 2. Effervescent powder of *Anonna muricata* L.: (A) 25% concentration; (B) 35% concentration; (C) 45% concentration

Transversal strength test was performed by Universal Testing Machine (UTM) Shimadzu Autograph AGS-X Series, Japan by measuring the length of the test rod and marking the center line using a pencil. The marked test rod was placed in the center of the press so that the pressure was on one side. Turning on the machine on the tool, the center line of the test rod was pressed using the weight of the tool until the machine stopped pressing, and it would automatically stop. The transversal strength value (N/mm^2) was measured using the following formula:[4] $S = 3LP/2bd^2$. S = transversal strength (N/mm^2), b = thickness (mm), d = diameter samples (mm), L = length (mm), P = load(N).

Figure 3. Transversal strength test by UTM (Universal Testing Machine) Shimadzu, Japan

A statistical analysis was performed on the transversal strength data obtained from the formula results. The Saphiro-Wilk normality test was performed, and a $p<0.05$ was considered an abnormal data distribution. Following that, Kruskal-Wallis test data analysis was carried out. If the Kruskal-Wallis test obtained a $p<0.05$, the analysis was then continued by a post hoc test using the Mann-Whitney test. If the $p>0.05$, it could be concluded that there was no significant difference in the transversal strength values of the sample groups and the post hoc test was not carried out.

RESULTS

Figure 4 shows that the highest transverse strength value is in group P2 (soaked in 35% extract *Anonna muricata* L. effervescent) and the lowest transverse strength value is in group P3 (soaked in 45% extract *Anonna muricata* L. effervescent). The stress-strain response of the tested specimens was nearly linear elastic with slight increasing levels of strain in accordance with the higher concentrations of extract *Annona muricata* L. effervescent.

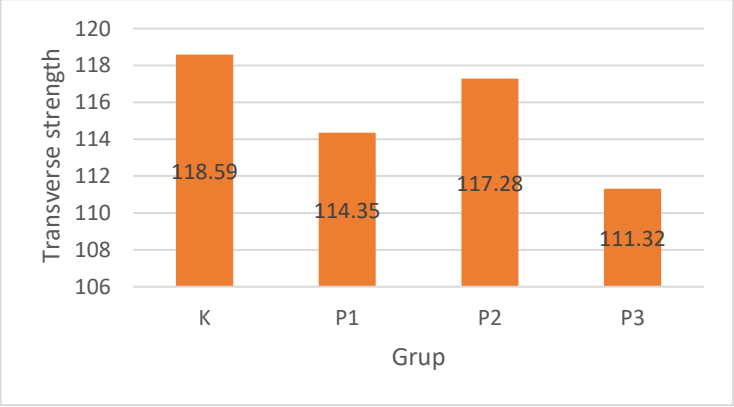

Figure 4. Bar chart of heat-cured acrylic plate transverse strength values in each group

Table 1. Shapiro-Wilk normality test results

Group	Shapiro-Wilk *p*-value
K	0.552
P1	0.004
P2	0.023
P3	0.454

Description*: $p>0.05$ (data is normally distributed)

Table 1 displays the results of the Shapiro-Wilk normality test. Data in groups K and P3 are normally distributed (p >0.05), while data in groups P1 and P2 are not normally distribute (p <0.05). This indicates that the value of the transverse strength of the heat-cured acrylic plate is not normally distributed. Therefore, the Kruskal-Wallis test was performed.

Table 2. Kruskal-Wallis test results

Variabel	*p*-value
Transverse strength	0.886

The results of the Kruskal–Wallis test are presented in Table 2. The significance value was 0.886 (p >0.05), which indicates that there is no significant difference between the control group and the treatment group. Because there is no significant difference between all the sample groups, the post hoc test was not carried out.

