Dentistry 3000

Vol 14, No 3 (2026)
ISSN 2167-8677 (online)
DOI 10.5195/d3000.2026.1657

Comparative Color Stability of a Micro-Hybrid and a Nano-Hybrid Composite Resin Following Staining and Office Bleaching

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Abstract

This in vitro study aimed to assess and compare the color stability of two commercial restorative resin composites (Charisma Classic, BEAUTIIFIL II) following office bleaching and exposure to popular drinks (tea and cola). Forty composite disc-shaped specimens were made using two composite materials (Charisma Classic and BEAUTIIFIL II). Twenty specimens measuring 8 mm in diameter and 2 mm in thickness were made from each composite resin using a specially made mold. Transparent and two thin glass slides In the mold, mylar strips were placed in between the resin composite. The samples were then light-cured for 40 seconds using a light-emitting diode device (Perfection Plus, Totton, UK). After that, the samples were polished using polishing disks in compliance with the manufacturer's specifications. After sample preparation, they were left in distilled water for a whole day to complete the rehydration and polymerization process. The initial color was ascertained using a calibrated spectrophotometer. The specimens were immersed in two staining solutions. After 10 days, spectrophotometric measurements were taken again to determine the color changes. Each specimen's color was assessed following office bleaching. A final measurement was taken a week later. ΔE, the color difference, was calculated. To find any significant differences, one-way analysis of variance (ANOVA) was used to compare each beverage between the two groups. A one-way ANOVA identified a significantly different result between the groups (F=6.858, p=0.000). Group B1 (Beautifil \ Tea) had the greatest color change (mean 6.09 ± 1.21), whereas group A2 (Charisma \ Cola) had the lowest mean (4.18 ± 0.97). Clinically noticeable staining and color change were indicated by ΔE1 >3.3 in all research groups. Stained composite restorations do not always need to be replaced; after one week, in-office bleaching (40% HP) can successfully remove tea and cola stains and restore them to a suitable color.

Open Access

Citation: Hanoon ZA. (2026) Comparative Color Stability of a Micro-Hybrid and a Nano-Hybrid Composite Resin Following Staining and Office Bleaching. Dentistry 3000. 1:a001 doi:10.5195/d3000.2026.1657
Received: October 14, 2026
Accepted: November 20, 2026
Published: November 24, 2026
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Introduction

Conventional composite restorations are currently the most widely used restorative materials by dentists worldwide. Because they come in a variety of shades, dentists can use them to mimic the hues of the surrounding natural tooth. It is challenging to match the color of a composite to the surrounding tooth structure, and it depends on environmental and operator-dependent variables. The physical, chemical, and mechanical properties of dental composites, which define their clinical effectiveness, are greatly influenced by the oral environment and resin material parameters [1,2]. The three main components of resin-based composites are the resin matrix (organic content), fillers (inorganic part), and coupling agents. The resin matrix of these composites is mostly made up of bisphenol A-glycidyl dimethacrylate (Bis-GMA), which is mixed in different ways with short-chain monomers such urethane dimethacrylate (UDMA), triethene glycol-dimethacrylate (TEGDMA), and bisphenol Bis-EMA, a polyethylene glycol diether dimethacrylate. Glass, silica, or zirconia fillers are available in different forms and concentrations [3,4].

Even though composite resins' composition and properties have greatly improved, they still must cope with a variety of challenging circumstances when used in the oral cavity, such as pH fluctuations and temperature shifts. The

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Vol 14, No 3 (2026) DOI 10.5195/d3000.2026.1657

use of coffee and tea by adults, as well as the frequent intake of aerated beverages by children and young people, may have an influence on the esthetic and elemental aspects of composite resins. This can reduce the efficacy of the repair. External degradation or a tiny quantity of staining component seepage might cause composite discoloration in the oral environment [5-7].

Color stability is an essential physical property of composite materials. Color changes can be caused by a variety of etiologic factors, both internal and external. While intrinsic discoloration may result from a physio-mechanical response within the material, extrinsic discoloration is defined as the staining of the resin composite's exterior layer. Extrinsic discoloration is caused by dietary habits, water sorption, and smoking [8,9].

