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THE EFFECT OF 50% EDAMAME BEAN (GLYCINE MAX L. MERRIL) EXTRACTS ON THE SURFACE ROUGHNESS OF HEAT-CURED ACRYLIC RESIN

PENGARUH EKSTRAK EDAMAME (GLYCINE MAX L. MERRIL) 50% TERHADAP KEKASARAN PERMUKAAN RESIN AKRILIK HEAT-CURED

Original Research Article
Penelitian

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ABSTRACT

Background: *Edamame bean (Glycine max L. Merril) extract is an alternative to denture cleanser because it contains antifungal and antibacterial compounds, such as flavonoids. However, flavonoids may increase the surface roughness of heat-cured acrylic resin.* ***Purpose:*** *This research aims to analyze the effect of 50% edamame bean extract as a denture cleanser on the surface roughness of heat-cured acrylic resin.* ***Method:*** *Twenty four square shaped heat-cured acrylic resin plates of 10 x 10 x 2 mm were divided into four groups: A1, A2, B1, and B2. Each group was immersed in distilled water (A1 for four days and A2 for 11 days) and 50% edamame bean extract (B1 for four days and B2 for 11 days). The surface roughness was measured using a surface roughness tester TR 220. The data were then analyzed using the Two Way ANOVA test followed by the Tukey HSD test with a significance value of p-value < 0.05.* ***Result:*** *The average surface roughness in heat-cured acrylic resin increased in 50% edamame extract immersion for four and 11 days. The highest increase was experienced in 50 % edamame extract immersion for 11 days with a value of 0.158 µm. In contrast, the distilled water immersion group noted the lowest surface roughness for four days and 11 days.* ***Conclusion:*** *Edamame extract significantly affects the surface roughness of heat-cured acrylic resin after immersion for four and 11 days.*

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ABSTRAK

Latar belakang: Ekstrak kacang edamame (*Glycine max L. Merril*) merupakan salah satu alternatif pembersih gigi tiruan karena mengandung senyawa antijamur dan antibakteri, seperti flavonoid. Namun, senyawa flavonoid diketahui dapat meningkatkan kekasaran permukaan resin akrilik tipe *heat-cured*. **Tujuan:** Penelitian ini bertujuan untuk menganalisis pengaruh ekstrak kacang edamame 50% sebagai pembersih gigi tiruan terhadap kekasaran permukaan resin akrilik *heat-cured*. **Metode:** 24 buah pelat persegi resin akrilik *heat-cured* berukuran 10 x 10 x 2 mm dibagi menjadi empat kelompok: A1, A2, B1, dan B2. Masing-masing kelompok direndam dalam aquades (A1 selama 4 hari dan A2 selama 11 hari) dan ekstrak kacang edamame 50% (B1 selama 4 hari dan B2 selama 11 hari). Kekasaran permukaan diukur menggunakan *surface roughness tester* TR 220. Data kemudian dianalisis menggunakan uji *Two Way ANOVA* yang dilanjutkan dengan uji *Tukey HSD* dengan nilai signifikansi *p-value* < 0.05. **Hasil:** Rata-rata kekasaran permukaan resin akrilik *heat-cured* meningkat setelah perendaman dalam ekstrak edamame 50% selama empat dan 11 hari. Peningkatan tertinggi terjadi setelah perendaman selama 11 hari dengan nilai 0.158 µm. Sebaliknya, kelompok perendaman dalam aquadest mencatat kekasaran permukaan paling rendah, baik setelah empat hari maupun 11 hari. **Kesimpulan:** Ekstrak edamame berpengaruh secara signifikan terhadap kekasaran permukaan resin akrilik *heat-cured* setelah perendaman selama empat dan 11 hari.

Kata kunci:
Edamame, Pembersih gigi tiruan, Kekasaran permukaan, Resin akrilik *heat-cured*

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INTRODUCTION

Heat-cured acrylic resin is the most commonly used denture base material. Heat-cured acrylic resin, known as acrylic resin, has experienced thermal activation polymerization (Anjai *et al*., 2018). This material has a gingiva like texture and color, making it aesthetically pleasing, affordable, and easy to manipulate and repair. However, heat-cured acrylic resin is also porous and tends to absorb fluid (Naini, 2015).

