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# Comparative Effects of Turmeric, Coffee, and Chewable Tobacco on the Color Stability of Tooth-colored Restorative Materials

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**Abstract** **Objective:** To compare the staining intensity of turmeric and chewable tobacco with that of coffee and to investigate the impact of staining status on the bleaching efficacy of discolored restorative materials. **Study Design:** A total of 72 specimens from two types of dental composites (nanocomposite, and microhybrid composite) and two types of glass ionomer cements (conventional glass ionomers, and resin-modified glass ionomers) were immersed in different staining media including turmeric, coffee, and chewable tobacco (3 Hour/day). The color changes were measured at 15th, 30th, and 45th days of staining according to the CIELAB system. The discolored specimens were then bleached using a 10% carbamide peroxide solution (2×30 min daily) and the color changes were quantified after 7 and 14 days of bleaching. The obtained data were further analysed using ANOVA with complementary Tukey's test ($p<0.05$). **Results and Conclusion:** Chewable tobacco displayed the most overall staining effect on the selected materials, followed by coffee and turmeric. Nanocomposites showed the highest vulnerability to color change due to the exposure to coffee and turmeric, while the highest color change by chewable tobacco was observed in the resin-modified glass ionomers. In contrast, the conventional glass ionomers were least stained in all staining solutions. Carbamide peroxide also exhibited more bleaching effect on nanocomposites compared to other selected restorative materials. **Clinical Significance:** Conventional glass ionomers and microhybrid composites are more suitable compared to resin-modified glass ionomers and nanocomposites for utilization in places where esthetic longevity is the prime concern (anterior teeth and premolars in smile line) and patient has high intake of coffee, turmeric, or chewable tobacco.

**Keywords** Staining, Bleaching, Discoloration, Spectrophotometry

## 1. Introduction

Technological advancement in dental aesthetics has led to a growing interest on augmentation and repairing of damaged teeth with aesthetic restorative materials, rendering a flawless appearance. Among various restorative materials, dental composites and glass ionomer cements are the most preferred materials for aesthetic purposes. Dental composites are widely accepted materials due to their desirable color matching properties and excellent polishability[1]. On the other hand, glass ionomer cements possess a less favorable color matching quality compared to dental composites[2]. However, due to their shade being quite close to natural teeth as well as their anti-cariogenic activity, these materials are preferred for restorative treatments of young population and those with high caries risk[3, 4].

The crucial challenge of using the aesthetic restorative materials in clinical practice is to maintain their longevity and aesthetic compliance[5-7]. Color stability is a crucial property required for anterior dental restorations and considered as a significant criterion that determines the serviceability of these materials[8, 9]. Color alteration is mostly attributed to the oral hygiene, dietary, and other habits (drinking coffee, cola, alcohol, and smoking or chewing tobacco) of an individual[1, 10-13]. Discoloration may be due to a number of parameters including stain accumulation and surface roughness as extrinsic factors as well as water sorption, dissolution of ingredients, and degradation of material components as intrinsic factors[10, 11].

As an effective approach to restore the initial color of discolored teeth or restorative materials, the use of bleaching

agents such as hydrogen peroxide and carbamide peroxide has been proposed[14-17]. However, the bleaching agents may not exhibit similar impacts on different restorative materials. For instance, a 10% carbamide peroxide successfully bleaches dental composites and hybrid ionomer; whereas, this solution is not effective in removing the stains from compomer[18].

The present study aimed to explore the staining effects of turmeric and chewable tobacco on two types of dental composites and two types of glass ionomer cements as well as to compare their staining intensity with that of coffee. In spite of extensive researches on the color stability of tooth-colored restorative materials in different staining media, the impacts of turmeric and chewable tobacco on the color of these materials have received little attention. Turmeric (Curcuma longa) is a spice commonly used in Asian cuisine owing to its flavouring properties as well as antibacterial and anti-inflammatory effects[19, 20]. Chewable tobacco (Gutka) is another product with staining capability that is widely consumed in Asian countries because of personal, social, cultural and medicinal attributes[21]. However, the presence of colorants in the composition of these products leads to considerable changes in the color of aesthetic restorative materials. As another objective of this study, the ability of a 10% carbamide peroxide solution in removing these stains from the discolored restorative materials was also evaluated.

