The effect on color and dimensional stability of heat cured acrylic resin denture base after being immersed in chocolate and tea drinks

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ABSTRACT
The denture base is an important part because it acts as a support for the tissue around the tooth. Optimal support and aesthetic result in the manufacture of denture bases require several considerations. Color and dimensional stability are one of the important factors for denture bases. In this experimental laboratory study, the denture base was immersed in chocolate and tea drinks and measured the color and dimensional stability before and after immersing. Colorimeter is used as a measurement device for color stability and digital calipers as a measurement device for dimensional stability. The mean differences in color and base dimensions of the dentures were tabulated and the Kruskal-Wallis test was used to analyze them. The results showed that there were very high differences in color and dimensions of immersing tea drinks.
Keywords: color stability, dimensional stability, chocolate, tea

INTRODUCTION

The base of denture is an important part because it acts as a support for tissue around the tooth.[1-3] One of the materials that is often used is acrylic resin. There are various types of acrylic resin, namely heat polymerizing acrylic resin (HPAR), self-polymerizing acrylic resin, light polymerization acrylic resin and microwave polymerization resin. The type of acrylic resin that is often used is HPAR, which began to be used since 1946 because it has several advantages, namely fulfilling aesthetic requirements, good color stability, non-irritating, non-toxic, relatively cheap price, easy to manipulate and repair.[4,5]

The HPAR dentures usually need to be technically cleaned which is brushing and chemically cleaned by immerse the denture in cleaning solution at night for 6-8 hours. Despite having many advantages, there are also some disadvantages of HPAR such as loss of resistance, discoloration, porosity and dimensional changes can occur in clinical use.[6-7] Within a certain period of time HPAR has a tendency to absorb fluids because during HPAR polymerization, porosity possibly occurs on the surface of HPAR.[8] This will continuously have an impact on color and dimensional stability so patient would feel uncomfortable and could get psychologically disturbed because of improper aesthetic.[8] The HPAR undergoes changes in dimensional stability during polymerization such as in terms of shrinkage or expansion where it could impact the patient's occlusal.[9-12] Color of the denture base is very important because it affects aesthetics. The denture base material must have optimal color stability because it is often exposed to various types of food and drink in the oral environment.

Acrylic resin can absorb stains over time, and the resin material is adhesive to liquid molecules which during the abrasive process causes a color change.[13] This is a big minus of acrylic resin, because the change occurs gradually over time.[13] This change is caused by intrinsic or extrinsic factors. Intrinsic factor occurs when there is a change in chemical composition, material composition or material formula, extrinsic factors happen on pigmented foods and drinks intake.[13,14] Various types of beverages on the market that have ability to interfere with the stability of the color and dimensions of the denture base. Some of these drinks are tea and chocolate. Consumption of chocolate and tea drinks is common because it has high calories and can increase energy.

Based on that fact, this study is aimed to determine the effect of immersion of the HPAR denture base in chocolate and tea drinks to check the color and dimensional stability changes.

METHODS

Preparation of HPAR samples

The produced HPAR sample, obtained from stainless steel model with measurement circular diameter of 50x0.5 mm for measure color stability and 64x10x3.3 mm for measure dimensional stability. The first step was making a mold from a hard gypsum dough with ratio of the plaster to water is 300 g:90 mL. The dough was stirred with a spatu-

la for 15 seconds until it became homogeneous. Then place the dough into prepared cuvette while it was placed the cuvette on a vibrator. The stainless-steel model sample was placed on top of the gypsum dough which was hardening inside the cuvette.

After slightly hardens, the plaster was trimmed and allowed to stand until it hardened completely. The surface of the plaster and the cuvette was smeared with vaseline, then the cuvette was paired and filled with hard gypsum dough on top of the vibrator. After the cast hardens, the cuvette opened, the stainless-steel model sample was removed, the cuvette was poured with hot water to remove the remaining vaseline until clean.

Filling acrylic resin in the mold

The polymer and monomer were stirred in a pot ratio of 2 g:1 mL according to the manufacturer's instructions and wait for the mixture to reach dough stage. The mold that had been smeared with a separator was filled with acrylic resin dough. Thin plastic slide was placed between the top and bottom cuvettes, then closed and gently pressed with a hydraulic press with a pressure of 1000 psi (70 kg/cm^2). The cuvette was opened and cut the excess of acrylic layer then the cuvette was closed again, pressing with a pressure of 2200 psi (154 kg/cm^2) then bolts were fixed.

