RESEARCH REPORT

“EFFECTIVENESS OF DENTURE CLEANSER TABLETS ON TEA STAIN REMOVAL OF POLYAMIDE DENTURE BASE”

By

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Title: Effectiveness of Denture Cleanser Tablets on Tea Stain Removal of Polyamide Denture Base

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Abstract

This study aims to demonstrate the effect of time on tea staining on polyamide denture base and effect of different commercial brands of denture cleanser tablets on tea stain removal.

The experiment proceeds by 120 polyamide samples (Valpast®), polished and initial color measurement (CIE L*a*b* system) with spectrophotometer while preparing tea solution using Lipton® in hot water then temperature control at 37 °C. Thereafter, samples were soaked into tea solution for various of time; 1 day, 1 week, 1 month and 3 months while renewing tea solution every day. Samples were divided into 3 groups for three different denture cleanser tablet brand; Bony Plus®, Fitty Dent® and Polident®. When we reached to the immersion time, the samples were done for the second color measurement, then compared to the color value from initial measurement (ΔE_1), afterwards, immersed all samples into denture cleansers and performed the final color measurement, then compared to the color value from the second measurement (ΔE_2) with the clinically perceptible color change value (ΔE 3.3). The data analysis was analyzed by SPSS V 20.

The results show mean of ΔE_1; the group of 1 day and 1 week are less than 3.3, indicate indivisibility to detect clinically. On the other hand, the group of 1 month and 3 months are more than 3.3. The time period of 3 months was used for evaluate the effectiveness of denture cleanser. After soaked into denture cleanser; Bony Plus® shows the highest ΔE_2. There are no

significantly different among ΔE_2 of three commercial brands. The mean of ΔE_2 of all groups are less than 3.3.

In conclusion, there is the highest clinically perceptible color change after immersed denture in tea solution for 3 months. All commercial brand of denture cleanser tablets affect the tea stain removal, but indivisibility to detect clinically.

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List of abbreviations

Symbol	Meaning
ΔE	Color difference value
DP	Denture cleanser tablets treating stained polyamide
PMMA	Polymethyl methacrylate
SP	Stained polyamide
®	Trademark
UP	Unstained polyamide

Chapter 1

Introduction

1.1 Background

Tooth loss has become a problem affecting the style and the quality of life. Functions and esthetic are the two major concerns when the teeth are missing. Having teeth that are able to function properly builds the foundation of a happy and good quality of life. There are several choices for the treatment options in replacing missing teeth including dental implants, fixed partial denture, and/or removable partial denture. Each present with its own advantages and disadvantages. The dentists' ability, the patients' economic status and psychology influence the treatment choices.

Removable partial denture composes of different parts. However, the part that holds each component together as a whole is a denture base. There are several materials used in fabricating denture base such as polymethyl methacrylate, aramid and polyamide. The ideal properties of denture base for removable partial denture are flexural strength and flexibility, color stability etc.

Esthetics has become one of the major concerns in the present days. Just a small discoloration can have a huge effect on esthetic concern. Different beverages such as tea, coffee, red wine, and cola can cause staining on the denture base. One of the world widely drank beverage is tea. There are many studies on the staining caused by tea. The staining on the denture base affects both the function of the denture base and the esthetic aspect as well.

1.2 Objective

1. To study the effect of time on tea staining on the polyamide material.
2. To study and compare the obliteration of stain on polyamide by using denture cleanser.

1.3 Hypothesis

Part 1

1. Null hypothesis (H_0);
    1. Time of immersed polyamide in tea solution has not increased stained.
    2. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 day is not higher than 3.3.
    3. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 week is not higher than 3.3.
    4. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 month is not higher than 3.3.
    5. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 3 months is not higher than 3.3.

2. Alternative hypothesis (H_1);
    1. Time immersion of polyamide in tea solution has increase stained.
    2. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 day is higher than 3.3.
    3. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 week is higher than 3.3.
    4. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 1 month is higher than 3.3.
    5. The color difference value (ΔE_1) between the unstained polyamide group (UP) and the stained polyamide (SP) in 3 months is higher than 3.3.

Part 2

1. Null hypothesis (H_0);
    1. Denture cleanser cannot remove the tea stained on the polyamide denture base.
    2. There is not the difference value between commercial products to remove tea stained.
    3. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Bony Plus® is not higher than 3.3.
    4. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Fitty Dent® is not higher than 3.3.
    5. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Polident® is not higher than 3.3.

2. Alternative hypothesis (H_1);
    1. Denture cleanser can remove the tea stained on the polyamide denture base.
    2. There is the difference value between commercial products to remove tea stained.
    3. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Bony Plus® is higher than 3.3.
    4. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Fitty Dent® is higher than 3.3.
    5. The color difference value between ΔE_2 (the stained polyamide (SP) and the Denture cleanser tablets treating stained polyamide (DP)) in Polident® is higher than 3.3.

1.4 Conceptual framework

1. Relation between time immersion and polyamide

   1.1 Independent variable: Time immersion

   Dependent variable: The color change

   Controlled variable: Temperature, Polyamide, Tea

   1.2 Information during investigation

   Source of information: Literature, Advisor

   1.3 Results of investigation: Measurement the color changes with CIE L*a*b* system

2. Relation between stained polyamide and denture cleanser commercial products

   2.1 Independent variable: Denture cleanser commercial products

   Dependent variable: The color change

   Controlled variable: Stained polyamide, Denture cleanser preparation

   2.2 Information during investigation

   Source of information: Literature, Advisor

   2.3 Results of investigation: Measurement the color changes with CIE L*a*b* system

1.5 Keywords

Denture cleanser

Denture base

Polyamide

Tablet

Tea

Chapter 2
Literature reviews

2.1 Polyamide

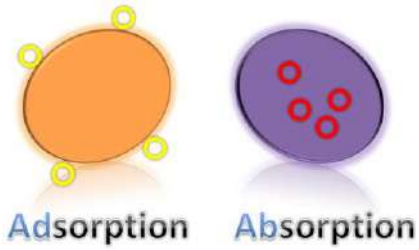
Polyamide was introduced as a denture base material in 1950s to compensate the disadvantages of polymethyl methacrylate denture base (PMMA) (1). The advantages of polyamide are high impact strength, abrasion resistance and elasticity. Polyamide, commonly known as nylon, is a type of thermoplastic polymers occurred from the condensation reaction between a diamine (NH_2-$(CH_2)_6$-NH_2) and a dibasic acid (CO_2H-$(CH_2)_4$-COOH). Whereas PMMA is amorphous, nylon is a crystalline polymer. The crystalline structure of polyamide affects the solubility of the nylon in solvents resulting in the decrease of solubility in solvent, resistance to heat, and high strength to ductility. Polyamide has a lower grade of water absorption and solubility that transform the physical properties of the material. Due to a higher elasticity and the advantage of toxicological safety property, containing no monomer, polyamide is used as denture base material. As mentioned above, nylon denture base has higher impact strength meaning that it has a higher resistance to fracture of the material than PMMA. This is because polyamide has lesser cross-linking agent than PMMA. According to flexural properties, nylon has flexible or deflection for strong resistance to fracture when compared with PMMA but when using in long times (thermocycling), it does not show any difference from PMMA. Last but not least, there is less polymerization shrinkage of polyamide when compared with PMMA. However, there are some disadvantages to polyamide such as water absorption, surface roughness, bacterial contamination, distortion, color instability, and polishing difficulty(2). According to water sorption and water solubility, nylon has more water resorption causing from greater degree of hydrophilic or higher the amide group concentration. Due to the high residual monomer content, polyamide has higher solubility. According to color change, color change of nylon has causing from co-polyamide in the tea solution and It is majority for discoloration at extrinsic stain (mechanism of tea stain can see in next review). However, nylon has different properties when look at mechanism of tea stain because nylon related to hydroscopic and also higher water resorption properties. It means that pigment can penetrate into nylon. According to surface roughness, nylon has rougher surface than PMMA because nylon is more difficult to

polishing than PMMA and some studies reported that surface of nylon is easily damaged compared to PMMA. Other study reported that rougher surface is more susceptible to staining due to the porosity of the material surface trapping the staining. Menaka A. et al, 2010 (3) Surface roughness shows direct link accumulation of plaque and adherence of Candida albicans. However, value of surface roughness at 0.2 µm where no further reduction in plaque accumulation.