## 2. Material and Methods

Specimen Preparation

A schematic diagram of the experimental method used in this study is presented in Figure 1. Table 1 also presents the details of the tooth-colored restorative materials selected for this study. Eighteen disc shaped specimens were prepared from each type by injecting the materials (excluding GIC) into Polytetrafluoroethylene (PTFE) molds with dimensions of 9×2.5 mm. Each mold containing uncured material was held between two glass slides that were covered with a transparent polyester strip (Mylar; Henry Schein, Melville, NY). Then, the glass slides were gently pressed together to ensure complete flow of the material into the mold. Both the upper and lower surfaces of the specimens were further cured for 40 seconds using a quartz-halogen lamp with wavelength of 450 nm. For preparation of GIC specimens (which was supplied in powder-liquid system), the dispensed powder and liquid were proportioned and mixed as per the manufacturer's instructions, followed by loading into PTFE molds and allowing to set.

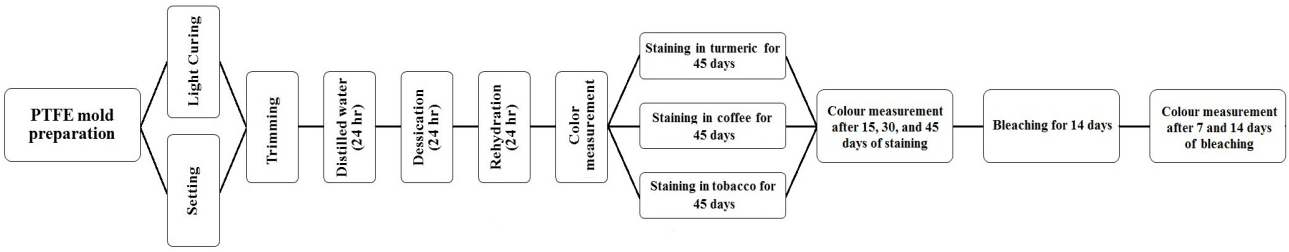



**Figure 1.** A schematic representation of the experimental method used in this study.

The specimens were retrieved from the molds after hardening and the excess flash was trimmed using a scalpel blade. Only those specimens with smooth surface finishes were chosen for further experiments and no subsequent polishing operation was performed. The specimens were then stored in distilled water for 24 hours, followed by desiccation for 24 hours in order to attain the equivalent weight. The specimens were finally rehydrated in distilled water for 24 hours prior to performing further experiments.

**Table 1.** The specifications of the restorative materials selected for this study.

| Name | Brief Composition | Category | Manufacturer |
|---|---|---|---|
| Esthet-x (MHC) | Resin:BisGMA,TEGDMA<br>Fillers:Zirconia/silica<br>(0.01-3.5µm) in 66vol% | Microhybrid composite | Dentsply Corp. India |
| Ceram® X (NC) | Resin: Methacrylate modified polysilioxane<br>Fillers: Glass & ceramic<br>(1-10nm) in 76vol% | Nanocomposite | Dentsply Corp. India |
| Fuji II (GIC) | Powder: flouroaluminosilicate glass.<br>Liquid: polyakenoic acid & copolymer of itaconic and maleic acid. | Conventional glass inomer cement | GC Corp. Japan |
| Fuji II LC (RMGIC) | Resin:HEMA<br>Flouroaluminosilicate glass, polyacrylic acid | Resin-modified glass inomer cement | GC Corp. Japan |

Preparation of Staining Solutions

The details of the staining agents used in this study are presented in Table 2. For preparation of the staining solutions, required quantities of staining materials (turmeric: 0.20%, coffee: 2.5%, chewable tobacco: 2.8%, based on their standard consumption regime) were weighed into a beaker and dissolved in 100 ml of distilled water. After thorough mixing, the solutions were boiled for 5 minutes to ensure the complete dissolution of the stains. The solutions were further filtered and the supernatant was kept as the staining media.

**Table 2.** The materials used for staining of the selected restorative materials.

| Commercial Name | Brief Composition | Manufacturer |
|---|---|---|
| Turmeric | Oleoresin, Curcumin, Glycine | MTR, India |
| Coffee | Caffeine, Tannic acid | Nescafe, India |
| Chewable tobacco | Butyl rubber, Wax, Flavours, processed tobacco leaves | Star Gutka, India |

Staining Method

The hydrated specimens were dipped in glass beakers containing 100 ml of staining solutions (6 specimens in each solution) for 3 hours daily. The specimens were then retrieved from the solutions, rinsed with distilled water, and stored in a beaker containing fresh distilled water until further staining. The staining experiments were continued for 45 days.

