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ORIGINAL ARTICLE

Effect of immersion in green tea (camellia sinensis) solution on the transverse strength of heat cured acrylic resin base

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Keywords: Green tea, Heat cured acrylic resin, Transverse strength

ABSTRACT

Objective: To determine the effect of tea solution on the transverse strength of heat cured acrylic resin base. Methods: This study was a laboratory experimental study with post test only with control group design using plate-shaped heat cured acrylic resin samples with a size of 65 mm × 10 mm × 2,5 mm as many as 24 samples. These samples were divided into 6 groups, namely 3 treatment groups immersed in green tea soluble for 3 days, 5 days, and 8 days, and 3 control groups immersed in artificial saliva for 3 days, 5 days, and 8 days. The transverse strength of each group was measured using a Universal Testing Machine (Galdabini). The results were analyzed by Two Way ANOVA test and LSD test. Results: The results of the Two-Way ANOVA test showed a significant difference between immersion in artificial saliva and green tea solution, namely $p = 0,000$ ($p < 0,05$). LSD test results showed significant differences between the three immersion duration groups. Between immersion for 3 and 8 days and immersion for 5 and 8 days, the probability value of $p = 0,000$ ($p < 0,05$) was obtained. While between immersion for 3 and 5 days, the probability value of $p = 0,001$ ($p < 0,05$) was obtained. Conclusion: There is an effect of soaking in green tea solution on the transverse strength of heat cured acrylic resin bases. (IJP 2024;5(2):160-164)

Introduction

Based on Riset Kesehatan Dasar (RISKESDAS) in 2018, 57,6% of oral problems are tooth loss. The percentage of tooth loss in Indonesia is 19%. The characteristic age group of 45-54 years has a percentage of tooth loss of 23,6%. The percentage of tooth loss increases with age. Increased prevalence occurs in the population over 65 years of age. Although the percentage of tooth loss increases, not all individuals who lose teeth use dentures. The percentage of people who use dentures is 1,4%.[1,2]

Tooth loss over a long period of time and not using a denture will result in decreased alveolar bone in the edentulous area, pathological migration of the remaining teeth, decreased masticatory function, impaired speech, aesthetic disturbances, and can affect the temporomandibular joint (TMJ).[3] The many adverse effects of tooth loss make it necessary to use dentures to replace missing teeth, one of which is a removable denture.

The component of a removable denture consists of artificial teeth, clamer, and base. The base of a removable denture can be made from acrylic or metal materials, but the most commonly used is acrylic resin. The denture base plays a role in the stability and retention of the denture. The denture base functions to support the artificial teeth, receive functional forces during occlusion, and then transfer functional forces to support the oral structure in a sustainable manner.[4-6]

Heat cured acrylic resin is widely used because of its advantages, such as transparency, aesthetics, low toxicity, and easy processing, manufacturing, and repair. However, acrylic resin also has some disadvantages, such as easy to absorb liquids, porous, discolored, and easy to fracture. Fractures of denture bases often occur especially in the maxillary midline area. Resistance to fracture depends on the mechanical properties of the material used, one of which is transverse strength.[7,8]

Transverse strength is the strength of a plate supported at each end against a static load. Transverse strength is affected by molecular weight, polymer particle size, residual monomer, porosity, material thickness, load, and moisture content. The transverse strength of acrylic resin is also affected by liquid absorption. The more liquid that penetrates into the base, the more physical changes will occur that will affect the strength and surface structure of the acrylic resin.[7-9]

Tea is a beverage that is often consumed among the public. Per capita tea consumption in Indonesia is around 0.35 kg/year. According to the International Tea Committee (ITC), in terms of green tea consumption, Indonesia ranks 4th among countries in the world. Tea contains three important components, namely caffeine, tannins, and polyphenols. Polyphenols are ingredients that have many health benefits. The highest tea polyphenol content in green tea is 20-30%. A cup of tea contains about 100 mg of polyphenols.[10-14]

When denture users consume tea, the acrylic resin base will

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Figure 1. Transverse strength testing of heat cured acrylic resin plates

