The effect of Beverages on Color Stability of Highly Impact Acrylic Resin

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ABSTRACT

Aim: To evaluate the effect of beverages (Distilled water ,Artificial orange, Zamzam water, Natural orange, Cola, coffee, and Tea) on the color stability of the highly impact resin. Materials and methods: Total samples of this research were (48) samples of highly impact resin were prepared 30 * 20 * 1.5 mm (length, width and thickness). Six samples were immersed in each type of beverage. The last six sample (control) without any type of beverage (after control group and other beverage groups were evaluated) system. the results of this research were analyzed statistically by ANOVA and Duncan’s multiple range test. Results : There was no significant difference among beverages at immersion time intervals (3 hrs, 9 hrs, 18 hrs, 36.5 hrs, and 73 hrs) immersion time intervals by using (CIE L* a* b*) system. The effect of beverages on color stability of acrylic resin. Al–Rafidain Dent J.; Al-Rafidain Dent J. 2015; 15(1): 329-339.

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INTRODUCTION

Acrylic resin has been introduced in 1937 for construction complete and partial dentures, and had been widely used due to their acceptable esthetic, low permeability in oral fluid and color stability1,2,3). Color was an important property for esthetic evaluation of acrylic resin denture base after exposure to beverages and food4,5,6).

One type of highly impact acrylic resin was prepared by adding the elastomer, to polymethyle methacrylate which act as a plastifying agent, the addition of elastomers to the material increase the ability of absorb energy and over come the possibility of resin fracture1,2,3,7).

Color change of prosthodontic materials might result in patient dissatisfaction and increase the possibility of prosthesis replacement8,9).

Studies demonstrated that coffee, cola, and juice deposite stains on dental materials and resulted in a gloss changes8,9). Increased experimental time period showed a decrease in the gloss of denture acrylic resin10).

Imirzalioglu et al11) found that the color shifts of heat polymerized acrylic, injection molded acrylic, and autopolymerized acrylic were clinically acceptable (ΔE < 3.7) after 30 days of soaking in tea, coffee and nicotine.

Navarro et al12) showed that the staining effect of coffee of two heat cured denture base acrylic (Lucitone 550, Vipircil), and one nylon denture base resin (Transflex) to...
be at a clinically acceptable levels after 30 days of immersion.

The present research was designed to evaluate the effect of beverages (Distilled water, Artificial orange, Zamzam water, Natural orange, Cola, Coffee, and tea) on color stability of highly impact acrylic resin. Also, to evaluate the effect of immersion time on color stability of highly impact acrylic resin.

**MATERIALS AND METHODS**

In this research, the used beverages were Distilled water, Artificial juice (Rani orange, Aujan Industries co., Kingdom of Saudi Arabia), zamam water, natural orange juice, cola, coffee, and tea. 30 gm of tea (Alghazaleen) and 30 gm of coffee powder (Brazilian coffee) were added into one liter of boiling distilled water, then simmered for 5 minutes and filtered through filter paper\(^{(13,14)}\).

Highly impact acrylic (VertexTM-Netherland) was polymerized in water bath at 70°C for 90 minutes and raised to 100°C for 30 minutes according to manufacturers instruction. After deflasking, the samples were abraded on both sides with (600) grit sand paper. A slurry of water and pumice were applied for polishing\(^{(12)}\).

The pH values of beverages were measured by using pH meter device. After cleaning the electrode and calibrating the device, then the pH values of beverages were measured as shown in Table (1).

Table (1) : pH Values of Beverages

| Beverage          | pH   |
|-------------------|------|
| Artificial orange | 2.66 |
| Distilled water   | 7.0  |
| Zamzam            | 7.92 |
| Natural orange    | 2.64 |
| Cola              | 1.84 |
| Coffee            | 5.24 |
| Tea               | 5.71 |

Forty eight samples of acrylic were prepared with dimensions of 30*20*1.5 mm (length, width, and thickness)\(^{(14,15)}\). Six samples were immersed for each type of beverages, the remain six sample being evaluated as a control (after deflaking, finishing, and polishing) with out immersion in beverage.

