Original Article

Spectrophotometric evaluation of color stability of novel composites following exposure to antioxidant beverages: An *in vitro* study

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Abstract

Background: Color matching and stability are the essential considerations in restorative dentistry, as they contribute to the longevity and esthetic appeal of the restorations. Composites with nanoparticles and more filler content are anticipated to be more color-stable.

Aim: The aim of the study was to assess and contrast the color stability of esthetic restoration materials following exposure to various antioxidant beverages.

Materials and Methods: A Class V cavity was prepared on the buccal surface of 40 maxillary premolars. The specimens were divided into two groups: microhybrid (MH) and nanohybrid (NH) composite. The baseline color of each tooth sample was measured and then, the samples were categorized into four subgroups based on the immersion solution (pomegranate juice, beetroot juice, black plum juice, and distilled water) and evaluated on day 1, day 7, day 14, and day 21 using a spectrophotometer-based on CIE L*a*b* color scale. For spectrophotometer analysis, CIE XYZ data were obtained and converted to CIELAB. The samples mean difference in ΔE values before and after being immersed in various beverages.

Statistical Analysis: The data were statistically analyzed using an independent *t*-test and one-way analysis of variance.

Results: MH and NH composite materials showed color change after being exposed to the test beverages.

Conclusion: MH composite causes more color change than NH composite at all-time intervals. Black plum showed the greatest discoloration in both composites.

Keywords: Beverages; color stability; flowable composite; Mani Flo V; microhybrid composite; nanohybrid composite; Neo Spectra ST; restorative

INTRODUCTION

We could use a lot more smiles in this chaotic, unsolvable world we live in.

Smile is one of the most crucial techniques for influencing people. However, teeth typically do not perfectly balance the structures around them. Smiles that are natural, repaired, or orthodontically improved may have several esthetic flaws. The most frequent issues include dysplasia, abrasion, erosion, and transposition of the anterior teeth following aplasia, existing or persistent diastemas, form abnormalities and discolorations, and abrasion.[1]

The field of restorative dentistry has witnessed significant advancements in recent years, with composite resins playing a central role in esthetic dental restorations.[2] Composite

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resins offer excellent esthetic potential, durability, and cost-effectiveness, making them a popular choice for both anterior and posterior tooth restorations. The color stability of composite restorations is crucial to their long-term success, as discoloration can compromise the esthetic outcome and patient satisfaction.[1]

Color matching and stability are the essential considerations in restorative dentistry, as they contribute to the longevity and esthetic appeal of the restorations. Numerous elements may impact the composite's color stability, including the composition of the resin matrix, the size and type of fillers, and exposure to environmental factors such as food, beverages, and oral hygiene habits. Understanding the effects of these factors is crucial for selecting the most suitable restorative materials and ensuring long-lasting esthetic results.[3]

Since 1931, CIELAB units have been employed for color quantification when comparing the color characteristics of various objects through mathematical analysis. The color space in this system is made up of the three coordinates: L^*, a^*, and b^*.[4]

Determination of color in dentistry can be performed visually, instrumentally, or a combination of the two. Commission Internationale de L'Eclariage (CIE) developed the CIELAB color system to better interpret color perception. This is the most popular measurement system and characterizes dental color. Previous studies have shown that the reliability and accuracy of spectrophotometers are superior to those of colorimeters and are considered "gold standard."[5]

Despite the material's ongoing development, internal mechanisms, external contamination, and staining are known to cause composites to discolor. Although the composition of the most recent composite systems has been customized to reduce interior discoloration, resistance to exterior staining is still not given much consideration.[6,7]

To facilitate the demands of long-lasting esthetics without any discolorations, nanohybrid (NH), and microhybrid (MH) composites with nanoparticles measuring around 25 nm and having about 79.5% filler have been recently introduced. These composites are anticipated to be more polishable and less discolored after pigment absorption because the particles have shrunk and have a smaller particle size.[8]

The most tested beverages were tea, coffee, and wine, which have shown considerable discoloration on adult teeth, even though there are several researches on the staining effects of beverages on composite restorations. However, as far as we are aware, no study in the past has evaluated the effect of beverages with antioxidant properties such as beetroot juice, pomegranate juice, and black plum juice on composite resin.

