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The Effect of Soaking Heat Cured Acrylic Resin in Edamame Seed Extract (Glycine max L. Merrill) at 50% Concentration as a Removable Denture Cleanser on Compressive Strength

By

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Abstract

Heat cured acrylic resin is widely used denture base material that has several properties such as porosity and can absorb water. Prolonged use of a denture requires periodical cleaning. However, chemical denture cleanser may increase the surface roughness of this acrylic resin. So nowadays, there are many natural-based denture cleanser was developed, one of the potential natural cleanser is edamame seed extract at 50% concentration. Edamame seed extract contains phenol as antibacterial dan antifungal, but phenol also have potential to affect the compressive strength of heat cured acrylic resin. This research aims to determine the effect of soaking heat cured acrylic resin in 50% concentration of edamame seed extract on the compressive strength of heat cured acrylic resin. This study was laboratory experimental used a post test only group design. The form of sample used is a square plate with size of 10x10x2mm, which divided into three groups : group soaked in steriled distilled water, group soaked in commersial effervescent tablets, and group soaked in edamame seed extract at 50% concentration. The test of compressive strength was using Universal Testing Machine. The results of compressive strength test showed that the group soaked with sterile distilled water had the highest strength of 407.12 MPa, second highest was the group soaked in edamame seed extract at 345,55 MPa, and the lowest was group soaked in commercial effervescent tablets at 323,76 MPa. Data was analyzed using Welch Anova and followed by Games-Howell Post-hoc test. The result obtained significant value ($p<0,05$), that indicated there are significant different between each of the group based on the Games Howell Post-hoc test. This study can conclude that soaking the heat cured acrylic resin in edamame seed extract at 50% concentration has an effect in reducing the compressive strength of heat cured acrylic resin.

Keyword: *Heat cured acrylic resin, edamame seed extract, removable denture, compressive strength*

Introduction.

Heat cured acrylic resin is widely used denture base material. Heat cured acrylic resin is chosen because of its advantageous characteristics, which encompass ease of processing and repairing, adequate mechanical properties, cost-effectiveness, and low toxicity.1 Despite its numerous advantages, heat cured acrylic resin has porosity and vulnerability to absorb liquid.2 Prolonged use of dentures without regular cleaning may result in the accumulation of plaque and the proliferation of Candida albicans, which can contribute to the development of denture stomatitis3. To avoid this case, a regular cleansing mechanism for the denture base using a denture cleanser is essential.4 Alkaline peroxide in the form of effervescent tablets is a common denture cleansing agent.5 However, because of their acid content, alkaline peroxide contain denture cleanser have been shown to make the surface of heat-cured acrylic resin rougher. Studies advise utilizing natural or herbal substances to reduce this disadvantage.6 A herbal substance that can be utilized as a denture cleanser is edamame. Edamame (Glycine max L. Merrill) is a Japanese green soybean that has been found to express antibacterial and antioxidant properties.7 Flavonoids, saponins, isoflavones, alkaloids, and tannins are among the vital substances found in edamame that have antifungal and antibacterial property.8,9 According to prior research, edamame extract can effectively work as an antifungal for C.albicans also as antibiotic for Streptococcus mutans at a concentration of 50g/ml.10,11

However, the vital substances of edamame, such as flavonoids, which are a class of phenols, potentially reduce the compressive strength of heat cured acrylic resin.12 Phenol is an aromatic hydrocarbon compound, believed to cause microporous spaces within acrylic resin by making the gap within its polymer chain13. Instability of the chain may affect the properties of acrylic resin, including its mechanical properties, such as compressive strength.14 Compressive strength is one of the mechanical properties of heat cured acrylic resin to withstand the pressure of mastication process so that the denture base is not easily fractured or broken.12 According to the American Society for Testing and Materials

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(ASTM D638) the compressive strength value of heat cured acrylic resin is 75 MPa.15 Hence, this in vitro study aimed to discover the effect of of soaking heat cured acrylic resin in edamame seed extract (Glycine max L. Merril) at 50% concentration as a removable denture cleanser on compressive strength.

