International Journal of Medical Science and Clinical Invention 5(10): 4092-4100, 2018
DOI:10.18535/ijmsci/v5i10.04 **ICV 2016: 77.2**
e-ISSN:2348-991X, p-ISSN: 2454-9576

Research Article

The Effect of Coffee And Tea On Immersion of Thermoplastic Acetal Resin and Polyamide 12

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Abstract:

Tooth loss causes unstable occlusion which affects person's mastication, phonetic and esthetic. Removable partial denture is a suitable treatment to overcome these conditions. However, patients sometimes refuse to receive the treatment due to several problems such as economic problem, anxious with poor prosthetic's retention and aesthetic dissatisfaction resulting from the use of metal claps. There are two types of thermoplastic resin material which used as aesthetic crystal material alternative, namely polyoxymethylene (acetal resin) and polyamide 12 (thermosens).

This study aimed to determine the highest colour change between acetal resins and thermosens, knowing the type of solution that causes the highest colour change in acetal resin and thermosens and to ascertain time required for the colour change of acetal resins and thermosens.

A laboratory experimental study was performed by using 48 samples consist of 24 acetal resin plates and 24 thermosens plates, which each divided into four groups soaked in coffee and tea for 7 days and 14 days. The result of statistical test of Mann Whitney in the study group obtained information of p value on variable National Bureau of Standards smaller than 0.05 (p value <0.05) which considered as significant or statistically significant. The conclusion of this study showed acetal resin experienced a higher color changes. Tea solution is the highest solution causing discoloration. Acetal resins and thermosens change colour after use for 2.7 years.

The conclusion of this study showed that acetal resin undergoes a higher color change compared with thermosens. Tea solution is the highest solution causing discoloration. Acetal resins and thermosens change color after immersion for 7 days.

Keywords: Immersion, tea, coffee, thermoplastic acetal resin, polyamide 12.

Introduction

Tooth loss is a problem that must be handled carefully by a dentist. Incomplete teeth causes unbalance occlusion which disrupted mastication process and food is not processed properly in the oral cavity.[1-3] Removable Partial denture is a solution to overcome these conditions.[4,5] There are two types of materials used in the manufacture of partially removable denture prostheses, ie, acrylic resin or Polymethyl Methacrylate (PMMA) and metal framework.[4.5] Some patients often reject this treatment for various reasons, such as economic problems, anxious with poor retention of the prosthesis and aesthetic dissatisfaction resulting from the use of metal clasps.[5-7]

Flexible resin is an innovation which first introduced in 1950.[5] This material is expected to be an alternative material that provides better quality results than PMMA and metal framework denture.[5] Polyamide is a flexible thermoplastic resin material which first introduced in Valplast and Flexiplast products in 1950. Other materials that are also a flexible thermoplastic resin group are Acetal resin or Polyoxymethylene (POM). This material has been used since 1986 and considered to provide excellent aesthetic results.[4,7]

Acetal resins in addition to having excellent aesthetics, these materials are also very flexible materials and have good biocompatibility.[4-9] Acetal resin also has a variety of colours which suitable with gums and teeth.[4] Therefore, Acetal resin can be used as denture and clasp materials .[10-13] Low acetal resin modulus of elasticity allows this material to be used as a suitable clasp material in a deep undercut area.[4-6,8,9] This material may also be an option for patients who are allergic to Co-Cr alloys and PMMA.[4-6,8-11] Acetal resin has excellent biocompatibility and also has a very small porosity causing the accumulation of plaque decreases and low water absorption so it will be difficult to discolour.[5.12,14-16]

Thermosens is a new product of Vertex-Dental BV generation Polyamide 12 with improved quality, making it almost unbreakable, rigid, free monomer, has good strength and available in 12 colors.[17.18] The thermosens contraction rate has been reduced by 1% and has been added to the crystal filler, so thermosens become more polished, more shiny and not absorb water and other stains.[19] Polyamides and Acetal resins are type of materials that can be used as an alternative in the manufacture of esthetic clasps.[20]

Materials and Research Methods

The samples of this study were 24 Acetal resin plates and 24 Polyamide 12 plates 10x20x2 mm which soaked in coffee solution and tea solution for 7 days and 12 days.

Preparation of 48 sample plates.

The injection cavity for the manufacture of Acetal resin and Polyamide 12 plates is made of a layer of Easy Vac Gasket 3A meds with measurement of 12.7x12.7 cm and thickness of 2 mm and wax for sprue. Easy Vac Gasket Sheets 3A medes and waxes are buried in flask that was filled with mixtures of gypsum type IV and water in accordance with the manufacturer's provisions. Acetal resin and polyamide 12 grain were taken into cylindrical cartridge, then both cartridge and flask are inserted into the injector machine. The engine is heated at a temperature according to the factory rules of Acetal resin and polyamide 12 products. Materials are then injected into the model cavity in the flask.These plates with measurement of 12,7x12,7 cm were cut into plates with measurement of 10x20 mm and thickness of 2 mm. Acetal resin and polyamide 12 plates were being smoothed by using coarse and fine abrasives, then polished using a polishing machine with a black and white brush each with 9 times at 2800 rpm.

Preparation of immersion solution.

The coffee solution is a solution made from 32.5 grams of coffee dissolved in 1000 ml of hot water and allowed its temperature to drop until at room temperature. Tea solution is a solution made by brewing 9.25 grams of tea into 1000 ml of hot water for 10 minutes. The coffee and tea solution were then filtered by filter paper and pump rocker. The immersion solution will be divided into 4 groups, ie the coffee solution to saturate in one week and two weeks, as well as the tea solution to saturate in one week and two weeks. The solutions are poured into each storage container until the plate is submerged. Then the sample will be stored in the incubator with temperature 37^{o}C. The immersion solution should be stirred once a day to avoid precipitation of the solution particles. The solution should also be changed every once in two days to maintain its concentration.