Perfect color stability between teeth and restorations is prioritized over all other factors since dental esthetics are extremely important to patients.[9]

Therefore, this study aimed to assess and contrast the color stability of esthetic restoration materials following exposure to various antioxidant-rich beverages.

The null hypothesis states that:

1. There is no statistically significant difference in the color stability of the composite after immersion in beetroot juice, black plum juice, and pomegranate juice
2. There are no statistically significant differences in the staining ability of beetroot juice, black plum juice, pomegranate juice, and distilled water
3. There is no statistically significant difference between the color stability of Micro Flo V and Neo Spectra ST composites
4. There is no statistically significant difference in ΔE values of Mani Flo V flowable composite at day 1, day 7, day 14, and day 21 after immersion in beetroot juice, black plum juice, pomegranate juice, and distilled water
5. There is no statistically significant difference in ΔE values of Neo Spectra ST flowable composite at day 1, day 7, day 14, and day 21 after immersion in beetroot juice, black plum juice, pomegranate juice, and distilled water.

MATERIALS AND METHODS

Sample selection

In this investigation, 40 newly extracted human maxillary premolars with developed apices and intact roots that had just undergone orthodontic extraction were employed. Teeth were inspected under an operating microscope (×10) to exclude the possibility of any cracks, caries, fractures, resorption, caries, and restorations. Using a digital Vernier caliper, the intercuspal distance, buccopalatal, and mesiodistal dimensions of the teeth were measured to standardize the size of the maxillary premolars. The external surfaces of teeth were cleaned with an ultrasonic scaler. Teeth were immediately stored in 0.9% thymol solution at the room temperature until use.

Specimen preparation

Cavity preparation

A Class V cavity was created on the buccal surface of each tooth using a round diamond bur #4 (MANI). The dimensions of each cavity were 2 mm in depth, 3 mm in height, and 5 mm in length. Cavity dimensions were confirmed using a digital Vernier caliper and periodontal probe [Figure 1].

Restoration of specimen

After cavity preparation, etching was done with 37% phosphoric acid (3M Scotchbond Universal Etchant) followed by dentin bonding agent (Adper Single Bond 2; 3M ESPE, St. Paul MN, USA) as per manufacturer's instructions. The prepared cavities were either filled with Neo Spectra ST (Dentsply Sirona) or Mani Flo V (Mani) flowable composite. LED curing light (Bluephase N-Ivoclar, Viadent, USA) was used to cure each composite for 20 s.

Beverage preparation

We used readily available beetroot juice, black plum juice, and pomegranate juice as beverages and distilled water as a control group.

Specimens immersion

Samples for each group ($n = 5$) were immersed separately in either of four solutions (treatment of control group) for 1 h each day at 37°C, then taken out with a tweezer and dipped in artificial saliva for the whole day to simulate oral conditions.

The solutions were changed daily and the procedure was followed for 3 weeks.

Color change assessment

After being removed from any liquids, each tooth sample was dried with an absorbent paper point before being tested. The specimen's color was tested before immersion (Baseline; T0), after 1st day (24 h) (T1), after 7th day (1 week) (T7), after 14th day (2 weeks) (T14), and after 21st day (3 weeks) (T21).

The color parameters were measured using a spectrophotometer and were expressed using the International Commission on Illumination System (CIE L*a*b*), where the chromaticity of the color is represented by the b* (blue to yellow) and the L* coordinate (white to black), which represents color luminosity.

Each sample was briefly placed on the device's evaluating head and covered with a lid. After the device was turned on, an automatic calculation of the sample's mean color (L*) (a*) (b*) was made.