The samples were converted to digital images by using digital scanner (HP scanner, HP desk jet F 2280). The images were digitized with an input resolution of 1200 pixels per inch\(^{(16)}\). These digital images were prepared with dimension 85 pixels X85 pixels for each sample by soft were program Adobe photoshop 9.0, then these images were saved. Special program were used, operating with in MATLAB to reach direct values of (CIE L*a*b*) for (7225) pixels that were presented in these surface area of image\(^{(17)}\). Each (CIE L*a*b*) for all pixels will be given values, and the result present directly on excel program. The total color change \(\Delta E\) of each sample was calculated using the following formula\(^{(18,19)}\):

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

When no color difference will be detected after its exposure to the testing environment (\(\Delta E = 0\)). \(\Delta E\) value of 3.7 or less was considered to be clinically acceptable\(^{(19)}\).

The protocol of immersion time was as a continues immersion\(^{(20)}\) and was estimated in this research as follows: 3 caps of liquid per day time, 2 minute of each cup through 365 days (3×2×365) equal to 2190 min (36.5 hours per year) so, the immersion time intervals were 3, 9, 18, 36.5 and 73 hours represent 1, 3, 6, 12, and 24 months respectively.

The following statistical methods were used to analyze and assess the results with SPSS V 11.5 for windows, descriptive statistics include mean ± standard deviation values, ANOVA and Duncan multiple range test were used. The statistical results were considered significant at P≤0.05.

**RESULTS**

In this research, the scanner image was used because it could be used to digitally evaluate color change of dental materials with (CIE L*a*b*) system\(^{(15,16)}\). Color change (\(\Delta E\)) measurements of
Color Stability Of Highly Impact Acrylic Resin

highly impact resin in comparison among beverages (Figures 1-5) demonstrated the mean ± standard deviation values and Duncan’s multiple range test of color change ΔE.

Figure (1) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among beverages at 3hrs of immersion

Figure (2) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among beverages at 9hrs of immersion

Figure (3) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among beverages at 18 hrs of immersion
The one way analysis of variance (ANOVA) as shown in (Table 2) demonstrated that there was no significant differences among beverages at immersion time intervals (3 hrs, 9 hrs, 18 hrs, and 73 hrs) except at (36.5 hrs) there was a significant difference among beverages where the lowest color change, showed with cola that significantly not differ from Zamzam water (Figure 4).

Figure (4) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among beverages at 36.5 hrs of immersion

Figure (5) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among beverages at 73 hrs of immersion
The explanation of this results might due to low pH of cola (pH – 1.84) that cause solubility of the resin and later, absorption might take place with increasing immersion time. The very high acidity of the solution leads to an increase in water sorption(21). The equilibrium between solubility and absorption processes resulting in decreasing the color change(13). Zamzam water was alkaline (pH = 7.92) and characterized by the presence of metals, cations and anions(22), resulting in a difference in color change from that of distilled water (pH = 7.0).

Color change (ΔE) measurements of highly impact resin in comparison among immersion time intervals (Figures 6-12) demonstrated the mean ± standard deviation values and Duncan’s multiple range test of color change (ΔE).

### Table (2) : Analysis of variance (ANOVA) for comparison of color change ΔE among different types of beverage

| Time | SOV        | SS   | df | MS   | F-value | p-value |
|------|------------|------|----|------|---------|---------|
| 3 Hr | Between Groups | 73.589 | 6  | 12.265 | 1.193   | 0.333   |
|      | Within Groups  | 359.961 | 35 | 10.285 |         |         |
|      | Total        | 433.550 | 41 |       |         |         |
| 9 Hrs| Between Groups | 10.469 | 6  | 1.745  |         |         |
|      | Within Groups  | 110.891 | 35 | 3.168  | 0.551   | 0.766   |
|      | Total        | 121.360 | 41 |       |         |         |
| 18 Hrs| Between Groups | 31.336 | 6  | 5.223  | 1.174   | 0.342   |
|      | Within Groups  | 155.718 | 35 | 4.449  |         |         |
|      | Total        | 187.054 | 41 |       |         |         |
| 36.5 Hrs| Between Groups | 50.309 | 6  | 8.385  | 2.451   | 0.044*  |
|       | Within Groups  | 119.758 | 35 | 3.422  |         |         |
|       | Total        | 170.067 | 41 |       |         |         |
| 73 Hrs| Between Groups | 52.821 | 6  | 8.804  | 2.266   | 0.059   |
|      | Within Groups  | 135.979 | 35 | 3.885  |         |         |
|      | Total        | 188.800 | 41 |       |         |         |