Colour change test with spectrophotometer.

Before being immersed in the immersion solution, Acetal resin and Polyamide 12 plates first were being measured the value of the initial colour spectrum by spectrophotometer (T0). Measurements will be made after 7 days of immersion (T1) and 14 days of immersion (T2). The plate is rinsed with water and dried with tissue paper before it is placed on the spectrophotometer mechine. The plate colour change will be measured with the Comission Internal d'Eclairage L * a * b * colour space. Total colour change will be measured by the following formula:

$\Delta E^* = [(\Delta L^*) 2 + (\Delta a^*) 2 + (\Delta b^*) 2] ½$

L *: The value of whiteness measurement or object brightness.
a *: The value of redness measurement (positive) and greenish (negative).
b *: The value of yellow (positive) and bluish (negative).
The value of ΔE * will be calibrated with National Bureau of Standards Units (NBS Unit). The NBS Unit is ΔE x 0.92. This is done to get the conclusion of colour change expression.

Statistical data analysis

Numerical data were assessed by normality tests using the Shapiro-Wilk test because the amount of data was less than 50, where the test was used to test whether the data was normally distributed or not normally distributed. The significance test for comparing the characteristics of the two study groups used unpaired t-test if the data were normally distributed. If the results of the analysis show that the data is not normally distributed then the data is transformed by a logarithmic transformation. If after transformation there is no change of distribution then further analysis with non parametric statistical analysis. And Mann Whitney test as an alternative if the data is not normally distributed.

Result

The results of this study showed that the group of Asetal resin immersion in coffee 7 days with the average of NBS 3.45 included in the Appreciable: Marked change category, the changes are wide enough, the group of Asetal resin immersion in coffee 14 days with the average of NBS 5.48 included in the category is Appreciable: Marked change, considerable change, acetal resin group in tea 7 days with average NBS 3.62 included in the Appreciable: Marked change category, Asetal tea immersion resin group 14 days with mean NBS 5.92 included in the category of Appreciable: Marked change, the Polyamide group 12 immersion in a 7-day coffee with an average of NBS 1.35 include in slightly changed category, the Polyamide group of 12 immersed in coffee 14 days with the average NBS 3.86 include in the Appreciable: Marked change, group of Polyamide 12 immersion in tea 7 days with mean of NBS 2.58 included in category of Noticeable: Perceivable change and group of Polyamide 12 immersion in tea 14 days with average NBS 4.68 included in category the Appreciable: Marked change.

From the above description of the highest colour change materials between Asetal and Polyamide 12 resins are Acetal resin in 14-day Asetal resin group of tea in a day with mean of NBS 5,92 included in the Appreciable: Marked change. The results can be seen from the table and graph 4.1. describes the average NBS.

Table 4. 1. Table of descriptive analysis results of colour change of Acetal resin and Polyamide 12

Group	Mean ΔE	Mean NBS (ΔE x 0,92)	Category
ACT.K.I	3,74	3.45	Appreciable: Marked change
ACT.K.II	5,96	5.48	Appreciable: Marked change

ACT.T.I	3,93	3.62	Appreciable: Marked change
ACT.T.II	6,43	5.92	Appreciable: Marked change
THR.K.I	1,46	1.35	Slight: Slight change
THR.K.II	4,19	3.86	Appreciable: Marked change
THR.T.I	2,80	2.58	Noticeable: Perceivable change
THR.T.II	5,09	4.68	Appreciable: Marked change

Tabel description :

ACT : Acetal resin.
THR : *Thermosens.*
THR.K.I.1 : *Thermosens are soaked in coffee for 7 days.*
THR.T.I.1 : *Thermosens are soaked in tea for 7 days.*
THR.K.II.1 : *Thermosens are soaked in coffee for 14 days.*
THR.T.II.1 : *Thermosens are soaked in tea for 14 days.*
ACT.K.I.1 : Acetal soaked in coffee for 7 days.
ACT.T.I.1 : Acetal soaked in tea for 7 days.
ACT.K.II.1 : Acetal soaked in coffee for 14 days.
ACT.T.II.1 : Acetal soaked in tea for 14 days