2.2 Staining

The factors related to staining are extrinsic and intrinsic factors. When the denture base is exposed to the factors other than the material of denture itself, the factors are called extrinsic factors such as Tabaco, eating habits, composition of saliva, or denture hygiene habit. The overheating or processing pressure is considered intrinsic factors. Staining can be differentiated into two types: intrinsic staining and extrinsic staining. The staining limited only on the surface of the material and being able to mechanically swap off is called the extrinsic staining. On the opposite, intrinsic staining is the staining into the material. This can be observed through cross sectional cut. The invasion of the color into the body of the material indicates that the stain is intrinsic. However, if there is no color observed within the material in cross sectional cut, the staining is extrinsic. To compare the color stability between different denture base materials, different methods have been used to evaluate the changes in color (4).

2.3 Mechanism of stain



Mechanism of stain, we can divide into 2 groups; extrinsic stain and intrinsic stain, so it depends on the chemical of stain and materials. Extrinsic stain, also known as adsorption, is the process where the pigments in the stain attach to the surface of the material only. It does not penetrate into the body of the material. It can removed by brushing/ polishing or wiping off. In the other way, intrinsic stain or known as absorption, is when the pigments of stain penetrate into the material. It cannot be removed by the same process of removing the extrinsic stain.

The mostly of extrinsic stain caused by food/ beverage, so they have tannin in composition as such as tea, coffee, cola, red wine etc. however, some food have composition for inhibit activity of stain to attach at surface of material as such as sodium hexametaphosphate. It is a stain protection, inhibit activity in prevent crystallization/ stain chromogen adsorption (5). In the other way for intrinsic stain, they are depend on materials in the mostly as such as polyamide materials (see at previously review).

Sepulveda-Navarro et al in 2011 (6) observed color stability of two heat-cured denture base acrylic resins (Lucitone 550, VipiCril) with thermoplastic nylon resins (Transflex®) in coffee, Cola, red wine, and distilled water by using digital analysis, projection of photographic slides, visual group ranking, and shade guide matching as a method to evaluate color changes in the study. The most advance method is the use of ultraviolet-visible spectrophotometer. The significant color change was found in Transflex® after 15 and 30 days with hard staining shown with red wine followed by coffee.

Lai et al in 2003 (7) studied the color stability, stain resistance, and water sorption of four removable gingival flange materials including 1 copolyamide (Flexite Supreme), 1 silicone (Gingivamoll), and 2 heat-polymerized acrylic resins (QC-20 and Vertex). The materials were immersed in coffee and tea solutions for 180 days. The color stability was evaluated after 7, 14, 30, 120, 180 days with a spectrophotometer. The result of the study showed that silicone material had the greatest staining in coffee solution, whereas the greatest staining of tea solution was with copolyamide material. The study concluded that the discoloration of the materials resulted from extrinsic stain after the observation of the color in materials remaining in air and water for 6 months.

2.4 Color measurement

In dentistry, the goal for obtaining the accurate color measurement is to replicate the prosthesis appearance of natural oral structures. Tooth color has originally gained a lot of attention, however, gingival colors and facial skin color have also been given importance in prostheses as the increasing of aesthetic concerns (8).

The human observers perception covers the spectrum of visible light and invigorating the three types of color receptors in the retina of the eyes then the information is transferred to the brain through the optic nerve (8).

The measurement of color in dentistry is divided into two ways including the visual technique and the instrumental technique (9). Munsell color system is a common color measurement system in the visual technique category for color determination. Munsell was the first to established the three-dimensional space and separated the dimension into hue, chrome and value (8). Value determines the lightness and the darkness of the color, whereas chrome is the intensity of the hue which defines as the quality of the color. The CIE L*a*b* is considered an instrumental technique by the use of spectrophotometer and colorimeters to determine the color. Sikri, V. K. in 2010 (9) discovered that colorimeters is designed for a color measurement of a flat surface. Therefore, spectrophotometer is used more often as a color measurement device.

The International Commission on Illumination or known as CIE in its French name describes the spectrophotometric measurements when converted to the three color parameters (8). 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 (10) 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 human eyes 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 between yellow and blue, the color position is represented by b* value. The ΔE was calculated by using this equation.

$\Delta E^* = [(L_1* - L_0*)^2 + (a_1* - a_0*)^2 + (b_1* - b_0*)^2]^{1/2}$ to evaluate the color changes of the denture base. ΔE represents the color change and the estimated value of 3.3 suggested a clinically perceptible color change (11).

Sagsoz et al in 2014 (12) performed a study on color changes of denture base materials of both polyamide and PMMA. The study aimed to investigate the color changes when the materials were immersed in different staining solutions. Distilled water, denture base cleaner, and two staining solutions (tea and coffee) were used to store the specimens. The result showed that the highest color change between the two materials was found in polyamide denture base and the highest value of ΔE was seen in polyamide denture base in coffee solution for 7 days. As many reports show that different beverages can cause staining on denture bases, there are, however, very little on how to clean or reduce the staining.

2.5 Denture cleanser tablets

There are different methods and materials in cleaning the denture base including mechanical and chemical. The most common mechanical method is brushing with soap, tooth powder or toothpaste. This method, however, increase the wear of denture base which related to the diameter and the length of the brittles. Another mechanical method in cleaning denture

base is the use of pastes and powders. This method increases the wear and more in pastes and powder that contain insoluble calcium carbonate. Other pastes containing chloroform can cause denture wear in acrylic resin because of the chemical solubility of acrylic resin. Ultrasonic can remove plaque in denture bases, however, it does not reduce the number of microorganisms. Ultrasonic works better with the use of disinfectant solutions.

Chemical denture cleansers mostly used an immersion type and usually divided based on chemical compositions. The most common chemical denture cleanser used is alkaline peroxides, which comes in a form of tablet or powder. The chemical reaction of peroxide cleanser is tablet or powder in water resulting in 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. However, when compared to brushing with soap, the result is not as effective as brushing. The time of immersion effects the potency of the peroxide cleansers. It is not effective when immersed denture base for 15-30 minutes but more effective when soaked for several hours or overnight. When use peroxide cleanser regularly, the solution can cause bleaching of the denture base.

Another chemical denture cleanser is alkaline hypochlorides which contains the bactericidal and fungicidal properties and can also act as an effective stain remover. Hydrochloric acids and phosphoric acids are the two acids used in chemical denture cleanser composition. The dilute solution of chlorhexidine gluconate or salicylate acts as disinfectants and can cause reduction of plaque. When immersed denture in 0.2% chlorhexidine gluconate can help reduce the reinfection in patients with stomatitis. However, in the treatment of stomatitis, 0.05% salicylate solution is less effective than 0.2% solution of chlorhexidine gluconate.

A more recent method in cleaning denture base is denture cleansers containing chelating agent including ethylene diamine tetra acetic acid, EDTA, and a mixture of enzymes including papain, lipase, amylase, and trypsin. These denture cleansers are effective in

removing calculus from denture bases (13).

One of the most common methods is the use of denture cleansing tablets. The use of denture cleanser is aimed to reduce Candidal biofilm. The study performed by Roka R in 1987 (14) aimed to compare and evaluate Candida removing effects of three different commercial denture cleansers from heat polymerized acrylic resins. The result of the study showed different effectiveness in removing Candidal biofilm depending on the composition of the denture cleansers. It can be concluded that using denture cleansers demonstrated the ability to remove Candidal biofilm from denture base. The study performed by Nurdan in 2014 (12) showed that soaking the denture in chlorhexidine containing cleansing solution can cause staining of the denture base.