The following formula was used to calculate the color changes (ΔE*):

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

Statistical analysis

SPSS Statistics program (IBM Corp., version 16.0, Armonk, NY, USA). Independent *t*-tests were used to compare the ΔE values of Mani Flo V and Neo Spectra ST composites for each solution at each time interval. One-way analysis of variance tests were conducted to compare the ΔE values of each composite among the four different solutions at different intervals. The Shapiro–Wilk test was utilized to evaluate the data's normality. A significance level of 0.05 was used for all statistical analyses.

RESULTS

Table 1 and Figure 2 compare ΔE of two composite materials for each solution on day 1. In all the solutions tested, Mani Flo V composite material showed more color change as compared to Neo Spectra ST material but there was a nonsignificant difference in color change of the two materials.

Table 2 and Figure 3 compare ΔE of two composite materials for each solution at day 7. In all the solutions tested, Mani Flo V composite material showed more color change as compared to Neo Spectra ST material but a

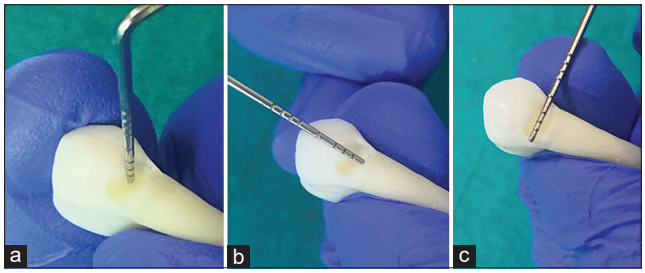

Figure 1: Dimensions of Class V cavity. (a) Depth, (b) Height, (c) Length

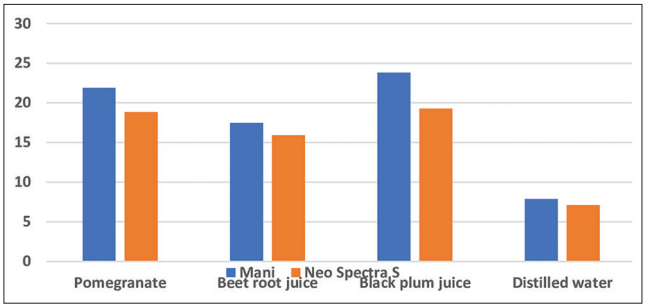

Figure 2: Comparison of ΔE of two composite materials for each solution at day 1

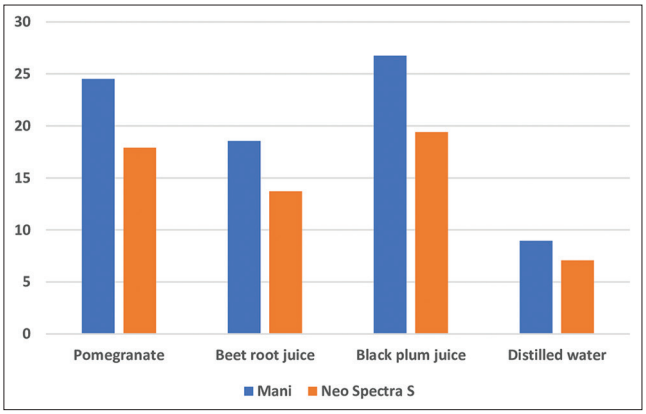

Figure 3: Comparison of ΔE of two composite materials for each solution at day 7

significant difference between the two materials was seen only for pomegranate juice and black plum juice.

Table 3 and Figure 4 compare ΔE of two composite materials for each solution at day 14. In all the solutions tested, Mani Flo V composite material showed more color change as compared to Neo Spectra ST material but a significant difference between the two materials was seen only for pomegranate juice and black plum juice.

Table 4 and Figure 5 compare ΔE of two composite materials for each solution at day 21. In all the solutions tested, Mani Flo V composite material showed more color change as compared to Neo Spectra ST material but a significant difference between the two materials was seen only for pomegranate juice and black plum juices.