Curing

Curing unit was filled with water, temperature and time were set to phase I 70ºC for 90 minutes and phase II 100ºC for 30 minutes. The cuvette was removed from the water bath and allowed to cool to room temperature.

Final procedure

The samples were removed from the cuvette, then trimmed to remove sharp parts using a fraser bur with a rotary grinder and sand paper type AA 240 to obtain the desired size.

Procedure for making chocolate drinks

The chocolate drink was *Delfi* cocoa powder of which 5 g was dissolved in 625 mL of boiling water then 500 mL of the solution was precipitated. The drink was allowed to cool before immersion. The drink was placed in a room temperature environment and immersion was carried out for 7 days, assuming 7 days are identical to usage for 2 years. One consumption took 15 minutes. Immersing for 7 days means 7x24 hoursx60 minutes = 10080 minutes divided by 15 minutes/day = 672 days; identical to 2 years of use to measure color stability. Immersing was carried out for 92 hours, that are identical to that of 1 year of use. One consumption takes 15 minutes. Consumption of 92 hours means 92 hoursx60 minutes = 5520 minutes: 15 minutes/day = 368 days which was identical to 1 year of use to measure dimensional stability.

Procedure for making tea drinks

Two *Sari Wangi* tea bags dos 2x2 g were immersed in 200 mL boiling water for 1 minute. The drink was allowed to cool down before starting immersing. The drink was placed in a room temperature environment and immersed for 7 days, assuming 7 days was identical to 2 years usage. One consumption takes 15 minutes. Immersing for 7 days means 7x24 hoursx60 minutes = 10080 minutes: 15 minutes/day = 672 days identical to 2 years of use for the measurement of color stability. The resin was immersing for 92 hours, it is assumed that 92 hoursare identical to that of 1 year of use. One Consumption takes 15 minutes. Consumption of 92 hours means 92x60 minutes = 5520 minutes: 15 minutes/day = 368 days identical to 1 year usage for dimensional stability measurements.

Color stability measurement

Sample color was measured before and after immersion using a colorimeter after rinsing with distilled water. Immersion was carried out for 7 days. Drinks were changed every 3 days. The samples were divided into 3 groups, namely A immersed in chocolate drink, B immersed in tea drinks, and C immersed in distilled water. The colorimeter was set to measure mode and placed perpendicular to the sample surface. The instrument was held in the direction against the 90^0-surface center of the sample and the test button was pressed until the machine beeped to indicate the completion of the measurement and the result was displayed on device screen. The results were displayed in L*a*b format. Each reading was repeated three times by the researcher to obtain identical readings, so that an average was recorded.

Dimensional stability measurement

Measurement of changes in dimensional stability was carried out before and after immersion, and the surface area of the sample was calculated. Each end of the sample was marked A, B, C, D. Measurement of dimensions after immersion was the final value measured using a digital caliper. The reading was included in the vector formula, namely $v \| = \sqrt{AB2 + BC^2 + CD^2 + DA^2}$.

Data analysis

The data were analyzed with descriptive test to determine average standard deviation of each group. Then, the changes in the stability of the denture base material of HPAR in immersion of chocolate and tea drinks was determined by the Kruskal-Wallis test and continued with the Mann-Whitney test to find out the differences between groups.

RESULT

The results indicated the color stability value of the HPAR denture base in chocolate immersion was 2.283. The smallest color stability value in immersion of a resin denture base chocolate drink was 1.13, while the largest value was 3.58. The value of the color stability of the base color of HPAR dentures in tea immersion were 4.630, while the smallest value was 1.87 and the largest value was 6.42. The value of immersion in distilled water is 0.663. The smallest color value was 0.35 and the largest value was 1.4.

The mean value and standard deviation of color stability for HPAR denture base immersed in a chocolate drink was 2.283±0.865, while the mean value and standard deviation of color stability for HPAR denture base immersed in tea was 4.630± 1.709. The standard deviation of the color stability of the HPAR denture base immersed in distilled water was 0.663±0.45.