Salman et al in 2011 (15) studied the effect of different denture cleanser solutions on some mechanical and physical properties of nylon and acrylic denture base materials. Physical and mechanical properties of nylon compared with conventional heat cured acrylic and the effect of denture cleansers (4% oxalic acid, 4% tartaric acid) and one commercial denture cleanser (lacalut dent) were observed in the study for hardness, flexural strength, flexibility, surface roughness and color stability. The result in this study, using one-way ANOVA, showed that there were significant difference between acrylic and nylon at 400nm and higher significant difference at 500nm. The study also concluded that there was no significant effect on nylon or acrylic color by the three cleansers. However, the study did not mention the effectiveness of denture cleanser in removing stain.

2.6 Tea

The second low-cost beverage next to water is tea. It is consumed by two-third of the people in the world. The process of harvesting the tea leaves determine the type of tea such as fermented tea leaves is defined as black tea, green tea is a non-fermented type, and oolong is a semi-fermented type. The chemical composition of each type of tea is established by the procedures of drying and fermentation. The main compositions of black tea include thearubigins, theaflavins, flavonols and catechins. Green and black tea contain similar contents

but with different flavonoids due to the degree of oxidation during the processing (16).

Tea has now become a popular beverage among people living in Thailand. There are increasing reports on staining of nylon denture base in different beverages including tea (12, 17). From the pilot study, we found that the polyamide specimens were stained when immersed in the tea solution for 3 hours. The use of nylon denture base increases as more people emphasize concerns on esthetic (1).

2.7 Denture cleanser with tea stain in PMMA

There are many studies on denture cleanser in removing stain from PMMA that demonstrate a lot of results to remove stain. The given examples are as follow:

Daryll C. Jagger et al in 2002 (18) found that alkaline hypochlorite in denture cleanser composition had the highest ability to remove tea stain from PMMA and there's result for bleaching effect. Especially in the smooth surface can resistance to tea stains and remove tea stains when using the denture cleanser.

In 2015, Hamidreza et al (19) found that sodium hypochlorite solution has more effect on tea stain removal from PMMA and strong antiseptic for fungal infection (Candida species), so it may be caused by chloride ion in the solution. However, sodium hypochlorite had more disadvantage such as flexural strength decrease, porosity increase etc.

Hong G. et al in 2009 (20) found that color change of PMMA can convert follow long time immersion in the denture cleanser, so denture cleanser is a chemical reaction for stain removal then the side effect of denture cleanser are whitening/ bleaching the PMMA and increase water absorption.

2.8 Ultrasonic

Ultrasonic cleansing is the one method to contribute in removing the microorganism and stain on denture surface in current day besides brushing or using of denture cleansing tablet alone. It is very useful method for help elderly people who cannot brush the denture effectively. The mechanism of ultrasonic is the process of converting high electrical energy into high frequency sound waves, creating a scrubbing brush action within the fluid, causing the rapid formation and collapse of bubbles, the bubbles increase in size until they implode against the surface of the item, which lifts contamination off the surface, this phenomenon known as cavitation.

De Andrade et al. 2011 (21) demonstrated that ultrasonic cleaning with water did not reduce the numbers of Candida albicans or Streptococcus mutans compared with cleaning with peroxide-based effervescent cleanser solution alone.

Hashiguchi et al. 2009 (22) reported that ultrasonic cleaning with a glycine-type amphoteric surfactant solution resulted in superior Candida spp. disinfection.

Yasuhiro et al. 2012 (23) reported that ultrasonic cleaning with peroxide based cleanser solution produced the lowest median number of viable microorganisms.

The effects of ultrasonic cleaning methods could be associated with the chemical activity of the immersion liquid rather than the mechanical action of the ultrasound device. Using ultrasonic with water or without cleanser solution is not effective in removal microorganisms on the surface of denture. This method removes denture plaque but does not effectively reduce the number of microorganisms. Ultrasonic treatment of dentures in disinfectant solutions increases the efficiency of the disinfectant.

Chapter 3

Materials and methods

3.1 Study population

Polyamide (Visclear® Trinidad) was taken to the experiment for evaluation of staining and stain removal with denture cleanser tablets. This material becomes more popular in dentistry due to this material has the similar color to tooth or gingiva in oral cavity but still a minimal studies about polyamide compare to PMMA.

Denture cleanser brands (Bony Plus® (BP), Fitty Dent® (FD) and Polident® (PD)) were randomize the sample products in the market that ease to buy for the experiment for testing efficiency of stain removal at surface of polyamide material.

3.2 Instruments required

Spectrophotometer (UltraScan® PRO, Hunterlab) was used for measure color of polyamide denture base and comparison of color change values between before and after immersed in tea solution and denture cleanser tablets.

Incubator (Heating incubator® BPH-9082, Thailand) was controlled during the trial a 37 °C in order to simulate the temperature in the oral cavity.

3.3 Materials & Methods

The instruments and equipments used in this study:

1.1. Dental floss	1 unit
1.2. Adhesive tape	1 unit
1.3. Abrasive paper	2 units
1.4. Dental stone	1 kg.

1.5. Paraffin wax	1 pack
1.6. Lipton tea	11 packs
1.7. Permanent marker	1 piece
1.8. Glass beaker	1 unit
1.9. Plastic cup	100 cups
1.10. Polyamide	260 pieces
1.11. Bony Plus®	2 packs
1.12. Polident®	4 packs
1.13. Fitty Dent®	2 packs
1.14. Distilled water	

Methods

1. Samples preparation

The 120 specimens of clear-colored polyamide denture based material (Visiclear® Trinidad) were used in this study. Firstly, the specimens were fabricated by using paraffin wax. The paraffin was cut into the dimensions of 20*20*2 mm and cut off the paraffin wax 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. Next, the wax samples were invested in dental stone and process in polyamide following the manufacturer's instructions using the flexpress® injection system (at a temperature of 290 °C and a pressure of 6.5 bar). The polyamide specimens were polished to a flat surface using wet 2,000-grit silicon carbide abrasive paper and labeled the number of sample according to the brand of the denture cleanser tablets (1.1, 1.2, 1.3…1.10) by using permanent marker and left air dried. The samples were rinsed by distilled water for 5 minutes, ultrasonically cleaned in distill water for 10 minutes, then gently air dried. The specimens were randomly divided into 4 groups (n=30) according to time period and denture cleanser tablet commercial brands.

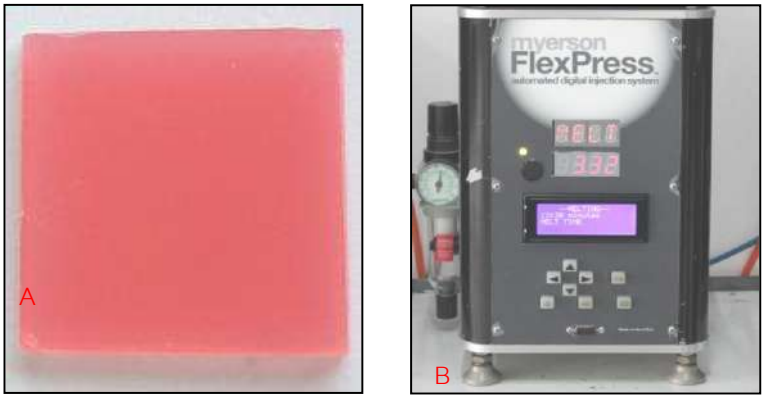


Figure 1. Parafin wax (20*20*2 mm)(A), FlexPress® injection machine (B)

2. Unstained polyamide (UP) color measurement

Figure 2. Spectrophotometer (UltraScan® PRO, Hunterlab)

Color measurements were evaluated using a spectrophotometer (UltraScan® PRO, Hunterlab). Before each measurement session, the spectrophotometer was calibrated with its white reference tile, used the white calibration standard provided, according to the manufacturer's instruction. For the same location recorded of each specimen, we placed it in the block guide. Then, the spectrophotometer set to multi-measure mode in which three readings were taken in the center of the samples (right side, left side and center) for the mean data record and the spectrophotometer's tip diameter was smaller than the specimen's diameter to ensure an extensive boundary readings of the specimen. The lighting conditions in the area of measurements were constant throughout the data collection period.