Specimen Bleaching

After completion of the staining experiments, the specimens were subjected to bleaching tests using 10% carbamide peroxide with suitable thickening agents (Visalys whitening, Kettenbach, Germany). The bleaching agent was placed between two sheets of polyvinyl chloride (PVC), followed by inserting the discolored specimens between these sheets for 30 minutes twice daily. After each treatment, the specimens were retrieved, washed with distilled water, and stored in distilled water until further treatment. Bleaching treatments were conducted for 14 consecutive days.

Color Measurement

A reflection type spectrophotometer (Spectroscan/Spectrolino with Profile-maker software v4.1, GretagMacbeth AG, Regensdorf, Switzerland) was used for measurement of color changes (ΔE) based on the Commission Internationale de l'Eclairage Lab (CIELAB) system. The color values of the specimens prior to staining were considered as baseline.

The ΔE values of each specimen were measured during the staining and bleaching to evaluate the degree of color alteration at different stages. The ΔE values of the stained materials were measured at 15th, 30th, and 45th days of staining and the values higher than 3.48 were considered as clinically perceptible discolorations[22]. The ΔE values of the bleached specimens were also measured at 7th and 14th days of bleaching. The obtained ΔE values were later analysed using ANOVA (SPSS 20, SPSS Inc, USA) and complementary Tukey's test with 95% confidence interval.

# 3. Results

Staining

The ΔE values of selected restorative materials after staining in different media for 15 days are shown in Figure 2. This Figure shows that among studied restorative materials, GIC specimens were least stained with turmeric and coffee; whereas, MHC specimens stained the least when tobacco was used as staining agent. On the other hand, in both turmeric and coffee solutions, the maximum color changes were observed in NC, while RMGIC showed the highest susceptibility to discoloration in tobacco solution. The descending order in which the studied restorative materials stained with turmeric was NC, RMGIC, MHC, and GIC, respectively. A similar trend was observed when the restorative materials were stained in coffee solution. However, exposure to tobacco solution resulted in a different order of staining as RMGIC was stained the most followed by NC, GIC, and MHC. Figure 2 demonstrates that turmeric and tobacco solutions exhibit the lowest and highest overall staining effects on different aesthetic materials, respectively.

Table 3 presents two-way ANOVA comparisons between the color changes of the four studied aesthetic materials after staining in different solutions for 15 days. The ANOVA analysis (post-hoc Tukey's test) shows significant differences between the ΔE of all aesthetic materials when stained in turmeric solution (excluding the differences between GIC and MHC, as well as RMGIC and MHC). A similar result was also obtained when coffee was used as staining solution. In the case of staining with tobacco, there was no significant difference between the ΔE values of GIC and MHC; however, the two-way ANOVA shows significant differences in color change between all other studied aesthetic materials. Therefore, according to Figure 2 and Table 3 and considering the fact that the ΔE values of GIC and RMGIC were not statistically different from that of MHC in turmeric and coffee solutions, it could be seen that the total effect of turmeric and coffee solutions are higher in composite restorative materials than that of glass ionomer specimens. On the other hand, the glass ionomer specimens are more affected by tobacco solution compared to composite restorative materials. For instance, despite the color change in GIC due to the staining with tobacco is smaller than that of NC, the ΔE value of GIC is 5.6 times higher compared to its color change by turmeric solution; whereas this ratio is about 1.8 for NC specimens. In the case of composite restorative materials, there is a statistical significant difference in staining with all three stains between NC and MHC. A similar significant difference in staining with all three stains was noted between the two glass ionomer materials.

