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Research Article

Colour Change of Hot Immersed Polymerized Acrylic Resin Steeped into Roselle Tea (*Hibiscus sabdariffa*) and Black Tea (*Camellia sinensis*)

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Abstract

Steeping rosella tea and black tea are effective as denture cleaning agents as they contain flavonoids that can inhibit the growth of *C. Albicans*. Flavonoids in the brewing of rosella tea and black tea are found in pigment compounds, so when the acrylic resin is soaked in the steeping of roselle tea and black tea, it can cause discoloration. This study aims to compare the color changes of acrylic resin soaked in roselle tea and black tea with the same treatment. A total of 18 samples of acrylic resin were divided into three groups; six samples immersed in 20% concentrated roselle tea, six samples immersed in 20% concentration of black tea, and six samples immersed in steeping mineral water for 22 hours 30 minutes at room temperature. The research results' data were analyzed using the one-way Anova test. Acrylic resin soaked in steeping roselle and black tea experienced a color change, and the largest color change occurred in acrylic resin soaked in black tea. The results showed that hot polymerized acrylic resin soaked in black tea had a greater color change than that of acrylic resin soaked in roselle tea.

Keywords: acrylic resin; color change; steeping black tea; steeping rosella tea

INTRODUCTION

One of the keys to a successful denture treatment is denture hygiene. Improperly hygienic dentures can cause denture stomatitis, candidiasis, inflammatory papillary hyperplasia, bad breath, and oral bone loss, so dentures should be cleaned regularly.[1] Maintaining the cleanliness of dentures can be done by using a denture cleanser or denture cleaning materials.[2]

Denture cleaners are generally made of chemicals, such as peroxides. However, the use of chemicals as denture cleaners can cause side effects on dentures, such as the effect of bleaching.[3,4] Hence, many natural ingredients have now been developed that can be used as denture cleaners, such as roselle tea.[5,6]

Roselle tea is said to be effective as a denture-cleaning agent as it can inhibit the growth of *C. Albicans*. The flavonoid content in roselle tea steeping with a concentration of 20% could denature protein and cause protein function failure of *C. Albicans* colonies.[6] The inhibition of steeping roselle tea with 20% concentration on the growth of *C. Albicans* grown on agar media for 24 hours was 26.20 mm. The infusion of roselle tea with a concentration of 20% could inhibit the growth of *C. Albicans* on acrylic resin.[5] Flavonoids are not only found in roselle tea but are also found in other teas, such as black tea.

The flavonoids found in black tea are said to be effective as denture cleaners due to their ability to inhibit the growth of *C. Albicans*. Brewed black tea at a

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concentration of 20% could inhibit the growth of *C. Albicans*. The inhibition of steeping black tea with a concentration of 20% on *C. Albicans* grown in a Petri dish containing agar medium for 24-48 hours was 6.90±0.14 mm.[7] Acrylic resin soaked in steeping black tea with a concentration of 13.33% for 4 hours had an inhibitory effect on the growth of *C. Albicans*.[8] In addition, The higher concentrations of black tea infusions were more effective in inhibiting the growth of *C. Albicans* and other microorganisms in the oral cavity.[8]

Based on previous studies, Roselle tea and black tea were considered effective as denture cleansers. However, the use of roselle tea and black tea as denture cleansers can trigger discoloration of the acrylic resin. The color change process can occur due to the process of diffusion of tea liquid into the acrylic resin, which can result in the movement of the tea pigment towards the acrylic resin chain.[9,10] In addition, the acid content in steeping can also trigger a greater color change due to the ability of the acid to affect the acrylic resin chain bonds.[11]

The color change in acrylic resin soaked in roselle tea was explained in a study which explained that acrylic resin soaked in roselle tea with concentrations of 5%, 10%, and 20% for 1 week, 2 weeks, 3 weeks, and 4 weeks did not experience significant color changes.[5] Meanwhile, based on research, it was proven that acrylic resin soaked in steeping black tea with a concentration of 2% for 70 minutes, 5 hours, and 15 hours experienced a color change.[12] However, it should be with higher levels of roselle tea flavonoids (44.856%/100 gr dry weight) when the acrylic resin is soaked in roselle tea brewing can cause a greater color change in acrylic resin compared to acrylic resin soaked in black tea steeping with lower flavonoid levels (15.1%/100 gr dry weight).[13,14] Based on the background above, this study aims to compare the color changes of hot polymerized acrylic resin immersed in steeping roselle tea and black tea with the same concentration and duration of immersion.

