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Effect of Immersion of Denture Base Thermoplastic Nylon in Alkaline Peroxide and 10% Castor Oil (*Ricinus Communis Oil*) on Color Stability and Flexural Strength

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ABSTRACT
Discoloration and flexural strength of denture bases are important factors affecting the comfort and durability of denture users. This study aims to determine the effect of immersion of nylon thermoplastic denture base in alkaline peroxide solution and 10% castor oil (Ricinus Communis Oil) on color stability and flexural strength. This study used a laboratory experimental design with samples of cylindrical (20 x 2 mm) thermoplastic nylon resin for color stability test and rectangular (65 x 10 x 3 mm) for flexural strength test. There were two study groups: one control group and two treatment groups immersed in alkaline peroxide and 10% castor oil solution, with two time variables, 8 days and 12 days. The total number of samples was 60, with each group having 10 samples. The color stability test used a colorimeter, and the flexural strength test used a universal testing machine. The results showed that there was no effect of soaking the nylon thermoplastic denture base in alkaline peroxide on color stability, with a value of p = 0.412 for 8 days and p = 0.179 for 12 days. In addition, there was no effect of immersion in alkaline peroxide and 10% castor oil on flexural strength, with p value = 0.076 for 8 days and p = 0.917 for 12 days. The implication of this study is that immersion in alkaline peroxide and castor oil solution does not affect the color stability or flexural strength of nylon thermoplastic denture bases, making them safe for long-term use.

Keywords: Denture, Thermoplastic Nylon, Alkaline Peroxide, Castor Oil, Color Stability, Flexural Strength.

INTRODUCTION

Tooth loss is the loss of one or more teeth from their sockets, which can lead to disruption of speech, mastication, and social relationships that will impact on quality of life. A denture is a device that can replace the function of missing teeth. The denture base is the part of the denture that lies in the soft tissue (Kim, 2019). Denture bases are divided into metal bases and non-metal bases. Non-metallic bases are divided into two, namely thermo-hardening materials such as acrylic resins and thermoplastic materials such as nylon. Thermoplastic nylon base is a denture base made from a special nylon that is lightweight and durable (Hamanaka et al., 2017).

Thermoplastic nylon has hydrophilic properties that may affect physical or mechanical properties related to water absorption such as color stability and flexural strength. During wear, the denture must be disinfected by various disinfection methods such as mechanical, chemical, and combined methods. Mechanical methods are done by brushing, chemical methods by using chemical disinfectants such as alkaline peroxide and chlorhexidine which are common disinfectants or with natural oils, and combined methods are done by combining the two (Anshary et al., 2014); (Zarb et al., 2012).

Denture disinfectant preparations have been found in the market, but research is still ongoing because there are still many natural ingredients that have potential as disinfectants and need to be developed. The Indonesian government is encouraging health practitioners to use traditional materials derived from nature as an alternative treatment. Currently, there are many studies on plants that have antimicrobial properties to find alternative cleaning agents. One that is starting to be researched in the health sector is castor oil. Castor oil is an oil derived from castor seeds and is starting to be used in the medical field, has biocompatible, antimicrobial, and antifungal properties because it contains alkaloids, saponins, tannins, phenols, and flavonoids. Research on castor oil is currently still small so other studies are used that have similar content to castor oil such as extracts of clove leaves, cashew leaves, bay leaves, coffee, and tea because they have flavonoids, tannins, and phenols. Castor oil is considered superior as a good antimicrobial agent on Staphylococcus aureus, Eschericha coli, and Candida albicans. According to (Salles et al., 2015) the use of 10% castor oil solution is effective in removing biofilm due to the formation of microbial colonies on the surface of artificial teeth. In a study by Kavita G (2018) 10% castor oil was also effective in disinfecting Candida Albicans and did not affect the color stability of the denture.

The use of castor oil as a disinfectant may affect denture base properties such as color stability. Color stability is the ability of a surface layer or pigment to survive degradation caused by exposure from the environment. According to previous research, immersion in clove extract in concentrations of 0.8%, 1%, 1.2% 1.4%, and 1.6% for 12 days did not change color. (Wibawaningtyas et al., 2017). In another previous study, a 15-minute immersion of 25% cashew leaf extract for 8 days affected the color stability of thermoplastic nylon (Dini, 2013). This also supports the statement according to (Mayasari, 2015), thermoplastic nylon soaked 15 minutes in 25% bay leaf extract for 6 days and 13 days showed that color changes occurred. Alkaline peroxide as a commonly used disinfectant may affect the color stability of denture bases. According to Awing M (2013), immersion of thermoplastic nylon in alkaline peroxide for 8 hours with 7 immersions did not experience color fading (Awing & Koyama, 2013). According to (Durkan et al., 2013) alkaline peroxide immersion of 15 minutes for 20 days causes significant color changes. Likewise, research according to (Shah et al., 2015) immersion of thermoplastic nylon in alkaline peroxide using different brands, namely Clinsodent, Calclean, and Polident for 1 month, 3 months, and 6 months did not show significant color changes.