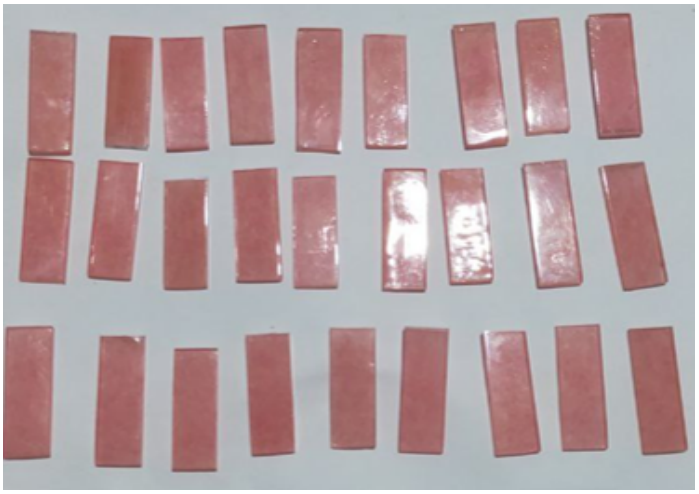

Figure 2. Heat cured acrylic resin plate after transverse strength test

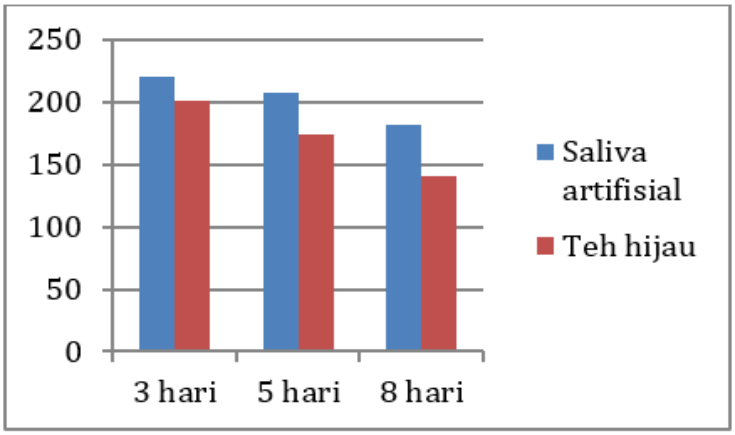

Figure 3. Average value of transverse strength based on immersion duration

come into contact with the tea solution. The polyphenol content then penetrates into the acrylic resin base, breaking the long chain of acrylic resin polymer. As a result, there is a decrease in the intermolecular bonds, thus reducing the strength of the acrylic resin base. Polyphenols can also affect the transverse strength of acrylic resins because they form microporosity that causes chemical damage to the surface of acrylic resins.7,8 Based on this, the authors are interested in examining the effect of immersion in green tea (Camellia sinensis) solution on the transverse strength of heat cured acrylic resin bases.

Material and Methods

This research is an experimental laboratory research with post test only with control group design. This research was conducted from November to December 2023 at Manise Dental Laboratorium Makassar, Oral Biology Laboratory Faculty of Dentistry Hasanuddin University, and Mechanical Engineering Mechanical Laboratory of Politeknik Negeri Ujung Pandang. This study used plate-shaped heat cured acrylic resin samples with a size of 65mm×10 mm×2.5mm as many as 24 samples. These samples were divided into 6 groups, namely 3 treatment groups immersed in green tea soluble for 3 days, 5 days, and 8 days, and 3 control groups immersed in artificial saliva for 3 days, 5 days, and 8 days.

The tools used in this experiment are measuring cup, porcelain cup, petri dish, rubber bowl, spatel, lecron, plaster knife, brush, cuvette, cuvette pressing tool (press), stove, pot, cellophane plastic, polishing tool, caliper (sigmat), clean cloth, incubator (Memmert), and universal testing machine (Galdabini). The materials used in this experiment are heat cured acrylic resin (Huge Denture Base Polymers), base plate wax, type 3 hard cast, soft cast, vaseline, mold seal (CMS), rope, pumice, artificial saliva, water, and green tea (Tong Tji).

