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ORIGINAL RESEARCH

Color Stability of Restorative Materials in Response to Arabic Coffee, Turkish Coffee and Nescafe

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ABSTRACT

Objective: To evaluate the effect of Arabic coffee, Turkish coffee and Nescafe on the color stability of four different composite resins after a period of aging time 1, 7 and 30 days.

Materials and methods: Twenty specimens from each type of tested composite resin material were prepared. Five specimens from each tested material (Z350 XT, Artist, GC and Z250) was evaluated after storage in Arabic coffee, Turkish coffee, Nescafe and distil water (control) at 37°C in a dark container for 1, 7 and 30 days. Color measurement was done using colorimeter based on the CIE L* a* b* color scale. Color differences ΔE^*_{ab}, Δb^* and Δa^* among specimens immersed in distil water and staining coffee beverages were evaluated overtime. Mean values were statistically analyzed with one-way analysis of variance (ANOVA), followed by Tukey test with $p < 0.05$ as significance level.

Results: All tested composite resins showed increase color change after a period of 1, 7 and 30 days. The color change ΔE^*_{ab} , Δb^* and Δa^* exhibited by Arabic coffee, in Turkish coffee and Nescafe except Δa^*. The highest total color difference ΔE^*_{ab} after 30 days was in group A Arabic coffee ($\Delta E > 1.5$ perceivable) and not perceivable in group B Turkish coffee and group C Nescafe. For Δb^* all materials discolored toward yellowness after 30 days except Arabic coffee group which shifted from yellowness toward blueness ($\Delta b^* > 1.5$ perceivable).

Conclusion: The effect of staining beverages on the resin composite materials increases with time of aging toward yellowness and not perceivable in all groups except with Arabic coffee which had highest effect after 30 days and the discoloration shifted from yellowness to blueness perceivable.

Keywords: Arabic coffee, Artist, Z350 XT, Composite resins, Beverages, Turkish coffee.

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INTRODUCTION

Color, translucency and opalescence are optical properties that give a natural tooth its vital-looking appearance.[1,2] Clinical performance of dental resin composites has been significantly improved over last decades through innovations of nanofillers to produce adequate strength and excellent wear resistance along with retaining translucency, development of stable polymerization promoters to enhance color stability; reduction of polymerization shrinkage to improve marginal adaptation and to prevent recurrent caries. Application of nanotechnology contributed most important role since last few years. Dental resin composites with nanofillers (1-50 nm) showed increased strength, surface smoothness and gloss, and decreased polymerization shrinkage while maintaining low viscosity.[3] However, there is still controversy regarding the effect of Nanofillers on the color stability of resin composites.[4-9] Although, it is generally regarded that reduced filler size would increase the resistance to discoloration,[7] But one of the recent study indicated that the filler size did not affect the color stability.[8] Meanwhile, it was reported that the type of dental resin composites such as nanohybrid, microhybrid and hybrid significantly affected the color stability[9] and hybrid resin composites showed better color stability than nanofilled resin composites.[5,6,10] One of the apparent problems stems from the fact that there are greater propensities in these materials to stain or loose their color overtime and to accumulate plaque.[1,10] Clinical trials investigated that the color stability of dental resin composites not remain stable even after 1 to 2 years, and visible color change occurred.[1,11,12] Therefore discoloration was one of the main reasons for the replacement of resin composite restorations.[11,12] Color changes of dental resin composites were due to exogenous or endogenous reasons.[1] Since, dental resin composites showed clinically acceptable or unacceptable discolorations based on color stability tests, it was concluded that the resistance of modern dental resin composites to discolorations still depended on their structures, compositions and manipulations.[4-7] It is well known that beverages such as tea, coffee, wine and some artificial dyes used in food may increase the discoloration of dental resin composites.

To determine and quantify the changes in the color of dental materials, an understanding of color space and differential colorimetry is required. Current photometric and calorimetric instruments are capable of reliably quantifying the color of acrylic resin specimens.[13] Photometric and colorimetric instruments measure color and express it in terms of three coordinate values (L*, a*, b*), which locate the object's color within the CIELAB color space.[14] The L* coordinate represents the brightness of an object, the a* value represent the red or green chroma, and the b* value represents the yellow or blue chroma. The color difference (ΔE) of two objects can then determine by comparing the differences between respective coordinate values for each object.[15,16]

The magnitude of the color difference is based on the human perception of color. It was previously reported that color differences greater than 1ΔE unit are visually perceivable by 50% of human observers. Besides, under uncontrolled clinical conditions, such small differences in color would be unnoticeable, as average color differences below 3.7 are rated a 'match' in clinical conditions.[16]

MATERIALS AND METHODS

Four different solutions (beverages), Arabic coffee, Turkish coffee, Nescafé and distilled water as control were evaluated and their effects on stainability of Filtek Z350 XT nanofiller Artist nanocomposite, GC Fuji II LC Capsule and Filtek Z250 (3M ESPE, products D-82229 Seefeld- Germany) restorative materials were, aged for 1, 7 and 30 days and stored at 37°C. The restorative materials and staining agents used in this study are shown in Table 1. Eighty specimens of restorative materials were prepared in which five specimens for each material of different aging beverages in groups.