The staining of resin-based composites is a major drawback, even when utilizing composites with different compositions. Examples of colored drinks that might cause discoloration are coffee, tea, and cola. A staining agent can permeate a composite's top layer. Staining is therefore more common in composites with more resin because of the high percentage of water sorption, which increases the presentation of microcracks and interfacial gaps at the resin filler interface—through which the stains can penetrate and contribute to color changes of the resin composite. Discolored composites can be repaired with expert cleaning, polishing, and bleaching. In extreme cases, replacement treatment is advised. The application of H2O2 bleaching to remove stains and restore the composite's natural color is supported by several research [8,10,11].

Charisma Classic (Kulzer GmbH) is a light-curing, radio-opaque micro-hybrid universal dental composite that uses second-generation Microglass II filler technology. About 61% of Charisma Classic's filler is made of barium aluminum fluoride glass. Because pyrogenic SiO2 is no longer needed, the new Microglass II filler technology offers an intrinsic shade brilliance and improved color adaptability of up to 56%. The refractive indices of our matrix and filler system match exactly. Color pigments ensure an improved shade brightness. Beautifil II is a bioactive, nano-hybrid direct restorative composite that uses Surface Pre-reacted Glass Ionomer technology. The material continually releases fluoride and reabsorbs it from mouth secretions to protect teeth. Charisma Classic is a micro-hybrid composite, whereas Beautifil II is a giomer-based nanohybrid composite. Variations in filler type and matrix composition may lead to different staining tendencies.

Visual examination evaluates color changes, a completely nonsensical physiological and psychological process. However, when used as a color evaluation tool, the spectrophotometer removes subjective judgments and enables the detection of minute color changes. Colorimetry, which is based on the digital representation of the color viewed from the item, may be used to evaluate color. The Munsell colorimetric system and the traditional CIE L*a*b* colorimetric system are two colorimetric methods used to evaluate chromatic difference. The L* coordinate indicates an object's brightness, the a* value indicates its red or green chroma, and the b* value indicates its yellow or blue chroma. The CIE L*a*b* scheme is recommended by the ADA. This theory holds that the three primary hues—red, blue, and green—are blended in certain ratios to produce all the colors present in nature. Dental researchers frequently utilize this method to examine the color of dental materials [12-14].

To the best of our knowledge, no previous study has looked at the color stability of Charisma Classic as a micro-hybrid composite and Beautifil II as a nano-hybrid composite after office bleaching and immersion in tea and cola. In order to understand the effect of office bleaching on the color stability of these resin composites, this in vitro study examined the color changes of Charisma Classic (Kulzer GmbH) and Beautifil II (Shofu) following ten days of immersion in tea and cola and subsequent in-office bleaching with 40% hydrogen peroxide (H2O2). The null hypothesis states that there would be no appreciable difference in ΔE values across materials and staining solutions before and after bleaching.

Material and Methods

This study employed two commercially available composite resin materials: Beautifil II A2 (Shofu Dental Corporation, Japan) and Charisma Classic A2 (Kulzer Dental Corporation, Germany). This study also used two staining solutions (Tea, Cola) and one in-office bleaching product (Table 1). The specimens of each material were randomly divided into two subgroups of 10 each. Each set was stained and bleached.

Specimen Preparation

Using a specially designed mold, forty disc-shaped specimens (8 mm in diameter and 3 mm in thickness) were created from each material (n = 20). The sample size was determined using data from earlier research [15-17]. Each composite was packed into a mold using a plastic filing tool. During the specimen preparation process, a 1 mm thick glass slide and a Mylar strip were placed over the silicone mold. A gentle pressure of 5–10 N was applied to the glass slide. This pressure was employed to eliminate any excess composite material from the mold in addition to guaranteeing uniformity of the specimen thickness and the distance between the specimens and the light curing tip. One operator was preparing each specimen. The samples were then light-cured for 20 seconds on both the top and bottom surfaces using a light-emitting diode (LED) (Perfection Plus, Totton, UK). This LED light-curing device provides a light intensity of 850–1000 mW/cm2, according to the user manual (Figure 1).

