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THE EFFECT OF COFFEE BREWING METHODS ON TOOTH DISCOLORATION

Rizki Nurida Rahmawati[1], Nadia Hardini[2], Lusiana Batubara[3]
[1,2] Department of Dental Medicine, Faculty of Medicine, University of Diponegoro, Semarang, Indonesia
[3] Department of Biochemistry, Faculty of Medicine, University of Diponegoro, Semarang, Indonesia

ABSTRACT

Background: The color of teeth in each individual varies greatly in which it is influenced by the color of dentin and enamel. The most frequent tooth discoloration that happened is caused by extrinsic stains like coffee. Coffee consumption habits are increasing along with the level of creativity in serving coffee. Nowadays, coffee with conventional methods like black/Turkish coffee and manual brewing methods such as drip brewing and espresso become popular coffee that are fancied by Indonesian people. Exposure to chromogenic substances and the acidic nature of coffee can cause the formation of pores in enamel and facilitate the deposition of dyes, which cause the color changes. **Aim:** The aim of this research was to analyze the effect of brewing methods on tooth discoloration. **Method:** This research was a true experimental study with a pre-post test control group design. Twenty eight post-extracted first premolar teeth samples divided into 4 groups for drip, espresso, black coffee and control by implementing random allocation. All samples were immersed in each coffee brewing group for 3 hours, 6 hours, and 9 hours. The teeth color was measured using a Chromameter based on the CIE L*a*b system. Statistical tests used Kruskal Wallis and Mann-Whitney test. **Result:** The Kruskal Wallis test showed differences in the color change Δa * between the four groups ($p < 0.05$). Mann-Whitney test indicated a significant difference between the treatment group (drip, espresso, and black coffee group) and the control group ($p < 0.05$). **Conclusion:** Drip coffee, espresso and black coffee brewing methods can affect tooth discoloration, especially affects the red discoloration. But there is no difference in the effect of the drip, espresso, and black coffee brewing methods on tooth discoloration.
Keywords : *Discoloration; Coffee Brewing Methods; Tooth Color Change, Discoloration*

INTRODUCTION

Aesthetic issues like an appearance on the face are now a concern for Indonesian people. Dental discoloration treatment is considered more important than setting dental malposition to obtain an aesthetic smile.[1,2] 65.9% of 220 study participants reported feeling dissatisfied with the color of teeth.[3]

The color of teeth in each individual varies greatly in which it is influenced by the color of dentin and the color of enamel. Tooth discoloration is largely caused by extrinsic and intrinsic stains. Coffee and tea are drinks that can cause severe discoloration.[4]

Coffee is one of the popular drinks either in Indonesia or in the world. Coffee contains chromogenic substances that are tannin in which they are as binder and color provider. Another ingredient that acts as a color provider in coffee drinks is chlorogenic acid. Chlorogenic acid is the main phenolic compound in coffee.[5] The increased chlorogenic acid compound can cause a decrease in coffee pH below the critical pH value of < 5.5. The discoloration of teeth is caused by the acidic pH of drinks due to the dissolution of calcium hydroxyapatite in tooth enamel so that tooth pores are formed in the enamel which facilitates the deposition of dyes, especially if exposed for a long time.[6,7,8]

The habit of drinking coffee is increasing along with the level of creativity in serving coffee. In general, the most widely used coffee serving of Indonesian people is the conventional method of brewed/black coffee. However, the current presentation of coffee based on the manual brewing method has developed. The manual brewing method that is popular in coffee

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shops includes drip brewing and espresso.[9] Brewing process hugely affects the antioxidant composition and bioactive composition of coffee due to the interaction between water and roasted coffee. The high pressure of water can increase coffee phenolic levels, like in the espresso coffee.[5]

It has not been known yet whether coffee using a manual brewing method that is popular in Indonesia, namely drip brewing and espresso, and black coffe can affect tooth discoloration by immersing for 3 hours, 6 hours and 9 hours, so this study broaches the topic.

MATERIALS AND METHODS

This research was true experimental research with pre-post test control group design. The number of samples used in this study was 28 post-extraction premolar teeth and were divided into four groups namely the drip method group, the espresso method, the collision method (black coffee), and the control group. Each group was performed four treatment times (before immersing, immersing for 3 hours, immersing for 6 hours, and immersing for 9 hours). Twenty-eight samples were provided number using markers on the roots. The entire surface of the tooth root was smeared with clear nail polish to prevent penetration of coffee solution through the roots.