For initial color measurement ⟶ L_{UP}, a_{UP}, b_{UP}

Principle of spectrophotometer: There was a light source beam to the surface of specimen and reflected to photo detector, then read out the result to L*a*b*, respectively.

The color change values of all specimens were calculated by mean and standard deviation of ΔE^* with the used of CIE L*a*b* color system. Individual analysis was perform using the three variables inherent to the device, in which L* represented the coordinate the lightness or darkness of the object, a* indicated the red/green chromaticity of the object, and b* corresponded to the yellow/blue axis of the object.

The color measurement was performed by using CIE L*a*b* color space system, calibrated the difference color of specimens before and after immersion in several denture cleanser tablets. ΔE could be calculated using the following equation:

$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$

L* : indicate White-Black, $\Delta L = L_t - L_0$

a* : indicate Redness - Greenness, $\Delta a = a_t - a_0$

b* : indicate Yellowness - Blueness, $\Delta b = b_t - b_0$

(L_t, a_t, b_t : final color measurement / L_0, a_0, b_0 : initial color measurement)

3. Solution preparation and staining preparation

One pack of tea was placed in 300 ml. of distilled boiling water and left for 2 minutes (18). The solution was stirred forward and backward for 15 times then keep the temperature at 37 ºC by using an incubator (Heating incubator BPH-9082, Thailand).

Figure 3. Lipton Tea® (A), Tea stained solution (B)

Each specimen was tied by using dental floss with 6 cm. in length. Another end of dental floss was fixed to a plastic cup with adhesive tape at the bottom of cup. The distance of dental floss between the adhesive tape and specimen was 2 cm. Poured the tea solution (300 ml.) into each plastic cup (with specimen tied with floss) and made the tea solution level cover above the specimen approximately 2 cm. and took all cup of specimen into the incubator at 37 ºC. The specimen was immersed in tea solution for 1 day, 1 week, 1 month and 3 months which was renewed daily (24). In the remaining time for each day, the specimens were washed and immersed in distilled water, which replaced daily. The specimens were distributed into 3 groups of 10 specimens; Bony Plus® (BP), Fitty Dent® (FD) and Polident® (PD).

4. Stained polyamide (SP) color measurement (the second color measurement)

After staining the specimens with teas follow 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.

For stained polyamide color measurement ⟶ L_{SP}, a_{SP}, b_{SP}

Then the spectrophotometer was used to record the color measurements of the specimens before immersed in denture cleanser tablets and ultrasonic.

5. Denture cleanser tablets preparation

The commercial product of denture cleanser tablets were prepared according to the manufacturers' instructions by using one tablet to 300 ml. of warm distilled water at 40 °C for 5 minutes. A tablet of each group dropped at the bottom of each cup. The container with denture cleanser tablet contained one piece of specimen and the solution would cover 2 cm. above the specimen.

Figure 4. Denture cleanser brands; Bony Plus® (A), Fitty Dent® (B), Polident® (C)

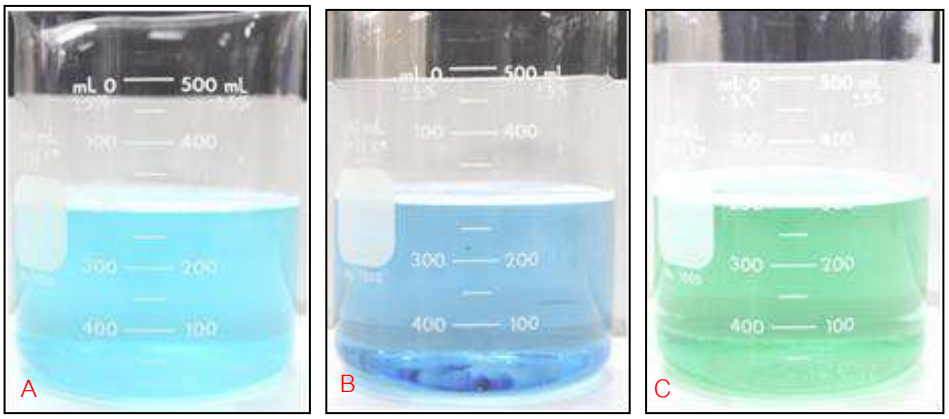
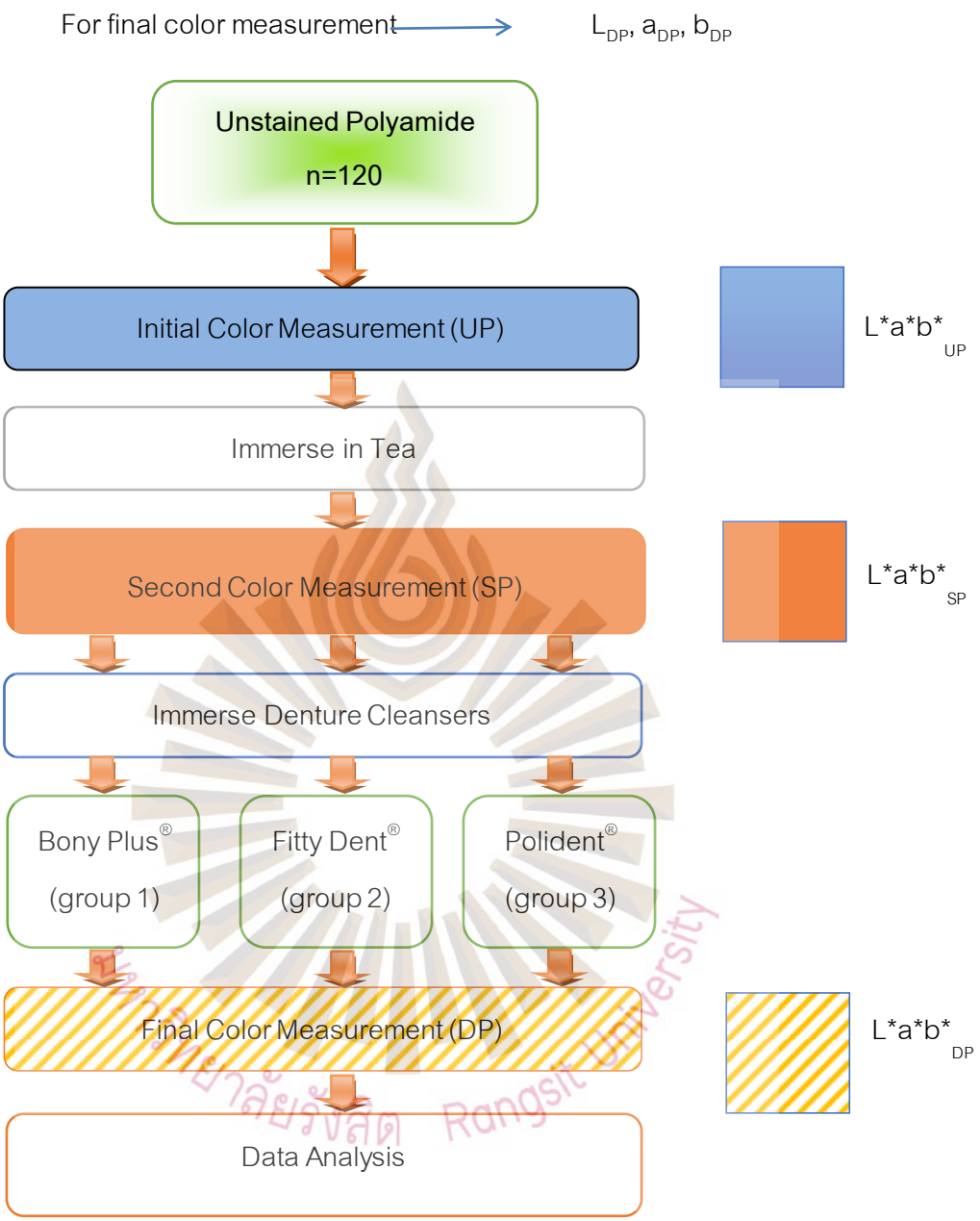


Figure 5. Denture cleanser solution; Bony Plus® (A), Fitty Dent® (B), Polident® (C)

Denture cleanser tablets treating staining polyamide (DP) color measurement (Final color measurements)

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 using the CIE L*a*b* color system.