All specimens of the materials were dispended, manipulated, and polymerized according to the manufacturer's instructions. Teflon molds, measuring 6 mm internal diameter and 3 mm height were used to produce the specimens. A glass microscope slide, overlaid with a cover glass 22 × 22 mm (BDH Borosilicate glass) to act as a separator, was placed at each open end of the mold. Their dual function was to provide compaction of the materials into a flat surface and to act as a separator between the mold and the glass microscope slide. The layering technique was employed, especially in the preparation of the specimens of the light-activated dental restorative materials. This technique entailed incremental filling of the mold and compacting with a plastic spatula, after which the restorative material was irradiated with a 20s pulse from a light-curing unit LED light emitting diode. The mold was completely filled with the material using this step-wise method, and was irradiated at each stage with 40s light pulses, with the light tip approximately 1 mm away from the specimens were kept dry at room temperature until all specimens were fabricated.

For the purpose of surface standardization, all specimens were polished to obtain a clinical finish while in the Teflon disk, with 3M Sof-Lex disks. The specimens while in the Teflon disk were labelled and stored in a 25 ml HDPE wide mouth bottled filled with distilled water at 37°C for 24 hours (Bibby Sterilin Ltd, Stone, Staffs., England). The rehydration simulated the first day of service for provisional restorations in the oral environment. It is known that the type of materials used in this study imbibe most of the water during the first day of immersion.[17]

A standard solution of aging medium (beverages) was prepared for all groups from 10 gm of a commercial brand in 100 ml of boiled distilled water for 5 minutes according to the suggestion of manufacturers and then solution was allowed to cool. Among the solution of all groups, group A, was Arabic coffee, group B Turkish coffee, group C Nescafe and group D distil water (control).

Table 1: The restorative materials and staining agents used in this study

Materials	*Type*	*Shade*	*Manufacturer*
Z350 XT	Nanocomposite	A_2	3M ESPE Dental Products D-82229 Seefeld – Germany.
Artiste	Nanocomposite	A_2	1717 West Collins Ave Orange, CA 92867203-265-7397.
GC	Resin reinforced glass ionomer	A_2	GC Corporation 76-1 Hasunuma-cho, Itabashi, Tokyo 174-8585, Japan.
Z250	Nanocomposite	A_2	Tetric EvoCeram D-82229 Seefeld-Germany
Beverage	*Composition*		*Manufacturer*
Arabian coffee	Harare coffee, cardamom and cloves		Al Amjaad Establishment, PO Box 8707, Jeddah 21492, Kingdom of Saudi Arabia
Turkish coffee	Roasted arabica coffee		Al Amjaad Establishment, PO Box 8707, Jeddah 21492, Kingdom of Saudi Arabia
Nescafe	Coffee		Nestle

All the specimens were immersed in the beverages of different groups to evaluate the color stability of the restorative materials at different time interval. The 20 specimens of the each 4 restorative materials were immersed in the solution of the groups A, B, C and D (control), for the periods of 1, 7 and 30 days at 37°C.

The colors of all specimens immersed in different four groups were measured before exposure (baseline) with a colorimeter (Minolta CR; Minolta Co, Osaka, Japan) using CIE (Commission International de 1Eclairage)[18] L* a *b* relative to standard illuminate A, against a white background. Since color differences were being tested, the choice of the illuminate was not important. Before each measurements session, the colorimeter was calibrated according to the manufacturers' recommendations by using the supplied white calibration standard. L* refers to the lightness coordinate, and its value ranges from zero (black) to 100 (white). The a* and b* are chromaticity coordinates in the red-green axis and the yellow-blue axis, respectively. Positive a* values indicate a shift to red, and negative values indicate a shift to green. Similarly, positive b* values indicate the yellow color range, and negative values indicate the blue range.

Following the removal of the specimens from the aging solutions in all groups, they were dipped in a cleansing solution, consisting of 10 ml soap and 700 ml distilled water, moved up and down 10 times, and subsequently flushed with running tap water. Then the specimens were dipped in distilled water and rinsed by moving them up and down 10 times. Excess fluid on the surface was removed using a tissue paper. After color measurements at the time intervals indicated, the specimens were reimmersed in fresh solutions.

Measurements were repeated 5 times for each specimen, the color measurement was done at baseline (before) and at a time intervals of 1, 7 and 30 days. However, the coffee manufacture purports that the average time for consumption of 1 cup of a drink is 15 minutes, and among coffee drinkers, average consumption of coffee is 3.2 cups per day. Therefore, 1 day storage time simulated consumption of the drink over 1 month, therefore, the time periods of storage in the groups at this study simulates 1, 7 and 30 months.