Another property that may be affected is flexural strength, which is the ability of a restoration to withstand loads from chewing pressure. According to (Sundari et al., 2016), 15 minutes of coffee soaking for 7 days did not cause a significant decrease in flexural strength. Another study by (Rossy A, 2018), 15 minutes of black tea immersion for 5 days decreased the flexural strength of thermoplastic nylon. In accordance with research by (M, 2018), 15 minutes of green tea immersion for 5 days also decreased the flexural strength of thermoplastic nylon bases. Disinfecting agents such as alkaline peroxide may also affect the flexural strength of denture bases. According to (Ragain et al., 2015), immersion of nylon base in alkaline peroxide at 370°C for 10 minutes did not cause a decrease in the flexural strength of thermoplastic nylon. According to (Shah et al., 2015) immersion of thermoplastic nylon in alkaline peroxide using different brands namely Clinsodent, Calclean, and Polident for 1 month, 3 months, and 6 months showed a significant decrease in flexural strength. In line with research by Manohar K (2019), immersion of nylon base for 1 month, 3 months, and 6 months in alkaline peroxide showed a decrease in flexural strength of thermoplastic nylon.

Thermoplastic nylon denture bases are currently in high demand as they have many advantages over acrylic resin bases. The completed denture is inserted into the patient's oral cavity and must be disinfected to prevent denture-related diseases. There are three disinfection methods that can be used, but the chemical method is the most effective method using chemicals or natural materials. Commonly used chemicals include alkaline peroxide. One of the natural ingredients that is starting to be developed is castor oil. Castor oil in a concentration of 10% can be used as a disinfection agent because it has good antimicrobial activity. Research on castor oil as a disinfectant has not been done much, so research is used that has the same content as castor oil such as flavonoids, tannins, and phenol compounds. The use of disinfectants and the hydrophilic nature of nylon may affect the properties of the base, such as color stability and flexural strength. Research by (Mayasari, 2015) showed that thermoplastic nylon soaked in 25% bay leaf extract for 6 days and 13 days showed that color changes occurred. According to (Awing & Koyama, 2013), immersion of thermoplastic nylon in alkaline peroxide with 7 times immersion does not experience color fading. Another property that may be affected is flexural strength. According to (Sundari et al., 2016), coffee soaking for 7 days did not cause a significant decrease in flexural strength. According to (Shah et al., 2015), immersion in alkaline peroxide for 1 month, 3 months, and 6 months caused a significant decrease in flexural strength.

Based on the background description above, this study aims to determine the effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on color stability and flexural strength for 8 days and 12 days. So that the benefits in this study are that the benefits in this study are to provide more in-depth information about the safety of using denture cleaning agents, especially alkaline peroxide and 10% castor oil, on the quality of thermoplastic nylon denture base material. This study is expected to serve as a reference for clinical practitioners in recommending denture care methods that are not only effective in

maintaining hygiene, but also do not damage important mechanical properties such as color stability and flexural strength. In addition, the results of this study can also contribute to the development of denture cleaning products that are safer and kinder to denture materials, thereby increasing the comfort and satisfaction of denture users in the long run.

RESEARCH METHOD

Research Design

The research design used was laboratory experimental to determine the effect of disinfection of thermoplastic nylon denture bases with alkaline peroxide and 10% castor oil (ricinus communis oil) on color stability and flexural strength. The research design used was post-test only control group design, which gives treatment to one or more groups then the results are compared with the control group.

Research Sample

The sample in this study uses thermoplastic nylon with size:

1. Cylinder with a diameter of 20 mm and thickness of 2 mm for color stability calculation sample (ISO 1567).
2. Rectangle with size 65 x 10 x 3 mm for flexural strength calculation sample (ADA No. 2).

Research Sample Size

In this study, there were six sample groups, namely one control group, and two treatment groups soaked for 8 days and 12 days with two variables, namely color stability and flexural strength, then t = 6 so that the number of samples for each group can be determined as follows:

$(t – 1)(r - 1) \geq 15$

$(6 - 1)(r - 1) \geq 15$

$5(r - 1) \geq 15$

$5r - 5 \geq 15$

$5r \geq 15 + 5$

$r \geq 20/5 = 4$

Thus, the number of samples for the three groups (one control group plus two treatment groups) was 15 samples, plus the time variable (8 days and 12 days) to 30 samples. Since there are two variables to be studied, namely color stability and flexural strength, the total number of samples is 60.