METHODS

A total of twenty-four heat-cured acrylic resin specimens were fabricated following the manufacturer's instructions, utilizing conventional flasking and pressure-pack methods. The acrylic resin was positioned within a square-shaped cuvette with dimensions of 10 x 10 x 2 mm. The resin polymerization was conducted using water bath method by soaking the flask in boiling water at 70°C for 30 minute continued at 100°C for a duration of 30 minute. The cuvette was opened after it had come to room temperature. The acrylic specimen was then polished until the surface was smooth and flat using 500-grit abrasive paper and polishing brush. Afterward, the acrylic resin samples were submerged in distilled water for twenty-four hours.

The variant of edamame that we used in this study is MF 116 (PT. Mitratani Dua Tujuh, Jember, Indonesia). Initially, edamame seed were dried in an oven at 50°C. Dried edamame seeds were ground into a fine powder and sieved. The edamame seed powder was then extracted using the maceration method, employing a 70% ethanol solvent for 72 hours at a 1:5 (gr/ml) ratio of powder and solvent. The obtained filtrate was then evaporated using a rotary evaporator. Then, tween 80 and sterile distilled water was used to dilute the extract until a 50% concentration was achieved.

Twenty-four specimens of acrylic resin (n=9/group) were distribute into three groups, namely A (soaked in distilled water), B (soaked in commercial effervescent tablets), and C (soaked in 50% concentration of edamame seed extract). The soaking process for the three groups was conducted over a period of 11 days, corresponding to the equivalent of three years of soaking.

The compressive strength test was conducted using a Universal Testing Machine (UTM). The samples were placed in a universal testing machine and the load was applied at a crosshead speed of 5 mm/ minute until the fracture of the acrylic resin sample. The load at the point of sample fracture was recorded and converted into megapascals (MPa) to represent the compressive strength, followed by data analysis. The research data were analyzed using a Statistical Package for the Social Sciences 26.0 (SPSS for Macbook; SPSS, Chicago, IL, USA). The differences between groups were assessed using Welch ANOVA, and multiple comparison tests were conducted with the Post Hoc Games-Howell test at a significance level of $p<0.05$, with a 95% confidence interval.

RESULT

The mean value of compressive strength in each group can be seen in Figure 1.

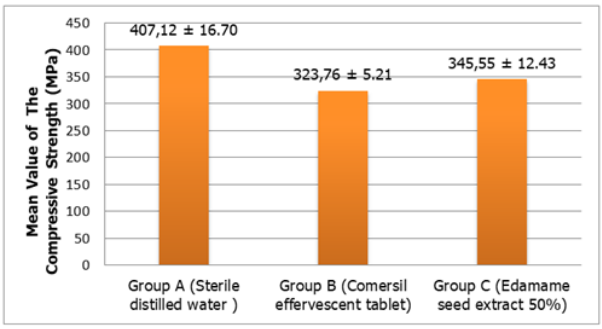

Figure 1 : Compressive strength value of each treatment groups

Figure 1 showed that the mean value of compressive strength for Group A was 407,12 ± 16,7 Mpa, for Group B was 323,76 ± 5,21 Mpa, and for Group C was 345,56 ± 12,43 Mpa. Statistical analysis using Welch ANOVA revealed significant differences among the groups ($p<0.05$).

The Post Hoc Games Howell test also identified significant differences between certain treatment groups ($p<0.05$), as shown in Table 1.

Table 1 : Post Hoc Games-Howell test result

Treatment Group		*Mean Difference*
Group A	Group B	83.35444*
	Group C	61.55778*
Group B	Group A	-83.35444*
	Group C	-21.79667*
Group C	Group A	-61.55778*
	Group B	21.79667*

Base Materials: A Review. Polymers (**Note**: *Significant result ($p<0,05$)

The results of the Games-Howell further test showed that each group had a significant difference with a significance value smaller than 0.05 ($p<0.05$). Table 1 interpreted that group A has the greatest compressive strength of all groups in 407,12 ± 16,7 Mpa, group C has greater compressive strength than group B in 345,55 ± 12,43 Mpa, and group B has the least compressive strength at 323,76 ± 5,21 Mpa.