Denture bases in contact with saliva form *Acquired Dental Pellicle* (ADP) and generate plaque formation, which increases the accumulation of microorganisms in the oral cavity, especially *Candida albicans*. This condition results in denture stomatitis (Dama, 2013; Wirayuni, 2017). Periodic cleaning using a denture cleanser is essential to prevent this possibility. However, chemical denture cleansers are reported to increase the surface roughness of heat-cured acrylic resin due to its acid content. Studies suggest using natural or herbal ingredients to minimize this drawback (Dewi *et al*., 2020).

Edamame (*Glycine max L. Merril*) is a soybean from the legume group, harvested at the peak of ripening before reaching the hardening period. This plant is originally from Japan. Edamame contains essential compounds such as flavonoids, saponins, isoflavones, alkaloids, and tannins, which have antifungal and antibacterial properties (Abd-Alla *et al*., 2019; Abdel-Hadya *et al*., 2019). A previous study proved that edamame extracts at a concentration of 50 mg/ml could inhibit the growth of *Candida albicans* (Igboabuchi and Ilodibia, 2018; Kristiana *et al*., 2022). In addition, other studies also show that 50% of edamame extracts effectively inhibit the number of *Streptococcus mutans* colonies (Devi *et al*., 2023). However, flavonoid compounds in edamame in contact with heat-cured acrylic resin might cause an increase in the surface roughness of heat-cured acrylic resin.

Surface roughness is crucial for dentures since it affects their quality and longevity and induces bacteria adhesion. The ideal cleanser should keep the mechanical and physical characteristics of the denture base resin the same after extended usage (Porwal *et al*., 2017; Sharma *et al*., 2017). For reference, the surface roughness of a heat-cured acrylic resin denture base is acceptable if the value is not more than 0.2 µm (Onwubu and Mdluli, 2022; Vinagre *et al*., 2023).

The surface roughness of heat-cured acrylic resin dentures generally increases as dimensional changes because of the duration of use (Arafa, 2016). Those changes might happen during intraoral use. Ningsih *et al*. (2020) suggested that after 1 to 3 years of wear. If adjusted to the contact time between the edamame extract and the acrylic resin plate for 15 minutes (in short-term soaking), the usage period of one year is equivalent to four days, and three years is equal to a soaking time of 11 days (Arruda *et al*., 2015). Thus, we chose those periods to analyze the possibility of 50% of edamame extracts changing surface roughness on prolonged use and whether it is still clinically tolerable.

MATERIAL AND METHOD

Specimen preparation

Twenty four heat-cured acrylic resin specimens were fabricated according to the manufacturer's guidelines using conventional flasking and pressure-pack techniques. The acrylic resin was placed in a square-shaped cuvette with a size of 10 x 10 x 2 mm (based on the *American Dental Association* (ADA) specification No. 12). The polymerization process of the resin was carried out by placing the flask in boiling water at 100 °C for 20 minutes. The cuvette was left until it reached room temperature before opening. Subsequently, the acrylic sample was smoothed with 500 number scouring paper until the surface was flat and smooth. Then, the acrylic resin specimens were immersed in distilled water for 48 hours and in artificial saliva for one hour.

Preparation of edamame bean extract

The variant of edamame that we used in this research is MF 116 (PT Mitratani Dua Tujuh, Jember, Indonesia). First, edamame beans were dried in an oven at 50 °C for one day. The dried edamame seeds were then ground into powder and sieved. Subsequently, maceration was carried out using 70% ethanol solvent at a 1 : 5 (gr/ml) ratio for three days. The obtained filtrate was then evaporated using a rotary evaporator (Siddiq, 2016). Finally, 50% edamame bean extract was obtained by diluting 1.5 ml extract in 1.5 ml distilled water.

Immersion process

Twenty-four specimens of acrylic resin (n = 6/ group) were distributed into two control groups and two treatment groups, namely A1 and A2 (immersion in distilled water for four days and 11 days, respectively), and B1 and B2 (immersion in 50% edamame bean extract for four and 11 days, respectively). Duration of four and 11 days for immersion was equivalent to using a denture cleanser solution for one year and three years, respectively.

The measurement of surface roughness (Ra)

The surface roughness of the samples before and after treatment was measured using a surface roughness tester TR 220. Measurements are taken on one side of the sample on three different lines. Each sample's average surface roughness (Ra) was then noted and analyzed.

Statistical analysis

The average surface roughness (Ra) data were analyzed using a Statistical Package for The Social Sciences 25.0 (SPSS for Macbook; SPSS, Chicago, IL, USA). The data obtained were analyzed through *Two Way ANOVA*, followed by a *Tukey HSD* test at a % confidence level of 95% (α = 0.05).