The coffee used was Robusta Temanggung coffee powder. The production of the coffee solution with drip brewing method used dripper tool (Coffee Dripper Stainless VD-075, China) with a ratio of 15 g of coffee powder, 100 mL of 92^{o}C mineral water. The extraction process took about 6 minutes. The production of the coffee solution with the espresso brewing method used espresso coffee machine (Nuova Simonelli model, Italy) with a ratio of 15 g of coffee powder,100 mL of 92^{o}C mineral water. The production of a brewed/black coffee solution was performed by dissolving 15 g of coffee powder into 100 mL of 92^{o}C mineral water. The pH of the coffee solution was measured using a pH meter in each group of brewing methods.

Samples were divided into four groups to be immersed for 3 hours, 6 hours, and 9 hours in a coffee solution using the drip, espresso, and black coffee/brewed methods. Immersion was done when the temperature of the coffee solution reaches 37^{o}C and the temperature was maintained in an incubator. For each time immersion, a new coffee solution was produced.

The color measurements of dental samples were carried out using Chromameter (Chromameter CR-400, Minolta, Japan) before and after immersing in a coffee solution. The measurement results were recorded based on the CIE* L*a*b system. Color change measurement was done in every time immersion for 3 hours, 6 hours, and 9 hours.

This study conducted the non-parametric Kruskall Wallis test and the Mann Whitney test for intergroup testing.

RESULTS

Measurement Result of the pH Value of Coffee Solution

In the measurement of pH, the results obtained by the drip and black coffee method possessed a pH of 4.9 which was not considerably different from the pH of the espresso coffee solution which was 4.8. The results of the pH value of the coffee solution in all three methods of brewing coffee are below the critical point of email which was 5.5.

Result of Change in Brightness (ΔL*)

The results of the measurement of color changes in the form of Brightness (L*) before and after immersion and the results of the calculation of the change in Brightness (ΔL*) in dental samples can be seen in Figure 1 and Table 1.

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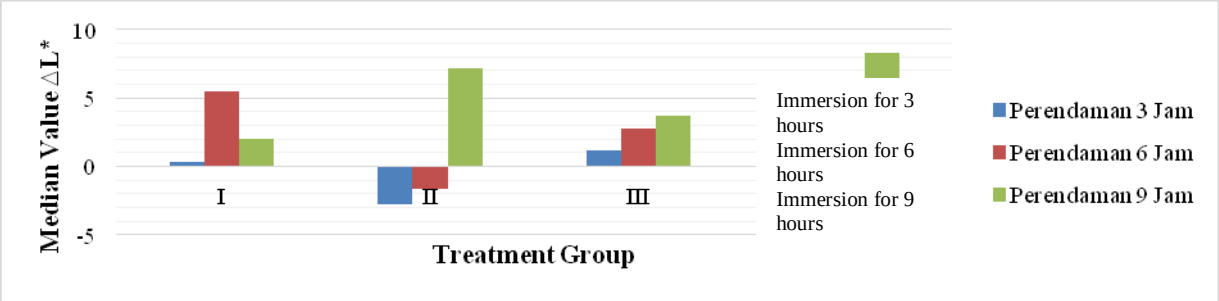

Figure 1. Median Value of Change in the Brightness (L*) in the Sample. (I) Immersion of teeth using drip brewing coffee. (II) Immersion of teeth using espresso coffee. (III) Immersion of teeth using brewed/black coffee. (K) Immersion of teeth using mineral water.

Table 1. Median Values of L* and ΔL* in dental samples before and after treatment

Treatment Group	N	Before Immersion	Immersion for 3 hours		Immersion for 6 hours		Immersion for 9 hours	
		Median Values						
		L*	L*	ΔL*	L*	ΔL*	L*	ΔL*
I	7	68.14	68.42	0.3	74.9	5.52	72.13	2.03
II	7	71.87	68.36	-2.75	71.98	-1.6	73.18	7.18
III	7	69.33	71.14	1.16	69.02	2.79	73.29	3.74
K	7	64.77	73.13	6.01	71.08	5.97	74.06	8.33

Information:
Treatment Group I : Immersion of teeth using drip brewing coffee
Treatment Group II : Immersion of teeth using espresso coffee
Treatment Group III : Immersion of teeth using brewed/black coffee
Control Group : Immersion teeth using mineral water

In figure 1, the drip brewing, espresso, and control groups appeared to have increased the brightness change (ΔL*). Meanwhile, in the drip group, there was a decrease in Brightness (ΔL*) in the samples of the teeth immersed for 9 hours. During immersion for 3 hours, 6 hours, and 9 hours, it was seen that the greatest change in Brightness (ΔL*) occurred in the control group.