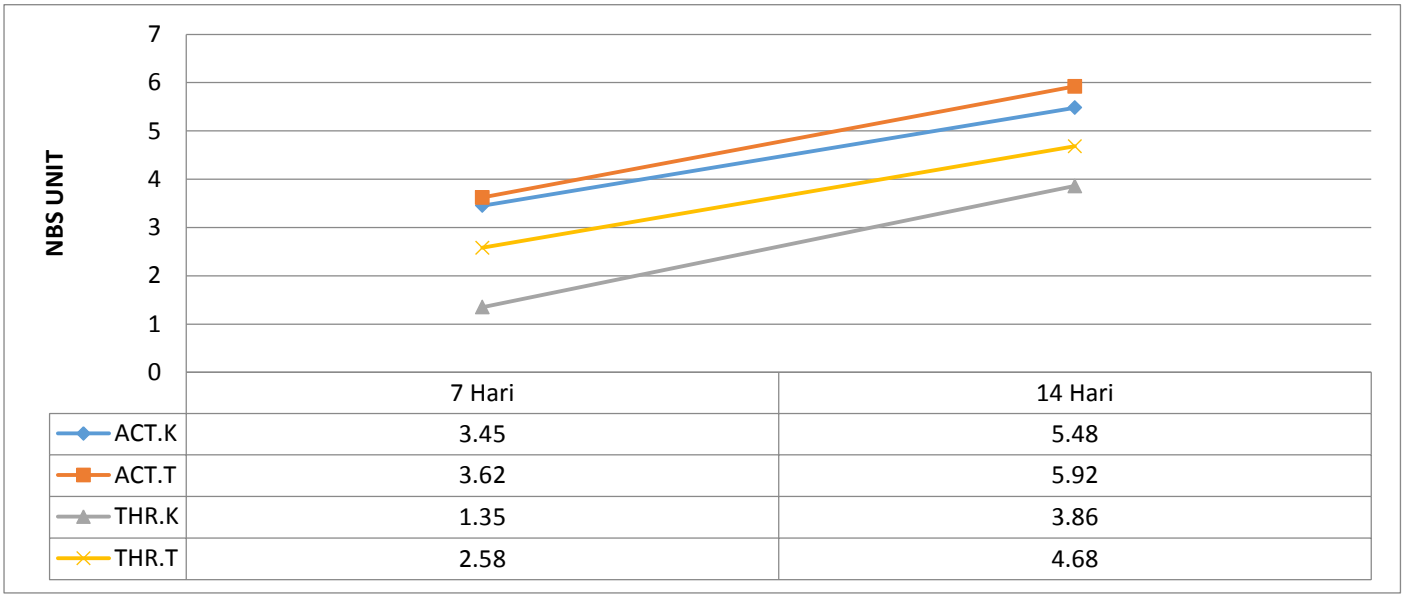


Figure 4. 1. Graph of result of descriptive analysis of colour change of acetal and Polyamide 12.

Table 4.2 Test Normality of Numerical Data

Variable	Group	Data Distribution	Value P
NBS Acetal Resin	Coffee 7 days	Normal	0.794
	Coffee 14 days	Abormal	0.000
	Tea 7 days	Abormal	0.000
	Tea 14 days	Abormal	0.000
NBS Polyamide 12	Coffee 7 days	Abormal	0.000
	Coffee 14 days	Abormal	0.000
	Tea 7 days	Abormal	0.000
	Tea 14 days	Normal	0.794

Description: The p value is calculated based on the Shapiro Wilks test, the p value greater than 0.05 (p> 0.05) indicates normal distributed data, and the p value is less than 0.05 (p <0.05) then shows the data is not normally distributed

Table 4.2 describes the numerical data normality test on the NBS variable of Acetal resin and NBS Polyamide 12. For the normality test this numerical data was tested by using Shapiro Wilks test due to the amount of NBS resin data of Acetal and NBS Polyamide 12 <50.

Table 4.3 Comparison between NBS Acetal resin and Polyamide 12 with coffee for 1 week.

Variable	Group	P value

	Acetal resin N=6	Polyamide 12 N=6	
NBS			**0.055**
Mean±Std	3.44±0.515	11.56±24.207	
Median	3.34	1.63	
Range (min-max)	2.86-4.27	1.31-60.97	

Description: For numerical data p value is tested by unpaired T test if data is normalized, while Mann Whitney test alternative if data is not normally distributed. Mean value based on p value <0,05. The * indicates a p value <0.05 meaning statistically significant or significant.

Table 4.3 shows that there was no statistically significant difference between the NBS variables in the Acetal resin group immersed in coffee for 1 week and Polyamide 12 immersed in coffee for 1 week.

Table 4.4 Comparison between NBS Acetal resin and Polyamide 12 with coffee for 2 weeks.

Variable	Group		P value
	Acetal resin N=6	Polyamide 12 N=6	
NBS			**0.055**
Mean±Std	14.26±21.560	13.00±22.378	
Median	5.57	3.87	
Range (min-max)	4.98-58.27	3.42-58.67	

Description: For numerical data p value is tested by unpaired T test if data is normalized, while Mann Whitney test alternative if data is not normally distributed. Mean value based on p value <0,05. The * indicates a p value <0.05 meaning statistically significant or significant.

Table 4.4 shows that there was no statistically significant difference between the NBS variables in the Acetal resin group immersed in coffee for 2 weeks and Polyamide 12 immersed in coffee for 2 weeks.

Table 4.5 shows that there was no statistically significant difference between the NBS variables in the Acetal resin group immersed in tea for 1 week and polyamide 12 immersed in tea for 1 week.

Table 4.5 Comparison between NBS Acetal resin and Polyamide 12 with Tea for 1 week.

Variable	Group		P value
	Acetal resin N=6	*Polyamide 12* N=6	
NBS			**0.055**
Mean±Std	13.27±23.191	11.50±22.96	
Median	3.87	2.09	
Range (min-max)	2.91-60.59	1.43-58.37	

Description: For numerical data p value is tested by unpaired T test if data is normalized, while Mann Whitney test alternative if data is not normally distributed. Mean value based on p value <0,05. The * indicates a p value <0.05 meaning statistically significant or significant.

Table 4.6 Comparison between NBS Acetal resin and Polyamide 12 with Tea for 2 weeks.

Variable	Group		P value
	Acetal resin N=6	*Polyamide 12* N=6	
NBS			**0.016***
Mean±Std	14.26±20.882	5.26±0.404	
Median	5.81	5.26	

Range (min-max)	5.34-56.89	4.67-5.75

Description: For numerical data p value is tested by unpaired T test if data is normalized, while Mann Whitney test alternative if data is not normally distributed. Mean value based on p value <0,05. The * indicates a p value <0.05 meaning statistically significant or significant.

Table 4.6 shows that there was a statistically significant difference between the NBS variables in the Acetal resin group immersed in tea for 2 weeks and Polyamide 12 immersed in tea for 2 weeks.