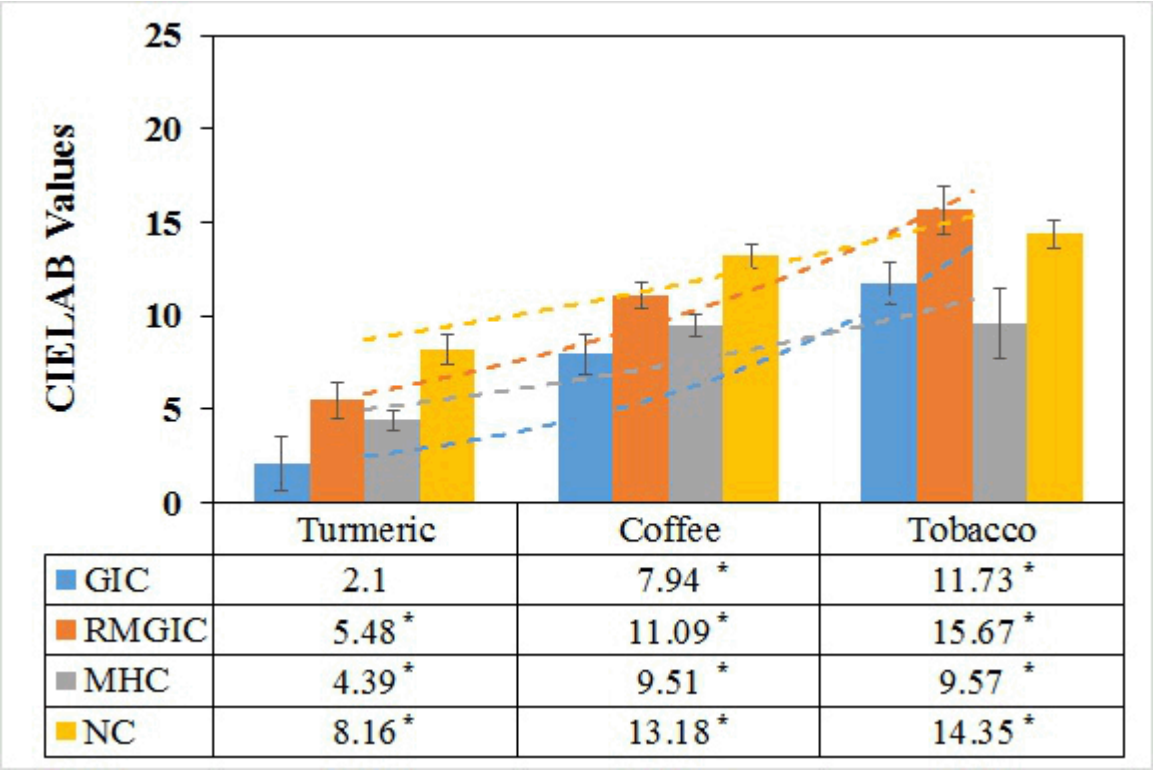



**Figure 2.** Changes in the CIELAB values of different restorative materials after staining for 15 days. *indicates clinically perceptible values ($\Delta E \geq 3.48$).

**Table 3.** Two-way ANOVA comparison between the color change values (ΔE) of various restorative materials after staining in three solutions for 15 days ($P<0.05$)

| | **Turmeric** | | | **Coffee** | | | **Tobacco** | | |
|---|---|---|---|---|---|---|---|---|---|
| | GIC (A) | RMGIC (B) | MHC (C) | GIC (A) | RMGIC (B) | MHC (C) | GIC (A) | RMGIC (B) | MHC (C) |
| RMGIC (B) | 0.002* (B>A) | | | 0.000* (B>A) | | | 0.010* (B>A) | | |
| MHC (C) | 0.058 | 0.600 | | 0.120 | 0.117 | | 0.274 | 0.000* (B>C) | |
| NC (D) | 0.000* (D>A) | 0.020* (D>B) | 0.001* (D>C) | 0.000* (D>A) | 0.022* (D>B) | 0.000* (D>C) | 0.135 | 0.679 | 0.001* (D>C) |

The ΔE values of different restorative materials after staining for 30 days are presented in Figure 3. Similar to time interval of 15 days, the ΔE values shown in this figure confirm that tobacco and turmeric show the most and the least staining effects on the studied restorative materials. Specifically (similar to time interval of 15 days), the influence of tobacco on glass ionomer specimens (GIC and RMGIC) was more intense, resulting in sharp increases in the slope of their trend line.

The results of two-way ANOVA analysis between the ΔE values of various restorative materials after staining for 30 days is listed in table 4. The data presented in this table show that there was no significant difference between the ΔE values of GIC and MHC with turmeric and coffee. The difference between the ΔE values of NC and MHC stained with turmeric was also not statistically significant. On the other hand, the ΔE values of all restorative materials were statistically different when stained with tobacco.