Result of Changes in Reddish/Greenish Degree (Δa*)

The results of the measurement of changes in color in the form of reddish/greenish degree (a*) before and after immersion and the results of the calculation of the change in the reddish/greenish degree (Δa*) in dental samples can be seen in Figure 2 and Table 2.

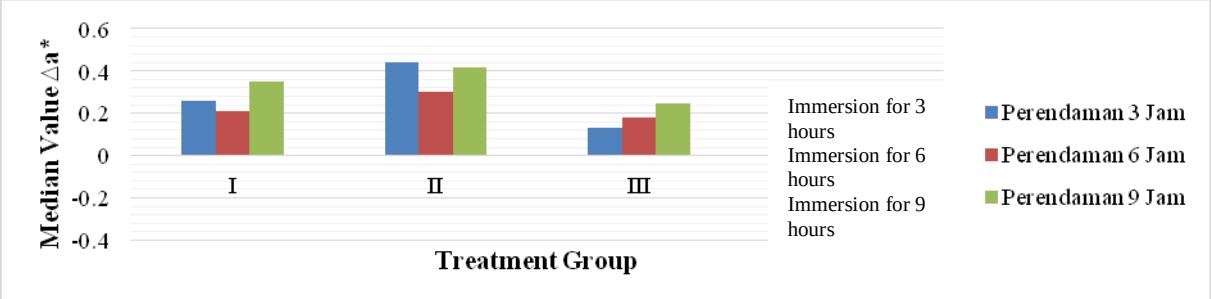

Figure 2. Median Value of Changing Degree of Reddish/Greenish (Δa*) in Samples. (I) Immersion of teeth using drip brewing coffee (II) Immersion of teeth using espresso coffee (III) Immersion of teeth using brewed/black coffee. (K) Immersion of teeth using mineral water.

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Table 2. Median Values a* and Δa* in Dental Samples Before and After Treatment

Treatment Group	N	Before Immersion	Immersion for 3 hours		Immersion for 6 hours		Immersion for 9 hours		*p Value*
		Median Values							
		a*	a*	Δa*	a*	Δa*	a*	Δa*	
I	7	0.01	0.28	0.26	0.32	0.21	0.43	0.35	
II	7	0.22	0.77	0.44	0.48	0.3	0.64	0.42	0.002*
III	7	0.59	0.71	0.13	0.92	0.18	0.99	0.25	
K	7	0.33	-0.01	-0.26	-0.09	-0.32	0.18	-0.15	

Information:
Treatment Group I : Immersion of teeth using drip brewing coffee
Treatment Group II : Immersion of teeth using espresso coffee
Treatment Group III : Immersion of teeth using brewed/black coffee
Control Group : Immersion teeth using mineral water

In the impact group, there was an increase in the degree of reddish (Δa*). Meanwhile, in the group of drip and espresso brewing, there was a decrease which was shown in the 6 hours of immersion. However, it increased again in 9 hours of immersion. In the control group an increase in the degree of Greenish (Δa*) increased along with the increase in immersion time. During the immersion for 3 hours, 6 hours, and 9 hours, the highest degree of reddish (Δa*) change was shown by the espresso group.

Kruskal Wallis test results on the results of changes in the degree of Reddish/Greenish (Δa*) showed the value of p = 0.002 (p < 0.05) shown in table 2. Therefore, it can be concluded that there were differences in the value of Δa* between treatment groups.

Table 3. Advanced Test Results Δa* Effects of Coffee Brewing Methods on Tooth Color Change

Group / *P Value*		II			III			K		
		Immersion (hour)								
		3	6	9	3	6	9	3	6	9
	Immersion (hour)									
I	3	0.06	-	-	0.48	-	-	0.09	-	-
	6	-	0.80	-	-	0.57	-	-	0.03*	-
	9	-	-	0.95	-	-	0.70	-	-	0.01*
II	3	-	-	-	0.04*	-	-	0.01*	-	-
	6	-	-	-	-	0.80	-	-	0.06	-
	9	-	-	-	-	-	0.90	-	-	0.01*
III	3	-	-	-	-	-	-	0.23	-	-
	6	-	-	-	-	-	-	-	0.08	-
	9	-	-	-	-	-	-	-	-	0.04*