SOV: Source of variance; SS: Sum of squares; MS: Mean square; df: Degree of freedom.
* indicated significant difference at p < 0.05.
Figure (7) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among immersion time intervals for distilled water

Figure (8) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among immersion time intervals for zamzam water

Figure (9) : Mean ± SD and Duncan’s multiple range test of color change ΔE for comparison among immersion time intervals for natural orange
Color Stability Of Highly Impact Acrylic Resin

The one way analysis of variance (ANOVA) as shown in (Table 3) demonstrated that there was no significant difference among immersion time intervals for different types of beverages (Artificial orange, Distilled water, Zamzam water, Natural orange, Cola, Coffee, and Tea).
### Table (3) : Analysis of variance (ANOVA) for comparison of color change ΔE among different types of beverage

| Time       | SOV          | SS       | df | MS   | F-value | p-value |
|------------|--------------|----------|----|------|---------|---------|
| Artificial Orange Between Groups | 19.596 | 4 | 4.899 | 0.818 | 0.526 |
| Artificial Orange Within Groups | 149.653 | 25 | 5.986 |        |         |
| Artificial Orange Total | 169.249 | 29 |      |        |         |
| Distilled Water Between Groups | 17.346 | 4 | 4.337 | 1.513 | 0.229 |
| Distilled Water Within Groups | 71.634 | 25 | 2.865 |        |         |
| Distilled Water Total | 88.980 | 29 |      |        |         |
| Zamzam Between Groups | 16.832 | 4 | 4.208 | 1.296 | 0.298 |
| Zamzam Within Groups | 81.167 | 25 | 3.247 |        |         |
| Zamzam Total | 97.999 | 29 |      |        |         |
| Natural Orange Between Groups | 9.639 | 4 | 2.410 | .613  | 0.657 |
| Natural Orange Within Groups | 98.318 | 25 | 3.933 |        |         |
| Natural Orange Total | 107.957 | 29 |      |        |         |
| Cola Between Groups | 73.344 | 4 | 18.336 | 1.622 | 0.200 |
| Cola Within Groups | 282.618 | 25 | 11.305 |        |         |
| Cola Total | 355.962 | 29 |      |        |         |
| Coffee Between Groups | 12.345 | 4 | 3.086 | 0.701 | 0.599 |
| Coffee Within Groups | 110.121 | 25 | 4.405 |        |         |
| Coffee Total | 122.466 | 29 |      |        |         |
| Tea Between Groups | 12.864 | 4 | 3.216 | 0.905 | 0.476 |
| Tea Within Groups | 88.797 | 25 | 3.552 |        |         |
| Tea Total | 101.661 | 29 |      |        |         |

SOV: Source of variance; SS: Sum of squares; MS: Mean square; df: Degree of freedom.

To measure color changes of highly impact resin, color change (ΔE) comparison between control group (without immersion) and other groups was shown in (Table 4).
Artificial orange, Distilled water, and Natural orange groups showed an accepted ($\Delta E$) values in vitro after (3 hrs, and 9 hrs) of immersion and then converted to unaccepted ($\Delta E$) values with increasing immersion time intervals (18 hrs, 36.5 hrs, and 73 hrs). The unaccepted ($\Delta E$) values associated with increasing immersion time might due to increase water sorption which affect the degree of color change\(^{(16)}\) because water sorption develop some change in visual appearance\(^{(20)}\). The erosive activity of citric acid that present in Artificial orange juice (pH = 2.66) and natural orange juice (pH = 2.64) might play a role in increasing color change ($\Delta E$) with increasing immersion time intervals\(^{(23, 24)}\).

