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The Effect of Immersion Duration in Cinnamon Extract on Color Stability of Heat-Polymerized Acrylic Resin Denture Base

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ABSTRACT

Heat-polymerized acrylic resin is a material often used as denture base. To maintain oral hygiene, denture cleaning agents are widely used but their application should not compromise color stability of resin. In this context, Cinnamon extract (*Cinnamomum burmannii*) has shown the ability to inhibit the growth of *Candida albicans*. This study aimed to evaluate the effect of immersion duration in cinnamon extract on color stability of heat-polymerized acrylic resin denture base. A total of 30 samples of heat-polymerized acrylic resin with measurement 20 x 2 mm were divided into 3 groups, group A (distilled water), B (alkaline peroxide), and C (50% cinnamon extract). After measuring the pretest values, the samples were soaked for 31, 61, 91, 122, and 152 hours. Discoloration (ΔE) was evaluated using a colorimeter according to CIELAB standards and data were analyzed with one-way Analysis of Variance (ANOVA) and LSD (Least Significant Difference) statistical tests. The results showed that there was an effect of immersion duration of heat-polymerized acrylic resin denture base in use for 31, 61, 91, 122, and 152 hours in groups A and B on color stability p=0.0001 (p<0.05). Color change in group B was greater compared to A. Although ΔE value of all samples in both groups continued to increase with the length of immersion duration, color change that occurred was clinically acceptable.

Keywords: Heat-Polymerized Acrylic Resin, Colour Stability, Cinnamon Extract

ABSTRAK

Resin akrilik polimerisasi panas merupakan bahan yang sering digunakan sebagai basis gigi tiruan. Untuk menjaga kebersihan mulut, bahan pembersih gigi tiruan banyak digunakan tetapi penggunaannya tidak memengaruhi stabilitas warna resin akrilik. Ekstrak kayu manis (*Cinnamomum burmannii*) telah terbukti mampu menghambat pertumbuhan *Candida albicans*. Penelitian ini bertujuan untuk mengevaluasi pengaruh lama perendaman dalam ekstrak kayu manis terhadap stabilitas warna basis gigi tiruan resin akrilik polimerisasi panas. Sebanyak 30 sampel resin akrilik polimerisasi panas berukuran 20 x 2 mm dibagi menjadi 3 kelompok, kelompok A (aquabidest), B (alkalin peroksida) dan C (ekstrak kayu manis 50%). Setelah pengukuran nilai *pretest*, sampel direndam selama 31 jam, 61 jam, 91 jam, 122 jam, dan 152 jam. Perubahan warna (ΔE) dievaluasi menggunakan *colorimeter* sesuai standar CIELAB dan data dianalisis dengan uji statistik *one-way* ANOVA dan LSD. Hasil penelitian menunjukkan bahwa terdapat pengaruh lama perendaman basis gigi tiruan resin akrilik polimerisasi panas perendaman selama 31 jam, 61 jam, 91 jam, 122 jam, dan 152 jam pada kelompok A dan B terhadap stabilitas warna p=0,0001 (p<0,05). Perubahan warna pada kelompok B lebih besar dibandingkan dengan kelompok A. Meskipun nilai ΔE semua sampel pada kedua kelompok terus meningkat seiring dengan lamanya perendaman, perubahan warna yang terjadi masih dapat diterima secara klinis.

Kata kunci: Resin Akrilik Polimerisasi Panas, Stabilitas Warna, Ekstrak Kayu Manis

1. Introduction

Denture is a prosthesis designed to replace missing natural teeth and surrounding tissue. It is supported by a combination of teeth and oral mucosa, which can be easily removed by the patient [1,2]. Denture base is one of the important parts of denture that rests on mucosal tissue and teeth or without teeth [3,4]. One of the materials still used for denture is heat-polymerized acrylic resin, which has several advantages including dimensional stability, insolubility in liquid, non-toxic, and good impact strength. However, the disadvantages of using these artificial teeth include the ability to be easily broken, the presence of porosity, and color changes after prolonged use [5,6].

Color stability is one of the important properties possessed by heat-polymerized acrylic resin materials [7]. Intrinsic and extrinsic factors can affect discoloration (ΔE) of denture base with heat-polymerized acrylic resin materials. The intrinsic factor is the change of chemise color due to an incomplete polymerization process during the manufacture of denture due to material properties, chemical structure, and monomers. Extrinsic factors are color changes due to the absorption of colored solutions containing substances such as coffee, tea, soft drinks, nicotine, and mouthwash. These substances can cause chemical-physical reactions and affect the absorption of color pigment from a solution to resin surface and into the microporosity. The condition of saliva in the mouth is an electrolyte liquid affecting the material of denture base. This occurs because the absorption of air is very high, causing air molecules in saliva to form hydrogen bonds with the middle group contained in polyamide. Therefore, air enters and fills the space between molecules, causing an increase in microporosity [8,9,10,21].

