

## Effectiveness of Denture Cleanser Tablets on Tea Stain Removal of Polyamide Denture Base

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### Abstract

The polyamide denture base was used in clinic for esthetic and natural appearance despite its sensitivity to discoloration. The objectives of this study were to study the effects of time on tea staining on the polyamide denture base and to study the removal of stain on polyamide by using denture cleanser. The experiment imposed a method of immersion of polyamide denture base in tea solution at different periods of time which was later soaked in denture cleanser tablet solution. The results were then recorded into tabulation and analyzed by SPSS version 20. It was found that tea staining on the polyamide surface increased by increased time period, especially after 1 month and 3 months. Right after 3-month immersion of samples in Polident®, the color value has significantly improved L\* value and b\* value ( $p < 0.05$ ). In conclusion, the staining increased by increased time period when immersed in tea solution. The denture cleansers also demonstrated the obvious incomplete removal of the staining on the denture base. Thus, patients are suggested for daily removal of staining to reduce the long-term accumulation of the stains on the denture base and color changes of the polyamide material.

**Keywords:** denture cleanser, denture base, polyamide, tablet, tea

### บทคัดย่อ

วัสดุฐานฟันปลอมชนิดพอลิเอไมด์มีการใช้คลินิกเพื่อความสวยงามและให้ดูเป็นธรรมชาติ ในขณะที่ง่ายในการดูแล วัสดุประเภทนี้ งานวิจัยนี้เพื่อศึกษาว่าระยะเวลาที่มีผลต่อการติดคราบสีชาบนฐานฟันปลอมชนิดพอลิเอไมด์ และประสิทธิภาพการกำจัดคราบสีชาบนวัสดุพอลิเอไมด์ โดยการใช้สารทำความสะอาดฟันปลอม วิธีดำเนินการวิจัยทดลองด้วยการนำฐานฟันปลอมชนิดพอลิเอไมด์แช่ในสารละลายชาในช่วงเวลาที่แตกต่างกันจากนั้นนำไปแช่ในสารทำความสะอาดฟันปลอมชนิดเม็ดและบันทึกผลการทดลอง ผลการทดลองพบว่าพื้นผิวของวัสดุพอลิเอไมด์มีการติดสีชาที่เพิ่มมากขึ้นเมื่อระยะเวลาเพิ่มมากขึ้น โดยเฉพาะ 1 เดือนและ 3 เดือน และเมื่อนำชิ้นงานที่ผ่านการแช่ในสารละลายชาแล้ว 3 เดือนมาแช่ในสารทำความสะอาดฟันปลอมพอลิเอไมด์ พบว่าค่าสีมีความสว่างและค่าสีเหลืองที่เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ( $p < 0.05$ ) สรุปหากแช่วัสดุลงไปนในสารละลายชาด้วยเวลาที่มากขึ้นจะทำให้ติดคราบสีที่เพิ่มขึ้น และสารทำความสะอาดที่ใช้ในการทดลองนี้แสดงให้เห็นว่าไม่สามารถกำจัดคราบสีชาบนวัสดุพอลิเอไมด์ออกได้ทั้งหมด ดังนั้นผู้ป่วยควรกำจัดคราบสีออกในทุกๆ วันเพื่อลดโอกาสการสะสมคราบสีบนฐานฟันปลอมเป็นเวลานานๆ และทำให้เกิดการเปลี่ยนสีของวัสดุพอลิเอไมด์

**คำสำคัญ:** ฐานฟันปลอม พอลิเอไมด์ เม็ดฟู่ สารทำความสะอาดฟันปลอม

### 1. Introduction

Tooth loss is a problem affecting the style and quality of life. Functions and esthetic are the two major concerns when teeth are missing. There are several choices for the treatment options in replacing missing teeth including removable partial denture. The part that holds each component of denture together as a whole is a denture base.