And the mean values of the ΔL*, Δa*, and Δb* data were calculated. The color difference ΔE^*_{ab} was calculated from the mean ΔL*, Δa*, and Δb* values for each specimen using the following formula.[19-21]

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

Where, ΔL*,Δa*, and Δb* are the differences in L* a* and b* values before and after immersion at each time interval. The mean estimated from the specimens of the materials aged with the beverages groups at different interval times were statistically analyzed. Mean values of the different groups at different aging times were compared using one-way analysis of variance and multiple comparisons of the mean values were done with Tukey test. In present study, $p < 0.05$ was considered as the level of significance.

RESULTS

The mean values of color changes ΔE^*_{ab}, Δb* and Δa* for all materials aged in a period of 1, 7 and 30 days after exposure to the different types of coffee Arabic, Turkish, Nescafe and distal water as control are summarized in Tables 2 to 5 and graphically represented in Graphs 1 to 9.

Table 2: Total color difference of materials in a period of time due to aging with Arabic coffee

Materials	*Total color diff. in 1 day*	*Total color diff. in 7 days*	*Total color diff. in 30 days*	*Significant level*
		*ΔE*ab*		
Z350 XT	0.24	0.61	2.90	p < 0.00 HS
Artist	0.13	0.51	2.83	
GC	0.25	0.55	3.27	
Z250	0.26	0.65	2.92	
		*Δb**		
Z350 XT	0.09	0.27	–1.84	p < 0.00 HS
Artist	0.03	0.13	–2.06	
GC	0.19	0.44	–2.08	
Z250	0.05	0.22	–1.94	
		*Δa**		
Z350 XT	–0.23	–0.47	–0.06	p = 0.001 HS
Artist	–0.12	–0.30	0.15	
GC	–0.16	–0.33	0.32	
Z250	–0.24	–0.48	–0.04	

HS: Highly significant

Table 3: Total color difference of materials in period of time due to aging with Turkish coffee

Materials	*Total color diff. in 1 day*	*Total color diff. in 7 days*	*Total color diff. in 30 days*	*Significant level*
		ΔE*ab		
Z350 XT	0.71	0.88	1.63	p = 0.004 S
Artist	0.57	0.57	1.41	
GC	0.80	1.08	1.29	
Z250	0.87	0.80	1.07	
		Δ*b**		
Z350 XT	0.44	0.66	1.06	p = 0.001 S
Artist	0.26	0.38	0.72	
GC	0.45	0.67	0.90	
Z250	0.33	0.65	0.95	
		Δ*a**		
Z350 XT	0.03	0.03	0.97	p = 0.154 NS
Artist	0.06	0.10	1.17	
GC	0.07	0.16	0.09	
Z250	0.04	0.03	–0.09	

S: Significant; NS: Not significant

Table 4: Total color difference of materials in period of time due to aging with Nescafe

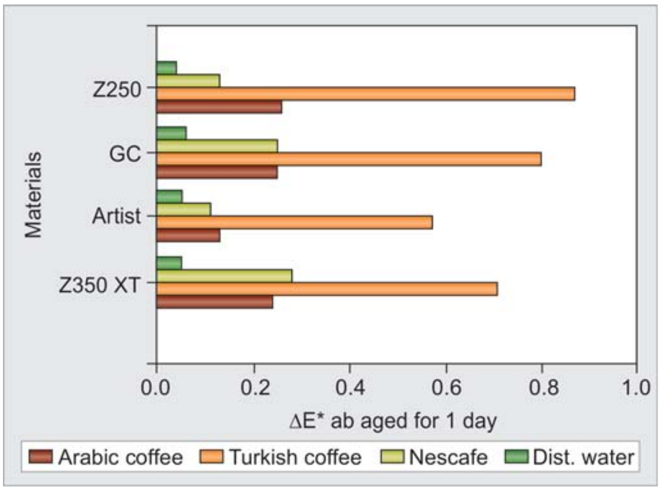
Materials	*Total color diff. in 1 day*	*Total color diff. in 7 days*	*Total color diff. in 30 days*	*Significant level*
		ΔE*ab		
Z350 XT	0.28	0.40	0.67	p < 0.000 HS
Artist	0.11	0.29	0.59	
GC	0.25	0.38	0.68	
Z250	0.13	0.29	0.58	
		Δb*		
Z350 XT	0.20	0.37	0.64	p < 0.000 HS
Artist	0.11	0.22	0.53	
GC	0.20	0.36	0.50	
Z250	0.11	0.25	0.49	
		Δa*		
Z350 XT	–0.05	–0.15	–0.20	p = 0.750 NS
Artist	–0.01	–0.04	–0.13	
GC	0.04	0.05	0.19	
Z250	–0.07	–0.10	–0.22	