Denture need to be cleaned, as unmaintained hygiene of removable denture can cause excess growth of microorganisms such as *Candida albicans.* According to a previous study, *Candida albicans* is a fungus of normal flora in the oral which is pathogenic [9]. Alkaline peroxide is a very frequently used denture cleaning agent, this material can be served in the form of tablet and powder. One of the commercial products on the market is polident with the procedure in use for 3-5 minutes each day. The tablet will dissolve in warm water, enabling decomposition and release of oxygen, until a mechanical cleaning process occurs on the deposit attached to denture. However, this material can affect the properties possessed by denture base, including roughness and color stability. Discoloration is due to the strong oxidizing property of alkaline peroxide solutions, as the oxygen released causes an unreacted double bond in the chemical bond of resin [10]. Chandu et al. (2015) stated that repeated immersion of denture base for 30 days in alkaline peroxide could cause discoloration of the base [11].

Cinnamon *(Cinnamomum burmannii)* is one of herbal ingredients that can be used as an alternative denture cleaning agent. *Cinnamaldehyde, eugenol, safrole, dammar, and tannin* are chemical ingredients found in cinnamon, which function as growth inhibitors of *Candida albicans.* Khatima et al. (2017) evaluated cinnamon extract concentrations of 20%, 30%, 40%, and 50%. The results showed that the 50% concentration was the most effective in inhibiting the growth of *Candida albicans* with an inhibitory zone of 42.18 mm on an acrylic resin base [12,9]. Zulkarnain et al. (2017) found that immersion of heat-polymerized acrylic resin denture base into rosella flower extract solution with a concentration of 40% in use for 1, 2, and 3, caused color change after use for 2 years [7]. According to Kadek (2019), immersion of heat-polymerized acrylic resin base into rosella flower extract with a concentration of 20% and 40% did not cause discoloration. However, immersion of acrylic resin base in a 60% concentration of rosella flower caused discoloration after 1 week [8]. Therefore, this study aimed to evaluate the effect of immersion duration in cinnamon extract simulating 1, 2, 3, 4, and 5 years of use on color stability of heat-polymerized acrylic resin denture base.

2. Materials and Methods

This study used an experimental laboratory method with a *post-test-only* control group design. The samples consisted of 30 disc-shaped heat-polymerized acrylic resin with a diameter of 20 mm and a thickness of 2 mm, in accordance with ISO specification No.1567.

The samples were fabricated by forming a mold using the master model with ISO No.1567 specification into the cuvette with the conventional compression molding method. The polymerization was carried out with hot water at 70°C for 90 minutes and continued at 100°C for 30 minutes. After the cooling phase, the sample was completed using a fraser bur, and final finishing was performed with 240, 400, 800, and 1200-grit waterproof sandpaper mounted on a rotary grinder machine. All the samples were stored in distilled

water 48 hours before recording color stability values. The 50% cinnamon extract was made by providing 1000 g of cinnamon bark, cleaned, and dried. Cinnamon bark was cut into small pieces, crushed using a wooden pestle until slightly smoother, and mixed with 96% ethanol of 15 liters. This was followed by evaporation until thickened to obtain 400 ml 50% cinnamon extract.

The samples were immersed in a solution of distilled water in an incubator 37°C to remove residual monomer. This was followed by grouping of samples into 3, each comprising 10 disc-shaped heat-polymerized acrylic resin immersed in distilled water (group A), alkaline peroxide (group B), and 50% cinnamon extract (group C) for 31, 61, 91, 122, and 152 hours simulated for 1, 2, 3, 4, and 5 years of use.

Color stability values of each sample were measured with a Colorimeter measuring instrument (CHN Spec Colorimeter Portable CS-10, China). The evaluation of color stability was performed using a colorimeter according to CIELAB standards. The display of color test tool will show the L* (lightness), a* (green-red component), and b* (blue-yellow component). Color stability can be obtained using the following formula: $\Delta E= \sqrt{(L1-L2)^2+(a1-a2)^2+(b1-b2)^2}$. The data were processed and tested with one-way Analysis of Variance (ANOVA) test to determine whether there was an effect of immersion duration of acrylic resin heat-polymerized denture base in alkaline peroxide and 50% cinnamon extract. This was continued with LSD (Least Significant Difference) test to determine a significant difference in the effect of immersion heat-polymerized acrylic resin denture base in alkaline peroxide and cinnamon extract 50%.