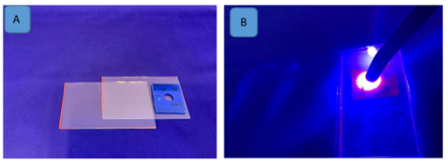

Figure 1. A- custom-made mold with the glass slide, B- light curing of the composite disc.

Using a composite polishing disk (POLISHING DISK DENCO PACK/40, Germany), the surface to be measured was polished and completed in the following order: blue to white (Figure 2).

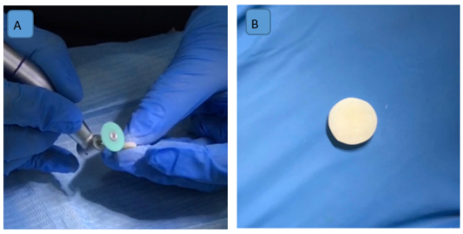

Figure 2. A-finishing and polishing of the disc, B- the prepared disc.

To replicate the first day of service for restoration in the oral environment, each composite disk was placed in a separate container with a number on its surface. These containers were then preserved in distilled water at 37 °C for 24 hours. Before baseline color measurement, all samples were removed after a 24-hour period, cleaned with distilled water, and blot-dried (Figure 3).


Figure 3. The prepared discs kept in separated containers.

Grouping and Staining Protocol

The forty specimens were split into two groups at random: -Group A: composed of Charisma

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Classic A2 composite, which was then split into two subgroups according on the immersion solution (N=10) (Figure 4).
A1: a composite disk soaked with tea.
A2: composite disk submerged in cola. Group B: composed of BEAUTIFUL II A2 composite, which was then split into two subgroups (N=10) (Figure 4).
B1: a composite disk soaked in tea.
B2: composite disk submerged in cola.

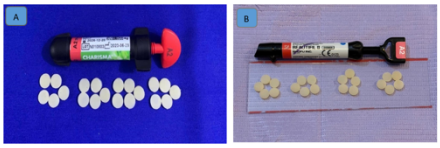

Figure 4. Composite materials used; (A) Charisma classic; (B) Beautifil-II.

After the initial measurement, one Lipton tea bag was used for every 100 milliliters of boiling water to create a total of 5 milliliters of tea solution. The beverage used was Coca-Cola®, and its pH (around 2.5) was measured using pH indicator paper. For ten days, all the specimens were kept in staining solutions at 37°C in an incubator, with refreshments every 24 hours (Figure 5).



Figure 5. Specimens were stored in staining solutions (tea, cola).
To avoid any possible chemical changes in the material, the solutions were replaced every 24 hours. The color shift after staining was recorded and quantified ten days later. Samples were cleaned with a toothbrush and toothpaste for ten seconds before to each measurement. They were then gently washed in distilled water and dried with tissue paper. Colgate Total toothpaste (Colgate Palmolive Ltd., Chharodi, India) was utilized in this investigation. A toothpaste should not surpass a relative dentin abrasiveness (RDA) value of 250, which is regarded as a safe limit for hard tissues, according to ISO specifications. Colgate Total toothpaste, whose RDA value was 70, was thus utilized in this investigation (Figure 6).

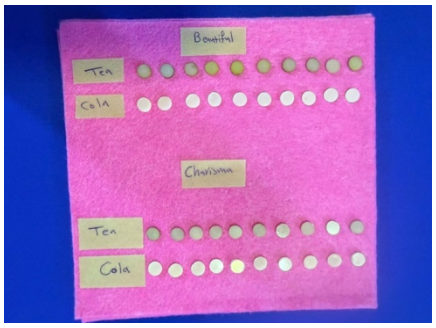

Figure 6. Discs cleaned and dried.
Bleaching Protocol
Following staining, all specimens underwent in-office bleaching using 40% hydrogen peroxide (Power whitening, WHITEsmile, Germany), where a 0.5 mm thick coating was applied for 20 minutes before being washed. As directed by the manufacturer, the process was performed three times (Figure 7).



Figure 7. The samples after bleaching procedure.