Table 5 and Figure 6 show that at each time interval assessed, the highest color change for the Mani Flo V composite was seen in black plum juice, and the least color change was seen in distilled water and the difference among the four solutions at each interval was significant.

Table 6 and Figure 7 show that at each time interval assessed, the highest color change for Neo Spectra ST composite was seen in black plum juice, and the least color change was seen in distilled water and the difference among the four solutions at each interval was significant.

DISCUSSION

Composite resins have become a preferred choice in restorative dentistry due to their excellent esthetic properties and cost-effectiveness. However, achieving color stability remains a challenge. This study sought to evaluate and contrast the color stability of MH and NH composites following exposure to different beverages with antioxidant properties.

The results of this investigation show how various beverages affect the color stability of cosmetic restoration

Table 1: Comparison of DELTA E (ΔE) of Mani Flo V and Neo Spectra ST flowable composite materials for each solution at day 1

Solution	Mani Flo V		Neo Spectra ST		Difference	*P*
	Mean	SD	Mean	SD		
Pomegranate	21.90	3.96	18.84	3.20	3.06	0.216
Beet root juice	17.49	5.11	15.92	2.62	1.57	0.558
Black plum juice	23.82	14.07	19.29	6.96	4.53	0.537
Distilled water	7.88	2.31	7.12	2.20	0.78	0.609

Independent *t*-test; *indicates significant difference at $P \leq 0.05$

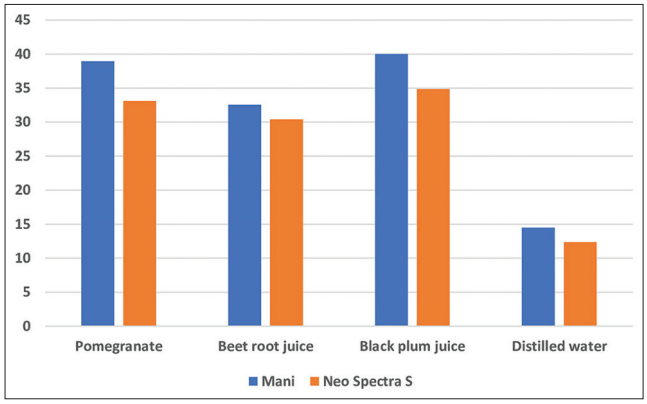

Figure 4: Comparison of ΔE of two composite materials for each solution at day 14

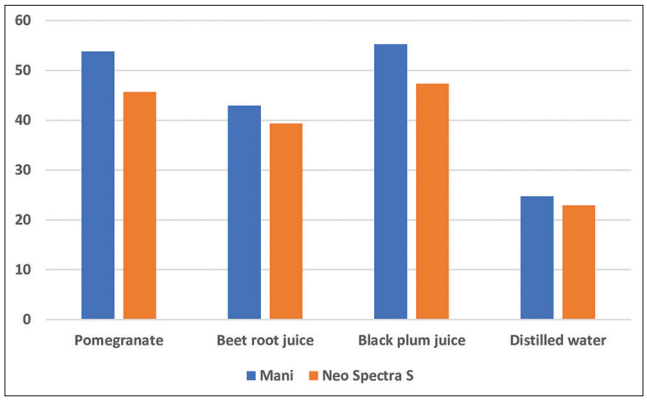

Figure 5: Comparison of ΔE of two composite materials for each solution at day 21

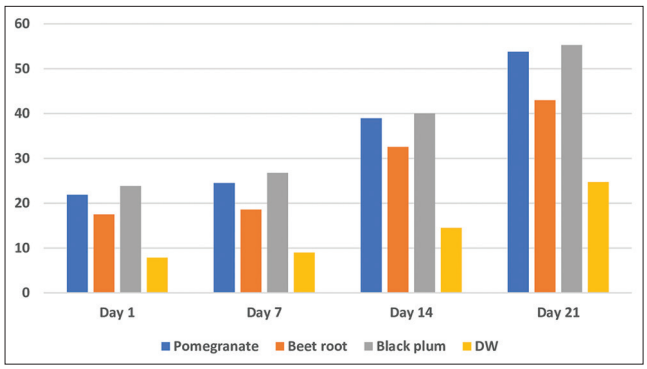

Figure 6: Comparison of ΔE of Mani Flo V among four different solutions at different intervals