Research Tools and Materials

Tools

a. Injection system for injecting thermoplastic nylon
b. Crownmess (parent model) to form the research subject
c. A cuvette for planting research subjects
d. Rubber bowl and spatula for stirring casts
e. Carborundum for cutting research subjects

f. Polishing bur to smooth the research subject
g. Sliding caliper to measure research subjects
h. Beaker for sample immersion
i. Incubator as a place to store samples during immersion
j. Colorimeter to measure color stability
k. Universal Testing Machine (UTM) to measure flexural strength

Material

a. Valplast® brand thermoplastic nylon resin
b. Thurga's® brand castor oil
c. Polident® brand alkaline peroxide
d. Plaster casts for embedding research subjects in cuvettes
e. Vaseline and Cold mold seal (CMS)
f. Pumice as a material for polishing thermoplastic nylon
g. Filter paper
h. Tween 80
i. Aquades
j. Plastic wrap

Data Analysis

The data analysis used in this study is:

a. Univariate test to test the mean and standard deviation.
b. Anova test to examine the effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil (Ricinus Communis Oil) on color stability and flexural strength for 8 days.
c. Kruskal-wallis test to examine the effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil (Ricinus Communis Oil) on color stability and flexural strength for 12 days.

RESULT AND DISCUSSION

Color Stability Value of Thermoplastic Nylon Denture Base After Immersion in Alkaline Peroxide and 10% Castor Oil for 8 Days and 12 Days

Color stability was measured using a colorimeter by calculating the value of the degree of color after immersion in a glass beaker with alkaline peroxide (group A1), 10% castor oil (group B1), and distilled water (group C1 (control group)) for 8 days and 12 days. The data obtained were then calculated the mean value and standard deviation using the univariate test.

Table 6. Immersion color stability values of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil for 8 days

No.	Day	Group A1	Group B1	Group C1
1.	8 days	39,64	38,93	37,27*

No.	Day	Group A1	Group B1	Group C1
2.		39,39	40,41	38,63
3.		41,35**	38,41*	39,11
4.		38,59*	40,47**	39,76**
5.		39,11	38,99	39,24
$\bar{X}$ ± SD		39,62 ± 1,05	39,44 ± 0,94	38,81 ± 0,95
Description:				
* Smallest value				
** Greatest value				

The value of color stability after 8 days of soaking in group A1 the largest color stability value was 41.35, the smallest value was 38.59, and the mean value and standard deviation were 39.62 ± 1.05, in group B1 the largest color stability value was 40.47, the smallest value was 38.41, and the mean value and standard deviation were 39.44 ± 0.94, and in group C1 the largest color stability value was 39.76, the smallest value was 37.27, with the mean value and standard deviation were 38.81 ± 0.95. (Table 6)

Table 7. Immersion color stability value of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil for 12 days

No.	Day	Group A1	Group B1	Group C1
1.		39,50	39,08	39,16*
2.		38,99*	38,50*	39,51
3.	12 days	39,64	38,99	39,70
4.		39,83**	41,39**	39,89
5.		39,04	38,86	40,90**
$\bar{X}$ ± SD		39,40 ± 0,37	39,36 ± 1,15	39,83 ± 0,66
Description:				
* Smallest value				
** Greatest value				

The color stability value after 12 days of soaking in group A1, the largest color stability value was 39.83, the smallest value was 38.99, and the mean and standard deviation values were 39.40 ± 0.37, in group B1, the largest color stability value was 41.39, the smallest value was 38.50, and the mean and standard deviation values were 39.36 ± 1.15, and in group C1, the largest color stability value was 40.90, the smallest value was 39.16, and the mean and standard deviation values were 39.83 ± 0.66.

Flexural Strength Value of Thermoplastic Nylon Denture Base After Immersion in Alkaline Peroxide and 10% Castor Oil for 8 Days and 12 Days

Calculation of flexural strength values after immersion of thermoplastic nylon samples for 8 days and 12 days with group A2 (alkaline peroxide), group B2 (10% castor oil), and group C2 (distilled water (control group)) was carried out by placing each sample in a glass jar containing 10% castor oil, alkaline peroxide, and distilled water. Furthermore, pressing was carried out with

a universal testing machine until the p value came out. The data obtained in the form of mean values and standard deviations were calculated using the univariant test.

