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EVALUATION OF THE COLOR STABILITY OF MONOCHROMATIC COMPOSITE AFTER EXPOSURE TO DIFFERENT BEVERAGES COMPARED TO CONVENTIONAL COMPOSITE

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ABSTRACT

Objective: Dental composites are considered one of the best direct restorative materials. The goal of this study was to evaluate how different staining solutions affected the color of monochromatic composite versus conventional composite.

Materials and Methods: Thirty specimens, divided into two groups of fifteen each, were randomly assigned based on the type of composite. Group (O) was a supra-nano-hybrid monochromatic composite (omnichroma; Tockuyama), while group (C) was a conventional composite (Estelite α; Tockuyama). A spectrophotometer was used to record each specimen's color 24 hours after specimen preparation. The beverage solution that was used for storage was then utilized to subdivide the specimens into three subgroups, each consisting of five specimens. After that, the composite specimens were submerged in Pepsi, orange juice, and artificial saliva for a period of 14 days. A spectrophotometer was then used to measure the color change.

Results: Statistical analysis showed statistical significance in color parameters (ΔL, Δa, Δb) recorded the specimens in different beverage solutions in each group where p-value were <0.001*. The color change (ΔE) mean values of the monochromatic composite group represented a statistically significant difference between the three beverage solutions used for storage where the p-value was <0.001*. However, there was no statistically significant difference recorded between the conventional and monochromatic composite groups.

Conclusion: Acidic beverages cause a significant deteriorating effect on the color of both types of composites.

KEYWORDS: Resin Composite, Omnichroma, Color stability, Pepsi, Orange Juice.

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INTRODUCTION

Resin composites are now the preferred material for aesthetic restorations on both anterior and posterior teeth, because of its enhanced physical and adhesive qualities. Color, surface gloss, and surface roughness are a restoration's most crucial aesthetic components.[1]

Resin composites' color stability is another obstacle facing the patient's satisfaction. It can seriously reduce the restorations' clinical effectiveness and longevity inside the oral cavity, which is one of the primary causes for replacement.[2,3] Resin composite color variations are caused by a variety of etiological reasons.[4]

Inadequate oral hygiene, certain chromogens in the diet, nicotine, water absorption, and imperfections in materials can all be extrinsic contributors.[5] While intrinsic factors result from the discoloration of the resin material itself, such as alteration of the resin matrix or the matrix filler interface, these can occur from accelerator oxidation, incomplete resin composite polymerization that leaves unreacted methacrylate groups, the nature of the matrix (hydrophilic or hydrophobic) as the hydrophilic matrix may cause hygroscopic absorption, the filler properties (weight, size, and distribution).[6] Therefore, the primary goals of current innovations are to improve the color stability of composite restorations and decrease the complexity of treatment.

The term "one-shade" or "single shade" composite resins refers to resin-based composites that are designed to aesthetically resemble all shades while employing only one nominal shade.[7] [8] The "chameleon effect," which describes a material's ability to take on a color that resembles the nearby tooth structure, is primarily responsible for the success of these novel dental composites.[9]

OMNICHROMA is the first universal, one-shade resin-based composite. It is Composed of nanofiller and nanoclusters particles without any pigments. The structural color of the surrounding area is the primary determinant of the optical qualities of Omnichroma composite, or "smart chromatic technology". As a result, inside the tooth color space, the resin-based composite precisely reflects a certain wavelength through interaction with light waves at a set frequency. Omnichroma's primary advantage is based on improved Color Adjustment Potential. [9] About its color stability, however, there is a dearth of evidence in the scholarly literature.[7]

As a result, the goal of the current study is to compare the color stability of monochromatic composite to that of bulk-fill composite and assess the impact of various coloring beverages. The null hypothesis was that coloring beverages would not cause color change of monochromatic composite restorations.

MATERIALS AND METHODS

Materials

The restorative materials and beverages solutions in the current study; their brand name, composition, manufacturers, and batch number, are listed in **Table (1)**

Methods

Specimens' Grouping:

Using G*Power version 3.1.9.2, FranzeFaul, University Kiel, Germany, the sample size was calculated. Based on the color change measurements, the mean and standard deviations were calculated in accordance with **Ahmed, Jouhar et al. 2022** [4]. Based on the findings, 15 specimens per group were used in the sample size calculation, which used an effect size of 1.487, an alpha level of significance (α) of 0.05, and a power of 0.8 for the study.

