ORIGINAL ARTICLE

The Effect of Coloured Beverages on The Colour Stability of a Flexible Denture

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ABSTRACT

Introduction: Colour stability of the material is an essential factor that contributes to the selection of a flexible denture material. Staining effects on the denture may result in unattractive appearance, the dissatisfaction of the wearer, and limited usage period of the denture. This study aims to identify the colour stability of the Valplast flexible denture material using three types of beverages. **Methods:** A total of 32 disc-shaped flexible resin materials (20 +/- 0.1 mm in diameter and thickness 3 +/- 0.1 mm) were prepared based on the manufacturer instructions. The samples were randomly divided into 4 groups of immersion: distilled water (control), coffee solution, tea solution and red wine. The samples were left in the specified immersion solution for up to 60 days. Colour changes were measured after 1, 3, 7, 14, 21, 30, 45 and 60 days of immersion. **Results:** The samples immersed in coffee solution changed from S1 to S2, whereas samples in tea solution changed from S1 to S3. Additionally, samples in red wine changed from S1 to S4, as observed using the Valplast colour tone guide. The highest reflection measured using spectroscopy was 65.146 at 385.19 nm of the control samples, whereas the lowest reflection was 1.974 at the wavelength of 385.97 nm on the samples immersed in the red wine. **Conclusion:** The most significant difference can be observed in the red wine group, followed by samples in tea and coffee solutions. Moreover, increasing the immersion period causes increasing staining effect of the denture.

Keywords: Colour stability, Dental material, Flexible denture, Staining, Thermoplastic

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INTRODUCTION

Flexible denture and artificial teeth made from acrylic resin material are known to be commonly used in the manufacture of a denture due to its ability to absorb liquids in the mouth surrounding. Furthermore, its strong, flexible nature of material and simplifying design suit variety of natural conditions in the mouth. Partially edentulous patients with challenging conditions such as undercuts due to angulated remaining abutment teeth, cancerous lesions and cleft palate create difficulty in constructing a successful removable partial denture. Hence, flexible denture offers a simpler and cost effective treatment for these cases.

Most of the dental patients do not prefer metal-made appliances compared to thermoplastic materials due to its unpleasant aesthetic appearance. In addition, non-metallic clasp dentures (NMCDs) or dentures made of thermoplastic materials such as polyamide, polyester, polycarbonate and polypropylene were more demanded in prosthodontic treatment as these materials appear more aesthetic than the metal. The semi-transparency of the material picks up the underlying tissue tones nicely. Moreover, thermoplastic material provides an alternative for those patients who are allergic to metal materials and dementia against metal (1). Its elastic and flexible properties make thermoplastic material a better selection than acrylic and metal resin (2-4).

There are also studies showing that thermoplastic resin materials such as polyamide and polyester for non-metallic clasp dentures (NMCD) have low water absorption, indicating an essential advantage of this material in hygiene aspects (2). Fueki et al. found that NMCD has the advantage of being compared to conventional dentures with metal holdings since wearer feels more comfortable using denture made of flexible aesthetic materials (5). More importantly, it is the ideal material for patients who are allergic to metals and monomer material.

Colour stability of denture material is an essential factor associated with the aesthetic of the denture. Discolouration of the denture can be due to either extrinsic or intrinsic factor or both. Additionally, colour changes may also occur due to porous denture surfaces. Several studies on colour stability of the flexible denture material have been reported, and some concluded that the thermoplastic polyamide resin has acceptable colour stability (6,7). Colour changes of the denture also attributed to eating habits of the wearer as reported in previous studies showing that beverages such as coffee and tea caused colour changes on dentures and denture surfaces (8). Besides, the frequency of acid-containing beverages intake can also cause erosion of the denture surface where this chemical change changes the mechanical properties of the doped thermoplastic material (9).