HS: Highly significant; NS: Not significant

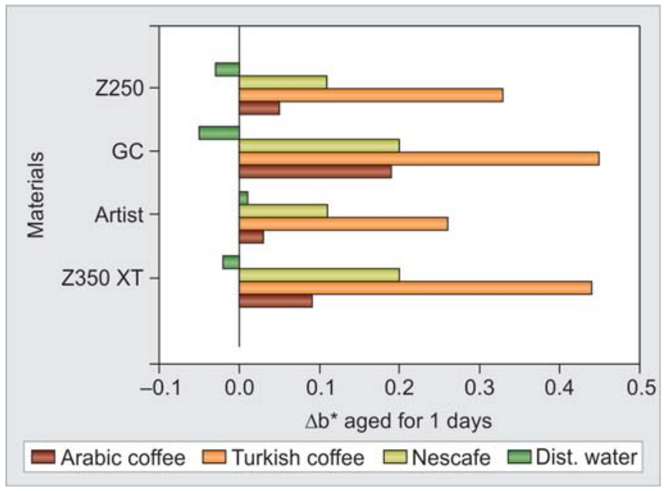
Table 5: Total color difference of materials in period of time due to aging with dist. water

Materials	*Total color diff. in 1 day*	*Total color diff. in 7 days*	*Total color diff. in 30 days*	*Significant level*
		ΔE*ab		
Z350 XT	0.05	0.09	0.12	p = 0.025 S
Artist	0.05	0.08	0.13	
GC	0.06	0.12	0.23	
Z250	0.04	0.10	0.12	
		Δ*b**		
Z350 XT	–0.02	–0.03	–0.05	p = 0.038 S
Artist	0.01	–0.02	0.07	
GC	–0.05	–0.07	–0.08	
Z250	–0.03	–0.05	–0.07	
		Δ*a**		
Z350 XT	–0.02	–0.04	–0.06	p < 0.000 HS
Artist	–0.04	–0.05	–0.07	
GC	–0.03	–0.04	–0.08	
Z250	–0.03	–0.06	–0.07	

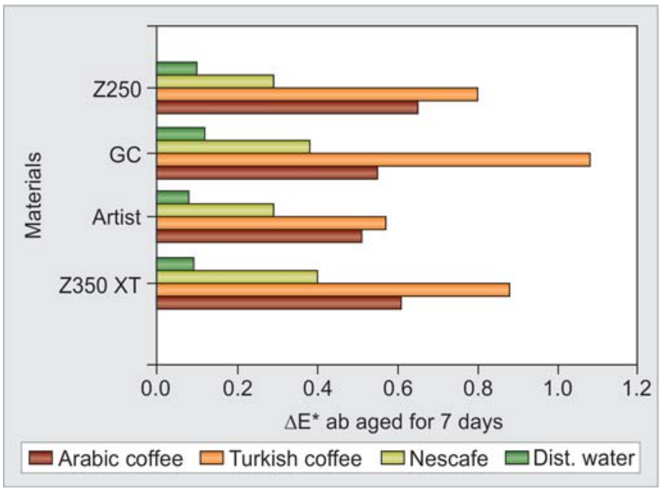
S: Significant; HS: Highly significant



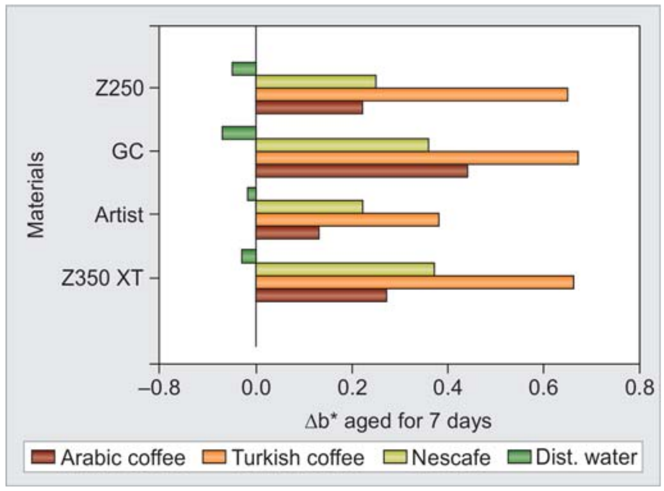
Graph 1: Total color difference (DE*ab) for the resin composites exposed to different beverages for 1 day



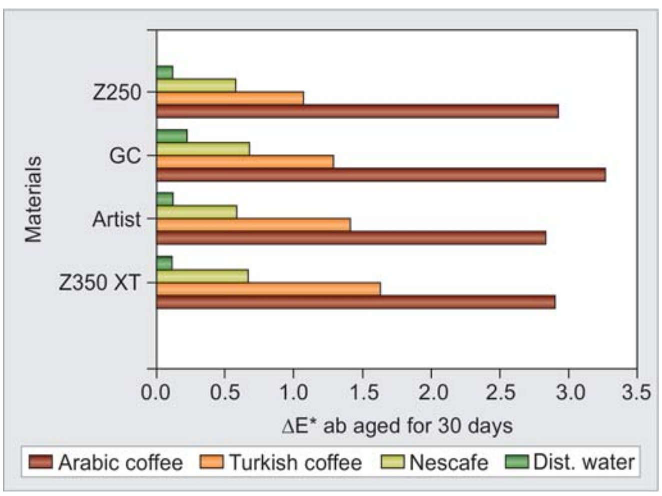
Graph 4: Yellowness and blueness of the resin composites aged for 1 day with different beverages