Table 8. Immersion flexural strength values of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil for 8 days

No.	Day	Group A2	Group B2	C2 group
1.	8 days	27,96*	31,65	32,01
2.		29,34**	31,42	27,45*
3.		29,14	31,06	33,27**
4.		28,94	31,78**	29,23
5.		29,29	28,62*	29,07
$\bar{X}$ ± SD		28,93 ± 0,57	30,91 ± 1,31	30,21 ± 2,37
Description:				
* Smallest value				
** Greatest value				

Table 8 shows the flexural strength value of the thermoplastic nylon denture base after 8 days immersion with group A2 the largest value is 29.34 MPa, the smallest value is 27.96 MPa, and the mean and standard deviation values are 28.93 ± 0.57, in group B2 the largest flexural strength value is 31,78, the smallest value was 28.62 MPa, and the mean and standard deviation were 30.91 ± 1.31, and in group C2 the flexural strength value with the largest value was 33.27 MPa, the smallest value was 27.45 MPa, and the mean and standard deviation were 30.21 ± 2.37. (Table 8)

Table 9. Immersion flexural strength values of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil for 12 days

No.	Day	Group A2	Group B2	C2 group
1.	12 days	29,86**	29,63	28,26*
2.		29,07	30,22	30,69
3.		28,18*	29,99	28,80
4.		29,80	30,50**	29,60
5.		29,68	25,57*	34,95**
$\bar{X}$ ± SD		29,32 ± 0,71	29,18 ± 2,04	30,46 ± 2,67
Description:				
* Smallest value				
** Greatest value				

The flexural strength value of the thermoplastic nylon denture base after 12 days immersion with group A2 the largest value was 29.86 MPa, the smallest value was 28.18 MPa, and the mean and standard deviation values were 29.32 ± 0.71, in group B2 the largest value was 30,50 MPa, the smallest value is 25.57 MPa, and the mean and standard deviation is 29.18 ± 2.04, in group C2 the flexural strength value with the largest value is 34.95 MPa, the smallest value is 28.26 MPa, and the mean and standard deviation is 30.46 ± 2.67. (Table 9)

Effect of Immersion of Thermoplastic Nylon Denture Base in Alkaline Peroxide and 10% Castor Oil (*Ricinus Communis Oil*) on Color Stability for 8 Days and 12 Days

The effect of soaking thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil with group A1 (alkaline peroxide), group B1 (10% castor oil), and group C1 (distilled water) on color stability can be seen from the mean value and standard deviation of color stability values after soaking for 8 days and 12 days. Immersion for 8 days (Table 6) shows the mean value and standard deviation of group A1 is 39.62 ± 1.05, and group B1 is 39.44 ± 0.94, and group C1 is 38.81 ± 0.95. At 12 days of soaking (Table 7) shows the mean value and standard deviation of group A1 is 39.40 ± 0.37, and group B1 is 39.36 ± 1.15, and group C1 is 39.83 ± 0.66.

Furthermore, a normality test was conducted to determine the normal distribution of the data. Based on the normality test, the color stability data on soaking for 8 days was normally distributed with a p value = 0.799 ($p > 0.05$), but the color stability data on soaking for 12 days was not normally distributed with a p value = 0.048 ($p < 0.05$).

Table 10. Effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil for 8 days on color stability

Day	Group	p
8 Days	Group A1	0,412
	Group B1	
	Group C1	

After the normality test was carried out, it was continued with the Anova test to determine the effect of soaking 10% castor oil and alkaline peroxide for 8 days. Based on statistical results that there is no effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on color stability for 8 days seen from the p value = 0.412 ($p > 0.05$).

Table 11. Effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil for 12 days on color stability

Day	Group	p
12 Days	Group A1	0,179
	Group B1	
	Group C1	

Furthermore, Kruskal-Wallis test was conducted to determine the effect of soaking 10% castor oil and alkaline peroxide for 12 days. In the 12-day immersion, there was no effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil on color stability as seen from the p value = 0.179 ($p > 0.05$). (Table 11)

Effect of Immersion of Thermoplastic Nylon Denture Base in Alkaline Peroxide and 10% Castor Oil (*Ricinus Communis Oil*) on Flexural Strength for 8 Days and 12 Days

The effect of immersion of thermoplastic nylon denture bases with group A2 (alkaline peroxide), group B2 (10% castor oil), and group C2 (distilled water) on flexural strength can be

seen from the mean value and standard deviation after immersion for 8 days and 12 days in each group. In the 8-day immersion (Table 8), the mean value and standard deviation of group A2 was 28.93 ± 0.57, group B2 was 30.91 ± 1.31, and group C2 was 30.21 ± 2.37. In the 12-day immersion (Table 9), the mean value and standard deviation of group A2 was 29.32 ± 0.71, group B2 was 29.18 ± 2.04, and group C2 was 30.46 ± 2.67.