However, they find that flexible materials have some disadvantages such as colour change problems, rapid material degradation and difficulty in polishing (5). Flexible resin material will experience colour changes caused by the absorption of coloured beverages such as black coffee, hence reducing the satisfaction of the denture wearer. In addition, various methods that have been used to measure the degree of the colour change of flexible denture materials such as visual assessment, digital image processing and colour space visualisation (10,11).

The colour change of the denture material depends on the nutrition and the level of hygiene of the denture wearer. High elasticity and non-toxic properties are among the advantages of this flexible denture material. Additionally, appropriate processing technique is required in material handling because this flexible denture material comes from a nylon family that is difficult to polish. One of the critical factors that cause the colour change to occur is the surface roughness of the material. If the surface is not smooth, the effect of impurities on the leftover food can easily attach to the surface of the denture and causes the colour change. Thus, the causes of colour changes in denture are related to the factors that contribute to the colour stability of the denture material.

The evaluation of the colour stability of the flexible denture material is vital to ensure that dental prosthesis is maintained. In this study, a flexible denture made of a thermoplastic resin material was evaluated in terms of its colour stability after being immersed in several staining solutions. The flexible denture material was selected due to several complaints made by denture wearers who received treatment from the Dental Clinic in Advanced Medical and Dental Institute (AMDI), Universiti Sains Malaysia (USM). The flexible denture material used in this study was Valplast since this is the only flexible denture material available at the AMDI Dental Clinic. Thus, this study aims to evaluate and compare the colour stability of a flexible denture material after being immersed into different types of beverages, including tea, coffee, and red wine solution within a specified period.

MATERIALS AND METHODS

Thermoplastic Resin

A plaster mould was prepared by forming the shape of wax according to the required shape of the thermoplastic resin polymer. The moulded wax was immersed in a plaster mix inside a flask. Once the plaster is hardened, the flask was opened, and the wax was removed from the mould. The resin polymer material known as Valplast polymer (Valplast In. Corp, USA) was filled into a cartridge and heated using a heating machine to soften the polymer. After reaching the melting temperature of the resin polymer, the hot cartridge was inserted into the pressing machine to inject the polymer from the cartridge into the mould. After cooling, the flask was opened to remove the sample disks produced from the resin polymer. An excess portion of the sample disk was cut and flatten using a bur. A total of 32 sample disks were prepared for this study. Each sample disk was immersed in a distilled water solution for 24 hours at room temperature to ensure complete polymerisation has been performed. All the specimens were prepared by the same operator to minimise technical errors.

Solution Preparation

There were three types of solution used in this experiment, which were coffee, tea, and red wine solutions. Additionally, the distilled water was used as a control solution. A 50 ml container with a plastic cover was used to store the staining solution. There were 8 containers for each type of staining solution.

For the preparation of coffee and tea solutions, boiling water was used without sugar and the solution was left to cool to room temperature before the specimen was included. The coffee solution was provided from 10 g of Tupai coffee brand with 50 ml of hot filtered water, and the solution was left to cool to room temperature. Tea solution was prepared using a 10 g of tea powder Ceylon 888 branded with 50 ml of hot filtered water. The tea powder was soaked into the boiling water and left boiled for 15 minutes. Then, the tea solution was filtered to remove the tea powder. The tea solution was left to cool to room temperature. 50 ml red wine solution was taken from Casa Carajou Cabernet Sauvignon brand (France) without dilution while distilled water was used as a control solution. All the solutions were prepared by a single operator to avoid variations. The wine and the distilled water were ready-made and available in bottles. Additionally, all solutions were renewed every three days to eliminate precipitation build-up and evaporation. The solutions were renewed by the same operator.

Experiment

Each specimen of the Valplast material (Valplast International Corp., USA) was formed to a disk shape with a diameter of 20 mm and a thickness of 3 mm. A total of 32 pieces (N=32) of specimens were prepared and randomly divided into four groups (n=8). Group 1 was immersed in a distilled water (control), Group 2 in a coffee solution, Group 3 was immersed in a tea solution, and Group 4 was immersed in a red wine solution.