Sample making begins with preparing a sample model of the wax base plate with a size of 65mmx10mmx-2.5mm. then the soft cast is mixed with water and stirred until homogeneous, then put into a cuvette and calibrated. After the cuvette is fully filled, the night model is immersed into the cuvette and waited until it hardens. After hardening, the surface of the cast is smeared with vaseline using a brush. The antagonist cuvette was assembled and then filled with the cast mixture until it was full and flat. The lid of the cuvette is installed then pressed using a press tool and then lock the cuvette by tightening the screws and let stand until the cast hardens. The cuvette is tied with string and put into boiling water for 5 minutes to remove the night model. Next, the cuvette is lifted and opened, then the remaining night is cleaned, then the mold surface is smeared with CMS. Powder and liquid heat cured acrylic resin were mixed in a porcelain cup and stirred until they reached the dough stage, then put into the cuvette and covered with

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Table 1. Transverse strength of heat cured acrylic resin plates in each sample group

Sample	Artificial saliva (MPa)			Green tea (MPa)		
	3 days	5 days	8 days	3 days	5 days	8 days
1	233.28	210.24	185.76	204.48	174.24	138.24
2	216	223.2	191.52	187.2	180	144
3	213.12	194.4	178.56	197.28	168.48	151.2
4	218.88	201.6	171.36	216	172.8	128.16
Mean	220.32	207.36	181.8	201.24	173.88	140.4

Table 2. Shapiro-Wilk test results of transverse strength of heat cured acrylic resin plates

Group	Statistic	df	Sig.
Artificial saliva	0.972	12	0.933
Green tea	0.973	12	0.940

Table 3. Two-Way ANOVA test results of transverse strength of heat cured acrylic resin plates

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Soaking type	5885.654	1	5885.654	61.463	0.000
Immersion duration	9989.222	2	4994.611	52.158	0.000
Total	861860.736	24			

Table 4. LSD test results of comparison of mean transverse strength of heat cured acrylic resin plates immersed in green tea solution

Immersion duration (I)	Immersion duration (J)	Mean difference (I-J)	Std. Error	Sig
3 days	5 days	20.1600*	4.89285	0.001
	8 days	49.6800*	4.89285	0.000
5 days	3 days	-20.1600*	4.89285	0.001
	8 days	29.5200*	4.89285	0.000
8 days	3 days	-49.6800*	4.89285	0.000
	5 days	-29.5200*	4.89285	0.000

cellophane. Next, pressing is done so that the excess dough flows out. The cuvette was opened again and the excess ingredients were cut off with a lekron, then the cuvette was closed and a second pressing was done and still covered by cellophane. Then the curing process is carried out, by processing the resin at 74°C for about 2 hours and increasing the temperature of the water bath to 100°C and processing for 1 hour, then removed and left to cool. After cooling, the cuvette was opened and the acrylic plate was removed and then the finishing and polishing process was carried out.

Green tea solution was prepared by dipping 1 green tea bag (2 g) in 200 ml of boiling water (100°C) for 2 minutes in a measuring cup. Then put into Petri dishes as much as 20 ml each and left to cool. The concentration of the green tea solution was 0,01 g/ml or 1%. The 24 samples were divided into 6 treatment groups based on the type and time of soaking. The first three groups as the control group were acrylic plates immersed in artificial saliva for 3, 5, and 8 days. The second three groups were acrylic plates immersed in green tea solution for 3, 5, and 8 days. The assumption of a 3-day soaking period is equal to 1 year of denture wear. The time required to consume green tea is 5 minutes. Suppose that in 1 day it is consumed 2 times, the amount of time required is 10 minutes per day. Thus, the consumption of green tea for 1 year is 10 minutes x 365 days = 3650 minutes = 2,5 days or rounded up to 3 days. Therefore, the three soaking durations were considered as 1 year, 2 years, and 3 years of denture use. The sample baths were kept in an incubator at approximately 37oC, in accordance with the temperature acceptable to the oral mucosa and the green tea solution was changed daily to avoid changes in the solution content.

Measurement of transverse strength using a Universal Testing Machine. The way this tool works is that it will press the center of the plate until it breaks. The monitor will show the maximum load value received by the plate. Furthermore, the value listed on the monitor is then converted into transverse strength using the formula S = 3PL / 2WT2.