Information: **Significance of the Mann Whitney test: p < 0.05*
Treatment Group I: Immersion of teeth using drip brewing coffee
Treatment Group II: Immersion of teeth using espresso coffee
Treatment Group III: Immersion of teeth using brewed/black coffee
Control Group: Immersion of teeth using mineral water

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Mann Whitney test results in table 3 showed a significant difference in the reddish degree changes between the drip brewing group compared with the control group at 6 hours of immersion with p = 0.03 and 9 hours of immersion with p = 0.01 (p < 0.05). Significant differences in changes in the degree of reddish were shown in the espresso brewing group against the brewed/black coffee brewing group on immersion for 3 hours with a value of p = 0.04 (p < 0.05). Then there was a significant difference in the espresso brewing group compared to the control group in the 3 hours of immersion with p = 0.01 and 9 hours of immersion with p = 0.01 (p < 0.05). Significant differences were identified in the black coffee group to the control group at 9 hours of immersion with p = 0.04 (p < 0.05). It can be concluded from the results of the analysis that the longer the immersion, the greater the change in the degree of reddish color produced.

Result of Changes in Yellowish/Bluish Degree (Δb*)

The results of the measurement of color changes in the form of yellowish/bluish degrees (b*) before and after immersion and the results of the calculation of yellowish/bluish degrees (Δb*) in the dental samples can be seen in Figure 3 and Table 4.

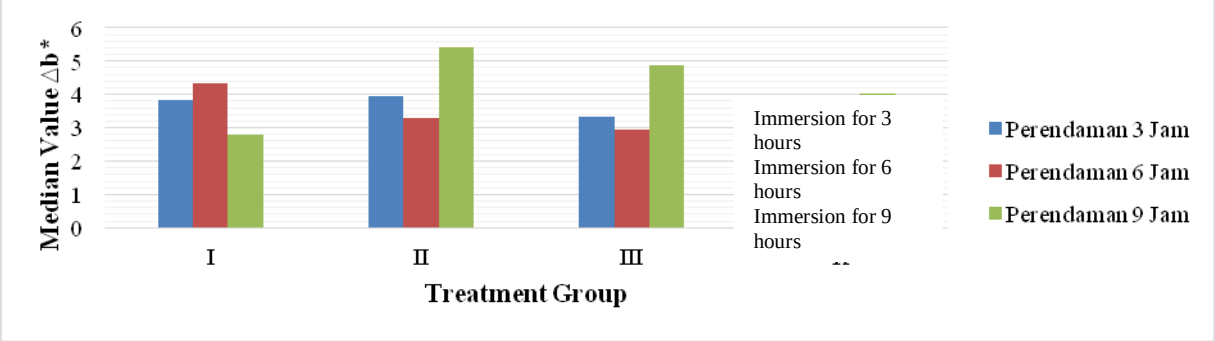

Figure 3. Median Value of Change in Yellowish/Bluish Degrees (Δb *) in the Sample. (I) Immersion of teeth using drip brewing coffee (II) Immersion of teeth using espresso coffee (III) Immersion of teeth using brewed/black coffee. (K) Immersion of teeth using mineral water.

Table 4. Median Values of b* and Δb* in dental samples before and after treatment

Treatment Group	N	Before Immersion	Immersion for 3 hours		Immersion for 6 hours		Immersion for 9 hours	
		Median Values						
		b*	b*	Δb*	b*	Δb*	b*	Δb*
I	7	7.61	11.38	3.83	10.63	4.34	11.7	2.81
II	7	8.29	12.3	3.96	12.3	3.28	13.18	5.41
III	7	9.4	12.82	3.32	11.48	2.95	14.27	4.87
K	7	7.08	11.57	3.32	9.75	3.35	12	4;01

Information:
Treatment Group I : Immersion of teeth using drip brewing coffee
Treatment Group II : Immersion of teeth using espresso coffee
Treatment Group III : Immersion of teeth using brewed/black coffee
Control Group : Immersion teeth using mineral water

In the immersion for 3 hours and 9 hours, the highest change in yellowish degree (Δb*) was shown in the espresso brewing group. During the 6 hours of

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immersion, the highest change in yellowish degree (Δb*) was shown in the drip brewing group. There was a decrease in the change in yellowish degree (Δb*) in the espresso and brewed/black coffee group during the 6 hours of immersion, but there was an increase again in the 9 hours of immersion.