Depending on the type of composite that was employed, the specimens were divided into two groups at random (15 specimens in each

TABLE (1) List of commercially available materials and beverages used in the study with their composition, brand name, manufacturer, and batch number.

Product name	Composition	Batch Number	Manufacturer
Supranano-Hybrid Monochrome Composite (Omnichroma)	**Organic Matrix (21 wt%)** UDMA, TEGDMA **Inorganic Filler (79 wt%)** 260 nm spherical SiO_2-ZrO	1615	**Tokuyama- Dental, Tokyo, Japan**
Nano-Hybrid Conventional Composite (Estelite α)	**Organic Matrix (18 wt%)** Bis-GMA, TEGDMA **Inorganic Filler (82 wt%)** 0.2 µm spherical SiO_2-ZrO	525671108	**Tokuyama- Dental, Tokyo, Japan**
Artificial Saliva	Sorbitol **(30 g),** Carboxymethylcellulose sodium **(11.7g),** Dipotassium monohydrogen phosphate **(804 mg),** Potassium chloride **(625 mg),** Potassium dihydrogen phosphate **(366 mg),** Calcium chloride **(166 mg),** Magnesium chloride **(59 mg),** Purified water **(1000 ml).**	----------	**Prepared by Faculty of Pharmacy, Ahram Canadian University, Egypt**
Pepsi	Carbonated Water, Sugar, Color (Caramel E150d), Acid (Phosphoric Acid), Flavorings (including Caffeine), Sweeteners (Acesulfame K, Sucralose).	6223001361725	**Pepsi®, Egypt**
Orange juice	Water, Sugar, Orange Juice Concentrate (Fruit content not less than 20%), Acidity Regulator (E330), Stabilizer (E440), Color (E160aii), Antioxidant (E300), Flavor	6223001875246	**Beyti®, Egypt**

group). The intervention group (O) consisted of a supra-nano-hybrid monochromatic composite **(omnichroma)**, while the control group (C) was made up of commercially available conventional composite (Estelite α). The specimens per group were subdivided into three subgroups (5 specimens) according to type of the staining solution used. The color coordinates of all the specimens were inspected twice: immediately after specimens' construction (T_0) and 14 days (T_1) from water storage.

Specimens' Preparation:

To fabricate 15 discs in each group, 10 mm in diameter and 2 mm in thickness sectional Teflon molds were used. For a uniformly finished surface, a glass slide was placed then a celluloid strip. Next, a spherical burnisher made of stainless steel was used to pack the composite into the mold **Figure (1).** Then on top of the resin composite, another celluloid strip was placed and a glass slide. Finally, the light curing equipment* was positioned on the glass slide on the top surface and perpendicular to it for 20 seconds. The specimen's other surface was subsequently subjected to the same curing process. Before spectral reflectance measurements, the specimens were kept in an incubator** for 24 hours at 37°C in distilled water.

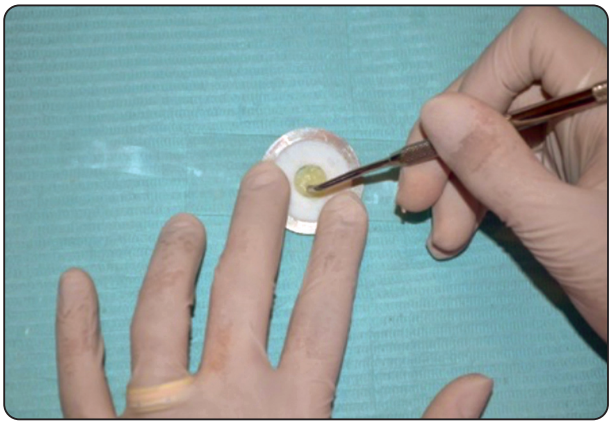

Fig. (1). Composite specimen preparation in a teflon mould

* Light curing device: woodpecker RTA light cure (1000-1200 watt), Guilin, Guangxi, China.
** Incubator: GENERAL INCUBATOR LIB-030M- Labtech, KOMACHINE- South Korea.

