Effects of turmeric (*Curcuma domestica*) on color changes of nanohybrid composite resins

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Abstract. In order to determine the susceptibility of nanohybrid composite resins to discoloration by turmeric, we immersed specimens in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions for 24 and 48 hours and then measured the color changes using a Vita Easyshade instrument. Differences in color intensities were then identified using Kruskal–Wallis and Spearman’s tests. Immersion of nanohybrid composite resins in turmeric solutions decreased brightness (*L**) and increased chroma *a* and chroma *b* values, leading to significant total color changes (ΔE). Moreover, higher turmeric concentrations were correlated with increases in the reddish-yellow staining of nanohybrid composite resins.

1. Introduction
Composite resins have been increasingly used for direct restoration of anterior and posterior teeth over the past 60 years [1], and further developments are currently expected in nanotechnological applications [2]. Accordingly, nanohybrid composite resins were recently selected for their esthetic and color properties [3]. However, color changes of susceptible composite resins may pose a disadvantage for patients [4] following consumption of various foods and drinks [5], including tea, coffee, and turmeric.

Turmeric rhizomes (*Curcuma domestica Val.*) have various medicinal benefits and are used in everyday life [6]. Turmeric plants and their rhizome commodities are abundant and easily accessible in Indonesia [7,8], and refined turmeric products of varying turmeric concentrations are used in many Indonesian foods. Although significant color changes have been attributed to turmeric [9], the effects of turmeric solutions of various concentrations on the colors of nanohybrid composite resins have not been widely reported. Therefore, we determined the color changes of nanohybrid composite resins after immersion in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions and correlated turmeric concentrations with resin color changes.

2. Methods
2.1. Specimen Preparation
Composite resins were prepared in molds by placing cellulose strips in piles and then placing a preparatory glass plate above these cellulose strips with a 1 kg load on each stack. Specimens were then irradiated using light-emitting diode light to cure them for 20 s. The tip of the light curing unit was positioned perpendicular to the surface of the mold ring, and the preparatory glass plate was released after 10 min. Finally, composite resins were numbered and parts to be measured were tagged.
2.2. Immersion
Composite resins were immersed for 24 h in water at 37°C in order to produce perfectly polymerized specimens. Composite resin plates were then lifted out and dried, and the initial colors of the specimens were measured using a white paper base.

2.3. Soaking in Turmeric Solution and Color Measurement
Composite resins were divided into treatment groups 1, 2, 3, and 4 (n = 6) and were soaked in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions, respectively. All treatment groups were soaked for 24 h, and color values were then measured and recorded. Specimens were then soaked in turmeric solutions for another 24 h, and 48 h color values were measured and recorded.

2.4. Data Analysis
Data were analyzed using the nonparametric Kruskal–Wallis test in order to identify the differences between the treatment groups. Subsequently, correlations between turmeric concentrations and changes in nanohybrid composite resin color values were identified using Spearman’s test.

3. Results
The present experiments were performed using composite nanofabricated resin Tetric® N-Ceram Shade A1 specimens, which were immersed in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions for 24 and 48 h. Color change values for lightness (L*), chroma a* (red-green), and chroma b* (yellow-blue) are presented in Table 1.

### Table 1. Mean L*, a*, and b* color values for resin specimens before and after immersion in turmeric solutions at 37°C for 24 and 48 h.

| Group Treatment Turmeric concentrations | Immersion time | 0 h | 24 h | 48 h |
|----------------------------------------|----------------|-----|------|------|
|                                        | L*  | a*  | b*  | L*  | a*  | b*  |
| 0.015%                                 | 76.2 | −0.8 | 17.2 | 74.4 | −2.0 | 26.4 |
| 0.15%                                  | 75.8 | −0.8 | 18.2 | 71.6 | −2.7 | 55.5 |
| 1.5%                                   | 75.9 | −1.1 | 18.9 | 65.9 | 2.4  | 59.2 |
| 15%                                    | 75.2 | −1.0 | 19.7 | 62.1 | 6.7  | 59.0 |

L*, Lightness 0 (black) – 100 (white)
a*, chroma, +a* indicates redness and −a* indicates greenness
b*, chroma, +b* indicates yellowness and −b* indicates blueness

Mean ΔL*, Δa*, Δb*, and total color (ΔE) values were calculated for each soaking group of nanohybrid composite resin specimens (Table 2).