The colour changes that occurred on the ACT.K.I, THR.K.I, ACT.T.I and THR.T.I plates visually compared to Acetal and Polyamide 12 resin plates before submersion did not have any different in Figure 4.2. Meanwhile, there was a difference in colour changes in ACT.K.II, THR.K.II, ACT.T.II and THR.T.II plates which visually compared with the Acetal and Polyamide 12 resin plates prior to submersion in Figure 4.3.

The surface morphology condition of Acetal and Polyamide 12 resin plate is also checked using Scanning Electron Microscope (SEM). This is done to ensure the changes that occur on the surface morphology of both plates. The results of an examination of Acetal and Polyamide 12 resin plate using SEM with magnification 10,000 times show the presence of layers formed on the plate surface after immersion in tea and coffee. The layer looks thicker as the immersion time increases. The surface plate plate morphology on SEM examination can be seen in Figure 4.4- 4.7.

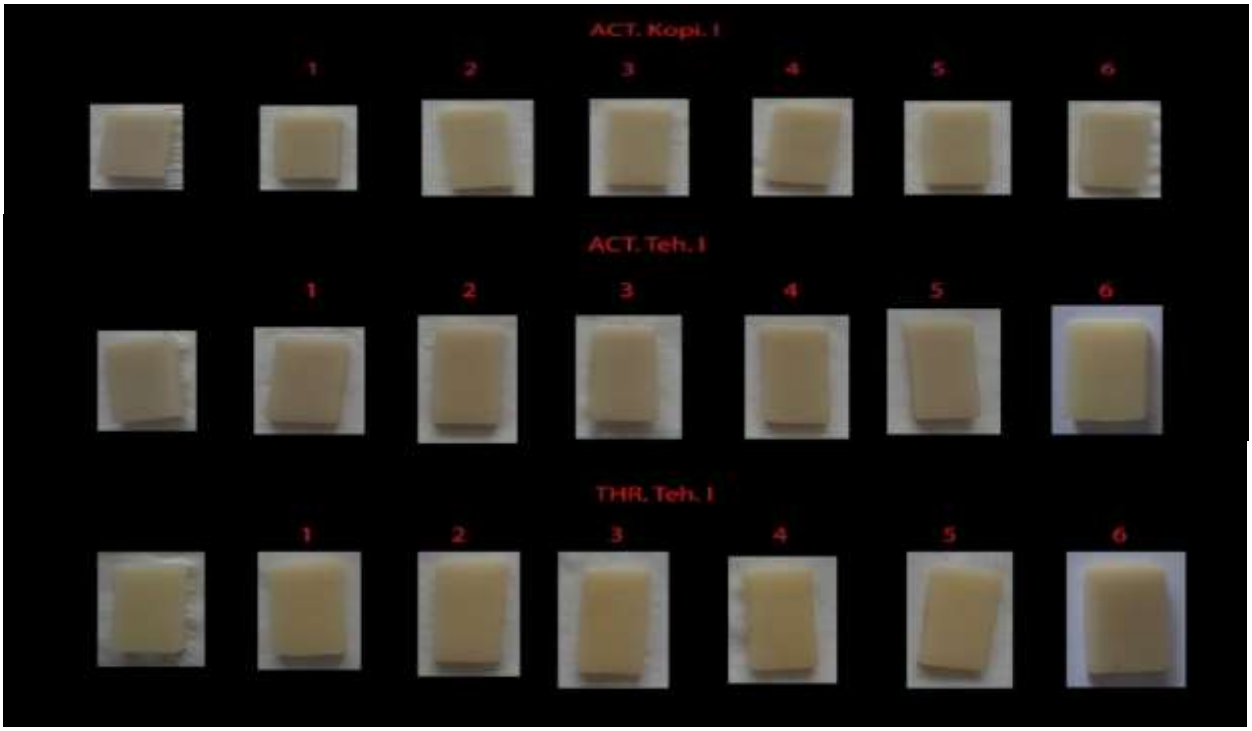
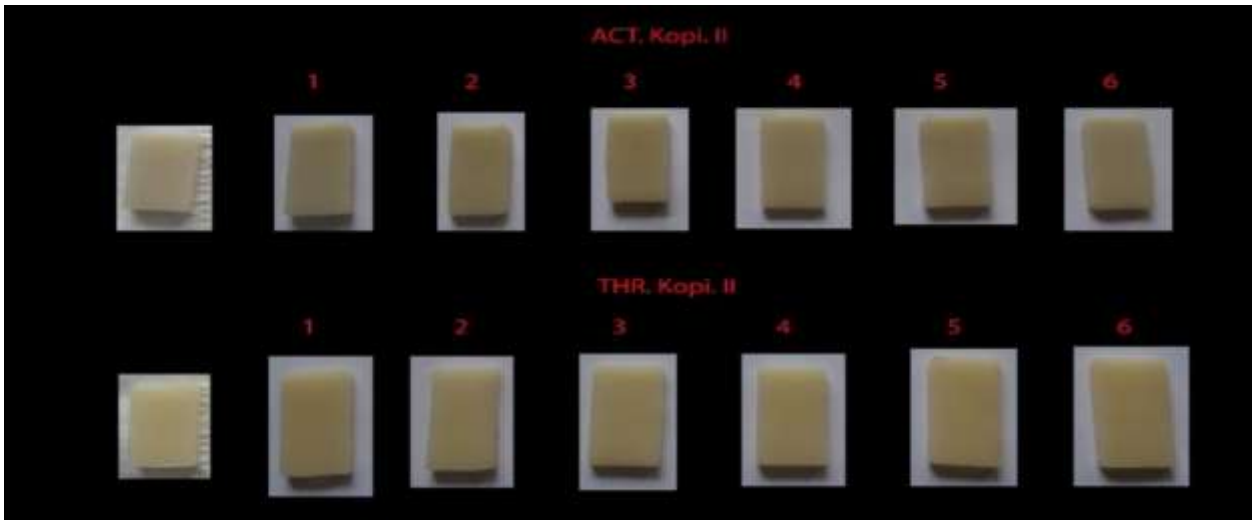