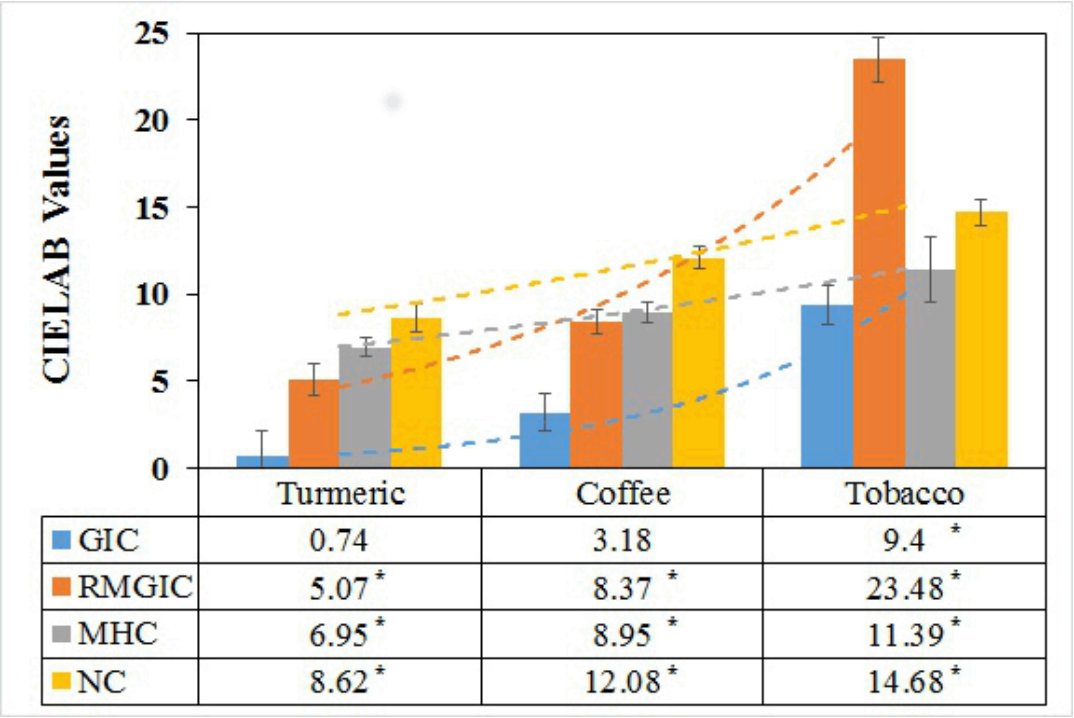



**Figure 3.** Changes in the CIELAB values of different restorative materials after staining for 30 days. *indicates clinically perceptible values (ΔE≥ 3.48).

**Table 4.** Two-way ANOVA comparison between the color change values (ΔE) of various restorative materials after staining in three solutions for 30 days (P<0.05).

| | Turmeric | | | Coffee | | | Tobacco | | |
|---|---|---|---|---|---|---|---|---|---|
| | GIC (A) | RMGIC (B) | MHC (C) | GIC (A) | RMGIC (B) | MHC (C) | GIC (A) | RMGIC (B) | MHC (C) |
| RMGIC (B) | 0.000* (B>A) | | | 0.000* (B>A) | | | 0.000* (B>A) | | |
| MHC (C) | 0.000* (C>A) | 0.167 | | 0.000* (C>A) | 0.826 | | 0.033* (C>A) | 0.000* (B>C) | |
| NC (D) | 0.000* (D>A) | 0.002* (D>B) | 0.254 | 0.000* (D>A) | 0.000* (D>B) | 0.000* (D>C) | 0.000* (D>A) | 0.000* (B>D) | 0.000* (D>C) |

It is important to note that that the staining of NC, MHC, GIC, and RMGIC for intervals greater than 30 days did not result in a statistically significant color change. Therefore, the data of staining for interval of 45 days were not provided in this study.