The specimen disks were immersed into a container that contains the specified solution to see the colour changes within the specified period: one day, three days, seven days, 14 days, 21 days, 30 days, 45 days and 60 days. All the solutions, including distilled water solution, were stirred for 60 seconds for every 24 hours to avoid precipitation of the solution. Additionally, all the solutions were replaced every 72 hours. Colour changes were recorded according to the predefined time frame.

Evaluation of Colour Change

The first evaluation of colour changes was made after the sample disks being immersed for 24 hours in each solution. Direct observation and measurements were carried out using a sample shade guide, as shown in Fig. 1. In addition, the colour shade was analysed based on a score schedule ranging from bright to darker colours as in Table I.

Valplast shade guide (Valplast International Corp., USA) was used to evaluate the colour changes of the samples according to the specified period within the 60 days of immersion. The samples were left in the specified solution for 24 hours a day for 60 days. The colour changes of the samples were measured according to the set time period (1 day, 3 days, 7 days, 14 days, 21 days, 30 days, 45 days and 60 days). Each sample was assessed three times by the same operator, and the mean value was recorded. Prior to the actual study, the operator had undergone an inter-examiner reliability assessment to rate the scoring values.

Sample Analysis

The colour changes of the samples were visually assessed based on the shade guide (Valplast International Corp., USA). Each sample was also analysed using a spectrometer device (Ocean Optics QE 65000, USA). The sample was placed at the probe for measuring the reflection of the light emitted by the spectrometer device. Reflectance values were captured via a computer for further analysis.

Figure 1: Valplast shade guide

Table I: Colour tone guidance according to scores (bright to dark colors)

Color Tone Guide	S1	S2	S3	S4
Score	1	2	3	4

RESULTS

Table II shows the colour changes of the samples after being immersed in tea, coffee, and red wine solutions within the specified period, which were after one day, three days, seven days, 14 days, 21 days, 30 days, 45 days, and 60 days (T1-T8). There were no significant colour changes observed in the samples immersed in the distilled water. However, as expected, some changes have been observed in the samples in other groups.

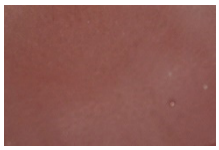
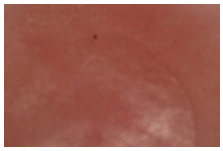
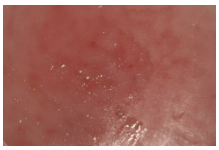
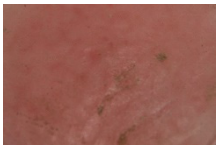
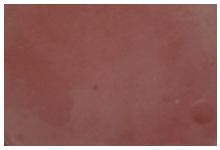
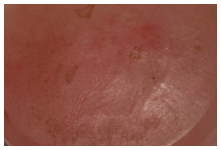
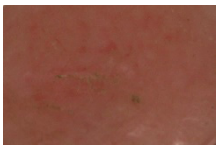
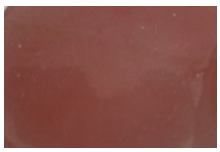
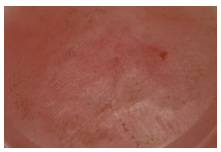
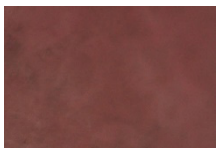
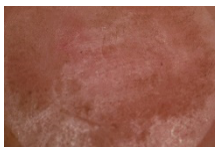
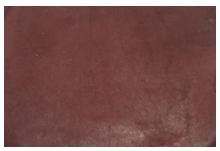
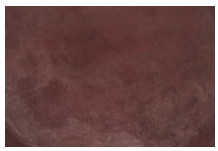
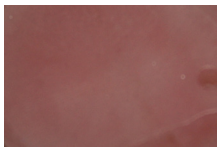
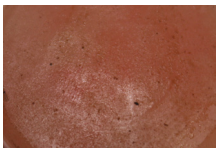
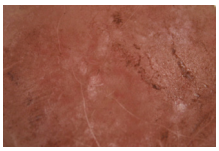
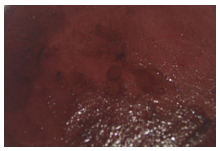
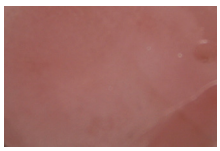
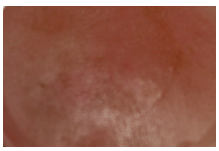
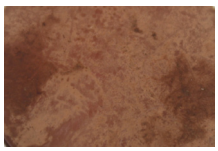
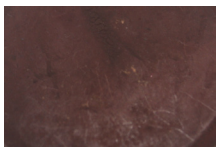
The samples in the coffee solution showed minimal colour changes from day 1 (T1) to day 60 (T8). However, all samples showed a darker shade in terms of colour changes of denture materials from T1-T8, as seen in sample groups of red wine and tea solution. For example, T3 had a lighter colour than T8, which T8 had a longer duration of immersion.