Before testing, it is necessary to conduct a normality test to determine the normal distribution of data. Based on the results of the normality test, data on immersion for 8 days is normally distributed with a p value = 0.227 (p> 0.05), but flexural strength data on immersion for 12 days is not normally distributed with a p value = 0.015 (p < 0.05).

Table 12. Effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil for 8 days on flexural strength

Day	Group	p
8 Days	Group A2	0,183
	Group B2	
	C2 group	

After the normality test was carried out, then the Anova test was carried out to determine the effect of soaking 10% castor oil and alkaline peroxide for 8 days. Based on statistical results, there is no effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on flexural strength for 8 days as seen from the p value = 0.183 (p> 0.05).

Table 13. Effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil for 12 days on flexural strength

Day	Group	p
12 Days	Group A2	0,756
	Group B2	
	C2 group	

Furthermore, Kruskal-wallis test was conducted to determine the effect of 10% castor oil and alkaline peroxide immersion for 12 days. At 12 days, there was no effect of soaking thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on flexural strength as seen from the p value = 0.756 (p> 0.05).

Discussion

Color Stability Value of Thermoplastic Nylon Denture Base After Immersion Based on the results of the study, the color stability of the thermoplastic nylon denture base after immersion in alkaline peroxide, 10% castor oil, and distilled water solutions showed relatively stable values for both 8 and 12 days. The same was found for the flexural strength of the denture base, where immersion in the three solutions did not give any significant difference. Statistical analysis showed that there was no significant effect on color stability or flexural strength after immersion in alkaline peroxide and 10% castor oil, with p values > 0.05 over the 8- and 12-day periods. These

results indicate that 10% castor oil can be an equivalent alternative to alkaline peroxide in maintaining color stability and flexural strength, in addition to having other advantages such as lower cost, better biocompatibility, non-toxicity, and ability to stimulate immunity. Therefore, 10% castor oil can be considered as an alternative disinfection agent for thermoplastic nylon denture base treatment. However, further research is needed regarding the effect of soaking on color stability using different measuring instruments, as well as the need for a more optimal polishing process to achieve a smooth surface on the sample.

Immersion in Alkaline Peroxide and 10% Castor Oil for 8 Days and 12 Days

The color stability values of groups A1, B1, and C1 were obtained by calculating the values of L, a, and b using a colorimeter after soaking with alkaline peroxide, 10% castor oil, and distilled water for 8 and 12 days. At 8 days of soaking (table 6) shows varying average values where in group A1 the largest color stability value is 41.35, the smallest value is 38.59, and the average value and standard deviation is 39.62 ± 1.05, in group B1 the largest color stability value is 40.47, the smallest value is 38.41, and the average value and standard deviation is 39.44 ± 0.94, and in group C1 the largest color stability value is 39.76, the smallest value is 37.27, with the average value and standard deviation is 38.81 ± 0.95.

The color stability value of the thermoplastic nylon denture base after soaking in alkaline peroxide and 10% castor oil for 12 days was obtained in group A1, the largest color stability value was 39.83, the smallest value was 38.99, and the mean and standard deviation values were 39.40 ± 0.37, in group B1 the largest color stability value is 41.39, the smallest value is 38.50, and the average value and standard deviation is 39.36 ± 1.15, and in group C1 the largest color stability value is 40.90, the smallest value is 39.16, and the average value and standard deviation is 39.83 ± 0.66.

The varying color stability values between each sample in one group may be due to differences in surface roughness between each sample due to manual polishing, the rougher the surface of the sample, the easier it is for color stains to accumulate on the surface of the sample. Another possible influencing factor is the diffusion process of alkaline peroxide, castor oil and distilled water, which is different and affects the color stability of the base less. Another possible influencing factor is the microporosity present in each sample, this microporosity is formed due to unnoticed air entering during the heating process of the nylon granules while going through the injection moldingprocess (Wibawaningtyas et al., 2017); (Sari et al., 2017).

Flexural Strength Value of Thermoplastic Nylon Denture Base After Immersion in Alkaline Peroxide and 10% Castor Oil for 8 Days and 12 Days

The flexural strength value was obtained by applying a compressive force to the sample until the maximum deformation until the p value came out using a universal testing machine in MPa. Measurements were taken after immersion of the thermoplastic nylon denture base in alkaline peroxide, 10% castor oil, and distilled water after 8 and 12 days. Immersion for 8 days showed varying average values where in group A2 the largest flexural strength value was 29.34

MPa, the smallest value was 27.96 MPa, and the mean value and standard deviation were 28.93 ± 0.57 MPa, in group B2 the largest flexural strength value was 31,78 MPa, the smallest value was 28.62 MPa, and the mean and standard deviation were 30.91 ± 1.31 MPa, and in group C2 the flexural strength value with the largest value was 33.27 MPa, the smallest value was 27.45 MPa, and the mean and standard deviation were 30.21 ± 2.37 MPa.