Assessment The Color Change of The Composite Specimens:

The Color Coordinates Recorded for The Composite Specimens:

The baseline color coordinates of each specimen were measured using a non-contact spectrophotometer* **Figure (2).** The spectrophotometer was positioned 40 cm away from the samples, with the measuring and illuminating geometries matching CIE 45◦/0◦. Spectral reflectance values were measured with a focus measurement hole in the middle of each disc, ranging from 380 to 780 nm for wavelengths at 1 nm. By utilizing the CIE 2◦ Standard Observer and the CIE D65 Standard Illuminant, the spectral reflectance data were transformed into CIE L*a*b*color coordinates. For every specimen, three repeats of the reflectance measurements were made, and the average was determined. After being kept in an incubator for 24 hours at 37°C with distilled water, the specimens were submerged in various beverage solutions.[7]

Fig. (2). Spectrophotometer Device

The Color Change (Δ E) of Composite Specimens after Storge in Beverage Solutions:

Next, based on the beverages (Pepsi, Orange Juice, and Artificial Saliva), the fifteen specimens from each group were split into three subgroups groups. Each sub-group's four specimens spent 14 days submerged in a sealed container containing the beverage solution. The sealed containers, during the storage period, were placed in the incubator at 37˚C. The beverage solutions were refilled every 24 hours to ensure that the specimens were fully immersed in the solutions. The color coordinates after the storage period were then measured with the same method as described before. The color coordinate values recorded for each specimen before and after immersion in various beverages were then compared to determine the mean difference (ΔE).

Statistical Methods

Using the Shapiro-Wilk and Kolmogorov-Smirnov tests, the normality of the data was investigated. The color change data displayed a parametric, or normal, distribution. For every group, the mean and standard deviation were calculated. One Way Anova was employed to compare more than two groups in related samples, while the independent sample t-test was utilized to compare two groups in unrelated samples. A significant threshold of $P < 0.05$ was established. For statistical analysis, IBM® SPSS® Statistics Version 22 for Windows was used.

RESULTS

Color Change recorded between groups after immersion in different solutions:

The CIE Lab mean values and standard deviations for the conventional and Omnichroma composite groups were listed **in the table (2), Figure (3).**

There was no statistically significant difference recorded between the conventional and Omnichroma composite groups in color change parameters (ΔL, Δa, Δb) after immersion in different solutions (Saliva, Pepsi, and Orange).

* Spectrophotometer: Cary 5000 Spectrophotometer provided from Agilent Technologies (USA)

Table (2): The mean, standard deviation (SD), and P-value of difference in CIE Lab parameters recorded between groups after immersion in different solutions.

Solution	Difference in CIE Lab Values	Groups				
		Conventional		**Omnichroma**		**P-value**
		Mean	**SD**	**Mean**	**SD**	
Saliva	**ΔL**	0.92	0.08	1.01	0.10	0.23 ns
	Δa	0.28	0.05	-0.23	0.03	0.47 ns
	Δb	-0.48	0.07	-0.53	0.07	0.54 ns
Pepsi	**ΔL**	-1.24	0.12	-1.41	0.12	0.84 ns
	Δa	1.83	0.15	1.79	0.16	0.77 ns
	Δb	1.77	0.14	1.93	0.16	0.79 ns
Orange	**ΔL**	2.18	0.15	2.39	0.15	0.9 ns
	Δa	0.44	0.07	0.43	0.09	0.78 ns
	Δb	2.85	0.18	3.09	0.13	0.52 ns

Superscripts with different Small letters indicate statistically significance difference within the same column while superscripts with different Capital letters indicate statistically significance difference within the same row *; significant (p≤ 0.05) ns; non-significant (p>0.05)

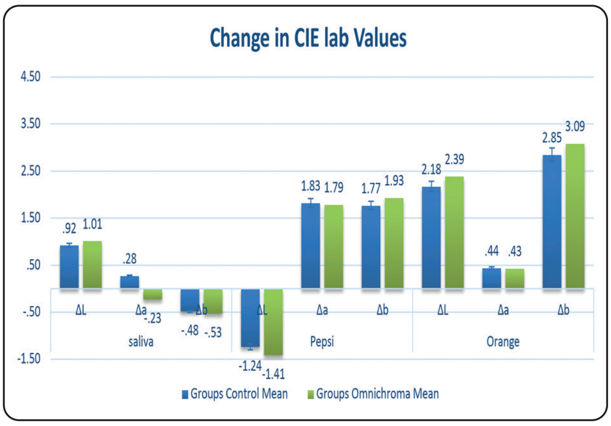

Fig. (3): Bar charts representing color change between groups after immersion in different solutions.