Result of Color Change (ΔE*)

The color change (ΔE*) was obtained by the formula: $\Delta E^* ab = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. The result of the calculation of color change (ΔE*) in dental samples can be seen in Figure 4 and Table 5.

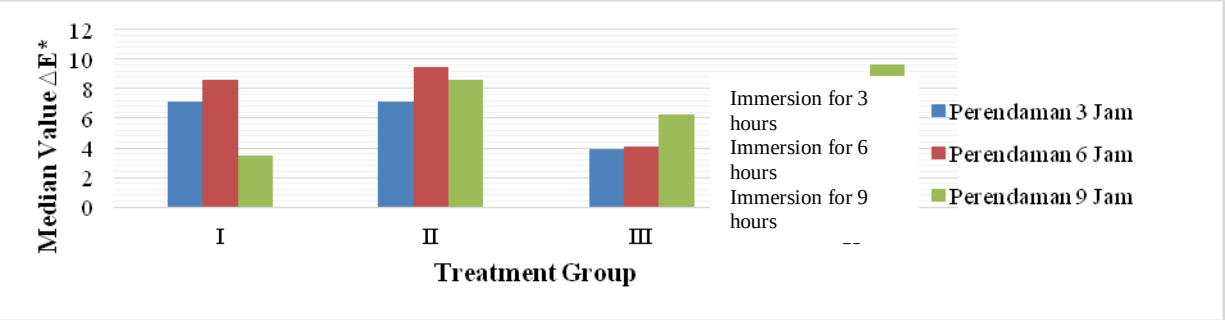

Figure 4. Median Value of color change (ΔE*) in Samples. (I) Immersion of teeth using drip brewing coffee (II) Immersion of teeth using espresso coffee (III) Immersion of teeth using brewed/black coffee. (K) Immersion of teeth using mineral water.

Table 6. Median Value of Color Change (ΔE *) in Dental Samples

Treatment Group	N	Color Change (ΔE *) Median Values		
		Immersion for 3 hours	Immersion for 6 hours	Immersion for 9 hours
I	7	7.15	8.58	3.47
II	7	7.09	9.46	8.59
III	7	3.93	4.08	6.25
K	7	6.26	6.33	9.67

Information :
Treatment Group I : Immersion of teeth using drip brewing coffee
Treatment Group II : Immersion of teeth using espresso coffee
Treatment Group III : Immersion of teeth using brewed/black coffee
Control Group : Immersion teeth using mineral water

During immersion for 3 hours and 6 hours, the most drastic change in color (ΔE*) was shown in the drip brewing and espresso groups. Each treatment group and control group indicated an increase in color change (ΔE*) along with increasing immersion, but there was a decrease in color change (ΔE*) in the drip brewing group during 9 hours of immersion. It can be concluded from the results of the analysis that the more the longer the immersion, the greater the color change produced.

DISCUSSION

In the drip brewing method group, the results obtained showed changes in the brightness (ΔL*), changes in the value of the reddish degree (Δa*), changes in the value of yellowish degree (Δb*), and changes in color (ΔE*). However, after the analysis test

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was conducted to compare changes in these values, which showed a significant difference was the change in the reddish degree (Δa*). Based on this study, 3 hours of immersion did not show any significant difference. This might be due to the drip brewing coffee pH which was 4.9 so that the demineralization that occurred in enamel during 3 hours of immersion has not caused the dyes contained in the coffee solution deposited on the enamel surface. Meanwhile, in the 6 hours and 9 hours of immersion the change in the value of the reddish degree (Δa*) of the drip brewing method group was significantly different compared to the control group. This might be because coffee is a food source that contains condensed tannins as one of the core phenolic components if condensed tannins come into contact with acids they can give a red pigment.[10] According to the study of Ludwig et. al and Perez-Martinez et. al the content of chlorogenic acid in drip brewing coffee is higher than that of espresso coffee because of the extended duration of extraction time and the turbulence that occurs on filter paper causes water to interact directly with coffee grounds so that additional phenolic compounds contained in coffee grounds can also be extracted.[5, 11] Chlorogenic acids in the drip brewing coffee solution reacted with condensed tannins causing direct staining in the enamel in the form of reddish degree.[12] This one is consistent with the research hypothesis that there was an influence of the drip coffee brewing method on changes in tooth color.