DISCUSSION

The mechanical properties of heat-cured acrylic resins can be modified by the inherent physical characteristics of the resins as well as the concentration of denture cleaning agents used. Important factors contributing to these changes include the level of microporosity and the resin's ability to absorb liquids.[16] Polymethyl methacrylate in acrylic resin is a hydrophilic substance due to the presence of its polar ester group (C=O). This absorption takes place through diffusion, where a substance moves through the intermolecular spaces and solution molecules that penetrate the polymethyl methacrylate chain will settle between the polymer chains, leading to the separation of these chains. The distance between polymer chains increases, causing the matrix to

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expand and soften, which ultimately leads to a reduction in the strength of the acrylic resin.[17]

The compressive strength (MPa) of the group soaked in 50% concentration of edamame seed extract was greater than the positive control group but less than the negative control group. This significant differences may occur due to differences in the content of denture cleaning agents used for soaking. The edamame seed extract-soaked includes phenol-group active chemicals like flavonoids, isoflavones, saponins, and tannins, which cause chemical damage to the surface of the heat-cured acrylic and becomes a rift, thereby reducing the strength of the acrylic resin, including the compressive strength.[7,12] This finding supports the previous study by Kristiana *et al*. examining examining the immersion of heat-cured acrylic resin in distilled water, tobacco leaf extract effervescent tablet in 75% concentration, and commercial effervescent tablet fot 16 days. The results indicated that the impact strength of heat-cured acrylic resin bases immersed in a 75% concentration of tobacco leaf extract effervescent tablet solution was lower compared to those soaked in sterile distilled water.[13] This implies that the components present in denture cleaners can influence the mechanical properties of the acrylic resins, including compressive strength.

Our results indicated that the compressive strength of the group soaked in 50% concentration edamame seed extract was 345.55 ± 12.43 MPa, which exceeds the standard value of 75 MPa (as per ASTM D638).[15] This suggests that the denture base remains highly capable of withstanding chewing forces over a 3-year period of denture use. On the other hand, this value remains lower when compared to the negative control group. This could likely be due to the presence of flavonoids or phenolic compounds in the extract. Phenol compounds tend to be acidic because they are able to release H+ ions from their hydroxyl groups (-OH) and form phenoxide anions ($C_6H_5O^-$)[17]. The reaction between phenol compounds and heat cured acrylic resins can occur when the H+ ions released by phenol compounds bind to ester groups in the polymer chain of heat cured acrylic resins. This ion exchange reaction leads to damage in the chemical structure of heat-cured acrylic resin, resulting in instability which causes many cracks and lowers the compressive strength value.[12,18]

The compressive strength of the positive control group was also lower than the negative control group at 323,76 ± 5.21 MPa. This occurs because the commercial effervescent tablets used as denture cleaning agents contain alkaline peroxide.[19] Alkaline peroxide can release hydrogen peroxide (H_2O_2) when dissolved in water, due to the weak bonds that generate hydrogen (H+) and oxygen (O) ions.[14] This leads to strong oxidation of the polymer bonds in heat-cured acrylic resins, which negatively impacts the compressive strength. Similar findings were observed in the study by Puspitasari et al., which demonstrated a decrease in the surface hardness of resins soaked in alkaline peroxide, compared to those soaked in celery extract (*Apium Graveolens L.*) containing phenol.

Compared to the two groups, the negative control group remain the highest compressive strength value at 407,12 ± 16.70 MPa. The solution used in the negative control group was distilled water containing only H_2O molecules.[13] This solution is used because it does not accelerate the degradation of the polymer chain in heat-cured acrylic resin, resulting in a relatively high compressive strength.[20] Denture cleaning with only distilled water is not recommended, as it is considered less effective and lacks active antibacterial properties. Edamame seeds are recognized for containing flavonoids, isoflavones, saponins, and tannins, which possess antibacterial and antifungal properties[8], positioning them as promising candidates for use as denture cleaners. The average compressive strength values of denture bases soaked in a 50% concentration of edamame seed extract for 11 days remain above the minimum standard of 75 MPa, as specified by ASTM D638.[15] This indicates that the denture base can still function effectively throughout the 3-year usage period.

CONCLUSION

The use and development of edamame seed extract as a denture cleaning agent can lead to a reduction in the compressive strength of the denture base. However, the post-soaking compressive strength values observed in the study remain above the standard, indicating that edamame seed extract has the potential to be developed into an alternative denture cleaning product made from natural ingredients.

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