Based on Table II, samples in red wine solution showed the most significant colour changes from the first day (T1) to the sixtieth day (T8). The samples that were immersed in the tea solution showed an intermediate colour change at the beginning as the colour was not as dark as the samples immersed in the red wine solution. However, the sample was getting darker and nearly similar as the sample in red wine solution, as there was an increasing tone on the dentures in tea solution from the first day (T1) to the sixtieth day (T8).

Fig. 2 shows the average score of colour changes on sample sheets of the flexible denture materials recorded using a score basis for the eight samples in each group. The score for each solution was recorded according to the immersion period. The samples immersed in red wine solution recorded the highest mean colour change (2.5), followed by samples immersion from tea solution (1.875) and, coffee solution (1.25) after 60 days of immersion. The least colour change was seen in samples immersed in the distilled water (control) with a score of 1.0 throughout the immersion period. One-way ANOVA test recorded a significant mean difference among all solution samples tested (F stat = 31.979, p-value < 0.001). A further analysis using multiple comparisons (Dunnett Post Hoc test) revealed that the score of the control group was significantly different only when compared with tea and red wine (p-value < 0.001).

Fig. 3 shows the mean light reflection of flexible denture materials versus wavelength after the samples being immersed in the distilled water (control), coffee

Table II: Colour tone changes of the samples according to their immersion period

Period	Distilled Water	Coffee solution	Tea Solution	Red Wine
T1 (24 hour)				
T2 (3 days)				
T3 (7 days)				
T4 (14 days)				
T5 (21 days)				
T6 (30 days)				
T7 (45 days)				
T8 (60 days)				

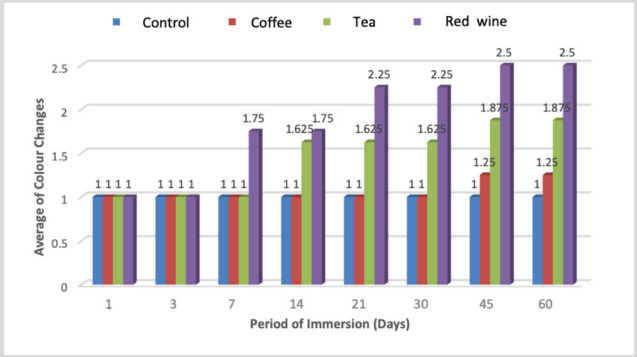


Figure 2: Average colour changes of the flexible denture according to the period of immersion in the specified solution