Polyamide was introduced as a denture base material in 1950s. The advantages of polyamide are abrasion resistance, elasticity and high impact strength which demonstrates a higher resistance to fracture of the material than PMMA (Fueki et al., 2014). This is because polyamide has a lesser cross-linking agent than polymethyl methacrylate. There is less polymerization shrinkage of polyamide when compared with polymethyl methacrylate. However, there are some disadvantages of polyamide such as water absorption, surface roughness, bacterial contamination, distortion, color instability, and polishing difficulty (Vojdani & Giti, 2015). As to water absorption and water solubility, polyamide has more water absorption causing from

greater degree of hydrophilic or higher the amide group concentration. However, stains in solution can infiltrate into polyamide due to water absorption.

Sepulveda-Navarro et al. (2011) observed color stability of two heat-cured denture base acrylic resins (Lucitone 550, VipiCril) with thermoplastic nylon resins (Transflex<sup>®</sup>) in coffee, cola, red wine, and distilled water by using digital analysis, projection of photographic slides, visual group ranking, and shade guide matching as methods to evaluate color changes in the study. The most advanced method is the use of ultraviolet-visible spectrophotometer. Therefore, the significant color changes were found in Transflex<sup>®</sup> after 15 and 30 days with hard staining.

Different beverages such as tea, coffee, red wine, and cola can cause staining on the denture base. Staining can be differentiated into two types: intrinsic staining and extrinsic staining. The extrinsic staining is mostly caused by food or such beverages as tea in which tannin is contained (Walters et al., 2004). Tea is a popular beverage among people living in Thailand. There has also been an increasing number of reports on staining of nylon denture base in different beverages including tea (Sagsoz, 2014; Oguz et al., 2007).

There are different methods and materials for stain removal of denture base including mechanical and chemical procedures. The most common mechanical method is brushing with soap, tooth powder or toothpaste. This method, however, increases the wear of denture base related to the diameter and the length of the brittles (Wictorin, 1972). Chemical denture cleansing mostly uses an immersion technique and is usually classified according to chemical compositions. The most common chemical denture cleanser used is alkaline peroxide, which comes in a form of tablet or powder. The chemical reaction of peroxide cleanser in water results hydrogen peroxide and alkali. Alkalis, chemical reagents resulting from the chemical reaction, decrease the surface tension of the denture base whereas hydrogen peroxide acts as water and nascent oxygen. Alkaline peroxide acts as an effective stain remover. Ultrasonic cleansing is the other method of removing the microorganism and stain on denture surface presently besides brushing or using denture cleansing tablets alone (Chittaranjan et al., 2011). So, it is one of the most useful methods for helping elderly people who cannot brush the denture effectively.

The CIE L\*a\*b\* color system is commonly used due to the high accuracy of the system. The study performed by Rutkunas et al. in 2010 suggested the color measurement using CIE L\*a\*b\* color space. By using three-dimensional representation, the CIE L\*a\*b\* color space represents the measurement of all the colors in the visible light range that can be seen with the naked eye whereas the lightness of an object is indicated by L\*, the position of the color between red and green is represented by a\* value, and by b\* value between yellow and blue. The  $\Delta E$  was calculated by using this equation to evaluate the color changes of the denture base.

$$\Delta E = [(L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2]^{1/2}$$

## 2. Objectives

1. To study the effects of time on tea staining of the polyamide materials.
2. To study the obliteration of stains on polyamide using denture cleanser.

## 3. Materials and methods

### 3.1 Sample preparation

The 120 specimens of clear-colored polyamide denture base (Visiclear<sup>®</sup> Trinidad) were used in this study. Firstly, the specimens were fabricated by using paraffin wax. The paraffin was first cut into the dimensions of 20x20x2 mm<sup>3</sup> and twice to form a hole at the angle of specimens about 1 mm in circle and away from the border of specimens about 3 by 3 mm with the use of the flexpress<sup>®</sup> injection system afterwards. The polyamide specimens were next polished to a flat surface using wet 2,000-grit silicon carbide abrasive paper. The samples were rinsed by distilled water for 5 minutes, ultrasonically cleaned in distilled water for 10 minutes, and then gently air dried. The specimens were randomly divided into 4 groups (n=30) according to immersion time period (1 day, 1 week, 1 month, 3 months) and color measurements were evaluated using a spectrophotometer (UltraScan<sup>®</sup> PRO, Hunterlab) for unstained polyamide (UP).

