Effect of acrylic denture immersion in mangosteen rind extract on shear bond strength of artificial teeth with denture base: experimental laboratory study

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ABSTRACT

Introduction: Determination of shear bond strength is important because artificial teeth being detached from their base is frequent. 15% mangosteen rind extract can be used as an alternative denture cleanser because it effectively reduces the number of Candida albicans. This study was conducted to analyze the effect of acrylic denture immersion in 15% mangosteen rind extract (*Garcinia mangostana Linn.*) and 0.2% chlorhexidine solution on the shear bond strength of artificial teeth to base for 1 year. **Methods:** This study was an experimental laboratory study. The samples used were mandibular first molar acrylic artificial teeth placed in a cylindrical heat-polymerized denture base resin with a diameter of 18 mm and height of 20 mm; the artificial teeth was placed in a depth of 3 mm buccally. The number of samples used were 30, divided into three immersion groups, 10 each. The shear bond strength value was obtained using the Universal Testing Machine. The results of the data were analyzed using a one-way ANOVA test. **Results:** The one-way ANOVA test results showed a significant effect ($p<0.05$) of acrylic denture immersion in 15% mangosteen rind extract and 0.2% chlorhexidine solution on shear bond strength for 1 year. **Conclusion:** After immersion in 15% mangosteen rind extract, the shear bond strength was higher than the value after immersion in 0.2% chlorhexidine solution; these results indicated that 15% mangosteen rind extract was better than 0.2% chlorhexidine in terms of shear bond strength. Therefore supporting the use of 15% mangosteen rind extract as an alternative denture cleanser.

Keywords

acrylic denture, shear bond strength, mangosteen rind extract

Pengaruh perendaman gigi tiruan akrilik dalam ekstrak kulit manggis terhadap kekuatan ikatan geser antara gigi artifisial dengan basis gigi tiruan: penelitian eksperimental laboratori

ABSTRAK

Pendahuluan: *Penentuan kekuatan ikatan geser merupakan hal yang penting karena fenomena pelepasan gigi artifisial dengan basisnya sering terjadi. Ekstrak kulit manggis 15% dapat digunakan sebagai alternatif bahan pembersih gigi tiruan karena efektivitasnya dalam menurunkan jumlah Candida albicans. Penelitian ini dilakukan untuk menganalisis pengaruh perendaman gigi tiruan akrilik dalam ekstrak kulit manggis (Garcinia mangostana Linn.) 15% dan larutan klorheksidin 0,2% terhadap kekuatan ikatan geser antara gigi artifisial dengan basis selama 1 tahun.* ***Metode:*** *Jenis penelitian ini adalah penelitian eksperimental laboratoris. Sampel yang digunakan adalah gigi artifisial akrilik molar satu mandibula yang ditanam dalam basis gigi tiruan resin akrilik polimerisasi panas berbentuk silindris dengan diameter 18 mm, ketinggian 20 mm, dan kedalaman penanaman gigi artifisial sebesar 3 mm di bagian bukal. Jumlah sampel yang digunakan adalah 30 sampel yang terbagi dalam tiga kelompok perendaman. Nilai kekuatan ikatan geser diperoleh dengan menggunakan alat Universal Testing Machine. Hasil data dianalisis dengan uji ANOVA satu arah.* ***Hasil:*** *Hasil uji ANOVA satu arah menunjukkan adanya pengaruh yang signifikan ($p<0,05$) dari perendaman gigi tiruan akrilik dalam ekstrak kulit manggis 15% dan larutan klorheksidin 0,2% terhadap kekuatan ikatan geser selama 1 tahun.* ***Simpulan:*** *Nilai kekuatan ikatan geser setelah direndam dalam ekstrak kulit manggis 15% menghasilkan nilai yang lebih tinggi dibandingkan larutan klorheksidin 0,2% sehingga mendukung penggunaan ekstrak kulit manggis 15% sebagai alternatif bahan pembersih gigi tiruan.*

Kata kunci

gigi tiruan akrilik, kekuatan ikatan geser, ekstrak kulit manggis

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INTRODUCTION

A denture consists of two components: base and artificial teeth.[1] The denture base is part of the denture that rests on the supporting tissue and is the attachment point for the artificial teeth. Artificial teeth are a component of dentures which function to replace missing teeth.[2] Heat-polymerised acrylic resin (HPAR) is one of the most commonly used denture base materials. Nowadays, most artificial teeth are made of acrylic resin materials, such as those used to build bases. The hot polymerized acrylic resin denture base will chemically bond with the acrylic denture.[1,3]

Cleaning dentures is important because it will increase dentures' shelf life, maintain the oral mucosa's health, and improve the patient's quality of life.[4] One of the components that can be an alternative to conventional denture cleaners is mangosteen rind extract because it contains saponins, which can create foam resembling soap and acts as a denture cleaner antifungal.[5] Lubis[6] research showed that immersing dentures in mangosteen rind extract significantly inhibited the growth of *Candida albicans* in dentures.[6] Cleaning dentures by immersion would cause the base part, along with the artificial teeth submerge at once. This submersion cause the dentures to change. One change affected the base part and artificial teeth on the shear bond strength between the two. The long chains of ester compounds present in acrylic resins will undergo hydrolysis so that the bond becomes weak and releases plasticizers which will affect the material's mechanical properties, namely the shear bond strength.

