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RESEARCH ARTICLE

Effect of Edible Coating on Color Stability and Strength of Heat-Cured Acrylic Soaked in Tea

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ABSTRACT

Background: *Dentures are a standard treatment option for replacing missing teeth. One of the most essential components of dentures is the denture base. However, the acrylic resin has a weakness, namely that it has porosity, which can cause water absorption and colour changes. Water absorption in the acrylic resin can affect its colour stability, flexural strength, and hardness over a specific period. Tea is a drink often consumed in Indonesia. Black tea has undergone oxidation of several polyphenolic compounds (catechins). The fermentation process results in the oxidation of simple polyphenols, where tea catechins are converted into more complex and concentrated molecules that give black tea its characteristic colour. The edible coating is a thin layer made from consumable materials that acts as a barrier.* ***Objective:*** *To determine the effect of edible coating on heat-cured acrylic resin denture plates on colour retention, flexural strength, and hardness after soaking in black tea.* ***Materials and Methods:*** *This research utilized 25 heat-cured acrylic resin plates, divided into five groups with varying soaking times for the edible coating. The plates were then soaked in black tea for 15 hours, after which testing was conducted on the color resistance, hardness, and flexural strength of the heat-cured acrylic resin plates.* ***Results:*** *Acrylic resin plates with chitosan have better colour retention than acrylic resin not soaked with chitosan. Meanwhile, flexural strength and hardness values between groups did not differ significantly.* ***Conclusion:*** *Chitosan immersion affects the colour durability of the heat-cured acrylic resin denture base without significantly decreasing the hardness and strength values.*

Keywords: *Black Tea, Chitosan, Edible Coating, Acrylic Resin*

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INTRODUCTION

One of the components of a denture is the denture base. Heat-cured acrylic resin is used as a base.1 Heat-cured acrylic resin has various advantages, including aesthetics, easy polishing and manufacturing techniques, non-toxic, cheaper, and lighter.[1] However, the acrylic resin has the weakness of having a porosity that can cause water absorption and colour changes.[2,3] Water absorption in the acrylic resin can affect colour stability, flexural strength, and hardness over a certain period.[4,5]

Tea is a popular beverage often consumed in Indonesia. Tea is divided into four main groups based on processing method: green, black, white, and oolong, which are most commonly consumed in Indonesia. Black tea is a trendy tea that is widely consumed worldwide.[6,7] Black tea has undergone oxidation of several polyphenolic compounds (catechins). Catechins undergo oxidation to form their oxidation compounds, namely theaflavin, a yellow substance, and thearubigin, a brownish substance.[6] The fermentation process results in the oxidation of simple polyphenols, where tea catechins are converted into more complex and concentrated molecules, which give black tea its colourful, robust, and flavorful characteristics.[7]

The physical properties of acrylic resin can be affected by liquid absorption, which disrupts the polymer chain bonds and can impact the surface hardness of the acrylic resin over time.[2,5] The liquid absorption problem on acrylic plates can be overcome with a barrier against external factors by coating with an edible coating. An edible coating is a thin layer made from consumable materials that serves as a barrier.[3] The three main components of edible coating are hydrocolloids (proteins and carbohydrates), lipids (wax, acylglycerols, and fatty acids), and composites (mixtures). The edible coating is a natural polymer coating material that has biocompatible and biodegradable properties, so it can be used to overcome the weakness of the properties of heat polymerized acrylic resin, namely the absorption of coloured liquids in dentures, so that there is no liquid absorption, which will affect the colour resistance of heat-cured acrylic plates.[3,8]

Based on the properties of chitosan-based edible coatings, they are believed to reduce water absorption when soaked in a black tea solution, which will also affect their flexural strength and hardness.

MATERIALS AND METHODS

The research was conducted at the ITB Bandung and Dental Materials laboratories at Maranatha Christian University. The colour stability test used 25 plate acrylic resin samples measuring 20 mm x 20 mm x 3 mm, divided into five groups based on ADA specifications.