MATERIALS AND METHODS

This research is an experimental laboratory study with a pre-test and post-test control group design. The research was conducted at the Dental Engineering Laboratory, Faculty of Dentistry, the University of Jember, and Bio Science Laboratory, Faculty of Dentistry, University of Jember. It was conducted from September to November 2020.

The tools used in this study were a sounding device, a color assessment application (Adobe capture), a hollow cylindrical mold with a diameter of 16mm and a height of 3 mm, gas and LPG stoves, light boxes and tripods, cuvettes, stainless steel pans, petridics, press beugel, trimming, and water bath. The materials used in this study were mineral water, aquades, sound material, could mold seal (CMS), hard gypsum, pH paper, red wax, hot polymerized acrylic resin, black tea, and roselle tea.[15,16]

The research sample used acrylic resin plates, as many as 18 samples. The determination of the number of samples was based on the Gay and Diehl formula calculation. A total of 18 samples were divided into three treatment groups: six acrylic resin samples soaked in 20% roselle tea steeping, six acrylic resin samples soaked in 20% black tea steeping, and six samples of acrylic resin immersed in mineral water. The sample criteria used were acrylic plates made of hot polymerized acrylic resin, cylindrical acrylic plates with a diameter of 15 mm and a thickness of 2 mm, and an acrylic plate with a smooth, flat, and not cracked surface.[17]

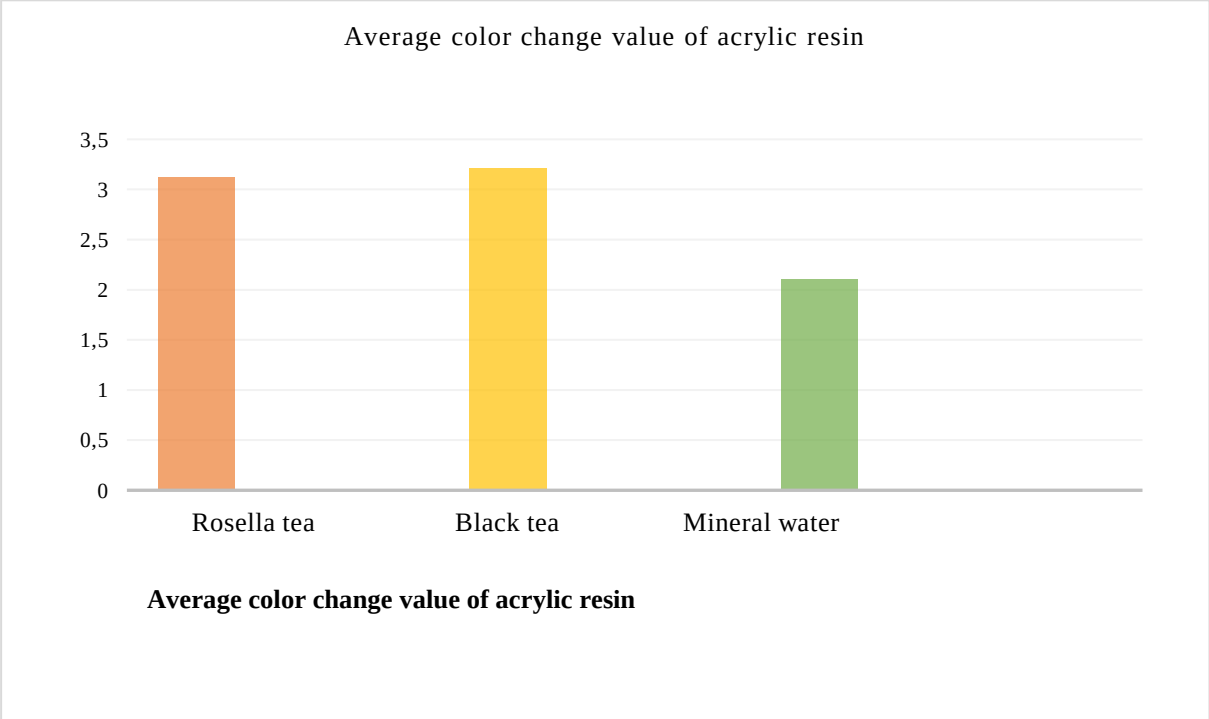
The first step of the research was manufacturing acrylic resin plates with a diameter of 15 mm and a thickness of 2 mm. The acrylic resin used was a hot polymerized acrylic resin whose