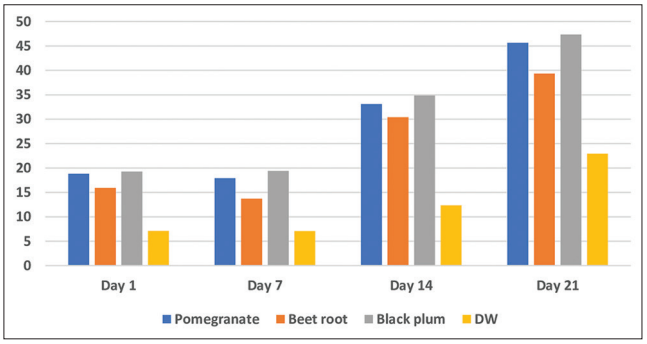

Figure 7: Comparison of ΔE of Neo Spectra ST material among four different solutions at different intervals

Table 2: Comparison of DELTA E (ΔE) of ani Flo V and Neo Spectra ST flowable composite materials for each solution at day 7

Solution	Mani Flo V		Neo Spectra ST		Difference	*P*
	Mean	SD	Mean	SD		
Pomegranate	24.53	4.83	17.91	3.13	6.62	0.033*
Beet root juice	18.57	6.88	13.72	5.76	4.85	0.261
Black plum juice	26.76	4.42	19.41	3.15	7.35	0.016*
Distilled water	8.97	1.99	7.09	4.55	4.88	0.423

Independent *t*-test; *indicates significant difference at $P \leq 0.05$

Table 3: Comparison of DELTA E (ΔE) of ani Flo V and Neo Spectra ST flowable composite materials for each solution at day 14

Solution	Mani Flo V		Neo Spectra ST		Difference	*P*
	Mean	SD	Mean	SD		
Pomegranate	38.96	4.61	33.10	3.30	5.86	0.050*
Beet root juice	32.55	6.23	30.40	4.64	2.15	0.553
Black plum juice	40.01	2.66	34.86	3.21	5.15	0.025*
Distilled water	14.49	2.93	12.36	2.31	2.13	0.236

Independent *t*-test; *indicates significant difference at $P \leq 0.05$

Table 4: Comparison of DELTA E (ΔE) of ani Flo V and Neo Spectra ST flowable composite materials for each solution at day 21

Solution	Mani		Neo Spectra S		Difference	*P*
	Mean	SD	Mean	SD		
Pomegranate	53.79	3.62	45.66	4.51	8.13	0.014*
Beet root juice	42.95	3.37	39.34	2.90	3.61	0.107
Black plum juice	55.27	3.50	47.35	2.71	7.92	0.004*
Distilled water	24.72	4.02	22.93	1.55	1.79	0.379

Independent *t* test; *indicates significant difference at $P \leq 0.05$

materials. The evaluation of ΔE values revealed that both Mani Flo V and Neo Spectra ST composites exhibited color changes when immersed in the tested beverages. However, some notable differences were observed between the two composites and the various solutions.

The demand for esthetic restorations is increasing owing to the need for esthetic solutions and preserving tooth structure by avoiding indirect restorations.[10] Although these direct formulations have properties such as translucency, good shade matching, and shade variety to blend with tooth structure. Multiple factors can affect the color stability of these resin composite formulations, including the type of resin matrix as well as the type, size, and amount of fillers.[11]

The extrinsic factors include the intensity and duration of polymerization, and exposure to environmental factors, including ambient and ultraviolet irradiation, heat, water, and food colorants.[12,13] Moreover, the structure of the composite resin matrix, as well as the characteristics of the filler particles contribute to the surface smoothness and consequently susceptibility to extrinsic staining.[14] It has been reported that increasing the filler content in composites provides escalated color stability, whereas a higher amount of resin volume portion has been reported to provide greater discoloration.[5]