The flexural strength value of the thermoplastic nylon denture base after 12 days immersion with group A2 the largest value was 29.86 MPa, the smallest value was 28.18 MPa, and the mean and standard deviation values were 29.32 ± 0.71 MPa, in group B2 the largest value was 30,50 MPa, the smallest value is 25.57 MPa, and the mean and standard deviation is 29.18 ± 2.04 MPa, and in group C2 the flexural strength value with the largest value is 34.95 MPa, the smallest value is 28.26 MPa, and the mean and standard deviation is 30.46 ± 2.67 MPa.

Based on these results, the flexural strength values varied for each sample in one group. The varying flexural strength values may be due to different microporosity in each sample so that there may be different densities, these microporosity are formed due to unnoticed air entering during the heating process of the nylon granules when going through the injection molding process. Another possible influencing factor is the diffusion process of alkaline peroxide, castor oil and distilled water, which is different and has less influence on the flexural strength structure. Another factor is the difference in base density due to the degree of crystallinity formed due to non-simultaneous cooling and the thickness of the base in each sample which may not be similar due to the manual polishing process (Dewi, 2015).

Effect of Immersion of Thermoplastic Nylon Denture Base in Alkaline Peroxide and 10% Castor Oil (*Ricinus Communis Oil*) on Color Stability for 8 Days and 12 Days

The effect of immersion of thermoplastic nylon denture base on immersion for 8 days based on the normality test showed that the data was normally distributed, then continued with the Anova test. Based on statistical results there is no effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil on color stability for 8 days as seen from the p value = 0.412 (p> 0.05).

In immersion for 12 days, the normality test showed that the data was not normally distributed, then continued with the Kruskal-wallis test. Based on statistical results, there is no effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on color stability for 12 days as seen from the p value = 0.179 (p> 0.05).

Group A1 showed no effect of immersion of thermoplastic nylon denture base in alkaline peroxide on color stability. This is because alkaline peroxide when in contact with water will release hydrogen peroxide (whitening agent) through the ionization process of H2O2 into water and oxygen which can cause bleaching, but this ionization process will work very slowly at room temperature, so that in this study there was no change in color stability after immersion in alkaline peroxide for 8 days or 12 days. The results of this study are in accordance with research (Awing & Koyama, 2013), immersion of thermoplastic nylon in alkaline peroxide for 8 hours with

7 times soaking did not experience color fading. The results of this study are also in accordance with research by (Shah et al., 2015), immersion of thermoplastic nylon in alkaline peroxide using different brands, namely Clinsodent 12 hours, Calclean 5 minutes, and Polident 3 minutes for 1 month, 3 months, and 6 months did not show significant color changes.

In group B1 there was also no effect of immersion of thermoplastic nylon denture base in 10% castor oil on color stability. This is because tannin (a natural coloring agent in plants) which is also included in the phenol group (weak acid) will diffuse longer in penetrating nylon microporosity because thermoplastic nylon polymers are crystalline which have regular, tight, and fairly dense molecular chains. The concentration of castor oil used is also small at 10%, meaning that the color density of the castor oil used is not too large so that it does not greatly affect the diffusion of water and color density (staining) on the thermoplastic nylon denture base for 8 days or 12 days. The results of this study are in line with research by (Wibawaningtyas et al., 2017) immersion in clove extract in concentrations of 0.8%, 1%, 1.2% 1.4%, and 1.6% for 12 days did not occur no color change.

Another possible influencing factor is the hydrophilic nature of the nylon base and soaking time, the absorption of water from this hydrophilic nature will enter the nylon microporosity and slowly dissolve the nylon structure which in a certain period of soaking will fill the nylon microporosity space with dye, the longer the duration of soaking the more dye that enters and the greater the color change that occurs (Dini, 2013). The soaking temperature factor also affects the diffusion and absorption of water, the higher the soaking temperature the easier it is for water to diffuse into the nylon structure (Sari et al., 2017). In this study, soaking time and soaking temperature can be controlled, so in this study there is no effect of soaking thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on color stability for 8 days or 12 days.

Effect of Immersion of Thermoplastic Nylon Denture Base in Alkaline Peroxide and 10% Castor Oil (*Ricinus Communis Oil*) on Flexural Strength for 8 Days and 12 Days

The effect of immersion of thermoplastic nylon denture base on immersion for 8 days was tested for normality. The results obtained showed normality testing of flexural strength data on immersion for 8 days was normally distributed and continued with the Anova test. Based on statistical results, there is no effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil on flexural strength after immersion for 8 days as seen from the p value = 0.183 ($p > 0.05$).