The detachment of artificial teeth from the denture base is a major problem when practicing prosthodontics. Surveys report that 26-33% of denture repairs involve detachment of artificial teeth which causes distress and increases costs for patients.[8] Shear bond strength is the maximum load or force needed to cause the artificial tooth to be detached from the denture base.[9] Mangosteen rind extract contains anthocyanin, which is a phenolic compound. Research by Neppelenbroek et al.[10] found that the anthocyanins present in red wine did not significantly affect the shear bond strength. Other phenolic compounds in mangosteen rind, such as flavonoids, tannins, and xanthones, can also affect the shear bond strength properties, so further research is required. Phenol in contact with acrylic resin will increase diffusion and cause chemical damage to the acrylic resin surface through hydrolysis reactions; then polymer matrix degradation occurs, which increases the roughness of the acrylic resin surface and continues to crack or craze and decrease the material's strengths, such as shear bond strength.[7] This study used mangosteen rind extract at a concentration of 15%, which is the minimum lethal dose of mangosteen rind extract against *Candida albicans*.[6]

Chlorhexidine is one of the most widely used denture cleaners in dentistry. Chlorhexidine 0.2% is an effective cleaning agent with a broad spectrum; it also acts quickly and has low toxicity.[11] Immersion was carried out for 15 minutes per day for one year of use because the immersion had caused significant changes in mechanical properties due to the presence of phenolic compounds and was also the most effective immersion time for denture cleaning in 0.2% chlorhexidine.[12] This study aimed to analyze the effect of immersing acrylic dentures in 15% mangosteen rind extract (*Garcinia mangostana Linn.*) and 0.2% chlorhexidine solution on the shear bond strength between artificial teeth and denture base.

METHODS

This study is an experimental laboratory study, and the research design is a post-test only control group design. The samples used in this study are acrylic artificial teeth (Million, Yamahachi Dental, Japan) mandibular first molars, which were implanted in denture bases (Acron, GC, Japan). The denture base for implanting artificial teeth is cylindrical with a diameter of 18 mm and a height of 20 mm, according to a study by Corsalini et al.[3] about shear bond strength. The implantation depth for all artificial teeth was 3 mm buccally. The number of samples used was 30 samples which were divided into three immersion groups, namely 15% mangosteen rind extract (group A) as the treatment group, 0.2% chlorhexidine solution (group B), and distilled water (group C) as the control group. Each group consists of 10 samples.

The creation of the sample model began by melting the wax and filling it into the pipe. After that, borders were made on the artificial teeth with a marker, which was 3 mm in the buccal part. The occlusal portion of the artificial tooth was attached to the flat surface of the bur disc with double-sided tape, which was then attached to the surveyor's vertical tip. The artificial teeth were put into the wax when the wax was almost setting according to the limit that had been made; then, the sample model was removed from the pipe. The sample model is implanted into a cuvette where one cuvette contains three sample models; then, wax is removed to form a mold. HPAR powder and liquid are stirred in a ratio of 2:1 until they are homogeneous and reach the dough stage. The acrylic resin mixture was poured into the mold; then, the cuvettes were pressed and placed in the water bath for heat curing. The sample was then removed from the cuvette and trimmed with a Fraser bur to remove excess acrylic and smoothed with waterproof sandpaper of sizes 400, 600 and 1000 mounted on a rotary grinder.

The manufacture of mangosteen rind extract started with purposive sampling of the fruit. The mangosteen rind is then separated from the flesh. Mangosteen rind was sliced into small pieces and blended with 70% ethanol until it formed a homogeneous mass and then macerated twice. The two macerates were combined and evaporated using a Rotavapor at 40°C until a thick extract was obtained. Dilution was carried out to obtain a concentration of 15% employing 15 g of thick mangosteen rind extract dissolved in 100 mL of distilled water and 0.3% CMC Na to obtain a suspension and evenly distribute the non-polar compounds contained in the mangosteen

rind. All samples were first soaked in distilled water and put in an incubator for 48 hours at 37°C before immersion to reduce the residual monomer in each group. Samples were divided into 3 groups and soaked in 15% mangosteen rind extract (A), 0.2% chlorhexidine solution (B), and distilled water (C) for 15 minutes per day for 1 year of use (3 days and 20 hours). The sample is then placed into the desiccator for drying and tested for shear bond strength.