polymerization process was carried out by immersion in hot water. The second step of the research was the brewing process of roselle tea and black tea, by brewing each type of tea as much as 20 grams of packaged tea bags into 100 ml of water. The third step was assessing the acrylic resin's color before immersion. The fourth step was soaking acrylic resin in roselle tea, black tea, and mineral water for 22 hours and 30 minutes. The fifth step was to assess the color of the acrylic resin after immersion and then calculate the value of the color change of the acrylic resin after immersion in roselle tea, black tea, and mineral water. Finally, the last step was data analysis.[15-19]

The data from the immersion of the acrylic resin plate was analyzed using the Shapiro-Wilk normality test and the Levene test for homogeneity. The results of the normally distributed data with homogeneous variance were then carried out with a one-way ANOVA parametric test to determine if there was a difference in color change.

RESULT

The research data were obtained by calculating the color change value of acrylic resin after immersion using the ΔE-CIELab color change formula. The color value was known through identification using the Adobe capture application with the CIELab method. Based on the CIELab method, it was known that there are three color scales consisting of the L* axis, a* axis, and b* axis. The L* axis had a maximum value of 100, representing light, and a minimum value of 0, representing black. The positive a* value axis means red; if a* negative is green and the positive b* value axis is yellow, the negative b* value is blue[20]. Furthermore, the data from the color change value is calculated on average to find out the average value of the change. The color of each treatment group can be seen in Graph 1 and Table 1.



Graph 1. Graph of the average color change value of acrylic resin soaked in roselle tea, black tea, and mineral water

The graph of the average color change value of acrylic resin shows that the acrylic resin sample group immersed in black tea experienced the highest color change compared to other groups, with an average value of 3.208 with the brightest light compared to other groups and the most reddish color compared to other groups. Meanwhile, the acrylic resin sample group soaked in roselle tea experienced a smaller color change than black tea brewed and larger than mineral water, with an average color change value of 3.122 with lighter light before immersion. However, it was the darkest one among other groups and had the highest yellow color compared to other groups. The last graph was a group of acrylic resin samples soaked in mineral water with an average color change value of 2.102 with a brighter and more yellowish-red light than before immersion. The average color change value of acrylic resin soaked in mineral water was the group with the lowest color change value compared to other groups. An example of the results of the acrylic resin color assessment using the Adobe capture application is shown in Figure 1.

The data from the research results were then tested for normality and homogeneity. This test aims to find out whether the data was normally distributed and to identify the homogeneity of the data. The test results showed that the data were normally distributed and had homogeneous variance, so a parametric test, namely One Way Anova, was used for statistical analysis of the data. The results of the One-Way ANOVA test showed that there were differences in color changes between groups of acrylic resin soaked in roselle tea, black tea, and mineral water.