Color Measurement and Time Points
A spectrophotometer (Colorimeter Hangzhou color spectrum technology, China) was used to measure color on a white backdrop (Figure 8). The CIE L_a_b_ system was employed, where (L) stands for lightness, (a) for red-green, and (b) for yellow-blue. Three measurements were used to determine the mean value for the L*, a*, and b* values for each specimen. Measurements were recorded at 4 time points:
T0: Baseline after 24h water storage
T1: After 10 days staining (Tea/Cola)
T2: Immediately after bleaching
T3: One week after bleaching (specimens stored in distilled water at 37°C) to evaluate color rebound.
Color change (ΔE) was calculated using the following formula [2,14]:
$\Delta E = \sqrt{[(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]}$
Where:
ΔE1 (T0-T1): Staining effect
ΔE2 (T0-T2): Effect of bleaching immediately
ΔE3 (T0-T3): Color stability after one week
ΔE (T1-T2) & (T1-T3): Bleaching efficacy and rebound
ΔE > 3.3 was considered clinically perceptible [18].



Figure 8. Wireless digital spectrophotometer, with CIEL*a*b color coordinates.

Statistical Analysis
The Statistical Package for the Social Sciences (SPSS) program, version XX (IBM Corp., Armonk, NY, USA), was used to analyze the data. Shapiro-Wilk tests were used to determine if the data distribution was normal. For each variable, descriptive statistics were displayed as mean ± standard deviation (SD).
The Independent Samples t-test was utilized to evaluate the mean values between two independent groups, and the ANOVA F test was employed to compare the mean values across the research groups for normally distributed (parametric) data (Figure 9).
For non-parametric data, the mean values of the study groups were compared using the Kruskal-Wallis test, and the mean values of two independent groups were compared using the Mann-Whitney U test. The mean values of the same group at two distinct time intervals were compared using the Paired Samples t-test. Statistical significance was defined as a p-value of less than 0.05.

Results
Table 2 displays the findings of the statistical analyzes of the ΔE1 values among the four research groups. A very significant difference between the groups was found using a one-way ANOVA (F=6.858, p=0.000). Group B1 (Beautifil \ Tea) had the greatest color change (mean 6.09 ± 1.21), whereas group A2 (Charisma \ Cola) had the lowest mean (4.18 ± 0.97). Clinically noticeable staining and color change were indicated by ΔE1 >3.3 in all research groups. B1 was substantially greater than A1, A2, and B2 ($p<0.05$) according to the post-hoc Tukey test, although there was no significant difference between A1, A2, and B2.
One-way ANOVA revealed a very significant difference between groups in ΔE2, which

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represents the color change between baseline and after bleaching (F=10.71, p=0.000) (Table 3).

Group B2 (Beautifil \ Cola) had the lowest ΔE2 (1.23±0.6), suggesting the best color recovery, whereas group B1 (Beautifil \ Tea) had the highest ΔE2 (2.5±0.53). The values displayed by groups A1 and A2 were the same (0.39±1.62).

According to Kruskal-Walli's test, the four groups' ΔE3 did not differ significantly (H=7.166, p=0.067 NS). After a week of bleaching, ΔE3 represents the final color in relation to the baseline.

After one week, all groups showed ΔE3 values below 3.3 (A1: 1.91±0.66, A2: 2.25±0.44, B1: 2.39±0.40, B2: 1.57±0.82), meaning that there was no substantial relapse and the color stayed near baseline. B2 had the best long-term color stability, with the lowest ΔE3 (1.57) (Table 4).

A highly significant difference in ΔE-bleach across groups was found by one-way ANOVA (F=9.76, p=0.000) (Table 5). The bleaching efficacy is represented by ΔE-bleach. Every group had bleaching values more than 3.3, indicating that bleaching was successful in eliminating the discoloration. Group B1 (Beautifil \ Tea) had the highest bleaching efficacy (mean 6.79±1.44), whereas group A2 (Charisma \ Cola) had the lowest (mean 4.64±0.47). This implies that teeth with more initial discoloration underwent more color change following whitening.