The shear bond strength was measured using a Universal Testing Machine. The compressive load was given to the lingual aspect of the artificial tooth with a crosshead speed of 0.5 mm/min and a compressive load of 1000 N. The test was carried out until the artificial tooth was detached from the denture base. A One-Way ANOVA test was performed to determine the effect of immersing acrylic dentures in 15% mangosteen rind extract and 0.2% chlorhexidine solution on the shear bond strength, after which it was followed by the Least Significant Difference (LSD) test to determine differences in the effect of immersing acrylic dentures in 15% mangosteen rind extract and 0.2% chlorhexidine solution on the shear bond strength between artificial teeth and denture base.

RESULTS

The mean value and standard deviation of shear bond strength in Group A was 7.75 ± 1.45 MPa, group B was 4.89 ± 0.78 MPa, and Group C was 7.84 ± 1.65 MPa (Table 1).

Table 1. The shear bond strength value between the artificial teeth and the base after being immersed in 15% mangosteen rind extract, 0.2% chlorhexidine solution, and distilled water

Sample	Shear Bond Strength (MPa)		
	A	B	C
1	6.96	5.62	7.05
2	8.24	4.61	8.46
3	10.20**	4.03	11.00**
4	7.46	3.99*	8.93
5	6.60	4.61	6.30
6	7.66	5.83	5.93*
7	6.81	6.30**	6.17
8	9.94	4.48	9.38
9	8.11	4.46	6.83
10	5.56*	4.97	8.35
$\underline{x}$ ± SD	7.75 ± 1.45	4.89 ± 0.78	7.84 ± 1.65

Note: *Lowest value; **Highest value

The results of the One-Way ANOVA test showed that there was a significant effect of immersing acrylic dentures in 15% mangosteen rind extract and 0.2% chlorhexidine solution on the shear bond strength between artificial teeth and denture base for 1 year with a value of p=0.001 (p<0.05) (Table 2).

Table 2. Effect of acrylic dentures immersion in 15% mangosteen rind extract, 0.2% chlorhexidine solution and distilled water on the shear bond strength between artificial teeth and denture base

Group	n	$\underline{x}$ ± SD (MPa)	p-value
A	10	7.75 ± 1.45	
B	10	4.89 ± 0.78	0.001*
C	10	7.84 ± 1.65	

Note: *Significant

LSD test results showed that there was a difference in effect between groups A and B with a value of p = 0.001 (p<0.05) and between groups B and C with a value of p=0.001 (p<0.05), but there was no difference in effect between group A with C with a value of p = 0.888 (p<0.05) (Table 3).

Table 3. Differences in the effect of acrylic dentures immersion in 15% mangosteen rind extract 0.2% chlorhexidine solution, and distilled water on the shear bond strength between artificial teeth and base

Group		p-value
A	B	0.001*
A	C	0.888
B	C	0.001*

Note *Significant

DISCUSSION

The various research results in Table 1 can be caused by contamination of the ridge lap by cold mold seal (CMS). This can happen because, during the application of CMS to the inside of the mold, which is close to the ridge lap of the artificial teeth, the brush bristles used for greasing touched a portion of the surface of the ridge lap, which then reduced the shear bond strength. This study's results align with Sharma's research[13,] which obtained shear bond strength values in groups contaminated with tin-foil substitutes such as CMS, reaching 35% lower than those not contaminated. Variation in value is also due to water absorption. Water absorption can be affected by various factors, such as the presence of residual monomer after polymerization and the type of sample immersion solution.[14] The remaining monomer in the polymer will reduce the molecular weight of the polymer and produce a more porous polymer structure, which significantly reduces hardness and strength, as well as increases solubility and liquid absorption rate.[15] The type of sample immersion solution also affects the absorption of water due to the content present in the solution.

The mean and SD values of group A were 7.75 ± 1.45 MPa, group B was 4.89 ± 0.78 MPa, and group C was 7.84 ± 1.65 MPa (Table 1). The value of the shear bond strength obtained after immersing the acrylic denture in distilled water was 9.44 ± 1.66 MPa in the study of Neppelenbroek et al.[10]. Pero et al.[15], who obtained a shear bond strength value of 11.91 ± 2.19 MPa in the distilled water soaked group and 6.08 ± 2.35 MPa in the chlorhexidine group. The values obtained in the two studies were lower than those obtained in this study. Differences can influence this in the surface area of the ridge lap. The value of the shear bond strength is obtained by dividing the maximum load on the sample before discharge by the ridge lap area of the artificial tooth. The ridge lap area between this study and previous studies is different, so it will produce different values. The latest national standard for shear bond strength is the Japanese Standard for Acrylic Resin Teeth (JIST 6506) which states that an acceptable value is 60 N for mandibular teeth, whereas, in this study, the lowest value was obtained from immersion in 0.2% chlorhexidine, namely 399 N which still meets the standards.[16] These results support using 15% mangosteen rind extract as an alternative denture cleaning agent.