RESULT

Parametric statistical analysis using the *Two-Way ANOVA* is shown in the Table 1. Table 1 represents a significance value of 0.027 (*p-value* < 0.05), which means that there is a significant difference in the average surface roughness (Ra) between the control and treatment groups. Furthermore, the *Tukey HSD* test illustrates a substantial difference between each group with a value of 0.000 (*p-value* < 0.05) in the 50% edamame extract group for four days and 11 days. While in the distilled water (control) group for four days and 11 days it showed no significant difference with a value of 0.232 (*p-value* > 0.05).

Figure 1 presents each group's average surface roughness (Ra) before and after immersion. The highest Ra value was experienced in 50% edamame bean extract immersion for 11 days with a value of 0.158 µm (increase by 0.026 µm). In contrast, the lowest was observed in both control groups (increase by 0.015 and 0.014 µm, respectively). The group immersed in 50% edamame bean extract for four days underwent an increase in Ra value by 0.020 to 0.141 µm.

Table 1. *Tukey HSD* test on all groups' average surface roughness (Ra)

	Distilled water (control) for 4 days	Distilled water (control) for 11 days	50% edamame extract for 4 days	50% edamame extract for 11 days
Distilled water (control) for 4 days	-	.232	.000	.000
Distilled water (control) for 11 days	.232	-	.000	.000
50% edamame extract for 4 days	.000	.000	-	.000
50% edamame extract for 11 days	.000	.000	.000	-

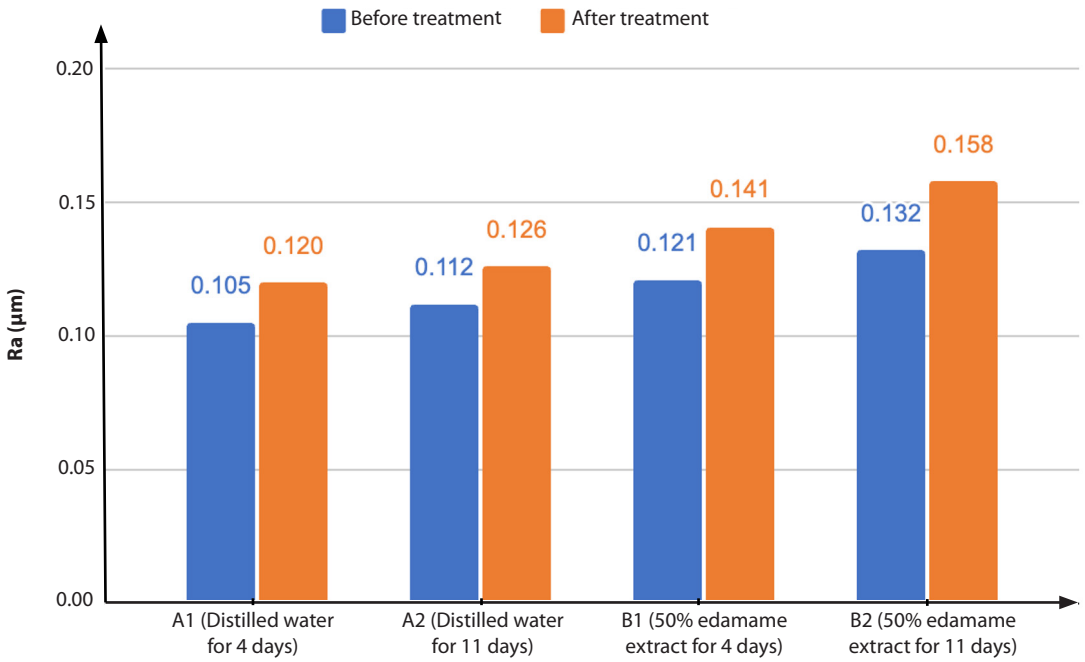

Figure 1. Average surface roughness (Ra) of heat-cured acrylic resin before and after treatment

DISCUSSION

The average surface roughness (Ra) of the group soaked in 50% edamame bean extract for four and 11 days experienced the highest increase in surface roughness value compared to the control group. This significant difference may be caused by the contact between the acrylic resin plate and the active compounds in the edamame extract, namely flavonoids (phenolic compounds), which cause chemical damage to the surface of the heat-cured type acrylic resin plate, increasing surface roughness (Dwimartha *et al*., 2018). This finding supports previous study (Wirayuni and Saputra, 2021) that a longer immersion time might increase the surface roughness of the heat-polymerized acrylic resin denture base. However, in this research, we tried to determine whether the 50% edamame bean extract increases the Ra in an acceptable range.