The effect of immersion of thermoplastic nylon denture base on immersion for 12 days was tested for normality. The results obtained showed the results of normality testing of flexural strength data on immersion for 12 days were not normally distributed then continued with the Kruskal-wallis test. Based on the statistical results, there is no effect of immersion of thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on flexural strength after immersion for 12 days as seen from the p value = 0.756 ($p > 0.05$).

Group A2 showed no effect of immersion of thermoplastic nylon denture base in alkaline peroxide on flexural strength. This is due to the content of alkaline peroxide, namely sodium perborate, which in the periodic table is in group IA, has atomic number 11, and only has 3 electron paths, where the fewer electron paths of an element, the closer the atomic nucleus is to the outer electrons, so that the bond strength is high and difficult to escape. Alkaline peroxide which functions to reduce the surface tension of water for the cleaning process to occur will work slower because it is more difficult to release electrons to reduce water tension, so it has less effect on water absorption. This slower water absorption causes no decrease in flexural strength because flexural strength is closely related to water absorption (Sutan, 2016). The results of this study are in line with previous research, immersion of nylon base in alkaline peroxide at a temperature of 370 for 10 minutes did not cause a decrease in the flexural strength of thermoplastic nylon (Ragain et al., 2015).

In group B2, there was no effect of immersion of thermoplastic nylon denture base in alkaline peroxide and 10% castor oil on flexural strength. This is because castor oil 10% is weakly acidic (pH 4.99) because it contains ricinoleic acid.6 The higher the acidity of a material, the easier it is for H+ ions to be released, and vice versa, the lower the acidity of a material, the weaker the H+ ions are released. Flexural strength, which is closely related to water absorption, occurs when H+ ions from acids degrade polymer bonds, so that some polymer bonds will break away and empty spaces are formed between the matrix and cause a decrease in flexural strength. The flexural strength of thermoplastic nylon will decrease as the acidity of the soaking material increases, but in this study castor oil is a weak acid so that the low H+ ion content is not easily released and there is no decrease in flexural strength.45 This is in accordance with research by (Sundari et al., 2016), 15 minutes of coffee soaking for 7 days (equivalent to 22 months) did not cause a significant decrease in flexural strength.

Another factor that may affect flexural strength is immersion time, the longer the duration of immersion, the greater the diffusion of water that occurs, causing a decrease in flexural strength. The immersion temperature factor also affects water absorption, the higher the immersion temperature, the easier it is for water to diffuse into the nylon structure (Sari et al., 2017). In this study, soaking time and soaking temperature can be controlled, so in this study there is no effect of soaking thermoplastic nylon denture bases in alkaline peroxide and 10% castor oil on flexural strength for 8 days or 12 days.

The weakness in this research is that in the process of polishing with sand paper with a micromotor tool, there are difficulties that require a long time to achieve a smooth surface. Another weakness of this research is the use of colorimeter tools where the working principle of colorimeter tools can only measure the color of the surface, can only read primary colors, and cannot measure metamerism and color strength, while compared to spectophotometer tools can analyze certain wavelengths very specifically, can measure the wavelength of white light more

selectively, and can analyze solutions with very small concentrations. These things certainly greatly affect the research results obtained.

CONCLUSION

Based on the results, the color stability of the thermoplastic nylon denture base after immersion in alkaline peroxide, 10% castor oil, and distilled water solutions showed relatively stable values for both 8 and 12 days. The same was found for the flexural strength of the denture base, where immersion in the three solutions did not give any significant difference. Statistical analysis showed that there was no significant effect on color stability or flexural strength after immersion in alkaline peroxide and 10% castor oil, with p values > 0.05 over the 8- and 12-day periods. These results indicate that 10% castor oil can be an equivalent alternative to alkaline peroxide in maintaining color stability and flexural strength, in addition to having other advantages such as lower cost, better biocompatibility, non-toxicity, and ability to stimulate immunity. Therefore, 10% castor oil can be considered as an alternative disinfection agent for thermoplastic nylon denture base treatment. However, further research is needed regarding the effect of soaking on color stability using different measuring instruments, as well as the need for a more optimal polishing process to achieve a smooth surface on the sample.

REFERENCES

Anshary, M. F., Cholil, A. I. W., & Arya, I. W. (2014). Gambaran pola kehilangan gigi sebagian pada masyarakat Desa Guntung Ujung Kabupaten Banjar. *Dentino (Jur. Ked. Gigi)*, *2*(2), 138–143.