Color Change recorded within each group after immersion in different solutions:

The CIE Lab mean values and standard deviations for the conventional and Omnichroma composite groups were listed **in the table (3), Figure (4).**

Regarding the conventional composite group, there was statistically significant difference in all color change parameters (ΔL, Δa, Δb) recorded after immersion in different solutions (Saliva, Pepsi, and Orange). The highest ΔL mean value recorded for conventional composite group after immersion in orange juice (2.18) followed by saliva (0.92) with the least mean value recorded after immersion in pepsi (-1.24). The highest Δa mean value recorded after immersion in pepsi (1.83) followed by orange juice (0.44) with the least mean value recorded after immersion in saliva (0.28). There is no significant difference between Δa recorded after immersion in both orange juice and saliva where p-value= 0.65. The Δb recoded for the conventional group after immersion in orange juice is the highest mean value (2.85).

Regarding the Omnichroma composite group, there was statistically significant difference in all color change parameters (ΔL, Δa, Δb) recorded after immersion in different solutions (Saliva, Pepsi, and Orange). The highest ΔL mean value recorded for Omnichroma composite group after immersion in orange juice (2.39) followed by saliva (1.01) with the least mean value recorded after immersion in

Table (3): The mean, standard deviation (SD), and P-value of difference in CIE Lab parameters recorded within each group after immersion in different solutions.

Groups	Conventional						Omnichroma					
Solution	**ΔL**		**Δa**		**Δb**		**ΔL**		**Δa**		**Δb**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Saliva	0.92^{b}	0.08	0.28^{b}	0.05	-0.48^{c}	0.07	1.01^{b}	0.10	-0.23^{c}	0.03	-0.53^{c}	0.07
Pepsi	-1.24^{c}	0.12	1.83^{a}	0.15	1.77^{b}	0.14	-1.41^{c}	0.12	1.79^{a}	0.16	1.93^{b}	0.16
Orange	2.18^{a}	0.15	0.44^{b}	0.07	2.85^{a}	0.18	2.39^{a}	0.15	0.43^{b}	0.09	3.09^{a}	0.13
P-value	<0.001*		<0.001*		<0.001*		<0.001*		<0.001*		<0.001*	

Groups	Conventional						Omnichroma					
Solution	**ΔL**		**Δa**		**Δb**		**ΔL**		**Δa**		**Δb**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Saliva	0.92^{b}	0.08	0.28^{b}	0.05	-0.48^{c}	0.07	1.01^{b}	0.10	-0.23^{c}	0.03	-0.53^{c}	0.07
Pepsi	-1.24^{c}	0.12	1.83^{a}	0.15	1.77^{b}	0.14	-1.41^{c}	0.12	1.79^{a}	0.16	1.93^{b}	0.16
Orange	2.18^{a}	0.15	0.44^{b}	0.07	2.85^{a}	0.18	2.39^{a}	0.15	0.43^{b}	0.09	3.09^{a}	0.13
P-value	<0.001*		<0.001*		<0.001*		<0.001*		<0.001*		<0.001*	

Superscripts with different small letters indicate statistically significance difference within the same column while superscripts with different Capital letters indicate statistically significance difference within the same row *; significant (p≤ 0.05) ns; non-significant (p>0.05)

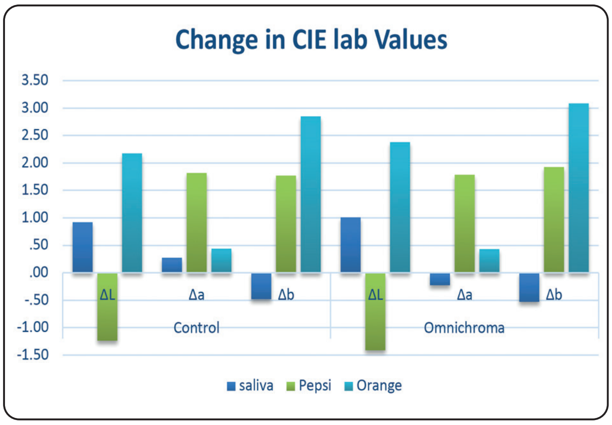

Fig. (4): Bar charts representing color change within each group after immersion in different solutions.

pepsi (-1.41). The highest Δa mean value recorded after immersion in pepsi (1.79) followed by orange juice (0.43) with the least mean value recorded after immersion in saliva (-0.23). The Δb recoded for the conventional group after immersion in orange juice is the highest mean value (3.09).

Overall color change (ΔE) recorded for groups after immersion in different solutions:

The (ΔE) mean values and standard deviations for the conventional and Omnichroma composite groups after immersion in different solutions were listed **in the table (4), Figure (5).**

Regarding the conventional composite group, there was statistically significant difference in overall color change **(ΔE)** recorded after immersion in different solutions where p-value <0.001. The highest mean value recorded after immersion in orange juice (3.61) followed by pepsi (2.83) while the least mean recorded after immersion in saliva (1.08).