For final color measurement
L_{DP}, a_{DP}, b_{DP}
Unstained Polyamide
n=120
Initial Color Measurement (UP)
L*a*b* UP
Immerse in Tea
Second Color Measurement (SP)
L*a*b* SP
Immerse Denture Cleansers
Bony Plus®
(group 1)
Fitty Dent®
(group 2)
Polident®
(group 3)
Final Color Measurement (DP)
L*a*b* DP
Data Analysis

The ΔE_1 was calculated from the equation:

$$\Delta E_1 = L_{SP} - L_{UP}$$
$$a_{SP} - a_{UP}$$
$$b_{SP} - b_{UP}$$

The ΔE_2 was calculated from the equation:

$$\Delta E_2 = L_{DP} - L_{SP}$$
$$a_{DP} - a_{SP}$$
$$b_{DP} - b_{SP}$$

3.4 Data collection

It was simple to use tabulation for record numerical data from spectrophotometer and interpreted into bar chart.

3.5 Data analysis

The SPSS version 20 was used for descriptive analysis, paired T-test and one-way ANOVA for analyzed the color difference value of polyamide. Moreover, a critical level of 0.05 was essential as a statistically significant.

The data analysis was done by compare mean color values with the clinically perceptible color change value (ΔE 3.3).

Chapter 4

Results

4.1 Result

Part1

Tea solution can cause staining to the polyamide surface by increased time period that it showed in figure 6.

Figure 6. Unstained polyamide (UP)(A), Stained polyamide (SP); 1 day (B), 1 week (C), 1 month (D) and 3 months (E)

Table 1. The CIE L*a*b* values of tea stained polyamide (SP)

Time		1 day	1 week	1 month	3 months
L*	Before soaking	80.8303	80.6020	80.9110	80.9410
	SD	0.6693	0.6224	1.1485	1.3839
	After soaking	79.6157	78.8347	78.3513	75.0600
	SD	0.6499	0.7230	1.1166	1.6815
a*	Before soaking	0.1747	0.2040	0.2560	0.2483
	SD	0.0871	0.0936	0.0815	0.1003
	After soaking	0.3583	0.3917	0.4580	0.8350
	SD	0.0703	0.1422	0.1845	0.4976
b*	Before soaking	2.5847	2.5513	2.8290	2.8677
	SD	0.1411	0.1594	0.1681	0.1389
	After soaking	3.8973	4.0457	5.2903	8.1937
	SD	0.2356	0.2850	0.8733	1.3564

The result of spectrophotometric color measurements shown in table 1. The L* values of all groups decreased after soaking in the tea solution, whereas the a* values increased in all groups. In contrast, the b* values of all groups increased after soaking in the tea solution .

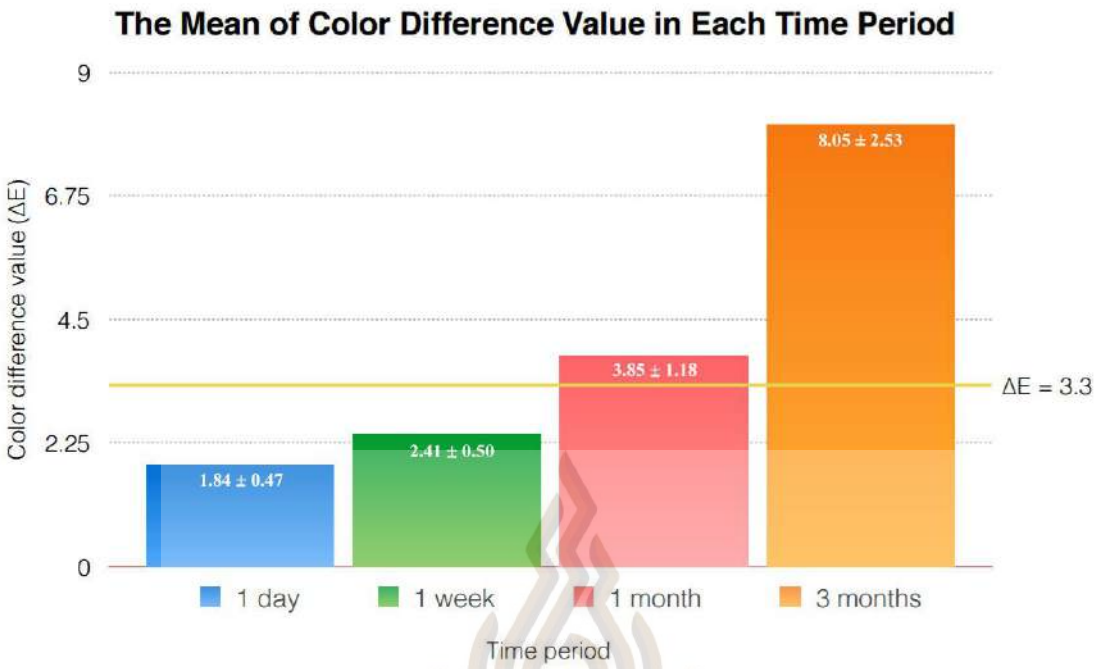


Table 2. The mean of color difference value in each time period (ΔE_1)

Table 2. shows the flow chart of the average of color difference value (ΔE_1) in each time periods in 1 day, 1 week, 1 month and 3 months. The color difference values were 1.84±0.47, 2.41±0.50, 3.85±1.18 and 8.05±2.53, respectively. The mean of the color difference value was the lowest in 1 day and the highest in 3 months.

And the color difference values (ΔE_1) of group 1 month and group 3 months are higher than 3.3.

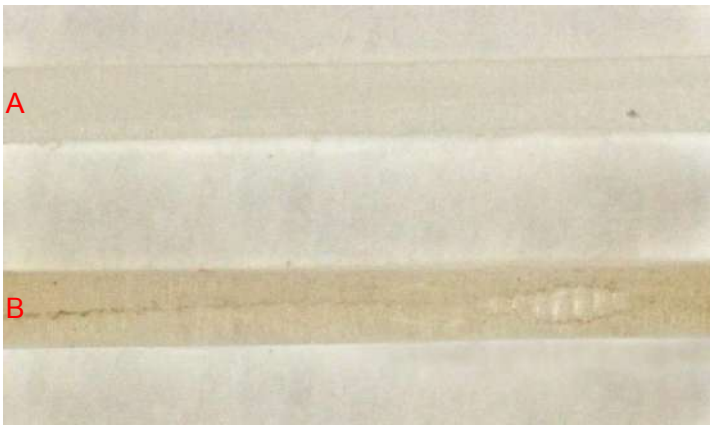


Figure 7. Cross-section of control polyamide (A), tea stained polyamide (B)

Figure 7. shows cross-section of two samples; A (control polyamide), B (tea stained polyamide for 3 months). Sample B exhibit discoloration of polyamide include the inner surface of material.