Awing, M. M., & Koyama, A. T. (2013). Stabilitas warna basis gigitiruan resin termoplastik nilon yang direndam dalam larutan pembersih gigitiruan peroksida alkalin Color stability of thermoplastic nylon denture base material immerse in alkaline peroxide denture cleanser. *Journal of Dentomaxillofacial Science*, *12*(2), 98–103.

Dewi, D. C. (2015). Produksi Biodiesel dari Minyak Jarak (Ricinus communis) dengan Microwave. *Tugas Akhir*.

Dini, M. M. (2013). *Pengaruh Perendaman Resin Poliamida Dalam 25% Ekstrakdaun Jambu Mete (Anacardium occidentale L) Dan Larutan 4% Sodium Perborat Terhadap Perubahan Warna*.

Durkan, R., Ayaz, E. A., Bagis, B., Gurbuz, A., Ozturk, N., & Korkmaz, F. M. (2013). Comparative effects of denture cleansers on physical properties of polyamide and polymethyl methacrylate base polymers. *Dental Materials Journal*, *32*(3), 367–375.

Hamanaka, I., Shimizu, H., & Takahashi, Y. (2017). Bond strength of a chairside autopolymerizing reline resin to injection-molded thermoplastic denture base resins. *Journal of Prosthodontic Research*, *61*(1), 67–72. https://doi.org/https://doi.org/10.1016/j.jpor.2016.04.006

Kim, J. J. (2019). Revisiting the Removable Partial Denture. *Dental Clinics of North America*, *63*(2), 263–278. https://doi.org/https://doi.org/10.1016/j.cden.2018.11.007

M, R. (2018). *Pengaruh Perendaman Minuman Teh Hijau Terhadap Kekuatan Fleksural Thermoplastic Nylon*. Universitas Gadjah Mada.

Mayasari. (2015). *Perbedaan Perubahan Warna Nilon Termoplastik (Valplast) Direndam Dalam Ekstrak Daun Salam (Eugenia Polyantha Wight) 25% dan Sodium Hipoklorit 0,5%*. Universitas Jember.

Ragain, J. J., Umsted, D., Morrow, B., Powell, C., Legrand, L., & Chavis, D. (2015). Effects of aging and denture cleansers on the flexural strength and surface microhardness of two flexible denture materials. *Int J Dent Oral Health*, *1*(6), 476–481.

Rossy A. (2018). *Pengaruh Kandungan Fenol Dalam Tannin Pada Minuman Teh Hitam Terhadap Kekuatan Fleksural Plat Thermoplastic Nylon*. Universitas Gadjah Mada.

Salles, M. M., Badaro, M. M., Arruda, C. N. F. de, Leite, V. M. F., Silva, C. H. L. da, Watanabe, E., Oliveira, V. de C., & Paranhos, H. de F. O. (2015). Antimicrobial activity of complete denture cleanser solutions based on sodium hypochlorite and Ricinus communis–a randomized clinical study. *Journal of Applied Oral Science*, *23*(6), 637–642.

Sari, N., Fardaniah, S., & Masulili, C. (2017). Color changing in denture base polyamide 12 and polyamide microcrystalline after polishing in laboratory and dental clinic. *Journal of Physics: Conference Series*, *884*(1), 12100.

Shah, V. R., Shah, D. N., Chauhan, C. J., Doshi, P. J., & Kumar, A. (2015). Evaluation of flexural strength and color stability of different denture base materials including flexible material after using different denture cleansers. *The Journal of Indian Prosthodontic Society*, *15*(4), 367–373.

Sundari, I., Sofya, P. A., & Hanifa, M. (2016). Studi kekuatan fleksural antara resin akrilik heat cured Dantermoplastik nilon setelah direndam dalam minuman kopi Uleekareng (Coffea robusta). *Journal of Syiah Kuala Dentistry Society*, *1*(1), 51–58.

Sutan, C. (2016). *Pengaruh Lama Perendaman Basis Gigi Tiruan Nilon Termoplastik dalam Alkalin Peroksida Terhadap Kekasaran Permukaan dan Penyerapan Air*. Universitas Sumatera Utara.

Wibawaningtyas, N., Kristiana, D., & Probosari, N. (2017). The effect of the thermoplastic nilon enterprises (valplast) on clove extract (syzygium aromaticum) in various concentrations on the color change. *Journal of Dentomaxillofacial Science*, *2*(3), 180–182.

Zarb, G. A., Hobkirk, J., Eckert, S., & Jacob, R. (2012). *Prosthodontic treatment for edentulous patients: complete dentures and implant-supported prostheses*. Elsevier Health Sciences.