The dimensional stability value of the HPAR base was obtained by recording the results of each sample using a digital caliper. They indicated the value of the dimensional stability of the HPAR base in chocolate immersion is 0.261. The smallest dimensional stability value of immersion the resin in chocolate drink was 0.09 while the largest value was 0.17. The dimensional stability of the HPAR denture base in tea immersion was 0.277. The smallest value is 0.23 and the largest value is 0.31. The value of immersed in aquadest, was 0.055. The smallest color value is 0.04 and the largest value is 0.06.

The dimensional stability of the HPAR denture were analyzed using descriptive test. The mean and standard deviation of the dimensional stability of the HPAR denture base immersed in a chocolate drink was 0.261±0.413, while the mean and the standard deviation of dimensional stability of the HPAR denture base immersed in tea drinks was 0.277±0.023. The mean and standard deviation of the dimensional stability of HPAR denture base immersed in aquadest was 0.05±0.012.

DISCUSSION

A colorimeter which is a light sensitive instrument used to measure the color intensity of an object or the color of a sample in relation to the red, blue and green components of light reflected from the object (table 1). The values in group A1 were 2.283±0.865 and group B1 was 4.630±1.703. The

Table 1 The color stability value of HPAR denture base after immersing in chocolate drink, tea drink and aquadest

No sample	Group A1 ΔE (L * a * b *)	Group B1 ΔE (L * a * b *)	Group C1 ΔE (L * a * b *)
1	1.13 *	3.90	0.98
2	2.20	5.43	0.90
3	1.99	6.42 **	0.78
4	1.42	6.16	0.75
5	3.58 **	3.90	0.35 *
6	2.2	1.87 *	0.36
7	2.62	6.16	1.4 **
8	1.99	5.43	0.48
9	3.58	2.18	0.36
X ± SD	2,283 ± 0.865	4,630 ± 1,709	0.663 ± 0.451

Table 2 The dimensional stability value of denture base after immersing in chocolate drink, tea drink and aquadest

No sample	Chocolate	Tea	Distilled water
1	0.11	0.27	0.06 **
2	0.14	0.28	0.06
3	0.17 **	0.23 *	0.05
4	0.16	0.29	0.04 *
5	0.09 *	0.27	0.06
6	0.09	0.31 **	0.06
7	0.3	0.26	0.06
8	0.13	0.29	0.05
9	0.13	0.3	0.05
X ± SD	0.261 ± 0.413	0.277 ± 0.023	0.05 ± 0.012

value in the C1 group was 0.663±0.451. The color stability values in groups A1, B1 and C1 were varied and the normality test was performed. Based on the results of normality testing using the Shapiro-Wilk test, it was found that all data were not normalmally distributed, so test was continued by using the Kruskal-Wallis test to determine the effect of immersion of HPAR denture bases in groups A1, B1 and C1 on color stability with the Kruskal-Wallis test. The statistical test results obtained a significant level of p = 0.001 <0.05 indicating that there was an effect of immersion of the HPAR denture base with group A1, group B1 and group C1 on color stability. The results of statistical tests from this study indicated that there was an effect of immersion of the HPAR denture base with group A1 (chocolate) and group B1 (tea) on color stability. Judging from the change in the color stability value group B1 was the highest while group C1 showed the least change in color stability. This difference proved that the C1 (control) group had no effect of immersion in the base of HPAR dentures on color stability. Judging from the change in the color stability value group B1 was the highest while group C1 showed the least change in color stability. This difference proved that the C1 (control) group had no effect of immersion in the base of HPAR dentures on color stability. Judging from the change in the color stability value group B1 was the highest while group C1 showed the least change in color stability. This difference proved that the C1 (control) group had no effect of immersion in the base of HPAR dentures on color stability.

Group A1 shows a moderate change in the value of the color stability. There are many benefits of chocolate drink because of the bioactive components of cocoa (flavonoids, saponins, catechins) namely preventing the initiation of pellicle adhesion. The contents of flavonoids as antibacterial and antifungal, saponins prevent the attachment of *C.albican*.[2] However, there are several disadvantages such as changes in color stability of the HPAR denture base. This is because the dissolved component undergoes diffusion capillary flow into the HPAR. The color change occurs due to the physical penetration of the pigments between the latic molecules or the absorption of the pigments on the HPAR surface. There were significant differences between the control group and the treatment group. It was suspected that there was a tannin component from the brown solution with a double bond conjunction on the polyphenol which functioned as a chromophore (color developer) and the presence of a (OH) group in the tannin functioned as an auxochrome (color binder). The presence of chromophores and auxochromes in tannins can cause a brown color. This finding supports Craig et al that stated natural substances absorbed by the resin will cause color changes.