The flexural strength test utilized 25 plate-shaped acrylic resins, each with a length of 65 mm, a width of 10 mm, and a thickness of 2.5 mm, as specified in ADA No. 12. The hardness test employed a tube-shaped acrylic resin sample with a diameter of 5 mm and a thickness of 3 mm. Each test was divided into five groups, namely group 1 control, where samples were soaked using distilled water; group 2 samples were soaked in black tea for 15 hours and not coated with edible coating; group 3 samples were soaked in black tea for 15 hours and coated with edible coating for 15 hours and coated with edible coating for 3 minutes, group 4 samples were soaked in black tea for 15 hours and coated with edible coating for 4 minutes, and group 5 samples were soaked in black tea for 15 hours and coated with edible coating for 5 minutes.

Brewing black tea is made with a ratio of 2 grams of black tea to 100 ml of mineral water. 2,500 ml of mineral water is heated until it boils at a temperature of 100 ± 10 °C, with the aid of a water bath, and 50 grams of black tea leaves are then dissolved in it. After 3-4 minutes, the brewed black tea was filtered and then transferred into autoclave bottles, each containing 100 mL. The temperature was maintained at 37 °C using an incubator.

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The chitosan coating application was carried out by pouring 250 mL of Chitosan Edible Coating (Chitasil, PT. BIKI Indonesia) solution into a beaker. Then, the sample was added and left to sit for the specified time for each group. After coating the samples in groups 3, 4, and 5, they were placed in distilled water for group 1 and black tea for groups 2, 3, 4, and 5. The beaker containing the samples with distilled water and black tea was placed in the incubator at a temperature of 37 °C and soaked for 15 hours. After 15 hours, the sample was removed, wiped with a cloth, and left in the open air for 15 seconds.

The colour stability test was conducted by comparing the colour before and after immersion using the CIELab system with an FTIR spectrophotometer. The flexural strength test was conducted using the Universal Testing Machine Shimadzu AGSX flexural strength testing machine. The measurement results obtained are in MPa. The hardness test was carried out using the Vickers hardness test with a Shimadzu HMV-G21 machine. The load used is 100 g in 15 seconds. Each sample was tested for hardness at three random points.

RESULTS

Table 1 shows the results of the influence of chitosan immersion on colour retention on heat-cured acrylic. Based on the Shapiro-Wilk normality test results, the data used in this study were not normal, so data analysis was continued with the Kruskal-Wallis non-parametric test.

Table 1. Average Wave Number Results for Acrylic Resin Plates

No	Group	Number	Wave Number (cm-1)($\bar{x}$)
1.	Aquades	5	3446.79
2.	Black Tea	5	3449.56
3.	Black Tea + coatingchitosan 1 minute	5	3433.29
4.	Black tea + coating chitosan 2 minutes	5	3433.29
5.	Black tea + coating Chitosan 3 minutes	5	3433.29

Based on the results of hypothesis testing using data 1 (Kruskal-Wallis), the data used in this study have a p-value of 0.000, indicating that there is a significant effect of immersion in chitosan on the colour retention of heat-cured acrylic resin denture bases steeped in black tea. Hypothesis test data 2 (Kruskal-Wallis) yielded a p-value of 1, indicating that there is no significant difference in the duration of chitosan soaking on the colour retention of heat-cured acrylic resin denture bases in black tea brewing.

The results of the flexural strength test are presented in Table 2. The most significant value was in group 3. The one-way ANOVA test using MINITAB yielded a p-value of 0.218, indicating that the flexural strength between groups was not significantly different.

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Table 2. Mean and standard deviation of flexural strength (MPa)

No	Group	Mean	SD
1.	Aquades	584,3	147,6
2.	Black Tea	778,8	75,6
3.	Black Tea + coating chitosan 1 minute	792,4	185,0
4.	Black tea + coating chitosan 2 minutes	647,2	183,0
5.	Black tea + coating Chitosan 3 minutes	697,1	164,5

The results of the hardness test are presented in Table 3. The normality test for the hardness values yielded a p-value <0.05, so the test between groups was continued with the Kruskal-Wallis test, which resulted in a p-value of 0.069. Therefore, it can be concluded that there was no difference in hardness values between groups.