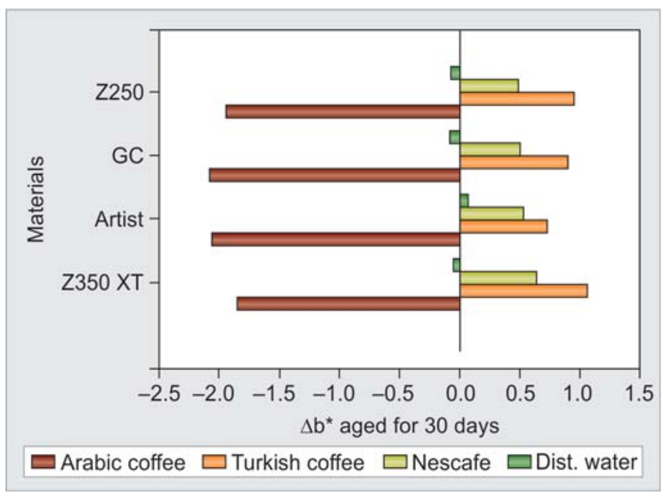
Graph 2: Total color difference (DE*ab) for the resin composites exposed to different beverages for 7 days



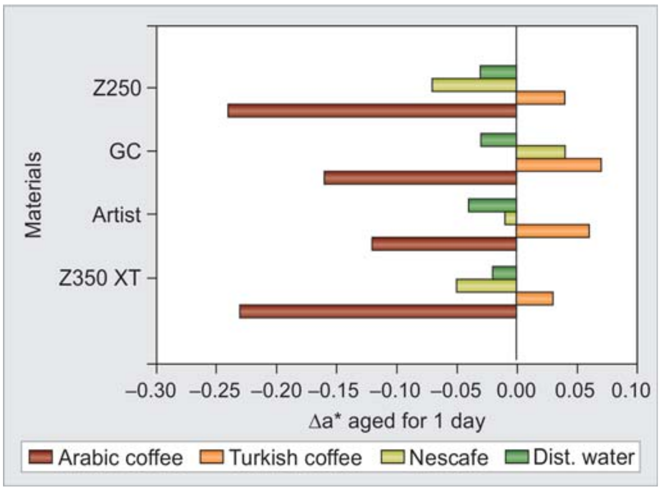
Graph 5: Yellowness and blueness of the resin composites aged for 7 days with different beverages



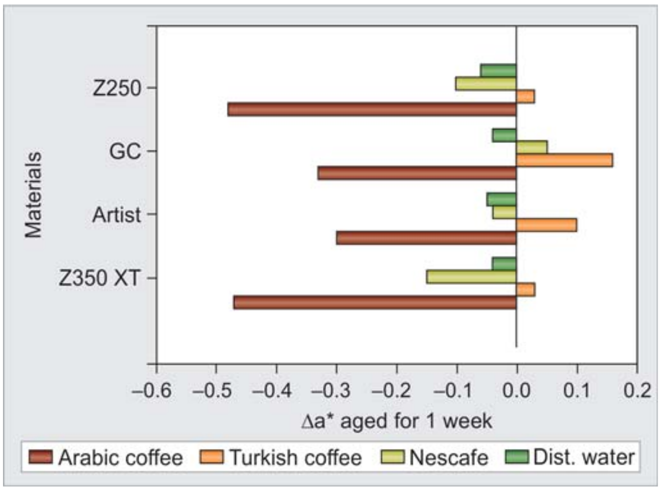
Graph 3: Total color difference (DE*ab) for the resin composites exposed to different beverages for 30 days



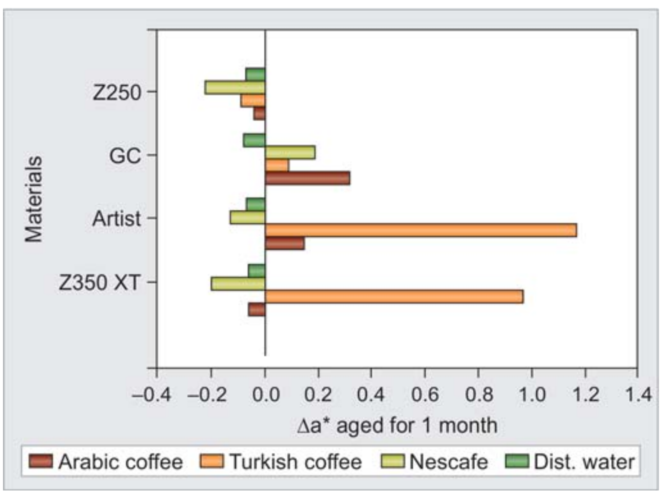
Graph 6: Yellowness and blueness of the resin composites aged for 30 days with different beverages



Graph 7: Redness and greenness of the resin composites aged for 1 day with different beverages



Graph 8: Redness and greenness of the resin composites aged for 7 days with different beverages



Graph 9: Redness and greenness of the resin composites aged for 30 days with different beverages

The total color differences ΔE^*_{ab}, Δb^* and Δa^* for all materials in a period of 1, 7 and 30 days with the three different types of coffee, Arabic, Turkish, Nescafe and distal water as control were analyzed statistically using one-way analysis of variance (ANOVA) followed by the Tukey multiple comparison tests, and found significant differences in color changes between materials at the three different aging period of times for each groups ($p < 0.05$), except for the Δa^* in the group B Turkish coffee and group C Nescafe ($p > 0.05$) (Tables 2 to 5).