The One-way ANOVA test revealed a highly significant difference (F=10.45, p=0.000) in ΔE-stability, which represents the bleaching efficacy after one week. After a week, all groups maintained significant ΔE values (>3.3), suggesting a durable bleaching effect (Table 6).

According to an inter-group comparison, there were significant differences for ΔE1 between B1-B2 (p=0.005) and A1-B1 (p=0.009), meaning that Beautifil stained more in tea than Charisma and that tea produced substantially more discoloration in Beautifil than cola. For ΔE2, all comparisons showed no significant differences (p>0.05), suggesting a consistent return to baseline. Only B1-B2 demonstrated significance for ΔE3 (p=0.02). B1-B2 (p=0.002) and A1-B1 (p=0.02) were significant for ΔE bleach, indicating that the specimens that stained the most had a stronger bleaching reaction. A1-A2 (p=0.023), A1-B1 (p=0.004), and A2-B2 (p=0.001) showed significant differences for ΔE stability, suggesting that the Beautifil groups had superior stability (Table 7).

Discussion

One of the main causes of restorations' cosmetic failure is discoloration, which is frequently the primary justification for replacing composite resin restorations. Numerous investigations have investigated color changes in esthetic restorative materials that are believed to be brought on by drinks including tea, coffee, and cola. Color stability plays a major role in the clinical and esthetic effectiveness of resin composite restorations. However, regular consumption of food and beverages can alter the color of restorative materials [19,20].

The color stability of two marketed restorative resin composites (Charisma Classic, BEAUTIIFIL II) was assessed in this study following external bleaching with 40% H2O2 and staining with popular drinks (tea, cola). The premise behind this investigation was that the color stability of these two composite resins is unaffected by staining and external bleaching. The null hypothesis was rejected based on the study's findings. Since tea and fizzy drinks like Coca-Cola are the most popular drinks in the world, they were chosen as the staining solutions. Furthermore, because it includes chromogens and tannins, it has a significant staining impact on both natural teeth and composites [6].

Discoloration can be measured objectively using an instrument or subjectively by comparing color differences visually. The CIEL*a*b color coordinates were determined in this investigation using a portable, cordless digital spectrophotometer with a white plate serving as the backdrop. Although there are several color systems in use, dental research has made substantial use of the CIEL*a*b* color system. This color-difference formula allowed for comparisons with earlier research and offered information on overall color change as well as values of the change across color coordinates [21,22].

Following immersion in tea and cola, all groups demonstrated clinically discernible discoloration (ΔE1>3.3), according to the current investigation. B1 (Beautifil/tea 6.09) had the largest ΔE1. This is consistent with the findings of Abdelhafez and Abu-Eittah (2024) and Mekky et al. (2024) [23,24], who found that tea's high tannin content and tiny polar colorants that pierce the resin matrix produce greater staining than other drinks. Additionally, Beautifil II (giomer nanohybrid composite) exhibited more color changes than Charisma (micro-hybrid composite). Although both materials have hydrophilic resin matrix composition, Beautifil II has a larger filler weight than Charisma. Thus, it is possible that the water sorption from S-PRG fillers is the cause of this discrepancy. A giomer called Beautifil II makes use of surface pre-reacted glass-ionomer (S-PRG) filler technology. This enables the material to dynamically release and replenish fluoride. Nevertheless, this chemical interaction increases the resin matrix's susceptibility to water absorption over time, attracting external food pigments (such as coffee, tea, or cola) and resulting in more significant color changes. This result is consistent with previous work [23-25]. This study's result that ΔE bleach values ranged from 4.64 to 6.79, all over the perceptibility threshold, is supported by the fact that all bleaching chemicals considerably decreased discoloration (p<0.05). Bleaching decreased discoloration but did not always result in a complete restoration to baseline, according to similar research. The use of 40% hydrogen peroxide in the workplace, as opposed to lesser quantities utilized in other research, may have contributed to the study's return to baseline. Given that more stained specimens exhibit higher ΔE following bleaching, the substantial difference in B1-B2 (p=0.002) and A1-B1 (p=0.02) makes sense. This result is consistent with the findings of Amedee et al. (2013) [26], who found that high-concentration hydrogen peroxide agents (35%–40%) interact with the resin matrix and filler particles, resulting in discernible changes in lightness (L*) and chromatic coordinates (a*, b*). However, it differs with the findings of Hafez et al. 2010 [27] that claimed that although in-office bleaching successfully lessens extrinsic stains (such those from coffee or tea), it typically cannot return a damaged composite to its precise original hue. Kury et al. (2026) stated that the degree of color change depends on the filler volume and composition of the composite (e.g., microfilled, micro-hybrid, nanohybrid, or bulk-fill) [28].