### 3.2 Solution preparation and staining procedures

One sachet of tea (Lipton tea<sup>®</sup>) was placed in 300 ml of distilled boiling water and left for 2 minutes; then keep the temperature at 37 °C by using an incubator (Heating incubator BPH-9082, Thailand). Each specimen was tied with dental floss of 6 cm in length. The other end of dental floss was fixed to a plastic cup with adhesive tape at the bottom. The distance of dental floss between adhesive tape and specimen was 2 cm. The 120 specimens were divided into 4 groups equally for 1 day, 1 week, 1 month and 3 months, which were renewed daily.

### 3.3 Stained polyamide (SP) color measurement

After staining the specimens with tea following each period, the specimens were rinsed with distilled water for 5 minutes, ultrasonically cleaned in distilled water for 5 minutes, and gently dried with tissue paper to ensure that it could be read by spectrophotometer (UltraScan<sup>®</sup> PRO, Hunterlab) and then be recorded as stained polyamide (SP).

### 3.4 Denture cleanser preparation

The Polident<sup>®</sup> was prepared according to the manufacturers' instructions by using one tablet for 300 ml of warm distilled water at 40 °C up for 5 minutes.

### 3.5 Denture cleanser tablets treating staining polyamide (DP) color measurement

The 10 specimens of 3-month tea soaking group were randomly chosen for this experiment. After the cleaning process, the treated specimens were rinsed with distilled water for 5 minutes, dried with absorbent paper, and measured for final color measurement. The spectrophotometer was used to record the final color measurement.

3.6 Data collection and statistical analysis were analyzed by SPSS version 20. Descriptive analysis and paired T-test were used.

## 4. Results

### Part 1

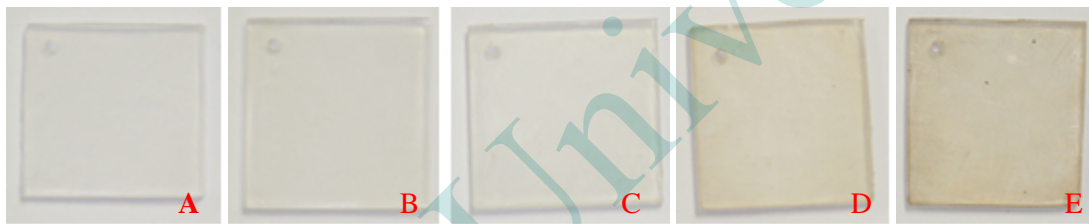
The tea staining on the polyamide surface developed over the increased time period. The color difference value (Table 1) showed the escalation respectively. Thus, the highest value of color difference value ( $\Delta E_1$ ) was found in the group of 3-month tea soaking (Table 1 and Figure 1). The results of spectrophotometric color measurements are shown in Table 1. The  $L^*$  values of all groups decreased after soaking in tea solution, whereas the  $a^*$  values and the  $b^*$  values increased in all groups.