Part 2

In addition, from the previous study had shown that 1 month and 3 months were stained by tea solution, so there was the color difference value more than 3.3. Therefore, the highest value of the color difference value of time period (3 months) was used for process to next study and evaluates the effectiveness of denture cleanser tablet followed by commercial products.

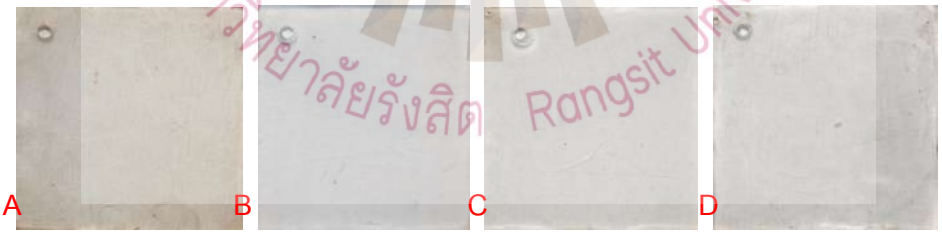


Figure 8. Stained polyamide (SP)(A), denture cleanser tablet brands; Bony Plus® (B), Fitty Dent® (C), Polident® (D)

Table 3. The CIE L*a*b* values of three denture cleanser

Denture cleanser tablet brands		Bony Plus®	Fitty Dent®	Polident®	Mean
L*	Before soaking	74.03	75.41	75.73	75.06
	SD	2.30	1.08	0.89	1.68
	After soaking	75.68	76.80	76.46	76.31
	SD	2.80	1.30	1.30	1.93
a*	Before soaking	1.28	0.43	0.78	0.83
	SD	0.58	0.13	0.15	0.49
	After soaking	0.81	0.82	0.82	0.82
	SD	0.10	0.09	0.07	0.09
b*	Before soaking	9.11	8.37	7.09	8.19
	SD	1.55	0.76	0.77	1.35
	After soaking	8.38	8.26	7.61	8.08
	SD	0.86	0.79	0.92	0.90

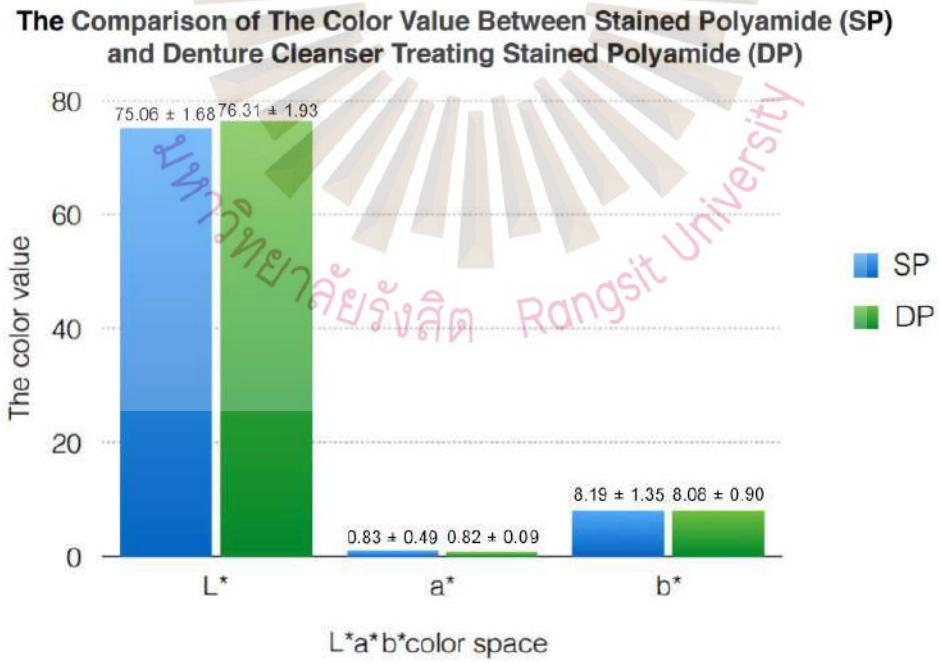


Table 4. The comparison of the color value between stained polyamide (SP) and denture cleanser treating stained polyamide (DP)

The results of spectrophotometric color measurements between SP and DP are shown in table 4. The L* value has significantly increased after soaked in the denture cleanser, whereas the a* value is decreased. In contrast, the b* value has significantly decreased after soaked in the denture cleanser.

Table 5. Multiple comparable of denture cleanser tablet brands

(I) cleanser	(J) cleanser	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bony Plus	Fitty Dent	.7392300	.7015590	.550	-1.000228	2.478688
	Polident	1.4972400	.7015590	.102	-.242218	3.236698
Fitty Dent	Bony Plus	-.7392300	.7015590	.550	-2.478688	1.000228
	Polident	.7580100	.7015590	.534	-.981448	2.497468
Polident	Bony Plus	-1.4972400	.7015590	.102	-3.236698	.242218
	Fitty Dent	-.7580100	.7015590	.534	-2.497468	.981448

However, after multiple comparable of denture cleanser tablet brands (table 5) for evaluated the effective on tea stain removal and no statistically significant was found in tea stain removal.

The mean of color difference value (ΔE_2) of denture cleanser tablet

Table 6. The mean of color difference value (ΔE_2) of denture cleanser tablet brands

Table 6. shows the effectiveness of denture cleanser tablets that decreased the color difference value when soaked the stained polyamides in the denture cleanser solution. So, we used it as ΔE_2 for evaluation.

The color difference value (ΔE_2) in Bony Plus®, Fitty Dent®, Polident® are 2.52±0.52, 1.78±0.80 and 1.02±0.68, respectively.

Chapter 5
Discussion and conclusion

5.1 Discussion

In this study, the time period of 1 day, 1 week, 1 month and 3 months when immersed polyamide denture base in tea solution. The polyamide denture base specimens were immersed in tea solution for the period of 1 day, 1 week, 1 month and 3 months. The mean of color difference value (ΔE) compare between unstained polyamide group (UP), stained polyamide (SP) was increased. So, the first hypothesis, according to figure 1 found the null hypothesis was rejected then accepted to the alternative hypothesis because the color difference value was increased by time period when immersed in tea solution. The second hypothesis, the color difference value of 1 day was accepted to the null hypothesis because it had color difference value less than 3.3. The third hypothesis, the color difference valu e of 1 week was accepted to the null hypothesis because it had color difference value less than 3.3. The forth hypothesis, the color difference value of 1 month was rejected to the null hypothesis then accepted to alternative hypothesis because the color difference value more than 3.3. The fifth hypothesis, the color difference value of 3 months was rejected to the null hypothesis then accepted to alternative hypothesis because the color difference value more than 3.3.

It showed that there are differences in color change value among denture cleanser tablet groups for removing staining of polyamide. The first hypothesis, according to table 3 found the null hypothesis was rejected then accepted to alternative hypothesis because the mean of color value between two groups were decrease. The second hypothesis was accepted to null hypothesis then rejected to alternative hypothesis because there is not statistically significant to removed tea staining from polyamide. The third hypothesis, the color difference value of Bony Plus® was accepted to null hypothesis because it has not the color difference value more than 3.3. The fourth hypothesis, the color difference value of Fitty Dent® was accepted to null hypothesis because it has not the color difference value more than 3.3. The fifth hypothesis, the color difference value of Polident® was accepted to null hypothesis because it has not the color difference value more than 3.3.

This experiment was composed to investigate the efficiency of different brands of denture cleanser tablets in removing tea stain from polyamide denture base. However, there were many limitations in this study. The restrictions of this experiment emerged from the differences between the actual uses of polyamide denture base compared to the desig ns that were practiced in the investigation. Numerous factors might have affected the process resulting in the divergent of the daily life uses 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 bases after the preparation and finished process of fabrication.