Regarding the Omnichroma composite group, there was statistically significant difference in overall color change **(ΔE)** recorded after immersion in different solutions where p-value <0.001. The highest mean value recorded after immersion in orange

Table (4): The mean, standard deviation (SD), and P-value of overall color change (ΔE) recorded for groups after immersion in different solutions

	Overall color change (ΔE) within Groups				**P-value**
	Conventional		**Omnichroma**		
	Mean	SD	Mean	SD	
Saliva	1.08[c]	0.10	1.17[c]	0.12	0.12 ns
Pepsi	2.83[b]	0.17	2.94[b]	0.10	0.10 ns
Orange	3.61[a]	0.21	3.93[a]	0.13	0.13 ns
P-value	<0.001*		<0.001*		

Superscripts with different Small letters indicate statistically significance difference within the same column while superscripts with different Capital letters indicate statistically significance difference within the same row *; significant (p≤ 0.05) ns; non-significant (p>0.05)

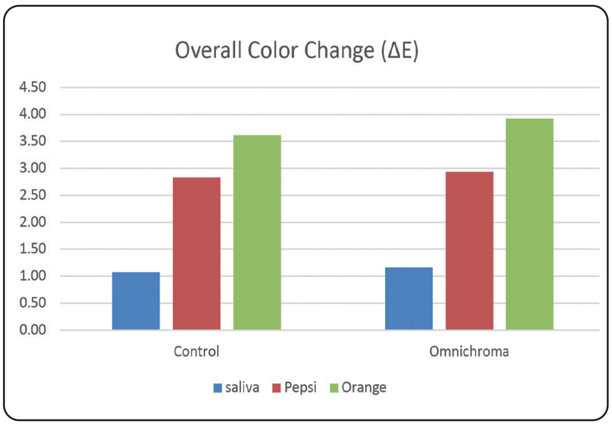

Fig. (5): Bar charts representing overall color change within each group after immersion in different solutions.

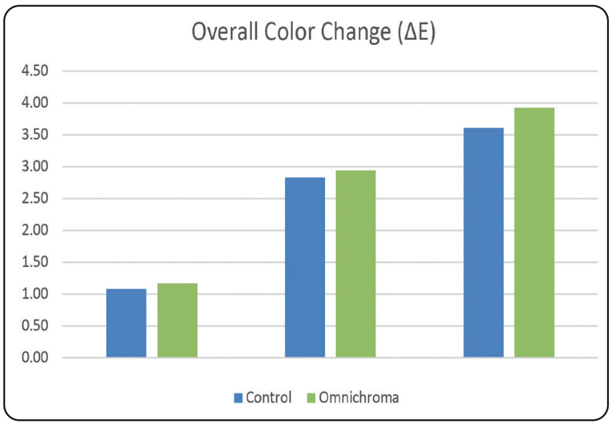

Fig. (6): Bar charts representing overall color change between groups after immersion in different solutions.

juice (3.93) followed by pepsi (2.94) while the least mean recorded after immersion in saliva (1.17).

The (ΔE) mean values recorded between the conventional and Omnichroma composite groups after immersion in different solutions were listed **in the table (4), Figure (6).** It represented no statistically significant difference recorded between both groups after immersion in saliva, Pepsi and Orange juice where the p-values recorded are 0.12, 0.10 and 0.13 respectively.

DISCUSSION

These days, dental composite resins are frequently used as aesthetic restorative materials. Nonetheless, the most common cause for composite restoration replacements is color changes. A crucial clinical characteristic that influences the lifespan and aesthetic success of composite restorations is color stability. The color change could be interpreted as an indication of aging or deterioration of the restoration. Therefore, in comparison to the conventional composite, the current study was carried out to assess the impact of several widely consumed beverages on the color stability of smart monochromatic resin composite.

In addition to their chemical composition, the environment that monochromatic composites are exposed to—such as chemicals that are periodically or consistently present in foods, drinks, and saliva—can also have an impact on their aesthetic qualities.