In the espresso method group, there was a change in the brightness (ΔL*), a change in the reddish degree (Δa*), a change in the value of a yellowish degree (Δb*), and a change in color (ΔE *). However, after the analysis test was conducted to compare changes in these values, which showed a significant difference was the change in the reddish degree (Δa*). At the immersion of 3 hours and 9 hours, the change in the value of the reddish degree (Δa *) the espresso method group compared to the impact group and the control group showed significant differences. The espresso brewing method might produce vaster levels of chlorogenic acid compared to other brewing methods. This happened because of differences in the technique between espresso coffee brewing tools with the other brewing techniques, large water pressure on espresso brewing could increase the yields of coffee extraction. The faster the duration of contact between water and coffee grounds, the higher the coffee, water ratio, and the phenolic component of coffee. It was also possible the lowest pH of espresso coffee was compared to the drip brewing and brewed/black coffee method which was 4.8. However, in the 6 hours of immersion, the espresso group showed no significant difference. This might occur because of the longer extraction duration or less water pressure, causing the phenolic component to be retained on coffee particles and chlorogenic acid content that was extracted more little.[5] This one corresponds to the research hypothesis that there was an influence of espresso coffee brewing methods on tooth discoloration.

In the brewed/black coffee method group, there was a change in the brightness (ΔL *), a change in the reddish degree (Δa*), a change in the value of a yellowish degree (Δb*), and a change in color (ΔE*). However, after the analysis test was conducted to compare changes in these values, which showed a significant difference was the change in the reddish degree (Δa*). In immersion of 3 and 6 hours, the black coffee solution did not indicate significant differences. However, during the 9 hours of immersion, there was a significant difference. These results were in line with Aprilda's study that the longer the

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immersion, the greater the discoloration that occurs.[13] This was due to the presence of a red dye contained in the coffee solution that is anthocyanin. Anthocyanins are phenolic components that provide color pigments that are present in plants, usually found in flowers and fruit that are colored like red fruit varieties.[10,14] This red pigment is a chromogenic agent that causes direct discoloration of teeth because the color formed is in accordance with the original color of the substrate or commonly referred to as direct staining.[15,16] Besides, the pH in the black coffee solution that is 4.9 was also a factor causing tooth discoloration because it can cause porous enamel so that the dye can be deposited in the enamel. This is consistent with the research hypothesis that there is an effect of brewing coffee methods on the discoloration of teeth.

In the control group, there was a change in the brightness (ΔL*), a change in the reddish degree (Δa*), a change in the value of a yellowish degree (Δb*), and a change in color (ΔE*). The study of dental discoloration by immersion method using mineral water was unfound, but the results of this study were in line with in vivo research conducted by Herdiyati et. al color of the central incisors (54.84%) and lateral maxillary (61.29%) respondents who consumed mineral water as a daily drink had a tooth shade of B1, which was the color group that had the color of youth and the intensest brightness.[17]

The results of the analysis of the changes in the value of the brightness in the three coffee brewing methods showed no significant difference. This might be caused by Maillard Reaction Product (MRP) or Maillard reaction products during the roasting process of coffee beans, namely melanoid which produced brownish color due to the degradation of chlorogenic acid in coffee powder is less extracted through the drip, espresso and black coffee brewing methods. This is in line with research by Ludwig et. al which states that melanoid is a polymer that is difficult to be released without water pressure as in the drip and brewed/black coffee method. In the espresso method, the phenolic component that binds to melanoid requires a greater extraction duration and water pressure.[5] Besides, the roasting process also causes a pyrolysis reaction which produces a yellowish-colored gallic acid from the degradation of chlorogenic acid in the three brewing methods that were supposed to possess an amount that is almost the same because coffee beans originated from the same roasting process, causing an insignificant change in the yellowish degree.

In each treatment, the most influential on tooth discoloration was the drip brewing method shown in the analysis of the highest color change (ΔE *) at 3 hours and 6 hours of immersion. However, based on the results of the inferential analysis test, there was no significant difference. This might be due to the color-producing phenolic levels in the three brewing methods which were almost the same as showed by the pH measurement results which were not much different from each other, namely espresso at 4.8 while the drip brewing and brewed/black coffee method by 4.9. This is not in accordance with the research hypothesis that there were differences in the effect of brewing drip, espresso, and balck coffee brewing methods on tooth discoloration.

CONCLUSION

Drip coffee, espresso and black coffee brewing methods can affect tooth discoloration, especially affects the red discoloration. But there is no difference in the effect of the drip, espresso, and black coffee brewing methods on tooth discoloration.

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