The color changes of the materials in a period of 1, 7 and 30 days exhibited by all groups A, B, C and D (control) was significantly different. The total color differences ΔE^*_{ab} shows that all materials discolored with aging groups and the total color difference ΔE^*_{ab} increase with the increasing of the aging time (Graphs 1 to 3). In 1 day period, the highest value of ΔE^*_{ab} was with group B Turkish coffee for all the materials and the highest value was with Z250. The lowest ΔE^*_{ab} was in the group C Nescafe with the Z250 material. Where in the 7 day of aging period the ΔE^*_{ab} value was the highest with group B Turkish coffee and the GC materials was having the highest value ($p < 0.004$), where as the lowest ΔE^*_{ab} was in group C Nescafe with Artist material ($p < 0.000$). In the period of 30 days of aging the highest ΔE^*_{ab} was in the group A Arabic coffee where all the materials were highly discolored and clinically un acceptable, the GC material showed high value with Arabic coffee ($p < 0.00$).

The color stability of the four composite specimen materials preaging with the initial measurement, are also different from those postaging with the final measurement (ΔE_{ab}), which reflects discoloration of the materials (Graphs 1 to 3). Δb^* (change along yellow-blue axis) values, the b* value, which represented the chroma value (+) yellowness and (–) blueness is derived from $b^* = b_f^* - b_i^*$. Where b_f^* = Final measurements postaging at specific condition (group), and b_i^* = initial measurement preaging at a specific condition in group.

A significant change was observed for all the materials after 1, 7 and 30 days period of aging ($p < 0.05$) in all groups. Positive Δb^* indicates a shifts toward yellow color whilst negative Δb^* denotes a shift toward blue color. After 1day of aging all groups showed positive Δb^* discoloration toward yellow axis and the highest material was GC, Z350 XT. In group B Turkish coffee, the Artist material was having the highest effect of discoloration after 1 day of aging, except in the group D distal water the GC, Z250 and Z350 XT showed toward blue axis (Graph 4). After 7 days of aging all groups A Arabic coffee, group B Turkish coffee and group C Nescafe increased shifting toward yellow axis

(Δb* positive) and the highest effect on the materials was with group B Turkish coffee where the GC, Z350 XT and Z250 were the highest discoloration, the group D distal water control toward blue axis (low values) as in Graph 5.

After 30 days of aging a maximum changes in Δb* for all materials were seen in group A, Arabic coffee. However, the effect of the Arabic coffee was the highest on color stability of all materials, where all materials in group A aged with Arabic coffee after 1 and 7 days Δb* was increased toward yellow axis (positive Δb*) with the increase of the aging time. While the time of aging increase to 30 days all materials in group A Arabic coffee had shifted from yellowness (positive axis) towards high values in blue nice (negative axis) and the highest Δb* was as follows GC, Artist, Z250 and Z350 XT (Δb* >1.5 preseivable) statistically highly significant ($p < 0.00$), but in group B Turkish coffee Δb* increased toward yellow axis and the highest value was seen in Z350 XT, Z250, GC and Artist ($p < 0.001$). The Δb* for the materials in group C Nescafe was increased to yellowness axis and the highest value was in Z350 XT and the lowest value was in Z250 ($p < 0.00$). (Graph 6).

The significant change was observed only in group A, Arabic coffee for all the materials after 1, 7 and 30 days period of aging ($p < 0.001$). While in group B Turkish coffee ($p = 0.154$) and in group C Nescafe ($p = 0.750$) there was no significant changes observed for all materials after all aging time. Positive Δa* indicates a shifts towards red color whilst negative Δa* denotes a shift towards green color. After 1 and 7 days of aging group A Arabic coffee (except GC toward positive axis) and group C Nescafe showed negative Δa* discoloration toward green axis where group B Turkish coffee showed positive Δa* discoloration toward red axis increasing with the time of aging, and the highest value materials in group A Arabic coffee Z250, Z350 XT, GC and Artist and in group C Nescafe Z350 XT, Z250 and artist increasing toward negative green except GC toward positive red axis. The group B Turkish coffee increasing toward positive red axis and the GC was the highest value (Graphs 7 and 8).

While the time of aging increase to 30th days materials GC and Artist in group A Arabic coffee had shifted from the green negative axis to red positive axis and the highest Δa* was as follows GC and Artist, except the Z350 XT and Z250 was decreased in high values of the green negative axis statistically highly significant ($p < 0.001$), but in group B Turkish coffee Δa* increased towards red axis except Z250 (negative green) and the highest value was seen in Artist, Z350 XT and GC ($p < 0.001$). The Δa* for the materials in group C Nescafe was increased to green axis except GC to red axis and the highest value was Z250 and the lowest value was Artist. The control group D distil water all the materials were increased in small value to green negative axis (Graph 9).