Among the drinks tested in this study, Pepsi has the lowest pH (3.8), being a popular soft drink mostly composed of phosphoric acid, which has a sour flavor and preservation quality. Numerous acids, including citric, tartaric, malic, benzoic, oxalic, and succinic acids, are found in citrus fruits. Citric juices contain primarily citric acid, a weak tricarboxylic acid made of 2 hydroxyl 1,2,3-propane. Packaged orange juice was used for this study because it is widely accessible and has an acidity level comparable to soft drinks. [11] As a control beverage, artificial saliva was employed to mimic the in vivo clinical setting. The composite specimens in the current study were submerged in the beverage solutions for a period of 14 days. Previous research indicates that immersing specimens in different beverages for a whole day at 37 °C is comparable to keeping them in vivo for around a month. [10][11].

Spectrophotometers were widely used to record the color measurements. Since color vision is a psychophysical process with wide individual variation, the spectrophotometer was used in the current study to reduce the possibility of human errors. The CIE L*a*b* system was chosen to calculate the color difference (E) because it can determine minor color changes precisely. It has also numerous benefits, including sensitivity, reproducibility, and objectivity. [12][13]

In the current study, the results of both conventional and omnichroma composite specimens showed significant color change (ΔE= 3.61 and 3.93, respectively) after immersion in orange juice compared to the color change recorded after immersion in Pepsi (ΔE= 2.83 and 2.94, respectively) and artificial saliva (ΔE= 1.08 and 1.17, respectively).

These findings support the findings of **Catelan, Anderson, et al. (2011),** who claimed that because higher pH solutions, like orange juice, induce more staining, the low pH of cola soft drinks did not affect the color shift. [10] The cause of these findings may be acidic drinks, which weaken the matrix, release structural ions, and reduce the wear resistance of dental materials—all of which might have a detrimental effect on surface integrity. [14][15] Moreover, different acids found in the soft drink (carbonic acid and phosphoric acid) and orange juice (citric acid) could be an explanation for such results. [10]

On the other side, these results disagreed with **Singh et al. in 2023** and also **Zaghloul and Ali in 2019**, who found that Pepsi had more significant color change in comparison with orange juice, they explained that Pepsi, a yellow-brown carbonated drink with a pH of about 2.4 due to the presence of orthophosphoric and carbonic acids; orange juice, on the other hand, has yellow stains and a pH of 3.8 because of citric acid; the pigments' penetration into the composite microcracks in the resin composites is what causes the noticeable color change. For this reason, compared to orange juice, Pepsi is said to have had a greater color change.[16][17]

Our findings showed that samples somewhat were altered in hue after they were dipped in artificial saliva. Monomers such diglycidyl methacrylate, urethane dimethacrylate, and triethylene glycol dimethacrylate cause the test samples to turn discolored. As a result, the resin matrix becomes hydrophilic, significantly increasing its absorption of water and other fluids, causing internal color changes. Filler particle dispersion and photoinitiator systems are two other potential causes of color shifts. This agreed with **Singh et al. in 2023**.[17]

However, the outcome of the current study showed no statistically significant difference regarding the color change between both composite groups after immersion in different beverage solutions (Saliva, Pepsi, and Orange) for 14 days. These results might be due to the resin component in composite. Several studies have shown that urethane di-methacrylate, TEGDMA and Bis-GMA expected to absorb water and affect the color stability of the composite. [4]

These results are in disagreement with **Rohym et al in 2023,** who studied the effect of staining solutions on Omnichroma and another nano-filled composite and found that there was a significant difference between both types of composite after 14 days of staining, because of the lower filler content of the comparator nano filled composite and presence of nanoclusters that could be the reason for the less color resistance in comparison to Omnichroma. [19]

Accordingly, the null hypothesis was rejected as the omnichroma composite showed color stability when compared to the conventional nano-hybrid composite after immersion in different staining solutions, this may be due to that the Omnichroma is mainly composed of UDMA, which is hydrophobic in nature, this might have been the cause of the low ΔE value as observed.

It is necessary to consider several limitations when interpreting the study's findings. It is important to note that because this study was conducted in vitro, which has inherent limitations when imitating an in vivo environment, care should be taken when interpreting the data. Unfortunately, the impact of aging and various finishing techniques on the color stability of the smart monochromatic composite was not evaluated due to time constraints. Future research is therefore preferred to assess how aging affects the monochromatic composite's long-term color stability. In addition, it has been shown that acidic foods and beverages can affect other properties including hardness and flexural strength. Therefore, further research is warranted considering these variables.

CONCLUSION

Within the limitations of this study, It can be deduced that:

- The color of resin composite restorations deteriorates with the usage of acidic beverages.
- The type of resin composite that is chosen for each patient should be carefully considered in light of the patient's drinking habits.

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