The most significant finding of this study is that both ΔE2 (T0→T2) and ΔE3 (T0→T3) values were below 3.3 in all groups (ΔE2: 1.21-2.29, ΔE3: 1.57-2.39), suggesting that bleaching was successful in returning the composite color to nearly original, which is clinically acceptable according to Paravina et al. (2019) [29]. but disagree with Atilan Yavuz et al. (2026) [30], who found that bleaching processes altered the color of all single-shade resin composites in a way that was clinically unsatisfactory. For ΔE2, there was no significant difference between the groups (Table 7), and for ΔE3, Kruskal-Wallis revealed a non-significant p=0.067. This demonstrated that bleaching is similarly successful in returning to baseline color independent of the kind of composite or staining solution.

Stability after one week (ΔE stability): In terms of stability after one week (ΔE stability T1→T3), values stayed high (4.49-6.61) and quite near to immediate bleaching levels (Table 5 vs. Table 6), suggesting stable outcomes without recurrence. A1-A2 p=0.023, A1-B1 p=0.004, and A2-B2 p=0.001 were found to be significant in the intergroup comparison. Compared to Charisma (5.01 and 4.49), the Beautifil groups (6.61 and 6.06) maintained stability better. This implies that giomer could be better at retaining

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the bleaching effect, perhaps because of surface features. Within Beautifil, only B1-B2 was NS (p=0.34), demonstrating consistent stability.

The fact that this study was conducted in vitro is its biggest drawback. To get findings that are more in line with clinical reality, more thorough studies that take aging and brushing techniques into account are also required, as are in vivo studies assessing recently produced materials with various components.

Conclusion

Dental restorations can change color due to a variety of factors, including the material's characteristics, the patient's daily routine, and ongoing exposure to pigmented materials. Understanding these interactions is crucial for choosing appropriate filler materials and preventative measures. Regular maintenance and patient education are necessary for long-term cosmetic preservation. Stained composite restorations do not always need to be replaced; after one week, in-office bleaching (40% HP) can successfully remove tea and cola stains and restore them to a suitable hue. Future developments should concentrate on better clinical procedures and stain-resistant compositions.

Conflict of Interest

The author confirms that this article content has no conflict of interest.

Acknowledgements

The author does not have any financial interest in the companies whose materials were used in this study. This study was self-funded.

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Table 1. Description of materials used in this study.

Materials	Composition	Brand Name and Manufacture
Charisma Classic A2	The second generation of Micro-glass II filler technology. By volume, barium aluminum fluoride glass accounts for around 61% of the filler.	Kulzer Dental Corporation; Germany
BEAUTIFIL II (A2)	filler particles made using S-PRG (Surface Pre-reacted Glass Ionomer) technology. By volume, it contains around 68.6% filler.	Shofu Dental Corporation, Japan
Lipton	Classic black tea	Lipton tea company; India
Cola	Coca-Cola, Ph ≈ 2.5	Coca-cola company; Iraq
Power whitening	40% Hydrogen peroxide	WHITEsmile, Germany