3. Results

Color stability value of heat-polymerized acrylic resin denture base after immersion in use for 31, 61, 91, 122, and 152 hours in distilled water, alkaline peroxide, and 50% cinnamon extract was obtained using a colorimeter tool. The mean value and standard deviation of color stability values were found in the group, as shown in Table 1.

Based on one-way ANOVA test, there was an effect of immersion duration of heat-polymerized acrylic resin denture base in groups B and C for 31, 61, 91, 122, and 152 hours on color stability with a p-value <0.05 (Table 2). Based on LSD test, a difference with p-value < 0.05 was observed in the effect of each immersion time of denture base on color stability in group B for 31 hours to 91 hours, 31 hours to 122 hours, 122 hours to 152 hours, 61 hours to 122 hours, 61 hours to 152 hours, and 91 hours to 152 hours. It was also found that there was a significant difference of p = 0.03 (p < 0.05) in the effect of the length of immersion of denture base in group C for 31 hours to 61 hours, 31 hours to 91 hours, 31 hours to 122 hours, 31 hours to 152 hours, 61 hours to 122 hours, and 61 hours to 152 hours, as shown in Table 3.

Table 1. Color stability value of heat-polymerized acrylic resin denture base in use for 31 hours, 61 hours, 91 hours, 122 hours, and 152 hours in distilled water, alkaline peroxide, and cinnamon extract 50%.

Mean ΔE, standard deviation of all the groups tested at different time intervals		
Groups	Duration immersion	Mean ΔE (SD)
Distilled water (A)	31 hours	0.92 (0.10)
	61 hours	1.22 (0.07)
	91 hours	1.40 (0.08)
	122 hours	1.59 (0.05)
	152 hours	1.68 (0.05)
Alkaline peroxide (B)	31 hours	1.24 (0.15)
	61 hours	1.39 (0.19)
	91 hours	1.51 (0.20)
	122 hours	1.62 (0.14)
	152 hours	1.71 (0.15)
Cinnamon extract (C)	31 hours	1.59 (0.20)
	61 hours	2.35 (0.29)
	91 hours	2.52 (0.30)
	122 hours	2.64 (0.30)
	152 hours	2.75 (0.27)

Table 2. Effect of immersion duration of heat-polymerized acrylic resin denture base in use for 31 hours, 61 hours, 91 hours, 122 hours, and 152 hours in alkaline peroxide and 50% cinnamon extract on color stability.

Effect of immersion duration on color stability				
Group	**n**	**Immersion time**	**Mean ± SD**	**p-value**
Alkaline peroxide (B)	10	31 hours	1.24 ± 0.15	0.0001*
	10	61 hours	1.39 ± 0.19	
	10	91 hours	1.51 ± 0.20	
	10	122 hours	1.62 ± 0.14	
	10	152 hours	1.71 ± 0.15	
50% Cinnamon extract (C)	10	31 hours	1.59 ± 0.20	0.0001*
	10	61 hours	2.35 ± 0.29	
	10	91 hours	2.52 ± 0.30	
	10	122 hours	2.64 ± 0.30	
	10	152 hours	2.75 ± 0.27	

Description: * $p < 0.05$: significant

Table 3. Effect of immersion duration of heat-polymerized acrylic resin denture base in use for 31 hours, 61 hours, 91 hours, 122 hours, and 152 hours in alkaline peroxide and 50% cinnamon extract on color stability.

Group	**Immersion time**		**p-value**
Alkaline peroxide (B)	31 hours	61 hours	0.059
		91 hours	0.001*
		122 hours	0.0001*
		152 hours	0.0001*
	61 hours	91 hours	0.111
		122 hours	0.004*
		152 hours	0.0001*
	91 hours	122 hours	0.164
		152 hours	0.014*
	122 hours	152 hours	0.256
50% Cinnamon extract (C)	31 hours	61 hours	0.0001*
		91 hours	0.0001*
		122 hours	0.0001*
		152 hours	0.0001*
	61 hours	91 hours	0.178
		122 hours	0.026*
		152 hours	0.003*
	91 hours	122 hours	0.359
		152 hours	0.081
	122 hours	152 hours	0.395

Description: *$p < 0.05$: significant

4. Discussion

Based on the mean value obtained (Table 1), there was an increase in color change value between group A on 31 to 152 hours. The same result was found in groups B and C from 31 to 152 hours, showing an increase in the value of color change. Color change value in group A was still lower compared to groups B and C. However, all samples in groups A, B, and C had color stability values below the clinically acceptable standard value of ΔE 3.3 [13,14].