### Part 2

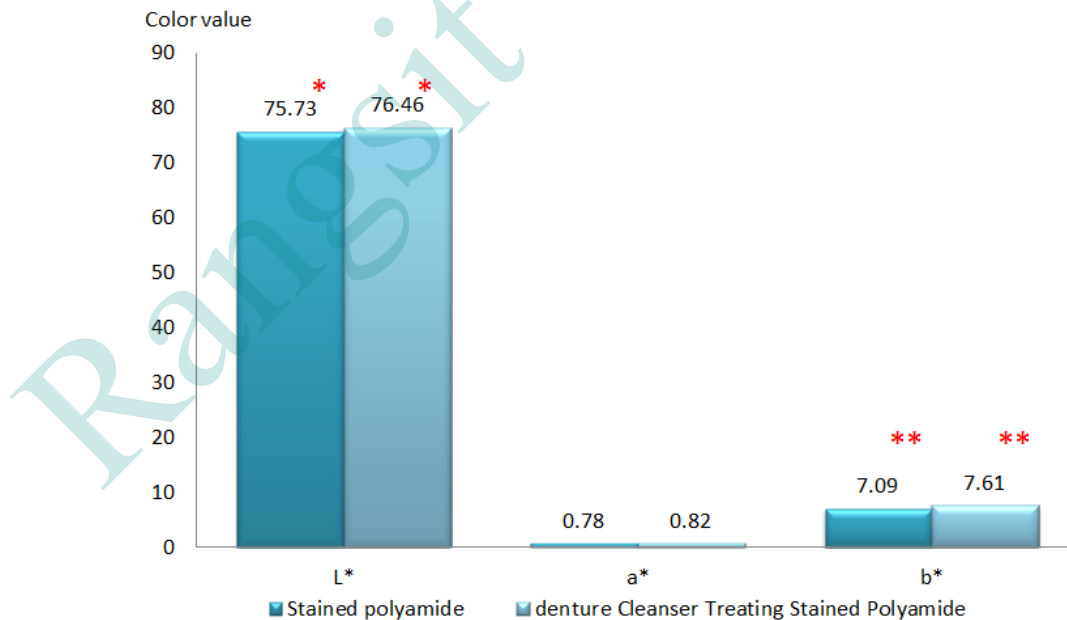
The 3-month tea soaking specimens were used to evaluate the effectiveness of denture cleanser tablets (Polident<sup>®</sup>). The comparison of the color value between stained polyamide (SP) and denture cleanser treating stained polyamide (DP) showed that the  $L^*$  value and  $b^*$  value have significantly increased after soaking specimens in the Polident<sup>®</sup> ( $p < 0.05$ ). (Figure 2)

**Table 1** The CIE L\*a\*b\* values of unstained polyamide (UP) and stained polyamide (SP)

Time		1 day	1 week	1 month	3 months
L*	Unstained polyamide	80.83	80.60	80.91	80.94
	SD	0.66	0.62	1.14	1.38
	Stained polyamide	79.61	78.83	78.35	75.06
	SD	0.64	0.72	1.11	1.68
a*	Unstained polyamide	0.17	0.20	0.25	0.24
	SD	0.08	0.09	0.08	0.10
	Stained polyamide	0.35	0.39	0.45	0.83
	SD	0.07	0.14	0.18	0.49
b*	Unstained polyamide	2.58	2.55	2.82	2.86
	SD	0.14	0.15	0.16	0.13
	Stained polyamide	3.89	4.04	5.29	8.19
	SD	0.23	0.28	0.87	1.35
Color difference value ( $\Delta E_1$ )		1.84	2.41	3.85	8.05



**Figure 1** Unstained polyamide (UP)(A), Stained polyamide (SP); 1 day (B), 1 week (C), 1 month (D) and 3 months (E)



**Figure 2** The Comparison of The Color Value between Stained Polyamide (SP) and Denture Cleanser Treating Stained Polyamide (DP)

Note: \*, \*\* represent significant differences between CIE L\*a\*b\* systems in each group.

## 5. Discussion

In this study, the time periods of 1 day, 1 week, 1 month and 3 months were used for the immersion of polyamide specimens in tea solution. The mean of color difference value ( $\Delta E_1$ ), compared to untreated polyamide group (UP) and stained polyamide (SP), increased. Therefore, the color difference values rose over the increased time period when polyamide was immersed in tea solution.

This experiment takes staining into account. There are two types of staining differentiated into intrinsic staining and extrinsic staining. Extrinsic staining is the staining limited only on the surface of the material and can be cleaned by rubbing or swapping off, whereas intrinsic staining results from the staining of the material itself, revealing the invasion of the color into the body of the material. (Lai et al., 2003)

First of all, time is a factor in this study. The time periods of 1 day, 1 week, 1 month, and 3 months of staining demonstrate the different levels of changes in color. From the observation, the color difference values of 1 month and 3 months were obvious as the color difference value kept rising given the extension of time. Thus, the period of 3 months showed the highest color changes in this study. The longer the time of staining is, the more discolored the material becomes. The study of Sagsöz in 2014 showed a similar result. The longer the time lasts, the more intense the staining becomes. The properties of the polyamide also determine the staining susceptibility. According to Vojdani and Giti (2015), the higher water absorption and hygroscopic properties could be the reasons for the higher color changes in comparison to PMMA.