Figure 4. 1. Colour change of Acetal resin plate (ACT) and Polyamide 12 (THR) after immersion in coffee and tea for 7 days



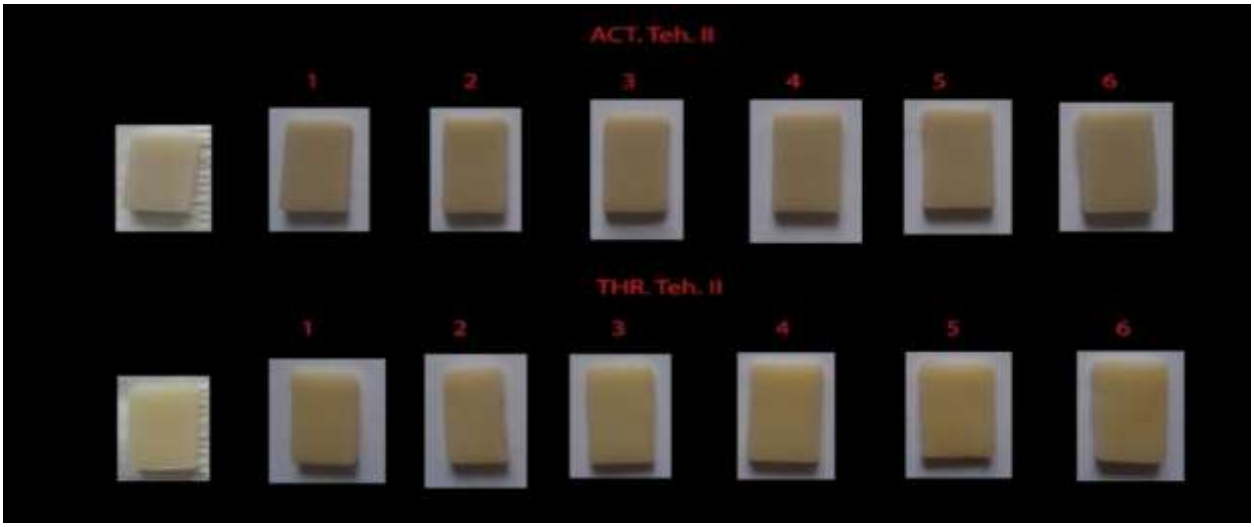


Figure 4. 2. Colour change of Acetal resin plate (ACT) and Polyamide 12 (THR) after immersion in coffee and tea for 14 days

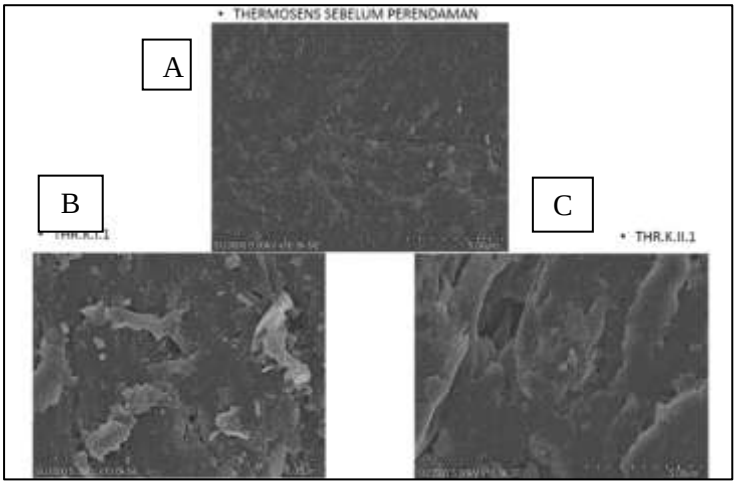


Figure 4. 3. The surface morphology of Polyamide plate 12 before immersion (A), after immersion of 7 days in coffee solution (B) and after immersion of 14 days in coffee solution (C) on SEM examination

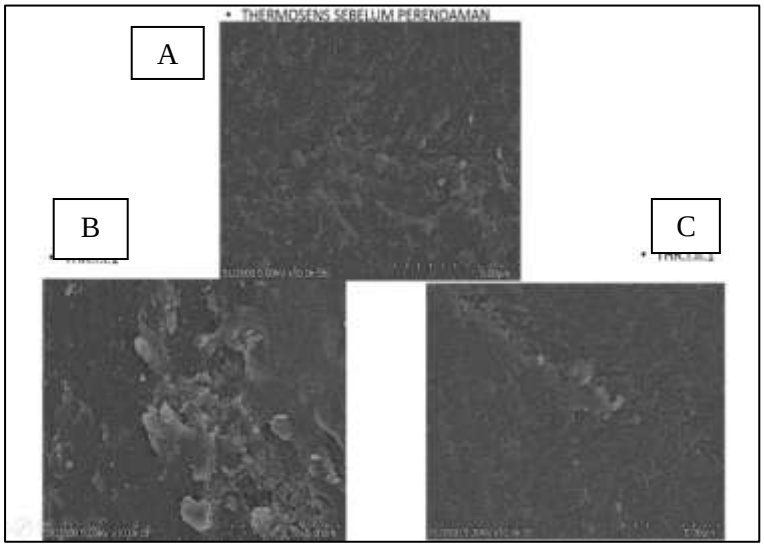


Figure 4. 4. The surface morphology of Polyamide plate 12 before immersion (A), after immersion of 7 days in tea solution (B) and after immersion of 14 days in tea solution (C) on SEM examination