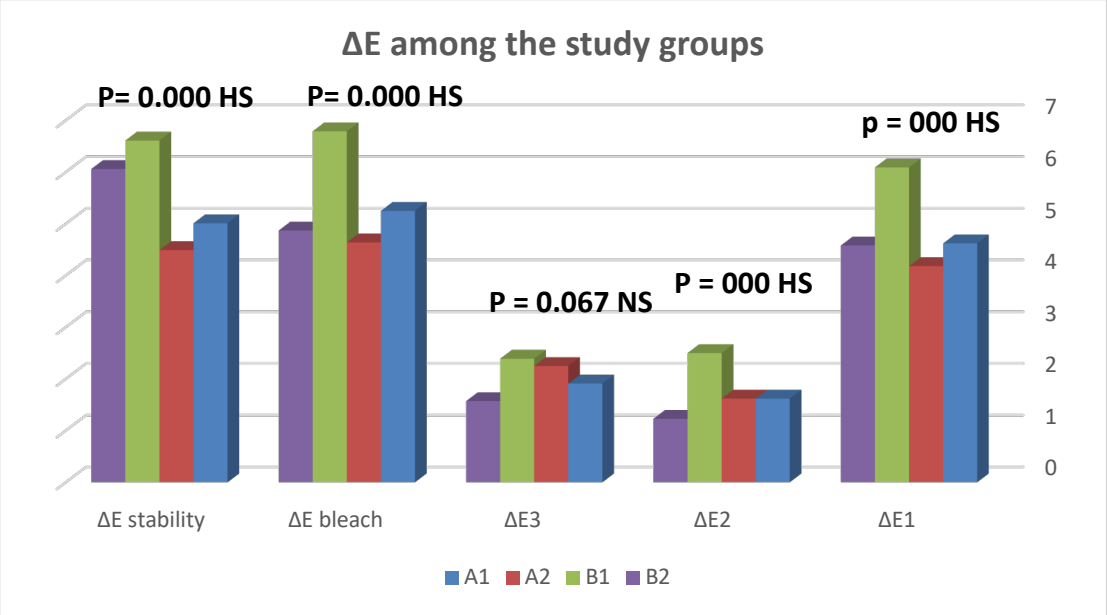

Figure 9. Mean, ANOVA F and Kruskal- Walli's tests for all ΔE among the study groups.

Table 2. ANOVA F test for ΔE1 among the study groups.

Groups	n	Mean	SD	ANOVA	P-value
A1	10	4.62	1.01	6.858	0.000
A2	10	4.18	0.97		
B1	10	6.09	1.21		
B2	10	4.58	0.83		

Table 3. ANOVA F test for ΔE2 among the study groups.

Groups	n	Mean	SD	ANOVA	P-value
A1	10	1.62	0.39	10.71	0.000
A2	10	1.62	0.39		
B1	10	2.5	0.53		
B2	10	1.23	0.6		

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Table 4. Kruskal- Walli's test for ΔE3 among the study groups.

Groups	n	Mean	SD	H-value	P-value
A1	10	1.91	0.66	7.166	0.067
A2	10	2.25	0.44		
B1	10	2.39	0.4		
B2	10	1.57	0.82		

Table 5. ANOVA F test for ΔE bleach among the study groups.

Groups	n	Mean	SD	ANOVA	P-value
A1	10	5.25	0.97	9.76	0.000
A2	10	4.64	0.47		
B1	10	6.79	1.44		
B2	10	4.87	0.76		

Table 6. ANOVA F test for ΔE stability among the study groups.

Groups	n	Mean	SD	ANOVA	P-value
A1	10	5.01	0.51	10.45	0.000
A2	10	4.49	0.4		
B1	10	6.61	1.44		
B2	10	6.06	1.02		

Table 7. Inter group comparison of the mean value of ΔE1, ΔE2, ΔE3, ΔE bleach, ΔE stability between study groups.

ΔE	Test	A1-A2	B1-B2	A1-B1	A2-B2
ΔE1	T-Test	0.99	3.25	-2.94	-0.99
	P-value	0.34	0.005	0.009	0.33
ΔE2	T-Test	2	4.95	1.84	1.7
	P-value	0.21	0.81	0.08	0.17
ΔE3	Mann- Whitney	36	80.5	28	74.5
	P-value	0.3	0.02	0.1	0.06
ΔE bleach	T-Test	1.78	3.71	-2.8	-0.8
	P-value	0.09	0.002	0.02	0.43
ΔE stability	T-Test	2.49	0.98	-3.29	4.5-
	P-value	0.023	0.34	0.004	0.001