Table 1. Summary of One-Way ANOVA test results in acrylic resin color change

	Number of samples	**Color change rate**	**Standard deviation**	**The significance value of One-Way Anova**
Rosella tea	6	3.12250	.546269	
Black tea	6	3.20883	675570	
Mineral water	6	2.10267	.371827	0.005
Total	18	2.81133	.727911	

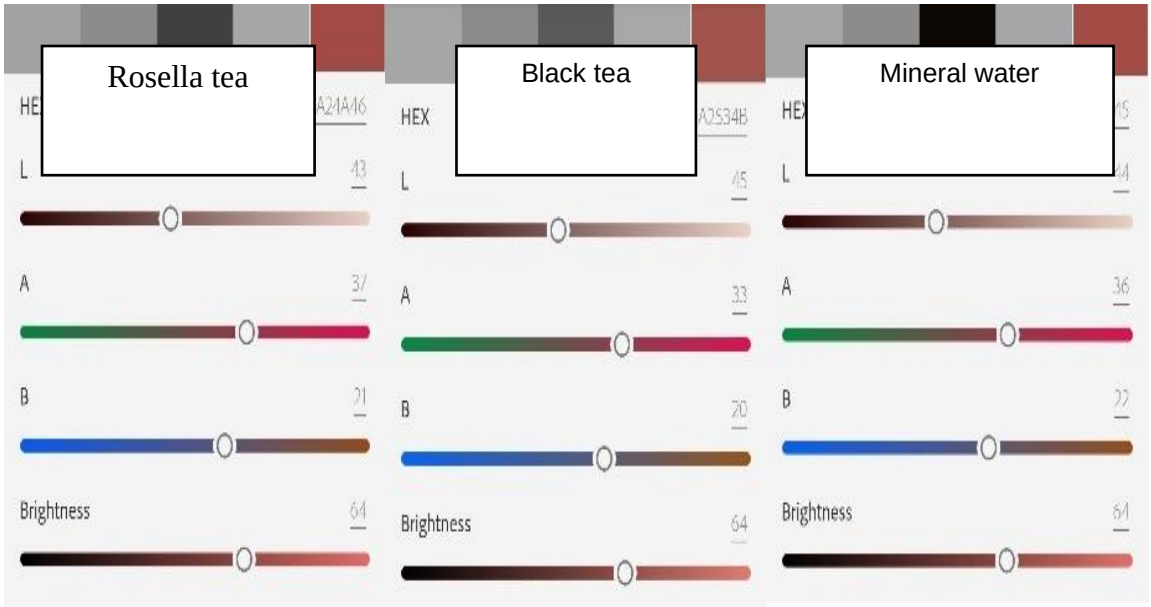


Figure 1. L*a*b* value of acrylic resin before immersion in Adobe capture application

DISCUSSION

This study discusses the discoloration of acrylic resin soaked in steeping roselle tea and black tea at a concentration of 20%. Researchers divided the samples into three treatment groups: a hot polymerized acrylic resin sample group soaked in 20% steeping roselle tea, a hot polymerized acrylic resin sample group soaked in 20% steeping black tea, and a hot polymerized acrylic resin sample group soaked in mineral water. The use of 20% concentration was sourced from previous research, which explained that roselle tea brewed with 20% concentration and black tea brewed with 20% concentration effectively inhibited the growth of *C. Albicans*.[6,7] Immersion was carried out for 22 hours 30 minutes at room temperature, with a compilation time—of acrylic resin soaking 15 minutes daily for 90 days.[6] Fifteen minutes is the recommended time for immersing the denture in a cleaning solution, while 90 days is the recommended time for the recall of denture users.[21,22]

The first treatment group was a sample group steeped in rosella tea with an average color change value of 3.122. The average value showed if the sample immersed in the 20% roselle tea steeping experienced changes in color after immersion. Color changes that occurred in acrylic resin soaked in roselle tea based on the classification of color changes according to the National Bureau of Standards (NBS) is included in the category of appreciable color change (a color change that is quite large in the process of occurrence) with a range of ΔE values from 3.0 to 6.0.[23,24]

The second treatment group was the sample group steeped in black tea with an average color change value of 3.208. The average value of color change in acrylic resin soaked in a 20% concentration of black tea was the highest change value compared to the other two groups. Based on this average value, it can be seen if the sample soaked in steeping black tea changes color after immersion. Color changes that occur in acrylic resin soaked in black tea based on the classification of color changes according to the National Bureau of Standards (NBS) are included in the category of appreciable color change (a color change that is quite large in the process of occurrence) with a range of ΔE values from 3.0 to 6.0.[23,24]