Results

This study was conducted to examine the transverse strength of heat cured acrylic resin plate samples after immersion in artificial saliva as the control group and green tea solution as the treatment group. Immersion of the samples was divided into three different time durations, namely 3 days, 5 days, and 8 days. The transverse strength test was conducted by applying a maximum load with a crosshead speed of 3 mm/min to the center of the sample until it broke. The transverse strength testing process can be seen in figures 1 and figure 2.

The maximum load value is then converted into a formula to obtain the transverse strength value. The results of the transverse strength calculation can be seen in table 1 and figure 1.

Table 1 shows the transverse strength values of each sample after immersion in artificial saliva and green tea solution. The results showed a decrease in the average value of transverse strength in each control and treatment group. The highest mean transverse strength value was obtained in the immersion group in artificial saliva for 3 days, namely 220.32 MPa. While the lowest average value of transverse strength was obtained in the immersion group in green tea for 8 days, namely 140.4 MPa.

The transverse strength value data was then analyzed to determine the effect of immersion in green tea solution on the transverse strength of heat cured acrylic resin plates. Before further testing, a normality test was performed using the Shapiro-Wilk test. The results of the Shapiro-Wilk test can be

seen in table 2.

Based on table 2, the probability value p=0.933 was obtained for immersion using artificial saliva and p=0.94 for immersion using green tea solution (p>0.05) which indicates that the data is normally distributed so that it qualifies for ANOVA test to see the difference of several variances. The results of the Two-Way ANOVA test can be seen in table 3.

Based on table 3, the probability value p=0.000 is obtained for the type and duration of immersion (p<0.05) which indicates that there is an effect of the type and time of immersion on the transverse strength of heat cured acrylic resin plates. To determine the average difference in transverse strength in the treatment groups, further tests were carried out with the Post Hoc Test test, namely Least Significance Difference (LSD) which can be seen in table 4.

Based on table 4, there is a significant difference between the three soaking duration groups. Between soaking for 3 and 8 days and soaking for 5 and 8 days, the probability value p=0.000 (p<0.05) was obtained. Meanwhile, between 3 and 5 days of soaking, the probability value of p=0.001 (p<0.05) was obtained. Therefore, it can be said that there is a significant difference in the transverse strength of heat cured acrylic resin plates immersed in green tea solution and artificial saliva for 3, 5, and 8 days.

Discussion

A widely used base material from the past to the present is heat cured acrylic resin. Modifications to heat cured acrylic resins continue to be made to improve their properties, such as impact strength, transverse strength, thermal properties, solubility, and so on. In 2020, it was reported that heat cured acrylic resins are available in powder and liquid form. The powder component contains PMMA, benzoyl peroxide initiator, plasticizers (dibutyl phthalate), opacifiers (titanium and zinc oxide), fibers, and pigments or dyes. While the liquid component contains methyl methacrylate monomer (MMA), ethylene glycol dimethacrylate as a cross-linking agent, and hydroquinone as an inhibitor. Acrylic resin is still used today because of its advantages, such as transparency, aesthetics, low toxicity, and easy processing, manufacturing, and repair. However, acrylic resin also has some disadvantages, such as easy to absorb liquids, easily porous, can change color, and easily fracture.[9,15]

Oral conditions that are often exposed to a lot of fluids can be a factor that affects the decline in mechanical properties of PMMA, one of which is transverse strength. The more liquid that penetrates into the base, it will result in physical changes that will affect the strength of the acrylic resin. In addition, temperature changes associated with food and beverage intake during denture use can affect acrylic resin polymer bonds.[7,8,16]

When denture users consume beverages such as green tea in a warm state, the acrylic resin base will come into contact with the green tea solution. Green tea contains three important components, namely caffeine, tannins, and polyphenols. The higher the brewing temperature of green tea, the higher the total polyphenols produced. The polyphenol content in green tea can penetrate into the acrylic resin base, thus breaking the long chain of acrylic resin polymer. As a result, there is a decrease in intermolecular bonding, thereby reducing the strength of the acrylic resin base. Polyphenols can also affect the transverse strength of acrylic resin because they will form microporosity which causes chemical damage to the surface of acrylic resin.[7,8,10,16]