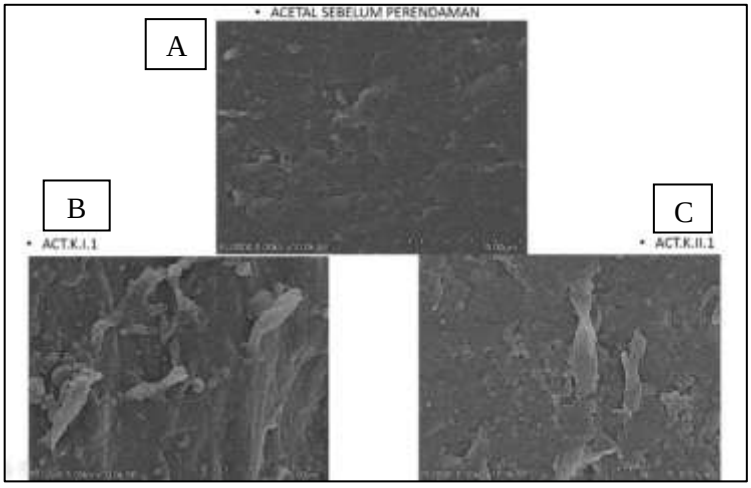


Figure 4. 5. Acetal resin plate surface morphology before immersion (A), after immersion of 7 days in coffee solution (B) and after immersion of 14 days in coffee solution (C) on SEM examination

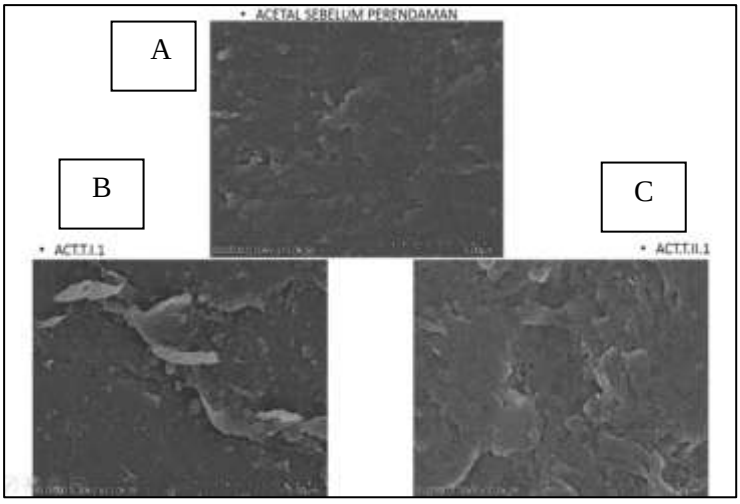


Figure 4. 6. Acetal resin plate surface morphology before immersion (A), after immersion of 7 days in tea solution (B) and after immersion of 14 days in tea solution (C) on SEM examination

Discussion

The colour changes of an object can be seen in several ways either by visual evaluation or by using tools. Some ways you can measure colour change include visual ratings, digital image processing, slide projection, colour visualization and colour comparison. Measurement of colour changes through the digital image processing system can be gained by using a spectrophotometer.[21] The spectrophotometer which used in this study is the MINOLTA CM 3600d spectrophotometer. Measurement with this tool will give the result of a complete data value of L * a * b * before and after the automatic immersion will be directly processed so it can give ΔE value easily without needing to calculate the value manually. Everyone has their own different interpretation of colour changes, therefore a certain standard is required to match the interpretation. Abdel and Sharkawy.[12] suggest that the ΔE value of the formula Internal d'Eclairage L * a * b * colour space is interpreted to the National Bureau of Standards Unit (NBS Unit) table to obtain a clear interpretation result.

Research on the immersion of 24 Acetal resin plates and 24 Polyamide 12 plates in tea and coffee solution were performed for 14 days of immersion. Acetal resin and Polyamide 12 plates were divided into 2 immersion groups, tea and coffee immersion for 7 days and tea and coffee immersion for 14 days starting at the same time. Acetal resin and Polyamide 12 plates do not need to be returned to the solution after the colour change check with the spectrophotometer. This is done in order to control the plate properly so as to reduce doubt about the contamination of the plate after the examination with a spectrophotometer.

Some earlier researchers revealed that the ingredients which soaked in a coffee would have a higher colour change than the ingredients which soaked in a tea. Jang et al.[21] conducted a study to measure colour stability, water absorption and cytotoxicity thermoplastic resin by immersing polyamide (biotone) and PMMA in coffee and green tea for 8 weeks. The results showed higher colour changes occurred in materials soaked in coffee than ingredients soaked in green tea. Sagsoz et al.[22] undertook a study of the colour change of the polyamide and PMMA prostheses soaked in coffee, tea, distilled water and cleaning solutions. The results showed the greatest changes occurred in Polyamide materials that soaked in coffee. Polyamide is larger in colour change than PMMA.

Koksal et al.[23] conducted a study of dental discoloration made of several types of acrylic and porcelain on immersion in the coffee, tea, coke and distilled water solutions. The highest colour changes occur in acrylic-based teeth soaked in coffee. Topcu et al.[24] conducted a study of colour changes of 4 different composite resins immersed in artificial saliva, lemon juice, coffee without sugar, coca-cola, cherry juice, carrot juice and red wine for 1 day. The results showed the highest colour changes occur in micro hybrid composite. While the minimum colour changes occur in nanocomposite. The highest solution which causes discoloration is red wine and the lowest is artificial saliva. The coffee solution is the second highest solution that causes discoloration. Mousavi et al.[25] conducted a study in comparing colour changes that occurred in four different brands of acrylic teeth immersed in coffee, cola and tea solution for 1.3 and 6 weeks. The highest colour change occurs in soaking in the coffee solution. While tea and cola have an average value of ΔE is almost the same.