### Table 2. Mean ΔL*, Δa*, Δb*, and ΔE values of resin specimens after soaking in turmeric solutions for 24 and 48 h at 37°C.

| Turmeric solution Concentrate | 24 h | Immerse time | 48 h |
|-------------------------------|------|--------------|------|
|                              | ΔL*  | Δa*  | Δb*  | ΔL*  | Δa*  | Δb*  | ΔE*  |
| 0.015%                       | −1.8 | −1.2 | 9.2   | 9.45 | −4.7 | −1.1 | 19.6 | 20.18 |
| 0.15%                        | −4.2 | −2.8 | 37.3  | 37.6 | −14.1| 6.1  | 46.7 | 49.2  |
| 1.5%                         | −10  | 3.5  | 40.3  | 41.7 | −19.6| 12.6 | 43.6 | 49.4  |
| 15%                          | −13.1 | 7.7  | 39.3  | 42.1 | −19  | 11.8 | 44.3 | 49.6  |
Average $\Delta L^*$ values of specimens decreased during immersion for 48 h in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions, indicating gradual decreases in brightness. Similarly, average $\Delta a^*$ and $\Delta b^*$ values of resin specimens increased after 48 h in the same turmeric solutions, indicating increased redness and yellowness, respectively.

Color changes of resin samples differed significantly between the 0.015% turmeric treatment group and the 0.15%, 1.5%, and 15% turmeric treatment groups at 24 and 48 h (Tables 3 and 4).

**Table 3.** Color changes of composite resins over 24 h vary with concentrations of turmeric solutions.

| Concentrate/ Concentrate | 0.015% | 0.15% | 1.5% | 15% |
|--------------------------|--------|-------|------|-----|
| 0.015%                   | *      | *     | *    | *   |
| 0.15%                    | *      |       | *    | *   |
| 1.5%                     | *      | -     | *    | *   |
| 15%                      | *      | -     | -    | -   |

*, p < 0.05
-, not significant

**Table 4.** Color changes of composite resins over 48 h vary with concentrations of turmeric solutions.

| Concentrate/ Concentrate | 0.015% | 0.15% | 1.5% | 15% |
|--------------------------|--------|-------|------|-----|
| 0.015%                   | *      | *     | *    | *   |
| 0.15%                    | *      |       | *    | *   |
| 1.5%                     | *      | -     | *    | *   |
| 15%                      | *      | -     | -    | -   |

*, p < 0.05
-, not significant

In the analyses of color indices using Spearman’s test, turmeric concentrations were significantly correlated with color changes ($\Delta E$) of nanohybrid composite resin specimens after 24 h, with a positive $r$ value of 0.571. Similarly, Spearman’s test revealed a significant correlation ($r = 0.598$) between $\Delta E$ values and turmeric concentrations after 48 h of soaking.

**4. Discussion**

In this study, bright color spectra ($L^*$) of nanohybrid composite resin specimens declined after soaking in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions for 24 and 48 h, suggesting the deposition of turmeric dyes on the composite resin surfaces. Moreover, in color analyses, the increased green spectra ($a^* < 0$) in the 0.015% turmeric treatment group were likely related to curcumin. In contrast, treatment with 0.15%, 1.5%, and 15% turmeric solutions increased the intensity of the reddish spectrum ($a^* > 0$), potentially indicating that carotene pigments were deposited on the surfaces of the nanohybrid composite resin specimens. These deposits may be avoided on polished surfaces, and the surface roughness of the present composite resin specimens may have increased because of the acidity of the turmeric solutions.

The present data show increases in the yellow color spectrum ($b^* > 0$) following immersion of nanohybrid composite resin specimens in 0.015%, 0.15%, 1.5%, and 15% turmeric solutions. Previous study showed that tertiary aromatic and aliphatic amines can accelerate yellow or brown discoloration during exposure to light or high temperatures [10]. However, this study attribute the present increases in the yellow spectra to the deposition of curcumin dyes onto rough nanohybrid composite resin surfaces, which may have been affected by the acidity of our turmeric solutions.

Nanocomposites with smaller filler sizes depreciate less during polymerization, and decreases in the number of microfissures may limit edge leakage and color changes [11]. However, the present nanohybrid composite resin specimens were all subjected to $\Delta E$ values of $>3.3$, indicating clinically
unacceptable color changes. Again, polishing of specimens’ surfaces may prevent the retention of dyes under the present conditions.

Finally, this study identified significant differences \((p < 0.05)\) between color value changes of specimens soaked in a 0.015% turmeric solution and those soaked in 0.15%, 1.5%, and 15% turmeric solutions, but no differences \((p > 0.05)\) were identified among 0.15%, 1.5%, and 15% turmeric treatments. These data suggest that the availability of dye content is not linearly related to turmeric concentrations, suggesting that the more concentrated solutions exceed the relative aqueous solubility of turmeric dyes. However, these effects failed to obscure the present positive correlation between turmeric concentrations and overall color changes of nanohybrid composite resin specimens.

5. Conclusion
Color changes from greenish yellow to reddish yellow in nanohybrid composite resin specimens were observed following immersion in turmeric solutions and were increased with turmeric concentrations of 0.015–15%.

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