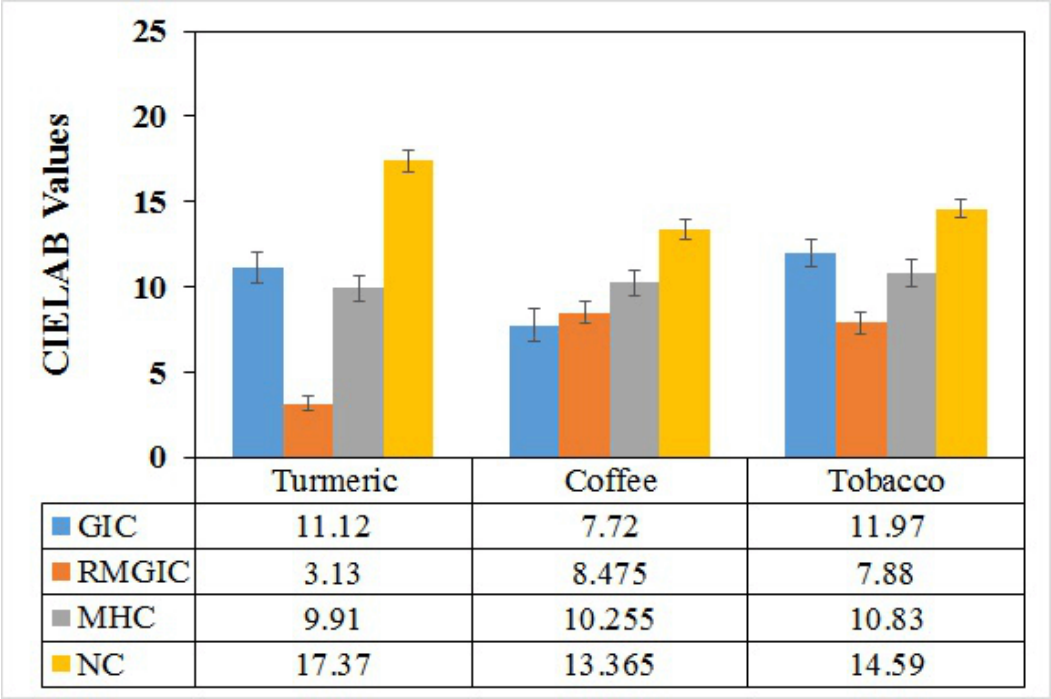
## Bleaching

The ΔE values obtained after bleaching of the discolored restorative materials for 7 days are presented in Figure 4. This figure illustrates that the ability of bleaching agent to remove the stain is both material and stain dependant. For instance, while the bleaching effect of carbamide peroxide was minimal on the RMGIC specimens stained by turmeric solution, its influence on the NC specimens was maximum. On the other hand, the impact of carbamide peroxide solution on the GIC and MHC specimens that were discolored by turmeric was not statistically significant. In the specimens stained with coffee, the maximum bleaching was obtained in NC and the least bleaching effect was observed in both glass ionomer specimens though the ΔE values of GIC and RMGIC specimens were not statistically different. When using tobacco as staining agent, the lowest and highest bleaching effects were seen in RMGIC and NC specimens, respectively. The bleaching impact of carbamide peroxide on the GIC and MHC stained with tobacco was not statistically different. Therefore, the results indicate that independent of staining status, the minimum and maximum bleaching effects were respectively observed in RMGIC and NC, while the bleaching effect of carbamide peroxide on GIC and MHC was not statistically different.

The influence of staining status on the bleaching efficacy was also investigated in this study. The results indicated that the ΔE values obtained after bleaching of three different groups of MHC specimens (which were previously stained with different solutions) were not statistically different. This shows that the staining history did not considerably influence the bleaching efficiency of MHC specimens. On the other hand, the color improvements due to the bleaching regimen were not statistically different in the NC specimens stained with tobacco and coffee. Similar results were obtained for RMGIC specimens. In the case of GIC specimens, the impact of carbamide peroxide on the specimens stained with