This current study has different results from previous three researchers' study. Immersion of Acetal resin and Polyamide 12 plates in tea for 7 days showed a higher mean value of NBS. Acetal resin plates immersed in coffee for 7 days had a lower mean NBS (ACT.KI = 3.45) value than the average NBS Acetal resin plate immersed in tea for 7 days (ACT.TI = 3.62). This also can be seen in the mean value of the NBS plate Polyamide 12 soaked in coffee for 7 days (THR.KI = 1.35) lower than the average value of NBS polyamide plate 12 immersed in tea for 7 days (THR.TI = 2.58). The mean values of NBS for immersion of Acetal resin and Polyamide 12 after 2 weeks being immersed in coffee also showed lower values than immersion in tea (ACT.K.II = 5.48, THR.K.II = 3.86 , ACT.T.II = 5.92 and THR.T.II = 4.68). The results of this study have in common with research by Abdel and Sharkawy.[12] who conducted the study of the colour stability of Acetal resin as a esthetic clasp. The highest solution to cause discoloration is coca cola and then followed by tea solution as the second highest solution causing discoloration. The coffee solution showed an average lower NBS value than the tea and coca cola solution. Jang et al.[21], Sagsoz et al.[22], Koksal et al.[23], Abdel and Sharkawy.[12], Topcu et al.[24], Mousavi et al.[25] using instant coffee and tea bags in their study, whereas researchers used coffee powder original and original dried tea leaves are brewed with hot water. Instant coffee in its processing has obtained additional preservatives for coffee to last for a long time.[26] Tea Bag products are made from tea leaves that have been cut small to crumble and stored in tea bags. Water circulation to the tea leaves during tea dip brewing is not optimal because it is limited by a narrow tea bag space. Tubruk tea has a larger leaf size and when the tea leaf tea will be exposed to optimal circulation.[27] Research using instant coffee and tea bags does not provide natural tea extract.

Tanin in tea and coffee can cause discolouration from yellow to brown. Tanin is soluble in water. The content of tannins on plant leaves more than the content of tannins in seeds or other parts of the plant. Tea leaves have higher tannin content than coffee beans.[28,29] This statement is supported by Ruyter et al.[30] which states that tea and coffee have yellow tannins of different polarities. Tea has a higher tannin polarity than coffee. This is what causes the colour change of Acetal resin and Polyamide 12 plates is higher on immersion in tea.

Vojdani and Giti.[31] suggested that colour molecules are easier to enter in amorphous polymers than polymers with high crystalline. Acetal resin (POM) is a semi-crystalline polymer.[32] Whereas thermosens are microcrystalline polyamides.[33] Microcrystalline polyamides have higher crystalline content than Acetal resins,[34] so Acetal resins will be more readily discoloured than Polyamide 12. This is consistent with the results of the study, visible acetal resin undergoes a higher colour change. The colour change is also influenced by the adsorption rate of the dye molecule to the adsorbent (the surface of the media). Small pore diameter of the adsorbent will cause a high surface area so that the adsorption increases. While the large pore diameter of the adsorbent will cause the surface area to be low so adsorption decreases.[35] Based on this theoretical relationship and its association with the results of the study, the acetal resin has a smaller pore diameter than Polyamide 12.

This study samples were stored in an incubator at 370 C for 7 days and 14 days. According to Abdel and Sharkawy.[12] immersed for 7 days is considered to be the same as consuming 2 cups of tea or coffee every day with a contact time of 5 minutes per cup. This is considered the same as the consumption of these types of drinks for 2.7 years. Acetal resin and Polyamide 12 plates undergo a visually invisible discolouration at the examination after immersion for 7 days. The colour changes of both types of plate look contrast after immersion for 14 days.

Conclusions

Based on the research that has been done, it can be concluded in several things, including:

1) Acetal resin undergoes a larger colour changes than polyamide 12.

2) Coffee does not cause large colour changes compared to tea with the immersion of Acetal resin and Polyamide 12.

3) Colour changes in Acetal resin and Polyamide12 constantly increased as the immersion time.

Refferences

[1] Sarandha DL. Textbook of complete denture prosthodontic. New Delhi: Jaypee brothers Medical Publishers (P) Ltd; 2007. Hal. 218-28.

[2] Santos DJ. Occlusion principles & treatment. New Zealand: Quintessence pub Co; 2007. Hal. 39-60.

[3] Gunadi H, Burhan L. Buku ajar ilmu geligi tiruan sebagian lepasan. Jakarta: Hipokrates; 1995. Hal.1-40, 134-41, 151-239.

[4] Arda T, Arikan A. An in vitro comparison of retentive force and deformation of acetal resin and cobalt-chromium clasp. J Prosthet Dent 2005;94(3):267-74.

[5] Gomes SG, Cury AA. Flexible resin: an esthetic option for partially edentulous patients. Rev Gauch Odontol 2014;63(1):81-6.

[6] Reddy JC, Chintapatla BS, Srikakula NK, Juturu RKR, Paidi SK, Tedlapu SK, Mannava P, Khatoon R. Comparison of retention of clasps made of different materials using three-dimensional finite element analysis. J Clin and Diagnostic Research 2016;10(5):13-6.