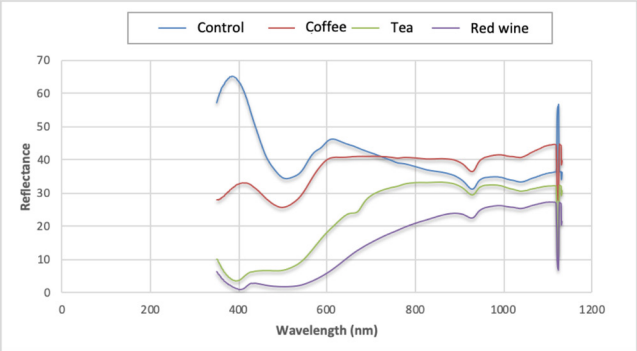


Figure 3: Mean light reflection of flexible denture materials after being immersed in four solutions after 60 days

solution, tea solution and red wine for 60 days. Table III shows the comparison of the peak light reflection of the samples after being immersed in four different solutions. The control solution (distilled water) reaches the highest reflectance value of 65.146, followed by samples immersed in a coffee solution of 31.987, tea solution samples with 4.909, and the red wine solution samples give the lowest reading of light reflection, which is 1.974.

Table III: Mean value of the light reflection of the samples at the peak point after 60 days of immersion

Immersion Solution	Distilled Water	Coffee Solution	Tea Solution	Red wine
Reflection	65.146	31.987	4.909	1.974
Wavelength (nm)	385.19	392.24	377.35	385.97

Based on Fig. 3, the reflectance indicates similar results as observations, as the samples immersion in red wine solution experienced the most significant colour change. The rate of reflection on dark samples is lesser than the light sample. Samples immersed in the red wine solution has the lowest reflectance value, and this is potentially due to the highest staining effect of red wine solution towards the samples.

Table IV shows the mean comparison of days of immersion for each solution. It was found that tea solution and red wine showed a statistically significance different between the days of immersion (p-value < 0.05). However, the Post Hoc analysis of tea solution indicated that there was no significant mean difference

Table IV: Mean of score of the specified solution according to the period of immersion

Immersion Solution	Distilled Water	Coffee Solution	Tea Solution	Red wine
Mean	1.00	1.06	1.45	1.88
Standard deviation	0.000	0.244	0.615	0.934
F-stat	-	2.000	4.415	4.941
p-value*	-	0.071	0.001	<0.001

**One-Way ANOVA test*

of score between each day of immersion. On the other hand, Post Hoc analysis of red wine indicated that there were significant mean differences of score between Day 1 and Day 7, and Day 1 and Day 14, with a similar mean difference of 0.75. Similarly, there was also a significant mean difference of score between Day 3 and Day 7, and Day 3 and Day 14, with a mean difference of 0.75 each.

DISCUSSION

In this study, the staining effect of four types of solutions on a flexible denture material was investigated. The four types of solutions used were tea solution, coffee solution, red wine and distilled water as a control solution. The discolouration on the flexible denture material was observed using visual assessment via a shade guide and quantitative analysis via a spectrometer device. Visual assessment was conducted over a specified period that was 24 hours, three days, seven days, 14 days, 21 days, 30 days, 45 days and 60 days. Eight samples were observed for each solution group. Reflection analysis using a spectrometer was also performed on the same sample over the specified period.

Flexible dentures can experience colour changes after a certain period due to the internal and external factors of the material. Internal factors are closely related to changes in the properties of materials resulting from exposure to temperature and humidity in the oral cavity environment over long periods. The external factor, however, is related to colour change due to the absorption or adsorption properties of the flexible denture material (12).

There have been colour changes observed in the samples, as shown in Table II. The colour of the samples getting darker after more extended immersion period, particularly on the samples immersed in the red wine. Interestingly, samples immersed in tea solution were darker compared to the samples immersed in the coffee solution. Even though the pigment colour of the coffee solution was darker than the tea solution, the results showed otherwise indicating pigment colour of the beverages was not the only factor contributed towards the staining effect on the denture material.