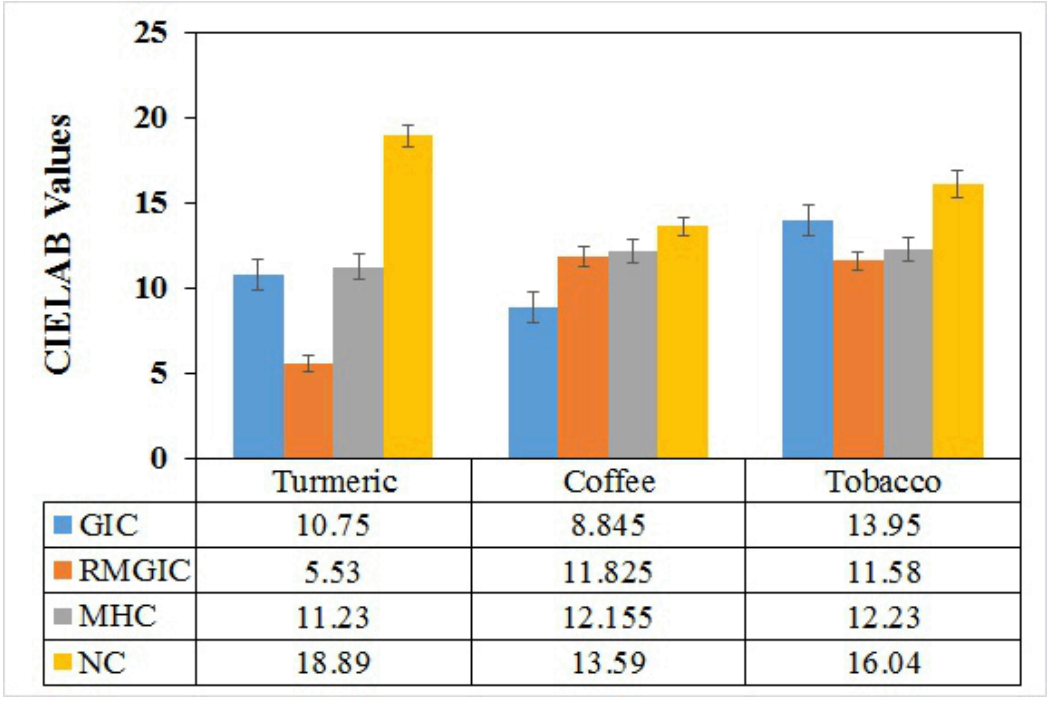
turmeric and tobacco was not statistically different. In overall, the data presented in Figure 4 also demonstrate that the bleaching effect of carbamide peroxide on the composite restorative materials is higher compared to that of glass ionomers (considering that the ΔE values of GIC and MHC are not statistically different in both tobacco and turmeric solutions).

Figure 5 shows the magnitude of color improvement in the previously stained restorative materials after bleaching with 10% carbamide peroxide for 14 days. Comparison of this figure with Figure 4 illustrates that the bleaching of previously stained restorative materials for time interval of 14 days resulted in almost similar outcomes to those of 7 days, although the magnitudes of color improvement were slightly higher after bleaching for 14 days.




| | Turmeric | Coffee | Tobacco |
|---|---|---|---|
| GIC | 11.12 | 7.72 | 11.97 |
| RMGIC | 3.13 | 8.475 | 7.88 |
| MHC | 9.91 | 10.255 | 10.83 |
| NC | 17.37 | 13.365 | 14.59 |

**Figure 4.** Changes in the CIELAB values of different restorative materials after bleaching for 7 days.




| | Turmeric | Coffee | Tobacco |
|---|---|---|---|
| GIC | 10.75 | 8.845 | 13.95 |
| RMGIC | 5.53 | 11.825 | 11.58 |
| MHC | 11.23 | 12.155 | 12.23 |
| NC | 18.89 | 13.59 | 16.04 |

**Figure 5.** Changes in the CIELAB values of different restorative materials after bleaching for 14 days.

# 4. Discussion

Color stability of esthetic restorative materials when exposed to various staining media has been of interest to many researches. However, with extensive esthetic studies, the staining influence of turmeric and chewable tobacco on the restorative materials has not been widely reported. The present study was carried out to evaluate the effects of turmeric and chewable tobacco on the color stability of glass ionomer cements and composite restorative materials as well as to compare their staining effects with coffee.

Turmeric is an extensively used Indian spice with both edible and therapeutic functions. Its major color constituent is an oleoresin called curcumin. Chewable tobacco is widely consumed by Indian communities. The coloring ingredient of chewable tobacco is a mixture of butyl rubber and microcrystalline wax. Coffee also contains caffeine and tannic acid that may be responsible for discoloration of the restorative materials. In the current study, it was observed that chewable tobacco showed overall higher staining compared to coffee and turmeric. RMGIC was maximally stained with tobacco followed by NC. The results also indicated that the values of color change were significantly different and clinically perceptible between NC and MHC as well as between NC and RMGIC when stained with turmeric. Exposure to turmeric solution resulted in maximum staining of NC whereas the least staining was observed in GIC after 30 days.