[7] Negrutiu M, Sinescu C, Romanu M, Pop D, Lakatos S. thermoplastic resins for flexible framework removable partial dentures. TMJ 2005;55(3):295-99.

[8] Tannous F, Steiner M, Shahin R, Kern M. Retentive forces and fatigue resistance of thermoplastic resin clasps. Germany: Elsevier Ltd; 2012;28:273-8

[9] Alwan S, Ismail I. Retentive force, tensile strength and deflection fatigue of acetal thermoplastic clasp material in comparison with cobalt-chromium alloy. J Bagh College Dent 2014;26(1):59-66

[10] Tannous F. Retentive forces and fatigue resistance of thermoplastic resin clasp. Dissertation. German: University of Kiel. 2013. 1-48.

[11] Kutsch VK, Whitehouse J, Schermerhorn K, Bowers R. The evolution and advancement of dental thermoplastics. 2003. [cited 5 Sep 2017]. Diunduh dari http://www.dentaltown.com/images/dentaltown/magimages/feb03/feb03dtpg52.pdf .

[12] Abdel DM, Sharkawy FE. Color stability of acetal resin tooth-colored clasp materials against various staining. EDJ 2013;59:2429-39.

[13] Abdel-Rahim NY, El-Fattah FE, El-Sheikh MM. Laboratory comparative study of three different types of clasp materials. Tanta Dent J 2016;13:41-9.

[14] Mekkawy MA, Hussein LA, Alsharawy MA. Comparative study of surface roughness between polyamide, thermoplastic polymethyl methacrylate and acetal resin flexible denture base materials before and after polishing. Life Sci J 2015;12(10):90-5.

[15] Ardelean L, Bortun C, Podariu A, Rusu L. Manufacture of different types of thermoplastic, Thermoplastic-composite materials. Romania: Intech; 2012. Hal.25-48.

[16] Thomas AS, Nandini VV. Acetal resin - a quantum leap in aesthetic restorative dentistry. J Clin Dent Sci 2011;2(4):36-9.

[17] Kreijns J. Monomer-free acrylic with extremely low shrinkage, the low-allergen denture. 2012. [cited 5 Sep 2017]. Diunduh dari: https://www.vertex-dental.com/uploads/images/articles/ThermoSens-Monomer-free-acrylic-TP06-2012-Eng.pdf.

[18] Mohsin HA, Abdul-Hadi NF, Jassim MM. Evaluating some mechanical and physical properties of vertex thermosens denture base material in comparison with heat cure acrylic denture base material. IJSR 2015;6(5):394-97.

[19] Tinone B. Thermosens is setting a new benchmark in flexible dentures. [cited 5 Sep 2017]. Diunduh dari: www.vertex-dental.com.

[20] Karbownik AM, Chladek G, Zmudzki J, Kasperski J. Chewing efficiency and occlusal forces in PMMA, acetal and polyamide removable partial denture wearers. Acta of Bioengineering and Biomechanics. 2016;18(1):137-44.

[21] Jang DE, Lee JY, Jang HS, Lee JJ, Son MK. Color stability, water sorption and cytotoxicity of thermoplastic acrylic resin for non metal clasp denture. J Adv Prosthodont 2015;7:278-87

[22] Sagsoz NP, Yanikoglu N, Ulu H, Bayindir F. Color changes of polyamid and polymethyl methacrylate denture base materials. Sci Research. 2014;4:489-96.

[23] Koksal T, Dikbas I. Color stability of different denture teeth materials against various staining agents. Dent Material J. 2008;27(1):139-44.

[24] Topcu FT, Sahinkesen G, Yamarel K, Erdemir U, Oktay EA, Ersahan S. Influence of different drinks on the color stability of dental resin composites. Eur J Dent 2009;3:50-6.

[25] Mousani S, Narimani S, Jafari K. Colour stability of various of acrylic teeth exposed to coffee, tea and cola. J. Dent Biomater 2016;3(4):335-40.

[26] Yuliandri MT. 5 alasan untuk tidak mengonsumsi kopi instan. 2016. [cited 26 Feb 2018]. Diunduh dari: https://majalah.ottencoffee.co.id/5-alasan-untuk-tidak-mengonsumsi-kopi-instan/.

[27] Yanti D. Teh tubruk vs teh celup, mana lebih baik?. 2013. [cited 26 Feb 2018]. Diunduh dari: https://lifestyle.okezone.com.

[28] Khasnabis J, Rai C, Roy A. Determination of tannin content by titrimetric method from different types of tea. J chem. Pharm. Res 2015;7(6):238-41.

[29] Ashok PK, Upadhyaya K. Tannins are astringent. J Pharmacognosy and phytochemistry 2012;1(3):45-50.

[30] Ruyter EI, Oysaed H, Kleven I. Release of formaldehyde from dental composites. J Dent Res 2014;67(10):1289-94.

[31] Vojdani M, Giti R. Polyamide as a denture base material: a literature review. J Dent Shiraz Univ Med Sci. 2015;16(1):1-9.

[32] Special chem. Polyacetal: detailed information on POM and its features. [cited 1 Des 2017]. Diunduh dari: https://omnexus.specialchem.com/selection-guide/polyacetal-polyoxymethylene-pom-plastic

[33] Hamouda IM, Faramay AMG. Aged flexural properties of vertex thermosens versus conventional denture base materials for one year water storage. Austin J Dent. 2018;5(2):1-4.

[34] Takabayashi Y. Characteristics of denture thermoplastic resin for non metal clasp dentures. Dent Materials J. 2010;29(4):353-61.

[35] Helmenstine AM. Adsorption definition. 2017. [cited 11 Feb 2018]. Diunduh dari: https://www.thoughtco.com/definition -of-adsorption-605820.