First of all, time is a significant factor in this study. The time period of 1 day, 1 week, 1 month, and 3 months of staining demonstrates the different level of color change. From the observation, the color difference value of 1 months and 3 months were more than 3.3. The color difference value was increased conforming to the extension of time. Thus, the period of 3 months showed the highest color change in this study. The longer the time of staining, the more discolored the material. The study of Sagsoz et al in 2014 shows similar result. The longer the time, the more intense the staining becomes.

Denture cleanser is widely used for removing staining and killing microorganisms. The dentures should be soaked in cleansing solution according to the manufacturer's instructions. Polident® 5 minutes, Bony Plus® 3 minutes and Fitty Dent® 30 minutes, it showed no statistically significant to removed staining between Bony Plus®, Fitty Dent® and Polident®. The compositions of the denture cleansers used in this study are similar to each other. The chemicals reaction of the cleanser tablets result in hydrogen peroxide creating bubbles for the surface cleansing. For ingredients of Polident® and Bony Plus® were similar but not included the additional compound. Fitty Dent® was different from the others in bleaching agents. Efficacy of denture cleansers on polyamide denture base might depend on ratio of the ingredients that unrevealed. For this reason, the different brands of denture cleansers give resemble results for cleaning the denture.

Individual's chemical composition in three denture cleanser tablets have similar chemical substance, especially the Polident® and Bony Plus® included oxidizing agent, effervescing agent and surfactant. The main composition act on cleansing the denture. However, Bony Plus® was show the best denture cleanser tablets brand for tea stain removal. It's also Fitty Dent® and Polident® were show tea stained removal less than Bony plus®, respectively. It's probably caused by different of ratio of each composition as secret of each brand. Fitty Dent® has different composition from Polident® and Bony plus® but no significant different value on remove tea stain compared to the other brands. Even this experiment showed the different value on tea stain removal by 3 brands of denture cleanser tablets but there still no significant different value on tea stain removal for each brand.

The color difference value is composed of L* value, a* value and b* value. The divergence of L* value compare between unstained polyamide group (UP) and stained polyamide (SP) was decrease and compare between stained polyamide (SP) and denture cleanser treating stained polyamide (DP) was increase. Therefore, denture cleanser can reduce L* value from stained polyamide. The variation of a* value and b* value compare between UP and SP was increase and compare between SP and DP was decrease. So, denture cleanser can raise L* value aside from a* value and b* value ware reduced from stained polyamide.

Moreover, consider about staining. 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, observed from the invasion of the color into the body of the material.

The properties of the polyamide denture base also determine the staining susceptibility. The higher water sorption and hygroscopic properties could be the reason for the higher color change according to Vojdani et al 2015. It was also found that the water sorption and the chemical properties of the polyamide are affected by the frequency of the amide groups in the chain. Dae-Eun Jang et al in 2015 submitted the hydrophilicity of the amide bonds in the chain

results in more water sorption rate. This could result in the 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 sorption and its chemical properties. A study by Kurtulmus et al proposed that the cross-linking agents in the material absorbed fewer solutions than the one without cross-linking agents.

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

Surface roughness is one of the important factors that cause staining on polyamide. A study by Menaka in 2010 suggests that polyamide has a rougher surface 3 times more than PMMA after the polishing process. A rougher surface of polyamide can cause more discoloration of the material. Vojdani in 2015 also found that the high temperature and the pressure from the mold injection of polyamide cause disintegration of the surface as well. Sepulveda-Navarro et al in 2011 also advocated that the process of finishing and surface treatment affect the surface staining of polyamide denture base. Pluemsumran et al in 2010 proposed that smooth surface has a lower discoloration than rougher surface because the rougher surface has more reflection and scattered of light resulting in the obvious discoloration of the material. However, there was dissimilar point between specimen and actual uses of denture base. In this study, the surfaces of polyamide denture base were polished on both sides. Contrarily in reality denture base was polished only on the outer side. Remarkably, it might affect 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 shows that the value of the Δb^*, the difference value of yellowish color, has higher value than the other difference colors (ΔL^* and Δa^*). This can be explained by the containment of tannic acid,

which trigger the brown pigmentation and results in the yellow staining of tea (Dae-Eun Jang, 2015).

The temperature in the mouth is about 37 °C. So, 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 degree of temperature when come in contact with hot or cold tea beverages passing through the cavity.

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 into the solution.

Conclusion

It is important to clean denture daily. From this study examined that there is no clinically perceptible color change after immersed denture in tea solution for 1 day and 1 week. The denture cleansers in this observation did not demonstrate the obvious complete removal of the staining on the denture base. Nevertheless, the cleaning instruction is still recommended for the tending of the denture base.

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Appendix A

The CIE L*a*b* values of tea stained polyamide (SP)

Table 7. L*a*b* values of 1 day

	N	Minimum	Maximum	Mean	Std. Deviation
ก่อนแช่ (L1)	30	79.16	82.10	80.8303	.66938
ก่อนแช่ (a1)	30	.01	.38	.1747	.08717
ก่อนแช่ (b1)	30	2.31	2.88	2.5847	.14115
หลังแช่ (L2)	30	78.26	81.27	79.6157	.64992
หลังแช่ (a2)	30	.20	.52	.3583	.07037
หลังแช่ (b2)	30	3.48	4.36	3.8973	.23562
Valid N (listwise)	30				

Table 8. L*a*b* values of 1 week

	N	Minimum	Maximum	Mean	Std. Deviation
ก่อนแช่ (L1)	30	79.47	81.94	80.6020	.62241
ก่อนแช่ (a1)	30	-.07	.41	.2040	.09368
ก่อนแช่ (b1)	30	2.28	2.95	2.5513	.15945
หลังแช่ (L2)	30	77.38	80.82	78.8347	.72301
หลังแช่ (a2)	30	.21	.66	.3917	.14458
หลังแช่ (b2)	30	3.47	4.70	4.0457	.28502
Valid N (listwise)	30				

Table 9. L*a*b* values of 1 month

	N	Minimum	Maximum	Mean	Std. Deviation
ก่อนแช่ (L1)	30	79.14	82.69	80.9110	1.14856
ก่อนแช่ (a1)	30	.07	.38	.2560	.08156
ก่อนแช่ (b1)	30	2.25	3.15	2.8290	.16818
หลังแช่ (L2)	30	75.93	81.14	78.3513	1.11663
หลังแช่ (a2)	30	-.22	.97	.4580	.18457
หลังแช่ (b2)	30	4.00	7.60	5.2903	.87339
Valid N (listwise)	30				

Table 10. L*a*b* values of 3 months

	N	Minimum	Maximum	Mean	Std. Deviation
ก่อนแช่ (L1)	30	79.20	83.34	80.9410	1.38393
ก่อนแช่ (a1)	30	.16	.58	.2483	.10038
ก่อนแช่ (b1)	30	2.52	3.15	2.8677	.13898
หลังแช่ (L2)	30	68.68	76.82	75.0600	1.68151
หลังแช่ (a2)	30	.22	2.85	.8350	.49768
หลังแช่ (b2)	30	5.81	12.44	8.1937	1.35640
Valid N (listwise)	30				

Appendix B

The mean of color difference value in each time period (ΔE_1)

Table 11. Descriptive the time period at 1 day

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
Bony Plus®	10	1.953830	.5544097	.1753197	1.557229	2.350431	1.3219	2.9608
Fitty Dent®	10	1.591150	.3757476	.1188218	1.322356	1.859944	1.0529	2.3390
Polident®	10	1.978250	.3892549	.1230932	1.699794	2.256706	1.4528	2.6468
Total	30	1.841077	.4675915	.0853701	1.666475	2.015678	1.0529	2.9608