In the present study, NC showed a higher overall staining compared to MHC that can be explained based on the compositional difference between these two composites. NCs contain methacrylate-modified polysiloxane, whereas MHCs consist of Bisphenol A-glycidyl methacrylate (Bis-GMA) and Triethylene glycol dimethacrylate (TEGDMA). Therefore, the least staining resistance of NCs may be attributed to the higher hydrophilicity and water sorption of methacrylate modified polysiloxane material compared to Bis-GMA. Following polymerization, the inward movement of water molecules causes mobilization of ions within the resin matrix and outward movement of unreacted monomers and ions leached from fillers and activators. Elution of leachable components contributes to further shrinkage and loss of weight, whereas hygroscopic absorption of water results in material swelling as well as weight increase[1]. This process may cause softening of the resin matrix and reduction of stain resistance. The presence of organically modified ceramic particles in NCs may also increase the water sorption, leading to a higher discoloration. Furthermore, the small size distribution of the NC fillers (1 to 10 nm) provides a higher surface area as well as increased interfacial space between the resin matrix and the filler particles compared to those of MHCs. Increased interfacial space, which is considered as the most susceptible area for stain deposition, could subsequently intensify the discoloration of the composite material. Thus, the amount of water sorption depends on the resin and filler hydrophilicity as well as the bond quality between the resin and filler.

The results also indicated that RMGIC was more susceptible to staining than GIC, possibly due to the presence of higher number of ethylene glycol units in the monomerhydroxyethyl methacrylate (HEMA) which causes a higher water sorption in RMGIC compared to GIC[23]. In addition, GICs contain some amounts of water within their structure in loosely bound water that gets easily removed by dehydration and tightly bound water that is linked with hydration shell of cement and is not effected by the dehydration and stays there even after the reaction completion. [24-26] This prohibits the absorption of additional water from the staining solutions, resulting in a higher staining resistance.

Although bleaching is currently the most widely used technique to improve the esthetics of the stained or discolored teeth, the present study indicates that bleaching procedure may not completely remove the stain from the discolored materials. The magnitude of color change was found to be material dependent. NC showed the maximum overall color change after bleaching though the obtained color values were not close to the baseline values (initial color values prior to staining). The bleaching of MHC specimens resulted in smaller ΔE values than those of NC specimens; however, the E values of the bleached MHC specimens were slightly close to their corresponding baseline compared to NC specimens. Color change of dental composites after bleaching was probably due to superficial cleansing of the specimens and not intrinsic color change. This color change of restorative materials is attributed to the oxidation of surface stain. The degree of color change may differ between the products and categories of materials because of the partial conversion of resin content into polymer and pigments. In the case of glass ionomers, our observation indicated that bleaching of GIC resulted in a higher degree of color change compared to RMGIC (especially in turmeric and tobacco), despite of exhibiting the least staining in most of the staining media. This may be attributed to a more intense attack of bleaching agent on the surface of GICs. Moreover, it was observed that in spite of clinically perceptible color changes in all investigated restorative materials, nanocomposites were more susceptible to color change in turmeric and coffee solutions compared to the other restorative materials, while the resin-modified glass ionomers showed the most color change in tobacco solution. Nanocomposites also showed the highest color change after bleaching with a 10% carbamide peroxide solution. Investigation of the influence of staining duration on the color change of studied restorative materials showed that staining interval of 30 days generally resulted in a maximum color change and after that, not any significant alteration in the CIELAB values was observed. Micro hybrid composites and glass ionomers (restorative type) can replace nanocomposites where esthetic longevity is the prime concern (anterior teeth and premolars in smile line) and the patient intakes high amounts of coffee and/or turmeric. Glass ionomer cement (luting type) can also replace resin-modified glass ionomer cement for luting crowns, bridges, and small

restorations if the patient is habitual of chewable tobacco and the addressed defect lies in the esthetic zone

## 5. Conclusions

Current research evaluated the influence of turmeric and chewable tobacco on the color stability of four commonly used restorative materials (conventional glass ionomer, resin-modified glass ionomers, microhybrid composites, and nanocomposites) and to compare their impact with that of coffee as a well-studied staining agent. The amount of change in the color of discolored restorative materials after bleaching with carbamide peroxide was also examined. Moreover, the effect of staining and bleaching interval on the magnitude of color change in various restorative materials was determined. The results demonstrated that among the selected staining media, chewable tobacco generally caused the highest degree of color change in different restorative materials followed by coffee and turmeric. The bleaching of the discolored restorative materials for 14 days also provided similar results to those of 7 days.

Present research indicated that the restorative materials could be selected depending on the colour stability of these materials, patients' habits, and the defect location. However, in order to prolong the esthetics of these restorations, the patients must be advised of the susceptibility of these materials to staining by tobacco.

Based on the results, despite bleaching is not the treatment of choice due to its inability in complete removal of the stains from the surface of discolored restorations, the restorations with mild colour changes can be given a bleaching treatment in order to lighten the shade and postpone the complete replacement of the restorations.

## Conflicts of Interest

The authors report no any conflict of interest.

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