Table 3. Mean and standard deviation of hardness (VHN)

No.	Group	N	Mean	SD
1.	1 (Aquades)	15	25,52	9,55
2.	2 (Black Tea)	15	26,97	6,30
3.	3 (Black Tea + coating chitosan 1 minute)	15	31,05	9,13
4.	4 (Black tea + coating chitosan 2 minutes)	15	33,24	9,32
5.	5 (Black tea + coating Chitosan 3 minutes)	15	31,17	10,68

DISCUSSION

An FTIR spectrophotometer is used to determine the color changes that occur by examining the water absorption of the acrylic resin plate. Based on the results, there are significant differences in the effect of water absorption between groups. Modern colourimetric spectrophotometers measure the light reflected or transmitted from an object. The data are sent to a processor, where it is multiplied by standard illuminant and standard observer functions to yield the XYZ tristimulus values. Absorption of colored fluids on the acrylic resin base can affect the transmission and reflection of light, influencing the intensity of light that passes through the acrylic resin. The more colour liquid the acrylic resin base absorbs, the more concentrated the acrylic resin base will be, and the less light intensity can be transmitted because the acrylic resin base reflects some of the light intensity.[10] Based on the FTIR spectrophotometer result, it can be concluded that the acrylic resin plate soaked with chitosan (groups 3,4,5) has better colour durability than acrylic resins that are not soaked with chitosan (groups 1 and 2).

In this study, heat-cured acrylic resin plates were soaked in black tea for 15 hours. This followed previous research, where the colour change in heat-cured acrylic resin was most significant on acrylic resin plates that were soaked in black tea for 15 hours or consumed black tea for three months.[11] The soaking time for a heat-cured acrylic resin plate can affect the water absorption of the plate because the longer the acrylic resin is in contact with water, the more water molecules will penetrate the polymer and occupy the space between the polymer chains.[12] Black tea contains acidic tannins, which can disrupt the polymer chain bonds of acrylic resin and increase its porosity.[13,14] Black tea contains theaflavin and thearubigin, which can cause more profound colour changes in the denture base.[11]

A heat-cured acrylic resin denture base soaked in chitosan can reduce water absorption and discoloration because the chitosan-coated denture base forms a layer on the surface of the heat-cured acrylic resin denture base. Chitosan and acrylic resin have different properties. Chitosan has basic properties, while PMMA or acrylic resin contains COOH and acidic properties. From these differences in properties, the interaction between chitosan and acrylic resin can occur through electrostatic interactions. The electrostatic interaction between positively charged chitosan and the

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negatively charged acrylic resin surface will form a solid ionic bond.[15-17]

Chitosan has hydrophobic properties, allowing it to form a hydrophobic bond with the material's surface, thereby reducing water absorption in the material, including heat-cured acrylic resin.[18] Soaking chitosan in a heat-cured acrylic resin plate can form a protective layer on the surface and inhibit water absorption on the plate of heat-cured acrylic resin, so that the chitosan-soaked denture base exposed to black tea can experience reduced water absorption and thus reduce discolouration. This study is in line with previous research where chitosan coating affects the water resistance of heat-cured acrylic resin denture base materials.[4]

Applying chitosan by immersion influences the absorption of coloured liquids, but the effectiveness of soaking acrylic resin plates in chitosan is similar. Soaking with chitosan can create even distribution throughout the base surface of the acrylic resin, occupying porous areas and potentially preventing the absorption of coloured liquid through these areas. [4]

The application of chitosan influences water absorption, which indicates the adsorption and absorption that occur when the material is used. Water absorption in the acrylic resin can act as a plasticizer, causing discolouration and decreased mechanical properties of acrylic resin, such as hardness, transverse strength, and fatigue limit. [19]

In this study, immersing chitosan in a heat-cured acrylic resin plate forms a protective layer on the surface, inhibiting water absorption and preventing a decrease in hardness and flexural strength values compared to the control. Nonetheless, a study by Adiana et al. suggested that high-molecular-weight chitosan Nano gel might preserve the colour stability of heat-polymerized PMMA DBR. Less water absorption and fewer leftover monomers may result in better colour stability. This is because the characteristics of the polymer material are restored upon the addition of nano-chitosan gel as a filler.[23]

CONSLUSIONS

Chitosan immersion affects the colour durability of the heat-cured acrylic resin denture base without significantly decreasing the hardness and strength values.

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