Intrinsic discoloration is due to modification of the resin matrix and the filler-matrix interface. Insufficient polymerization could be the cause of this inherent discoloration. Staining caused by colorant adsorption or absorption as a result of contamination from external sources, such as red wine, is one of the extrinsic reasons for discoloration.[15]

Mani Flo V composite, a MH composite, showed a higher degree of color change compared to Neo Spectra ST composite, an NH composite, in all tested beverages. This can be attributed to the differences in the resin matrix composition and filler particle sizes.[11] MH composites generally have a higher resin volume portion, which can increase water sorption and result in greater discoloration. On the other hand, NH composites with smaller filler particles exhibit improved color stability due to their enhanced surface smoothness and reduced pigment absorption.[5] With smaller particle sizes, one could reasonably expect an NH composite to have a smoother surface and be less likely to retain surface stains.[16]

The resin component in composite plays a crucial role in staining susceptibility. Studies have shown that urethane di methacrylate which is a component of NH composite is more stain-resistant compared to bisGMA and TEGDMA due to its low water solubility and absorption.[11]

Pomegranate juice, black plum juice, and beetroot juice, which are strong sources of Vitamin C and have antioxidant qualities, were chosen from commercial products on the market as the solutions employed in this investigation. The use of distilled water as a control was determined by numerous earlier research. The examined liquids were selected as the colorants since they are used often in daily life.

Antioxidant substances shield cells and tissues from oxidative stress and its effects. Numerous academic institutions have examined the antioxidant capabilities of natural compounds. It has been hypothesized that eating foods high in antioxidants can delay or prevent the development of numerous diseases.[17]

Drinking beverages is another way to ensure that you are getting enough fruits and veggies in your diet.

Among the tested beverages, black plum juice caused the most significant discoloration, followed by beetroot juice and pomegranate juice, while distilled water showed the least color change.[18] The acidic nature of the beverages, particularly black plum juice, and pomegranate juice, can erode the composite

Table 5: Comparison of ΔE of Mani Flo V composite material among Pomegranate juice, Beet Root juice, Black Plum juice and Distilled water at different intervals

Interval		Pomegranate	Beet root	Black plum	DW	*P*
Day 1	Mean	21.9	17.49	23.82	7.88	0.024*
	SD	3.96	5.11	14.07	2.31	
Day 7	Mean	24.53	18.57	26.76	8.97	<0.001*
	SD	4.83	6.88	4.42	1.99	
Day 14	Mean	38.96	32.55	40.01	14.49	<0.001*
	SD	4.61	6.23	2.66	2.93	
Day 21	Mean	53.79	42.95	55.27	24.72	<0.001*
	SD	3.62	3.37	3.5	4.02	

One-way ANOVA test; *indicates significant difference at $P \leq 0.05$

Table 6: Comparison of ΔE of Neo Spectra ST composite material among Pomegranate juice, Beet Root juice, Black Plum juice and Distilled water at different intervals

Interval		Pomegranate	Beet root	Black plum	DW	*P*
Day 1	Mean	18.84	15.92	19.29	7.12	0.001*
	SD	3.20	2.62	6.96	2.20	
Day 7	Mean	17.91	13.72	19.41	7.09	0.002*
	SD	3.13	5.76	3.15	4.55	
Day 14	Mean	33.10	30.40	34.86	12.36	<0.001*
	SD	3.30	4.64	3.21	2.31	
Day 21	Mean	45.66	39.34	47.35	22.93	<0.001*
	SD	4.51	2.90	2.71	1.55	

One-way ANOVA test; * indicates significant difference at $P \leq 0.05$

surface, increase water sorption, and enhance the affinity of the composite to extrinsic stains.[19] In addition, the tannins present in beetroot juice and black plum juice can contribute to surface roughness and further staining.[5,20]