Table (4) : Color change $\Delta E$ between control group and other beverage groups

| Time   | SOV          | SS            | df      |
|--------|--------------|---------------|---------|
| 3 Hrs  | Artificial orange | 2.7150214     | Accepted|
|        | Distilled water    | 2.21500900    | Accepted|
|        | Zamzam          | 2.19777261    | Accepted|
|        | Natural orange   | 3.40813775    | Accepted|
|        | Cola            | 5.97688046    | Unaccepted|
|        | Coffee          | 4.50446044    | Unaccepted|
|        | Tea             | 4.65746991    | Unaccepted|
|        | Artificial orange | 2.48562833    | Accepted|
|        | Distilled water    | 2.91202986    | Accepted|
|        | Zamzam          | 4.2146931     | Unaccepted|
| 9 Hrs  | Natural orange   | 3.25185107    | Accepted|
|        | Cola            | 3.09894761    | Accepted|
|        | Coffee          | 3.54181787    | Accepted|
|        | Tea             | 3.35132736    | Accepted|
|        | Artificial orange | 4.39822064    | Unaccepted|
|        | Distilled water    | 3.79544411    | Unaccepted|
|        | Zamzam          | 3.94215295    | Unaccepted|
| 18 Hrs | Natural orange   | 4.40538591    | Unaccepted|
|        | Cola            | 1.93118071    | Accepted|
|        | Coffee          | 4.31372002    | Unaccepted|
|        | Tea             | 4.69303309    | Unaccepted|
|        | Artificial orange | 4.27528225    | Unaccepted|
|        | Distilled water    | 4.35366683    | Unaccepted|
|        | Zamzam          | 3.02090021    | Accepted|
| 36.5 Hrs | Natural orange  | 4.68261597    | Unaccepted|
|        | Cola            | 1.99500953    | Accepted|
|        | Coffee          | 5.18020098    | Unaccepted|
|        | Tea             | 5.18997560    | Unaccepted|
|        | Artificial orange | 3.98207094    | Unaccepted|
|        | Distilled water    | 3.90318768    | Unaccepted|
|        | Zamzam          | 2.76049099    | Accepted|
| 73 Hrs | Natural orange   | 4.25718138    | Unaccepted|
|        | Cola            | 1.90373758    | Accepted|
|        | Coffee          | 5.31700963    | Unaccepted|
|        | Tea             | 5.07440180    | Unaccepted|

$* \Delta E \leq 3.7$ color change accepted in vitro
Color change (ΔE) after immersion in coffee and tea showed unaccepted values at all immersion time intervals except at (9 hrs) of immersion were the values of ΔE (3.54 and 3.35) for coffee and tea respectively. Generally, the unaccepted value of ΔE after immersion in coffee and tea might due to the discoloration effect of coffee and tea beverages and accumulated layers of stain from coffee and tea (25). The unaccepted values of color change (ΔE) associated with coffee was agreement with Rejab study (16). The unaccepted values of color change (ΔE) associated with tea was agreement with AlTahho study (14). The unaccepted values of ΔE associated with coffee and tea were disagreement with the findings of imirzalioglu et al., (11) who found that the color change (ΔE) of heat polymerized acrylic was accepts up to 30th days of storage in coffee and tea. The difference of findings of present research from Imirzalioglu et al., was due to the different strategy of test work between the two researches. In the present research the control group (without immersion) after deflasking, finishing and polishing while the control group in imirzalioylu et al., research was immersed in saliva. In addition to the difference in immersion time between the two researches. The immersion time in the present research up to 24 months while in Imizalioglu et al., research was up to one month.

The values of color change (ΔE) after immersion in Cola were accepted for all immersion time intervals except at (3 hrs) of immersion where ΔE value was unaccepted, which might due to high acidity of Cola (pH = 1.84) that cause solubility of resin resulting in unaccepted color change and with increasing the immersion time, absorption might take place. The equilibrium between two processes of solubility and absorption might decrease the color change (ΔE) within accepted values (13).

The values of color change (ΔE) after immersion in Zamzam water was accepted (ΔE) after (3 hrs) of immersion and became unaccepted after (9 hrs, and 18 hrs) of immersion and with increasing immersion time intervals to (36.5 hrs, and 73 hrs) would return to accepted values. This behavior of color change associated with Zamzam water (pH = 7.92) differ from that color change (ΔE) associated with distilled water (pH = 7.0) might due to the presence of metals, cations and anions in composition of Zamzam water (22).

CONCLUSIONS
Among beverages coffee and tea showed unaccepted value of ΔE at all immersion time intervals except at (9 hrs) while cola showed an accepted values of ΔE except at (3 hrs) of immersion where ΔE value was unaccepted.

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Color Stability Of Highly Impact Acrylic Resin

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