DISCUSSION

Color plays an important role in obtaining optimum esthetics. The major disadvantage of resin composites is their color instability which may be a major cause for replacement of restorations.[22] The color stability of a resin composites is related to the resin matrix, dimensions of filler particles, depth of polymerization and coloring agents.[23]

Liberman et al,[24] demonstrated that the eye can detect changes in Δb* values greater than 1.5 in acrylic denture base specimens. Where Δb* value represents the yellow-blue axis, any change in b* value is important and significant, due to the yellow color of the photo initiator in the visible light-cured composite resins. Discoloration can be evaluated with various instruments. Since, instrument measurements eliminate the subjective interpretation of visual color comparison, colorimeters and spectrophotometers have been used to measure color change in dental materials.[25] The CIE Lab systems for measuring chromacity was chosen to record color differences because it is well suited for determination of small color differences.[26] When measuring reflective surfaces, the measured color will depended on both the actual colors of the surface and the lighting conditions under which the surface is measured. In the present study, a standard illuminating agent with a white background was used. Since color differences were being tested, the choice of the illuminant was not so important.

Thickness and smoothness of the specimen surface also affect color. [27] The thickness of prepared restorative material specimens was 3 mm. The calculation of the color variation, ΔE^*_{ab} , between 3 color positions (1 day, 7 and 30 days) in the 3-D L* a *b* color space was investigated, even the thickness of the specimens were not so important.

In this study, the mean values of color change of the different groups after exposure to the three beverages and the control distil water for 1, 7 and 30 days are summarized in Table 2 to 5 and graphically represented in Graphs 5 to 9). The color change exhibited by all four tested groups was significantly different for all three beverages and distil water during the 3 time periods ($p < 0.05$).

In the present study, ΔE* values greater than or equal to 3.3 were considered clinically perceptible, based on previous studies. ΔE* values less than 1 were regarded as not detectable by the human eye. Color differences of 3.3 >

$\Delta E^* > 1$ may be detectable by a skilled operator but were considered clinically acceptable. On the other hand, values of $\Delta E^* > 3.3$ would be detectable by nonskilled person therefore considered clinically unacceptable.[28]

The human eye cannot detect ΔE values of less than 1.5, although this value is measurable with the help of colorimeter. In this study ΔE values equal to or greater than 3.3 were considered clinically perceptible, based on previous reports.[29]

Color differences were imperceptible and clinically acceptable when composite resins were immersed in distilled water (control) group D for 1, 7 and 30 days. This observation confirms that water sorption by itself did not alter the composite color in agreement with Burrow and Makinson.[30]

Significant color shifts occurred in each test group of staining beverages overtime. Moreover, the color shift in different test groups was significantly different when the magnitudes of color differences within the test groups were compared in the 1, 7th and 30 days ($p < 0.05$). The coffee affected the color of specimens overtime ($p < 0.05$). When the color of the materials in the group A aged with Arabic coffee in a period of time 1, 7 and 30 days was perceivable by the human eye in the period of 30 days of aging $\Delta E^*_{ab} > 1.5$, where the highest was GC ΔE^*_{ab} 3.27 (clinically unacceptable), Z250 ΔE^*_{ab} 2.92, Z350 XT ΔE^*_{ab} 2.90 and Artist ΔE^*_{ab} 2.83. Which was the highest ΔE^*_{ab} values for the materials in the group A, Arabic coffee among all groups and statistically highly significant values ($p < 0.000$). Where aging period of 1 and 7 days the ΔE^*_{ab} was <1.5.

It was reported that minimum differences in the CIE LAB color parameters (ΔL*, Δa* and Δb*) of 1 CIE unit would be perceptible to an observer depending on the CIE L* value, background color and lighting, while differences in the range 1 to 2 CIE units would be noticeable to most observers. [31]

Based on the results of the present study (Table 2 and Graph 6) color changes values of Δb* in the group A aged with Arabic coffee in a period of 1, 7 and 30 days was perceivable by the human eye in the period of 30 days of aging $\Delta b^* > 1.5$, where all the materials showed color shifting from the yellow (positive values) axis toward blue axis (negative values) with the increase of aging time. The highest value was GC Δb* –2.08 (clinically unacceptable), Artist Δb* –2.06, Z250 Δb* –1.94 and Z350 XT Δb* –1.84. As well it shows statistically highly significant values ($p < 0.000$). Where aging period of 1 and 7 days the Δb* was <1.5. In the group A of Arabic Coffee aging beverages the effect of the Arabic coffee was very high on all materials were the color shifts from the yellow axis toward the blue axis different from the other types of coffee where it discolored toward the yellow axis increasing with the aging time due to the presence of Cardamoms and Cloves in the component of the Arabic coffee.