Because of their low pH, the pomegranate juice (3.20) and black plum juice (3.10) may have harmed the samples' surfaces and increased erosion of the enamel. And yet, in comparison to other drinks, these acidic materials damage tooth enamel and result in more discoloration.[21]

In this study, the employed methodology followed the previous study.[22] Class V cavities were chosen on premolars because the location of noncarious cervical lesions is common on these teeth and patients are significantly prone to such lesions. The extracted human teeth were used as the studied materials to gain their color by induction from the surroundings. In addition, natural teeth have different optical properties, so they were used to reveal clinical conditions. Furthermore, many limited studies have used natural teeth to assess color change, mainly previous studies have used disks to evaluate color change. The choice of restoration in such a lesion is of utmost importance to prevent microleakage and maintain marginal integrity and sealing ability.

The composite shade chosen for this study is A2, which is the most commonly used shade for young patients as well as adults with higher expectations or esthetic requirements.

A 28-day staining time in solutions is similar to about 2 years in an oral environment. It is equivalent to 1 month of staining *in vivo* for 1 day of staining *in vitro*.[23]

The baseline color values and color change value after staining at different time intervals; day 1, day 7, day 14, and day 21 were measured using a spectrophotometer and evaluated using CIE L*, a*, b* system. A spectrophotometer can be used in dentistry to determine color objectively in addition to visually assessing samples against a reference illuminant. In addition to removing subjective inaccuracies, it is more accurate than the naked eye in detecting minute variations (Joiner 2004). To assess color change, the CIE strongly advised utilizing the equation E = ([L] 2+ [a] 2+ [b] 2) 1/2 rather than comparing the three color vectors (L*, a*, and b*). Since it summarizes the differences between the three color vectors and depicts their overall impact on color change, ΔE is more instructive.[24]

The CIE L*a*b* color coordinate system is used by spectrophotometers, making it a preferred technique for dental applications. It is capable of detecting minute color changes and has the added benefits of repeatability and sensitivity. The present study also relied on spectrophotometry for color determination because of its purportedly excellent accuracy, adaptability, and objectivity.

It is important to note the limitations of this study. The research was conducted *in vitro*, which may not fully replicate the oral environment. Factors such as bacterial flora and oral hygiene practices were not considered. Therefore, further long-term *in vivo* studies are necessary to validate these findings and evaluate the clinical impact of composite color stability.

CONCLUSION

Within the constraints of this investigation, the following conclusions can be drawn:

The color stability of esthetic restorative materials can be affected by exposure to beverages with antioxidant properties. While both Mani Flo V and Neo Spectra ST composites showed color changes, Neo Spectra ST exhibited slightly better color stability. Among the tested beverages, black plum juice caused the greatest discoloration, followed by beetroot juice and pomegranate juice, while distilled water had the least effect on color stability. These findings highlight the importance of considering the potential impact of varying beverages in terms of color stability of dental restorations and may aid clinicians in material selection for long-term esthetic outcomes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Kokich VO Jr., Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999;11:311-24.
2. Bhuvaneswaran M. Principles of smile design. J Conserv Dent 2010;13:225-32.
3. Macedo G, Raj V, Ritter AV. Longevity of anterior composite restorations. J Esthet Restor Dent 2006;18:310-1.
4. Gamal W, Safwat A, Abdou A. Effect of coloring beverages on color stability of single shade restorative material: An *in vitro* study. Open Access Maced J Med Sci 2022;10:28-32.
5. Al-Haj Ali SN, Alsulaim HN, Albarrak MI, Farah RI. Spectrophotometric comparison of color stability of microhybrid and nanocomposites following exposure to common soft drinks among adolescents: An *in vitro* study. Eur Arch Paediatr Dent 2021;22:675-83.
6. Şişmanoğlu S, Sengez G. Effects of acidic beverages on color stability of bulk-fill composites with different viscosities. Odovtos Int J Dent Sci 2022;24:90-9.
7. Schroeder T, da Silva PB, Basso GR, Franco MC, Maske TT, Cenci MS. Factors affecting the color stability and staining of esthetic restorations. Odontology 2019;107:507-12.
8. Mahajan RP, Shenoy VU, Sumanthini MV, Mahajan HP, Walzade PS, Mangrolia R. Comparative evaluation of the discoloration of microhybrid and nanohybrid composite resins by different beverages: A spectrophotometric analysis. J Contemp Dent Pract 2019;20:226-30.
9. Singh I, Kalyan SS, Gupta RK, Lone P, Chandarani S. Spectrophotometric analysis of color stability of esthetic restorative material in chlorhexidine mouthwash: An *in vitro* study. J Conserv Dent 2022;25:621-4.
10. Gupta R, Bhatheja A, John AG, Ramchandran M, Raina AA, Behera A, *et al*. Effect of beverages on color stability of resin composites: An in vitro study. Int J Appl Dent Sci 2019;5:92-5.
11. Alkhadim YK, Hulbah MJ, Nassar HM. Color shift, color stability, and post-polishing surface roughness of esthetic resin composites. Materials (Basel) 2020;13:1376.
12. Catelan A, Briso AL, Sundfeld RH, Goiato MC, dos Santos PH. Color stability of sealed composite resin restorative materials after ultraviolet artificial aging and immersion in staining solutions. J Prosthet Dent 2011;105:236-41.
13. Al-Qarni MA, Das G, Saquib S, Sibghatullah M, Alahmari MM, Arora S. The Effect of Arabian coffee, black tea and orange-juice on microhardness and color stability of hybrid composite resins. An *in vitro* study. Mater Plast 2021;58:218-27.
14. Erdemir U, Yildiz E, Eren MM. Effects of sports drinks on color stability of nanofilled and microhybrid composites after long-term immersion. J Dent 2012;40 Suppl 2:e55-63.
15. Chakravarthy Y, Clarence S. The effect of red wine on colour stability of three different types of esthetic restorative materials: An *in vitro* study. J Conserv Dent 2018;21:319-23.
16. Fathima JN, Hashir MM, Padmanabhan K. Spectrophotometric evaluation of color stability of composite resin after exposure to cold drinks: An *in vitro* study. J Conserv Dent Endod 2024;27:195-9.
17. Ertaş E, Güler AU, Yücel AC, Köprülü H, Güler E. Color stability of resin composites after immersion in different drinks. Dent Mater J 2006;25:371-6.
18. Meshki R, Rashidi M. Effect of natural and commercially produced juices on colour stability of microhybrid and nanohybrid composites. BDJ Open. 2022;8:11.
19. Yerliyurt K, Sarıkaya I. Color stability of hybrid ceramics exposed to beverages in different combinations. BMC Oral Health 2022;22:180.
20. Faris TM, Abdulrahim RH, Mahmood MA, Mhammed Dalloo GA, Gul SS. *In vitro* evaluation of dental color stability using various aesthetic restorative materials after immersion in different drinks. BMC Oral Health 2023;23:49.
21. Taneja S, Kumar M, Agarwal PM, Bhalla AS. Effect of potential remineralizing agent and antioxidants on color stability of bleached tooth exposed to different staining solutions. J Conserv Dent 2018;21:378-82.
22. Ahmed MA, Jouhar R, Vohra F. Effect of different pH beverages on the color stability of smart monochromatic composite. Appl Sci (Switzerland) 2022;12:4163.
23. Ebaya MM, Ali AI, El-Haliem HA, Mahmoud SH. Color stability and surface roughness of ormocer-versus methacrylate-based single shade composite in anterior restoration. BMC Oral Health 2022;22:430.
24. Huang W, Ren L, Cheng Y, Xu M, Luo W, Zhan D, *et al*. Evaluation of the color stability, water sorption, and solubility of current resin composites. Materials (Basel) 2022;15:6710.