The results of the study in table 1, show that the transverse strength of the immersion group using green tea solution is lower than that of the immersion group using artificial saliva as a control. This is in line with Rahmi et al research, which states that the presence of polyphenols in tea solutions can degrade the chemical bonds of acrylic resins. Acrylic resin is a polymer in the form of a long polyester, consisting of repeated methyl methacrylate units with low polarity, while phenol is acidic with high polarity. In an acidic atmosphere, the esters hydrolyze to form carboxylic acids and alcohols. The split polyester causes degradation of the chemical bonds of the acrylic resin resulting in a decrease in transverse strength. Islami et al's research also states that phenol in direct contact with acrylic resin will react with PMMA esters. The polymer chain bond of acrylic resin is getting weaker because the compound will enter the surface of acrylic resin and cause acrylic resin to expand. Therefore, the intermolecular bonds decrease, reducing the strength of the acrylic resin.[8,17]

This research is also in line with research conducted by Sujati, which states that polyphenols are chemical substances that have many phenol groups, while phenol is an acidic solution and has a molecular weight smaller than the molecular weight of acrylic resin polymers. Therefore, phenol can be absorbed by the surface of acrylic resin. The chemical absorption of phenol can damage the surface of acrylic resin, in the form of crazing, which is small cracks. This condition is the first sign of fracture of acrylic resin. In addition, the absorption of green tea solution with high polyphenol content, is able to hydrolyze the ester group (COOCH3) on PMMA into free carboxylic groups (COOH). The carboxylate group that is formed then releases a proton (H+) to form a carboxylate anion (COO-). Furthermore, there is repulsion between adjacent carboxylate anions due to space constraints. The solubility will cause a lot of empty space between the polymer matrix, making it easier for bonding between the elements in the liquid and the polymer matrix in that place and breaking the long chain of acrylic resin polymer, causing crazing and decreasing the transverse strength.[7]

The results in table 1 also show that the longer the immersion duration of heat cured acrylic resin plates, the more the transverse strength decreases. The results of statistical analysis in tables 3 and 4 show that there is a significant effect of immersion duration on the decrease in the transverse strength of heat cured acrylic resin plates. In addition to the influence of polyphenolic substances in green tea, the decrease in the transverse strength of heat cured acrylic resin plates is also caused by the ability of heat cured acrylic resin plates in liquid absorption. This is in line with the research of Sundari et al, which states that the ability of water absorption plays a role in the hydrolytic degradation and erosion of

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resin materials by stretching the matrix filler. Polymer-based materials can absorb water into the matrix through a controlled (continuous) diffusion process. The water absorption that occurs will cause solution particles to penetrate and affect the chemical bonds. The longer the immersion duration, the more solution that can penetrate into the microporosity space.[18]

The incoming solvent molecules will break the polymer chains by penetrating and occupying positions between the polymer chains. These polymer chain breaks can weaken the chemical structure, which can result in decreased polymer strength. Based on the matrix degradation theory, the resin immersed in water will absorb water molecules and will penetrate into the intermolecular space of the polymer chain, so that the polar interaction decreases. This causes the distance between polymers to increase, then matrix expansion occurs, then the matrix softens, resulting in a decrease in resin strength.[18]

Transverse strength is highly considered as an indicator of the strength of a material. Poor flexural strength can cause the denture base material to be unable to withstand excessive masticatory loads, causing the denture base to fracture easily. Therefore, high transverse strength is required by a denture base material to withstand masticatory stresses that may result in permanent deformation.[7,18]

The results of the transversal test showed that heat cured acrylic resin plates immersed in green tea solution had poor fracture resistance when compared to immersion in artificial saliva. The polyphenol content in green tea can destabilize the polymer chains in heat cured acrylic resin. While polyphenols are the components responsible for antioxidant activity in tea. Therefore, denture users only need to regulate the frequency of consuming green tea and the cleaning pattern of their dentures so that the impact caused by green tea consumption will not be too great.

Conclusion

The transverse strength value of the heat cured acrylic resin base decreased as the immersion duration increased. Thus, it can be concluded that there is an effect of immersion in green tea (Camellia sinensis) solution on the transverse strength of heat cured acrylic resin base.

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