The color changes values of Δa* in the group A aged with Arabic coffee for all the materials in a period of 1, 7 and 30 days was increasing from the 1day Z250 –0.24, Z350 XT –0.23, GC –0.16 and Artist –0.12 to the 7 days Z250 –0.48, Z350 XT –0.47, GC –0.33 and Artist –0.30 in the green axis (negative value), except in the period of 30 days the color of the materials GC 0.32 and Artist 0.15 shift toward the red axis (positive value) while, the Z250 –0.04 and Z350 XT – 0.06 decreases in the same green axis (negative value), statistically significant ($p < 0.001$).

The total color difference changing of the materials in the group B aged with Turkish coffee in a period of time 1, 7 and 30 day were perceivable by the human eye in the period of 30 days of aging $\Delta E^*_{ab} > 1.5$, only for the material Z350 XT ΔE^*_{ab} 1.63 ($\Delta E^*_{ab} > 1.5$), while the other materials ΔE^*_{ab} Artist ΔE^*_{ab} 1.41, GC ΔE^*_{ab} 1.29 and Z250 ΔE^*_{ab} 1.07 not perceivable by the human eye in the period of 30 days of aging $\Delta E^*_{ab} < 1.5$, where all the materials increases in the ΔE^*_{ab} with the increases of time aging toward the yellow axis statistically significant ($p < 0.004$) tabulated in Table 3 and Graph 3.

Color shifting of Δb* for the materials in the group B aged with Turkish coffee in a period of time 1st, 7th and 30th day was not perceivable by the human eye in the all periods of aging days 1, 7 and 30 days Δb*<1.5 Table 3 and Graphs 4 to 6. The highest Δb* value in this group was in the period of 30th day for the material Z350 XT Δb* 1.06 statistically significant ($p < 0.001$).

The color changes of Δa* of the materials in the group B aged with Turkish coffee in a period of time 1, 7 and 30 days was not statistically significant ($p = 0.154$). All the materials shows increase in Δa* values toward red axis (positive value) and the highest Δa* value was Artist 1.17, Z350 XT 0.97 and GC 0.09 in the period of 30 days of aging except Z250 Δa* –0.09 value shift from the red axis (positive value) towards the green axis (negative value).

While the group C aged with Nescafe beverages the total color difference ΔE^*_{ab} of the materials with in periods of 1st, 7th and 30th day increased significantly ($p < 0.000$), the discoloration clinically acceptable and not perceivable by the human eye in the all periods of aging days 1, 7 and 30 days Δb*<1.5 Table 4 and Graphs 1 to 3.

Color shifting of Δb* for the materials in the group C aged with Nescafe beverages in a period of time 1st, 7th and 30th day was highly significant ($p < 0.000$) it was increasing toward yellow axis (positive value), not perceivable by the human eye in the all periods of aging days 1, 7 and 30 days $\Delta b^* < 1.5$ and clinically acceptable Table 4 and Graphs 4 to 6.

The color changing of Δa^* values for the materials in the group C aged with Nescafe beverages was not statistically significant ($p = 0.750$) for the materials Z350 XT, Z250 and Artist increasing with the time period toward the green axis (negative value), except GC material increasing with time towards the red axis (positive value) Graphs 7 to 9.

Extrinsic factors for discoloration include staining by adsorption or absorption of colorants as a result of contamination from exogenous sources.[28] Extrinsic factors for discoloration are known to cause staining of oral tissues and restorations especially in combination with dietary factors. Among these, coffee, tea, nicotine and beverages have been reported.[28,32]

In contrast, with coffee, the discoloration is probably due to both surface adsorption and absorption of colorants. It was also reported that fewer polar colorants from coffee had penetrated deeper into the materials because the colorants were more compatible with the polymer matrices of the composite resin materials.[13,33]

There is evidence that beverages like coffee and tea significantly increase the development of stains on dental materials.[13] In the previous reports they compared the staining properties of coffee and tea on some commercial brands of composite resin and showed that these beverages increased the development of stain.[33] The composite resin materials exhibited staining after immersion in a coffee solution for 7 days.[13]

Similarly in the present study, the different types of coffee especially the Arabic coffee had a great effect of color shifting for all materials. It caused a considerable magnitude of color change on the composite resin materials with 1, 7 and 30 days of aging time. There was a significant change in ΔE^*_{ab} and Δb^* values in all groups after 1, 7 and 30 days of aging in the beverages except Δa^* in groups B and C. So, the duration of the aging does have a definitive influence on the color stability of resin composites. As the immersion time increases, color changes become more intense. This could be because of the increased interaction between the component of the beverages and the resin as well as better penetration of staining substance into the resin.[34] Color stability is an important variable to be considered when choosing composite resin material, for the clinicians and patients when working in the esthetic area.

CONCLUSION

It can be concluded that all beverages used in this study affected the color stability of tested resin composites materials with the increasing of aging time. Total color difference ΔE^*_{ab} was very high for all materials in the group A aged with Arabic coffee and the lowest in the group C aged with Nescafe. Δb^* for all materials aged with Arabic coffee in the period of 1 and 7 days increased discoloration toward yellowness, while the time of aging increase to 30 days all tested resin composites shifts from the yellow axis toward the blue axis.

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