Our finding showed that although 50% edamame bean extract increases the Ra value of both treatment groups, they did not exceed the tolerance threshold of denture base surface roughness, which is less than 0.2 µm. If the surface roughness is greater than 0.2 µm, it leads to a corresponding increase in plaque accumulation, raising the risk of periodontal inflammation and caries (Kodir *et al*., 2017; Vinagre *et al*., 2023).

The roughness generated by edamame extract likely appeared because of its flavonoids (phenols) compound. Phenol is a stronger acid than alcohol and water (Saputera *et al*., 2021). The H^+ ion in that compound will fill the gap by diffusion between the polymer chain bonds of the ester group (COOH), damaging the C = O double bond in the heat-cured type acrylic resin and leading to unstable polymer chain bonds. The ester group is more readily hydrolyzed and forms many cracks on the surface of the heat-cured acrylic resin. The number of cracks causes the surface to be uneven and increases the surface roughness of the heat-cured acrylic resin (Wirahadikusumah *et al*., 2020). However, in this research, we used the optimum concentration of 50% to give an effective cleansing result with minimum damage. The result shows that even though it caused surface roughness, the value is still acceptable for one to three years of use.

The distilled water is pure water with H_2O molecules (no other ionic elements). This solution served as a control because it contains no active substances that accelerate the separation of polymer chains of heat-cured acrylic resins (Ozyilmaz and Akin, 2019; Savitri *et al*., 2022). However, this research discovered that the Ra value of acrylic resin samples of both control groups insignificantly increased after immersion in aquadest (*p-value* > 0.05). The alterations of roughness value in the control groups might have occurred due to water absorption, which can lead to fatigue and change in dimensions, leading to cracks in the resin (Ozyilmaz and Akin, 2019).

Polymethyl methacrylate in acrylic resin is a hydrophilic compound because of its polar ester group (COOH) (Rifdayanti *et al*., 2019). Consequently, this acrylic resin can absorb or bind liquids strongly (Sofya *et al*., 2017). This absorption happens through diffusion, by which a substance moves through a gap or space on the surface of a heat-cured acrylic resin. Water molecules that penetrate the polymethyl methacrylate chain will occupy a position between the polymer chains, causing the polymer chains to push apart. A separated polymer chain will form spaces on the surface of the acrylic resin, called porosity, so that the surface of the heat-cured acrylic sheet becomes rougher (Kalasworojati *et al*., 2020). According to a study by Fouda *et al*. (2019), the surface of acrylic resin with more pores also had the roughest texture.

Another effect of heat-cured acrylic resin's liquid absorption and microporosity properties is allowing the base to absorb salivary proteins easily and form an *Acquired Dental Pellicle* (ADP). This pellicle becomes a reservoir of *Candida albicans* growth, resulting in denture stomatitis, so cleaning the denture chemically using a chemical cleanser is necessary. Based on our research, 50% edamame bean extract can be an ideal alternative denture cleanser for heat-cured acrylic resin for one to three years.

Edamame is known to contain essential compounds such as flavonoids (phenols), saponins, isoflavones, and tannins that act as antibacterial and antifungal agents (Igboabuchi and Ilodibia, 2018; Abdel-Hadya *et al*., 2019; Peiretti *et al*., 2019; Kristiana *et al*., 2022). Phenol is a stronger acid compared to alcohol and water because of its chemical formula (C_6H_5OH), where the structure has a hydroxyl group (^-OH) (Saputera *et al*., 2021). The acidic compounds containing H^+ ions can reduce the surface tension of heat-cured type acrylic resins so that the H^+ ions can easily penetrate between the acrylic resin molecules. The ion will then fill the gap by diffusion between the polymer chain bonds of the ester group (COOH) so that the H^+ ion will damage the C = O double bond in the heat-cured type acrylic resin. This event leads to unstable polymer chain bonds. The ester group is more readily hydrolyzed and forms many cracks on the surface of the heat-cured acrylic resin. The number of cracks causes the surface to be uneven and increases the surface roughness of the heat-cured acrylic resin (Wirahadikusumah *et al*., 2020).

CONCLUSION

The 50% edamame bean extract significantly affects the surface roughness of heat-cured acrylic resin after immersion for four and 11 days. The highest Ra value was recorded in the immersion for 11 days but is still clinically acceptable.

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