The variation in color stability value can be caused by heat-polymerized acrylic resin samples used for denture base, which allow for porosity and change the material's physical characteristics. The uncontrolled speed of acrylic resin materials manual stirring is also capable of affecting the differences in homogeneity between polymers and monomers. Generally, monomers that are not completely mixed will evaporate, causing

the formation of internal porosity at the base of denture. Roughness on the sample surface can affect color stability value. This is because rougher surface of a sample easily causes accumulation of stains and increases color change [15,16].

The result of one-way ANOVA test (Table 2) in group B showed that there was an effect of immersion duration on color stability of denture base in alkaline peroxide 31, 61, 91, 122, and 152 hours simulated for 1, 2, 3, 4, and 5 years of use. Lohitha et al (2016) also stated that there was a significant effect of immersion time on heat-polymerized acrylic resin denture base in alkaline peroxide denture cleaning agents for 90 days and 180 days on color stability [17]. This was caused by structural changes in the chemistry of acrylic resin denture base due to oxidation of the amine accelerator contained in effervescent tablets. Alkaline peroxide contains oxidizing (bleaching) agents, known as sodium perborate. When this compound comes into contact with water, there is a release of hydrogen peroxide which is also a bleaching agent through the process of ionizing H_2O_2 into water. Moreover, oxygen has a free radical in the form of oxygenase (O-), which does not have an electron pair. This free radical enters acrylic resin polymer chain to search for an electron pair, which allows oxidation and causes the bleaching process to occur. The duration of contact between heat-polymerized acrylic resin denture base and alkaline peroxide materials can influence a decrease in color stability [15,16].

In group C (Table 2), there was an effect of immersion duration of heat-polymerized acrylic resin denture base in 50% cinnamon extract for 31, 61, 91, 122, and 152 hours simulated for 1, 2, 3, 4, and 5 years of use. Zulkarnain et al (2017) also stated that there was a significant effect of immersion on rosella flower extract denture cleaning agents simulated for 1, 2, and 3, with a $p = 0.025$ ($p < 0.05$). This was due to the tannin compound content contained in 40% rosella flower extract which was supported by the length of exposure of samples with denture cleaning agents [7]. Tannin content in cinnamon extract is capable of functioning as a coloring agent which can lead to color change when combined with water. This occurs because the OH in tannins has the potential to oxidize the polymer chains and monomers in resin, causing a significant change in color [18].

Based on LSD test (Table 3), there were differences in the effect of immersion time on heat-polymerized acrylic resin denture base in alkaline peroxide on color stability in group B. According to Robinson et al, a water-soluble denture cleaning agent would penetrate heat-polymerized acrylic resin polymer bond. This would allow resin to settle between the polymer bond produced by the intrinsic factor. Color penetration by the extrinsic factor can cause discoloration during immersion for 90 and 180 days. The increasing value of color change is often caused by the increasing immersion time [17]. In group C, there was a significant difference in the effect of denture base immersion time in 50% cinnamon extract on color stability. The results showed a significant difference in the value of color stability of heat-polymerized acrylic resin base between 31 hours and 61 hours in group B. The exposure to color pigments in the form of tannins present in denture cleaning agents with 50% cinnamon extract affected the polymer chains of acrylic resin. The phenomenon caused internal porosity leading to the absorption of excess tannins in acrylic resin, thereby influencing color attachment to the surface of the base. This led to stain adhesion which was affected by immersion duration causing a colour change. Sagsoz et al. (2014) reported that there was a build-up of stains on the surface of the base due to the presence of tannins [19]. Wahyuni et al. (2020) found that tannin content in the tea solution could cause a color change. However, this color change was not permanent and able to vanish after repeated polishing [20].

5. Conclusion

Immersion of heat-polymerized acrylic resin using 50% cinnamon extract as denture cleaning agent is recommended because of their color change was still clinically acceptable for 31, 61, 91, 122, and 152 hours simulated for 1, 2, 3, 4, and 5 years on use.

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7. Conflict of Interest

All the authors report no conflicts of interest.

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