DISCUSSION

Commonly used materials for complete or partial dentures are heat-cured acrylic resins. Heat-cured acrylic resins as denture base materials provide good comfort in oral tissue; however, the masticatory strain on the prostheses and surrounding tissues should be taken into account when wearing dentures over an extended period of time. Therefore, it is expected that denture prosthesis have good mechanical properties. Transversal strength is one of the properties that dentures must possess. Transversal strength is the ability of a denture material to accept loads that increase regularly and occur continuously in the oral cavity during the masticatory process.[16]

Figure 4 displays the transversal strength values of heat-cured acrylic resin soaked in distilled water, 25, 35, and 45% *Anonna muricata* L. effervescent extract. In the control group (K), the average value was higher than the heat-cured acrylic resin group, which was soaked in *Anonna muricata L.* effervescent extract at 25 (P1), 35 (P2), and 45% (P3). In general, the value of the transversal strength showed non-significant differences. The transversal strength values were likely to decrease in the treatment groups. This can be caused by heat-cured acrylic resin's characteristics, which could absorb water. Besides, acrylic resin has two types of bonds: primary and secondary bonds. Primary bonds are bonds between atoms that make up polymer chains, while secondary bonds are bonds between chains and other polymer chains. Primary bonds have a good connection, while secondary bonds have weak connections. Water molecules can enter weak secondary bonds, which cause water ions to penetrate into the acrylic resin matrix. The water ion binds to the hydroxyl group, damaging the polymer chain in the acrylic resin matrix and causing a gap between atoms. Consequently, water absorption occurs.[17]

The polarity of the molecule polymethyl methacrylate in heat-cured acrylic resin caused water molecules to penetrate - the polymethyl methacrylate mass and occupy positions between the polymer chains, and forcing the polymer chains to break. As a result, the acrylic resin undergoes a slight expansion, and the material becomes plastic, which causes a decrease in transversal strength.[18,19] In the treatment group, the effervescent administration affected the decrease of the transversal strength value due to the sodium perborate in the effervescent, which forms alkaline peroxide compounds when in contact with and dissolved in water. The alkaline peroxide released oxygen, which caused the oxidation of the tertiary amine accelerator, and the polymer chain became weak, thereby reducing the transversal strength of the heat-cured acrylic resin.[20]

The value of transversal strength in group P1 (25% concentration) showed non-significant differences compared to group P2 (35% concentration). Likewise, the P1 group result showed no significant differences compared to group P3 (45% concentration). This can be explained by some of the conditions that affected transversal strength, such as non homogenous samples, the polymer molecular weight, polymer grain size, residual level of monomer liquid, plasticizer composition, number of cross-linking agents, internal porosity of the polymer matrix, and sample thickness. The maximum load received by heat-cured acrylic resin was also influenced by the sample's thickness.[21] The thinner the sample, the lower the load received, which led to different results in transversal strength.[4] Another aspect that played a role in the transversal strength result was porosity in heat-cured acrylic. Porosity caused a higher level of concentration in the samples, which may affect the result of the transversal strength value.[22]

Flavonoids and tannins contained in *Anonna muricata* L. extract also influenced the differences in the results of this research. Both of these compounds are phenolic groups that will affect the transversal strength value. Polymer chains in heat-cured acrylic resins consist of long polyester chains forming repeating methyl methacrylate molecules with low polarity, while phenol has high polarity. Under acidic conditions, polymer chains will hydrolyze and form carboxylic acids and alcohols. Then, the separation of the polyester bond causes the chemical bond of the acrylic resin to degrade, and decreasing the transversal strength of heat-cured acrylic resin.[23]

The results of the above study showed that the variation in concentration of *Anonna muricata* L. effervescent extract at 25, 35, and 45% had no significant effect on decreasing the transversal strength value of heat-cured acrylic resins. This result is in accordance with research by Arruda et al[20], which concluded there are no significant differences in transversal strength of heat-cured acrylic resins immersed in commonly used denture cleansers compared to control groups (immersed in aquadest). Arruda .[20], showed that the accuracy of immersion in denture cleanser according to product regulations and immersion at room temperature were contributing factors that influenced the results of the study. When a denture cleanser made from effervescent is used according to the usage rules for 15-20

minutes of immersion, the possibility of a decrease in transversal strength is smaller. Increasing the temperature of denture cleanser solution will increase the water absorption in heat-cured acrylic resin, thereby affecting the transversal strength of heat cured acrylic resin.[24] Based on the results of this study, a better concentration for further research is 35% because extract *Anonna muricata* L. effervescent 35% fulfilled the requirements for good transversal strength (117,28 MPa), which is not less than 79-86 MPa.[25] However, the use of 45% extract of *Anonna muricata* L. effervescent tends to decrease the transversal strength of heat-cured acrylic resin.

CONCLUSION

The immersion of heat-cured acrylic resin in the extract of *Anonna muricata* L. effervescent does not affect the transversal strength of the material.

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