Table 12. Descriptive the time period at 1 week

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
Bony Plus®	10	2.404160	.3704705	.1171531	2.139141	2.669179	1.8425	2.8939
Fitty Dent®	10	2.464580	.6268613	.1982310	2.016150	2.913010	1.2356	3.4432
Polident®	10	2.366140	.5166847	.1633901	1.996526	2.735754	1.4883	3.1763
Total	30	2.411627	.4990953	.0911219	2.225261	2.597992	1.2356	3.4432

Table 13. Descriptive the time period at 1 month

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
Bony Plus®	10	3.709450	1.3850678	.4379969	2.718632	4.700268	2.0018	5.8590
Fitty Dent®	10	4.370280	1.3091977	.4140047	3.433736	5.306824	2.3971	6.0070
Polident®	10	3.499150	.6205305	.1962290	3.055249	3.943051	2.3509	4.3746
Total	30	3.859627	1.1786880	.2151980	3.419497	4.299756	2.0018	6.0070

Table 14. Descriptive the time period at 3 months

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
Bony Plus®	10	10.211130	2.6465545	.8369140	8.317899	12.104361	7.3165	16.1342
Fitty Dent®	10	7.457450	1.6391444	.5183430	6.284877	8.630023	5.4980	10.3456
Polident®	10	6.499570	1.6584972	.5244629	5.313153	7.685987	4.8114	9.8177
Total	30	8.056050	2.5340995	.4626611	7.109802	9.002298	4.8114	16.1342

Appendix C

The CIE L*a*b* values of three denture cleanser

Table 15. Descriptive of L*a*b* in each denture cleanser tablets brand

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	95% Confidence Interval for Mean	Minimum	Maximum
						Lower Bound	Upper Bound		
หลังแช่	Bony plus	10	74.0340	2.30674	.72946	72.3839	75.6841	68.68	76.43
	Fitty dent	10	75.4160	1.08660	.34361	74.6387	76.1933	73.37	76.82
	Polident	10	75.7300	.89430	.28280	75.0903	76.3697	74.14	76.75
	Total	30	75.0600	1.68151	.30700	74.4321	75.6879	68.68	76.82
หลังแช่	Bony plus	10	1.2860	.58616	.18536	.8667	1.7053	.85	2.85
	Fitty dent	10	.4300	.13864	.04384	.3308	.5292	.22	.67
	Polident	10	.7890	.15709	.04968	.6766	.9014	.60	1.05
	Total	30	.8350	.49768	.09086	.6492	1.0208	.22	2.85
หลังแช่	Bony plus	10	9.1110	1.55567	.49195	7.9981	10.2239	7.47	12.44
	Fitty dent	10	8.3780	.76850	.24302	7.8282	8.9278	7.23	9.58
	Polident	10	7.0920	.77222	.24420	6.5396	7.6444	5.81	8.35
	Total	30	8.1937	1.35640	.24764	7.6872	8.7002	5.81	12.44

cleanser	Bony plus	10	75.6830	2.80799	.88797	73.6743	77.6917	69.96	81.38
	Fitty dent	10	76.8060	1.30605	.41301	75.8717	77.7403	74.50	78.99
	Polident	10	76.4620	1.30195	.41171	75.5306	77.3934	74.26	78.77
	Total	30	76.3170	1.93152	.35264	75.5958	77.0382	69.96	81.38
cleanser	Bony plus	10	.8190	.10609	.03355	.7431	.8949	.60	.97
	Fitty dent	10	.8200	.09775	.03091	.7501	.8899	.68	.98
	Polident	10	.8230	.07617	.02409	.7685	.8775	.73	.96
	Total	30	.8207	.09089	.01659	.7867	.8546	.60	.98
cleanser	Bony plus	10	8.3790	.86969	.27502	7.7569	9.0011	6.44	9.43
	Fitty dent	10	8.2650	.79576	.25164	7.6958	8.8342	6.55	9.16
	Polident	10	7.6170	.92107	.29127	6.9581	8.2759	6.31	9.00
	Total	30	8.0870	.90058	.16442	7.7507	8.4233	6.31	9.43

Table 16. Paired Samples Correlations

		N	Correlation	Sig.
L*	SP & DP	30	.642	.000
a*	SP & DP	30	.260	.166
b*	SP & DP	30	.400	.028

Appendix D

The mean of color difference value (ΔE_2) of denture cleanser tablet

Table 17. Descriptive of ΔE_2

SP - DP

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Bony plus	10	2.521060	2.5042555	.7919151	.729624	4.312496	.7019	8.5080
Fitty dent	10	1.781830	.8008062	.2532372	1.208968	2.354692	.7361	3.6327
Polident	10	1.023820	.6857032	.2168384	.533297	1.514343	.2472	2.5193
Total	30	1.775570	1.6363774	.2987603	1.164537	2.386603	.2472	8.5080

Table 18. One-way ANOVA between SP and DP

SP - DP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.209	2	5.605	2.277	.122
Within Groups	66.445	27	2.461		
Total	77.654	29			

Table 19. Multiple comparison between denture cleanser tablets brand

Dependent Variable: SP - DP

Tukey HSD

(I) Denture cleanser tablet	(J) Denture cleanser tablet	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Lower Bound
Bony plus	Fitty dent	.7392300	.7015590	.550	-1.000228	2.478688
	Polident	1.4972400	.7015590	.102	-.242218	3.236698
Fitty dent	Bony plus	-.7392300	.7015590	.550	-2.478688	1.000228
	Polident	.7580100	.7015590	.534	-.981448	2.497468
Polident	Bony plus	-1.4972400	.7015590	.102	-3.236698	.242218
	Fitty dent	-.7580100	.7015590	.534	-2.497468	.981448

ประวัติผู้วิจัย

ไฟล์รูปภาพ
นักวิจัยขนาด
150*200

คำนำหน้า ☐ นาย ☐ นาง ☑ นางสาว

ตำแหน่งทางวิชาการ ☐ ศ. ☐ รศ. ☐ ผศ. ☑ อื่นๆ

ชื่อผู้วิจัย สปัน

นามสกุลผู้วิจัย เล็งเลิศผล

ชื่อภาษาอังกฤษ SPUN

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ปีที่จบ 2546

สถาบัน มหาวิทยาลัยมหิดล

ประเทศ ไทย

ปริญญาโท

สาขา วิทยาศาสตร์มหาบัณฑิต (ทันตกรรมประดิษฐ์)

ปีที่จบ 2553

สถาบัน จุฬาลงกรณ์มหาวิทยาลัย

ประเทศ ไทย

ผลงานวิจัยที่ได้นำเสนอในการประชุมทางวิชาการภายในประเทศ(โปรดระบุหัวข้อประชุม/สัมมนาและสถานที่)

“การรั่วซึมของฟันที่บูรณะด้วยเรซินคอมโพสิตอินเลย์โดยใช้สารยึดเรซินก่อนและหลังการฟอกสีฟัน”

(Leakage of Tooth restored with Resin Composite Inlay using Resin adhesive Before and After)

งานประชุมทางวิชาการเสนอผลงานวิจัยระดับบัณฑิตศึกษาครั้งที่ 11 มหาวิทยาลัยขอนแก่น

“เสถียรภาพเชิงมิติของวัสดุพิมพ์ปากชนิดซิลิโคนเมื่อเก็บไว้ในเวลาต่างกัน “

(Dimensional Stability of Silicone Impression Material at Different Time)

การประชุมวิชาการระดับชาติ ประจำปี ๒๕๕๗ (National Research Conference 2014) มหาวิทยาลัยรังสิต

ผลงานวิจัยที่ได้นำเสนอในการประชุมทางวิชาการในต่างประเทศ(โปรดระบุหัวข้อประชุม/สัมมนาและสถานที่)

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IADR 2009, Wuhan, China

สาขาวิชาที่นักวิจัยเชี่ยวชาญ

ทันตกรรมประดิษฐ์ ทันตวัสดุศาสตร์