Table 2 shows that the shear bond strength value in Group A was greater than in Group B but lower than in Group C. This was due to the presence of phenolic compounds in mangosteen rind extract. This is supported by the research of Pisani et al.[4] who found an increase in the roughness of acrylic artificial teeth after immersion in 2% castor oil (Ricinus communis) which contains phenolic compounds, while immersion in distilled water caused a decrease in roughness. Phenol compounds in contact with acrylic resins will increase diffusion, and hydrolysis reactions occur, which cause chemical damage to the surface; then degradation of the polymer matrix occurs, which increases roughness which continues in cracking (crazing) and decreasing strength. This will then reduce the shear bond strength.[7,17] This process occurs in group A which contains phenolic compounds such as xanthones, anthocyanins, flavonoids, and tannins.

Mangosteen rind extract is acidic with a pH of 5-5.5. According to research by Sofya et al.[18], acids in contact with the resin accelerate damage to the chemical structure on the surface of the resin. H^+ ions will fill the space between the polymer chains in the ester group (COOH) so that H^+ ions will break the double bond from C (C=O) of PMMA by filling the space between the polymer chains which causes the polymer chains to detach so that the polymer chain bonds become unstable and the bond chemical structure will be broken. Acids easily hydrolyze esters, which will cause cracks in the acrylic resin specimen, making the surface irregular and increasing its roughness. The acrylic resin's strength also decreases, leading to a decrease in shear bond strength.[18]

Group B has the smallest shear bond strength value among the other two groups. Chlorhexidine 0.2% has a lower pH than mangosteen rind extract. Chlorhexidine 0.2% has a pH of 4.58.[16]. According to Sofya et al.[16], the lower the pH of a food or drink, the higher the surface roughness value of acrylic resin. Low pH shows more H+ ions which causes spaces in the polymer chains of acrylic resins. The more space contained in the polymer chain, the greater the monomer space, which causes a high degree of porosity in acrylic resin.[16]

Chlorhexidine contains chlorine compounds. Research by Mathar et al.[19], stated that the chlorine found in chlorinated water and carbonated drinks significantly reduced the bond strength of acrylic dentures. Chlorine will penetrate the space between the acrylic resin molecules, which causes the chemical structure of the acrylic resin polymer to be damaged and porous so that it experiences high water absorption. This will interfere and cause the bonds between polymers to decrease, reducing the shear bond strength.[19]

The LSD test results in Table 3 show that there is a difference in effect between groups A and B with a value of $p=0.001$ ($p<0.05$) and between groups B and C with a value of $p=0.001$ ($p<0.05$). According to a study by Neppelenbroek et al.[10], colored drinks such as red wine, that are often consumed daily, do not significantly affect the shear bond strength of acrylic dentures. Red wine (wine) contains anthocyanins from grapes which make the color purplish red. Neppelenbroek et al.[10] showed that the anthocyanin content did not significantly affect the shear bond strength value. This means that the anthocyanins in the mangosteen rind extract also do not significantly affect the shear bond strength. Other phenolic compounds in mangosteen rind extract besides anthocyanins are xanthones, flavonoids, and tannins.

Mangosteen rind extract contains xanthone with the highest content, namely 107.70 mg/100 g of rind. The anthocyanin content is 5.7-6.2 mg/100 g, then for flavonoids, it is 11.42 mg/100 g, and finally is the tannin content, which is 3.86 ± 0.39 mg/100 g.[20] If the phenol content in the mangosteen rind extract is totaled, you will get 0.13%. Five percent phenol can weaken the acrylic polymer bond so that the phenol will penetrate and soften the resin.[15] The total phenol content obtained was 0.13% and had not reached 5%, so that could be why there was no difference in effect between groups A and C. The values obtained in group B align with the research of Pero et al.[15], who concluded that immersion of acrylic dentures in 2% chlorhexidine affects the bond strength

by causing a decrease. Pero et al.[15] also obtained results that there was a difference in effect between the immersion groups in 2% chlorhexidine and distilled water[15]

CONCLUSION

The shear bond strength after immersion in 15% mangosteen rind extract was higher than the value after immersion in 0.2% chlorhexidine solution, and these results indicated that 15% mangosteen rind extract was better than 0.2% chlorhexidine in terms of shear bond strength. Therefore supporting the use of 15% mangosteen rind extract as an alternative denture cleanser.

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