The third group, as the control group, is the sample group immersed in mineral water with an average color change value of 2.102. Based on this average value, it can be seen if the sample immersed in mineral water changes color after immersion. The color changes in acrylic resins immersed in mineral water are based on the classification of color changes, according to the National Bureau of Standards (NBS). It is included in the category of noticeable color changes (color changes that need to be considered in the occurrence process) with a range of ΔE values from 1.5 to 3.0.[23,24]

The color changes in acrylic resin when immersed in roselle tea or steeping black tea occurred due to the movement of the steeping pigment towards the acrylic resin chain, absorbed through a diffusion mechanism. Diffusion is moving a solution from a high concentration to a low concentration. When the tea brewing solution is absorbed into the acrylic resin, it can cause empty or porous cavities to appear in the acrylic resin. The appearance of this porous is due to the breaking of secondary bonds between acrylic resin chains with low bond strength.[9,10]

The process of breaking the acrylic resin chain when soaked in steeping tea can be caused by acidic flavonoids. The acidic solutions would interfere with the hydrolysis reaction between phenol and polymethyl methacrylate esters; thus, it would cause cavities or porosity in the acrylic resin.[11] When the acrylic resin is immersed into the solution, the appearance of porosity in the acrylic resin will increase the intensity of the absorption of the liquid. If the adsorbed solution contains pigment, it will cause discoloration of the acrylic resin.[11,25]

The acrylic resin group soaked in mineral water as a control group also experienced a change in color value after 22 hours and 30 minutes at room temperature. The color changes can be caused by the process of fading the color of the acrylic resin plate. This process can occur due to the water absorption process, which causes the bonds between macromolecules to become weak, and a change in dimensions. The weakening of macromolecular bonds allows the release of pigment from the acrylic resin plate, thereby fading the color of the acrylic resin plate.[26]

The data obtained from the results of the next study were tested for normality and homogeneity to identify whether the data were normally distributed and the data's homogeneity. After testing, the results showed that the data were normally distributed and had homogeneous variance. Therefore, further statistical analysis was carried out using a parametric test, One-Way ANOVA. The results of the One-Way ANOVA test showed differences in color changes between groups of acrylic resin soaked in roselle tea, black tea, and mineral water.

The difference in color changes in each group could be influenced by differences in the pH level of the solution. The pH value of the mineral water used in this study ranged from 6.5-7, the average pH value of steeped roselle tea was 2.89-3.97, and the average pH value of black tea was 3.14-3.72.[27-30] In addition, based on the results of the pH level test, it showed that the pH paper steeped in black tea had a redder color than the pH paper steeped in roselle tea (the redder the pH paper is, the more acidic the solution will be). The pH level of a solution could affect the color change in acrylic resin.[11] The more acidic a solution is, the greater the effect on acrylic resin chain bonds will be. It occurs because it can cause resin chain bond degradation and porosity. The appearance of porosity in the acrylic resin can increase the intensity of steeping absorption into the acrylic resin so that more steeping pigments will be absorbed and move toward the acrylic resin chain. It also becomes the reason why the change in color of acrylic resin soaked in black tea has the greatest color change value compared to other groups.[11]

Color changes in the acrylic resin can be caused by three aspects.[31] The first thing is the contamination of materials during the manufacturing process. The second aspect is the ability to absorb (permeability) liquid in the material. The third aspect is the chemical reaction in the material and various processing techniques that result in empty voids or porosity on the surface to facilitate the accumulation of dirt and the habit of eating and drinking containing a lot of food and beverage dyes.[31] In addition, the length of contact between acrylic resin and materials can also affect the discoloration process. Acrylic resin would experience saturation continuously when it was saturated with liquid for 17 days.[8] The presence of liquid absorbed into the acrylic resin will cause cavities, which can increase the absorption intensity.[9,32]

CONCLUSION

Based on the results of the study, it can be concluded that the discoloration of the acrylic resin steeped in black tea was greater than that of the acrylic resin steeped in roselle tea

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