Other possible causes of changes in the colour of the flexible materials include the effects of accumulation of impurities, dehydration, water absorption, penetration

of material components, roughness or abrasion of materials, chemical changes or degradation of materials over time and oxidation (13). Referring to Table II, the samples immersed in a coffee solution appeared as non-uniform staining effect on its surface. The non-uniform staining effect was potentially caused by the accumulation of the solution impurities or chemical changes of the solution over time.

Some previous studies have reported that external factors are the main reason for flexible denture materials having a colour change compared to internal factors (13). Subsequently, a colour stability test attributed to external factors was performed by selecting types of beverages as a flexible toothpaste sample immersion material and observing the colour change resulting from the immersion in the beverages. There have been previous studies on the flexible denture pigmentation caused by absorption or adsorption (13, 14).

It has been reported that acrylic resin and flexible nylon materials show colour stability in water or air (10, 15). However, it loses its colour stability when immersed in drinks such as cola (10). The citric acid substance found in the water-soluble beverage is known to cause brown pigmentation (16). Besides, condensed herbal acids known as proanthocyanidins are found from plant sources such as tea, coffee, pomegranates and seeds and grapes (17). However, the differences in the basal acid content influenced the colour changes on the surface of the flexible materials.

The samples were also observed using the spectrometer to identify the reflectance value. The changes in the reflectance value of the same sample were minimal concerning the period of immersion. However, the difference of the reflectance value is more pronounced when comparing the samples with different types of immersion solution. The graph in Fig. 2 shows that the reflectance value is the lowest in the darker samples. The lowest reflectance is the samples immersed in the red wine, followed by the samples in tea solution, coffee solution and samples in the distilled water. The reflectance results using spectrometer provide similar finding to the visual observations, where the darkest sample of the flexible material samples resulted in the least reflectance value of the light produced by the spectrometer.

From this study, it was found that only tea solution and red wine showed a statistically significant difference in staining effect compared to the control sample. No significant staining effect was observed from the samples immersed in the coffee solution. Red wine caused significant changes at Day 7 and Day 14, as compared to Day 1 and Day 3 indicating prolong exposure of flexible denture to red wine will cause more significant colour changes. In particular, no significant differences were observed in the samples after more extended immersion period of more than 14 days. However, there was no significant difference in colour changes between each day of immersion for the samples immersed in the tea solution.

The flexible denture is worn inside a mouth and expected to be exposed to a variety of foods and drinks, including coloured food and drinks. The colour effect of the food and drink consumed by the denture wearer may attach to the surface of the denture and subsequently change the denture colour tone. For example, flexible resin material will experience colour changes caused by the absorption of coloured beverages such as black coffee and eventually reduce the satisfaction of the denture wearer. Therefore, the evaluation of the colour stability of the flexible denture material is essential to ensure that dental prosthesis is well maintained.

CONCLUSION

Within the limitation of this study, it can be concluded that red wine showed the most significant staining effect on the Valplast flexible denture followed by tea, and coffee, based on visual observation. However, the significant changes can be observed only on the samples immersed in the red wine and tea solution. Besides, increasing immersion period of the denture in staining solution led to the increase in staining effect to the samples. The reflectance results using spectrometer agrees to the finding by visual observations, where the lowest reflectance was on the samples immersed in the red wine, followed by the samples in tea solution, coffee solution and samples in the distilled water. Thus, Valplast flexible denture material is considered suitable to be used in the oral cavity due to its acceptable colour stability. Although there were colour changes observed in the samples, particularly samples that were immersed in the red wine, the changes were only significant after a prolonged period of immersion (Day 7, Day 14). Since the results show that there was a slight change in the colour of the flexible denture due to several types of beverages, the patient may be advised to reduce the frequency of consumption of these drinks to avoid changing the shade of the denture. In addition, good oral hygiene practices are recommended for the denture wearer so that the life expectancy of the denture can be extended. Furthermore, the dentist should take the initiative to increase their patient's awareness about the discolouration of certain beverages that might affect the denture and potential of additional expense for a new set of denture.

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