The properties of the polyamide also determine the staining susceptibility - higher water absorption and hygroscopic properties (Vojdani & Giti, 2015). It was also found that the water absorption and the chemical properties of the polyamide are affected by the frequency of the amide groups in the chain. Jang et al. in 2015 submitted the hydrophilicity of the amide bonds in the chain, resulting in more water absorption rate. This could lead to more discoloration of the material. Similar suggestion made by Sepulveda-Navarro et al. in 2011 stated that polyamide is hygroscopic and that the frequency of the amide group in polyamide has an effect on water absorption and its chemical properties. A study by Kurtulmus et al. in 2010 proposed that the cross-linking agents in the material absorbed fewer solutions than the one without cross-linking agents.

Surface roughness is one of the important factors that causes staining on polyamide. A study by Abuzar et al. in 2010 suggests that polyamide has a rougher surface 3 times than PMMA after the polishing process. A rougher surface of polyamide can cause more discoloration of the material. Vojdani and Giti (2015) also found that high temperature and pressure from the mold injection of polyamide can cause disintegration of the surface as well. Sepulveda-Navarro et al. (2011) also advocated that the process of finishing and surface treatment affect the surface staining of polyamide specimens. However, there were dissimilar points between specimen and actual use of denture base. In this study, the surface of polyamide specimens was polished on both sides. In reality, on the contrary, denture base was polished only on the outer side. Remarkably, it might provide a contrasting result.

Nowadays, tea has become a popular beverage among people living in Thailand, which is the reason for choosing tea solution in this study. The result from the tea staining found the value of the  $\Delta b^*$ , the difference value of yellowish color, has higher value than the other difference colors ( $\Delta L^*$  and  $\Delta a^*$ ). This can be explained by the containment of tannic acid, which triggers the brown pigmentation and results in the yellow staining of tea (Jang et al., 2015).

The temperature in the mouth is about 37 °C. Therefore, the temperature was controlled during the trial at 37 °C in order to simulate the temperature in the oral cavity. Nonetheless, the polyamide denture base experiences various degrees of temperature when it comes in contact with hot or cold tea beverages passing through the cavity.

Most of the stains can be cleaned off during the immersion of the specimens in denture cleanser, showing that extrinsic staining plays an important role in this study. The study performed by Lai et al. in 2003 showed the results of the highest staining in tea and after the materials remained in air and water for 6 months. This study showed that extrinsic staining plays an important role in discoloration of the polyamide.

Denture cleanser is widely used for removing staining and killing microorganisms (De Andrade et al., 2011). In addition, the results reported that there were changes in color value after immersing the base in Polident®. The color values, L\* value and b\* value, have significantly increased after having denture base soaked in the denture cleanser. Those indicated that the Polident® can improve the lightness (L\* value)

so it caused the higher yellowish ( $b^*$  value) of polyamide and there are effectiveness of antimicrobial from ingredient in denture cleanser.

Ultrasonic was used in this experiment for account of cleansing specimens before soaking in denture cleanser solution, serving as a control of the specimens. According to the instructions of the denture cleansers, the manufacturer advises brushing before plunging them into the solution.

This experiment was conducted to investigate the efficiency of Polident<sup>®</sup> in removing tea stains from polyamide specimens. However, there were many limitations in this study. The restrictions of this experiment lie in the differences between the actual uses of polyamide specimens compared to the designs that were practiced in the investigation. Numerous factors might have affected the process resulting in the divergence of the daily use of the polyamide denture base, for instance, the temperature in the oral cavity, the duration of the tea exposure, the ability of the patients to clean, or the surface roughness of each individual denture base after the preparation and the finished process of fabrication.

## 6. Conclusion

The staining developed over the increased time period when the denture base got immersed in tea solution. The denture cleanser in this observation demonstrated the obvious incomplete removal of the staining on the denture base. Thus, patients are suggested for daily removal of staining to reduce the long-term accumulation of the stains on the denture base and color changes of the polyamide material.

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