Group B1 showed a change in the value of high color stability. Tannin which was a dye contained in tea drinks where it is highly chromogenic, was a major factor in the occurrence of color pigmentation. The color change took effect after immersion due to the deep absorption of the dye. Then tea drinks also contain large amounts of flavonoid which give tea and flavor properties. However, the aflavins in tea leaves were reported to be the cause of the discoloration.[12] Um and Ruyter reported that tea caused more discoloration than coffee after 48 hours of storage of the five based ingredients resin in a coffee and tea solution.

Based on the results of the Mann-Whitney test, there was a significant difference between groups A1 and C1 (p=0.001 <0.05). There was a significant difference in light intensity between groups B1 and C1 (p=0.001 <0.0) and between groups A1 and B1 (p=0.004 <0.05). Based on the Mann-Whitney test, the results of group B1 had the most significant difference. This was because the tea drinks contained 1% tannin value and 15% flavonoids.

The values in the A2 group were 0.261±0.413 and the B2 group was 0.277±0.023. The value in the C2 group was 0.055±0.012. The values for dimensional stability in the A2, B2 and C2 groups were varied and were tested for normality. Based on the normality test using the Shapiro-Wilk, it was found that all data were not normally distributed, so the test was continued using the Kruskal-Wallis test to determine the effect of immersion of HPAR denture bases in A2, B2 and C2 groups on dimensional stability. The statistical test results obtained a significant level of p=0.001 <0.05, indicating that there was an effect of immersion of the HPAR denture base with the groups A2, B2 and C2 on dimensional stability. The results of statistical tests from this study indicated that there was an effect of immersion of the HPAR denture base with group A2 (chocolate) and group B2 (tea) on dimensional stability. Judging from the change in the value of dimensional stability group B2 was the highest, while group C2 showed the least change in dimensional stability. This difference proved that the C2 (control) group had no effect of immersion in the base of HPAR dentures on dimensional stability. Judging from the change in the value of dimensional stability group B2 was the highest, while group C2 showed the least change in dimensional sta-

bility. This difference proved that the C2 (control) group had no effect of immersion in the base of HPAR dentures on dimensional stability. Judging from the change in the value of dimensional stability group B2 was the highest, while group C2 showed the least change in dimensional stability. This difference proved that the C2 group (control) had no effect of immersion in the base of HPAR dentures on dimensional stability.

In group A2 the dimensional change was moderate; the water molecule combined in the macromolecular structure of HPAR which extended the chain of bonds of the PMMA group. Shrinkage and expansion were two dimensional changes that can not be avoided in any HPAR material. Ferrance stated that materials containing ester and ether groups have hydrophilic properties so that they easily absorbed solutions.

Group B2 gave the highest change because immersing the sample in tea solution resulted in a high dimensional change. This was because it was acidic compared to the control group. It was suspected that the acidic tea reacted with HPAR causing chemical damage to the surface of the acrylic resin. The result of exposure to acidic solutions can cause the release of ions contained in the HPAR, causing surface irregularity.[5] Acidic tea solutions could cause erosion on the HPAR surface. This finding follows Shakhashiri's research which states that the erosive power of acids depends on the type of acid contained in the drink. Acid solutions are also degradable from acrylic resins. This effect was discussed in the matrix decomposition timeframe. Matrix decomposition could occur due to hydrolysis of the matrix. Methacrylic acid has been produced as a result of the degradation process caused by matrix polymers. The degradation process was related to the absorption of the solution and swelling from the matrix which caused the release of organic substances and resulted in mass loss, the change in dimensions of the acrylic resin.

Based on the Mann-Whitney test, the B2 group had the most significant difference in dimensional stability. This is because the content of the drink has acidity properties.

It is concluded that there is an effect of immersion of HPAR denture base with chocolate drink and tea drink on the value of color stability; the effect of tea drinks is more on changes in the color and dimensions stability of the HPAR.

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