

Effect of single serve sachet powder drinks on color stability of a nano-hybrid composite resin

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ABSTRACT

Aim: Nano-filled composite resin materials used for aesthetic purposes have better mechanical, polish ability, and color stability properties compared to other composite resin types. The aim of this in vitro study was to evaluate the effect of 5 different single serve sachet powder drinks popular among adolescents in recent years on the color change of Nano hybrid composite resin material.

Material and Method: In this study, Nano hybrid composite resin (Filtek Z550) and five different types of sachet drinks (cherry flavored powdered drink [Cherry-dp], instant sachet Turkish coffee [IS-Turkish-c], instant sachet filter coffee [IS-Filter-c], instant tea [I-tea], 3-in-1 granulated coffee [3-in-1 Granulated-c] and distilled water [DW]) were used. A total of 42 2×10 mm disc-shaped samples were prepared. The prepared samples were kept in DW in an oven at 37°C for 24 hours and the initial color measurements were made with a spectrophotometer (Vita Easy Shade Advance 4.0., Germany). The samples were divided into 6 groups (n=7) to be kept in 5 colorant solutions and DW (control group). Composite samples were kept in an oven at 37°C and the solutions were changed once a week. Color change was measured before and after 1, 7, and 28 days of immersion. Shapiro Wilk test was used to check whether the data conformed to normal distribution. The variables were analyzed with one-way analysis of variance ANOVA and post-hoc Tukey test (p<0.05).

Results: After 28 days of immersion, IS-Turkish-c, IS-Filter-c, and I-tea led to statistically significant discoloration in composite resin (p<0.05). In contrast, no statistically significant difference in discoloration was observed after 24 hours and 7 days of immersion (p>0.05).

Conclusion: The results obtained in the present study showed that the Nano hybrid composite material is sensitive to discoloration by long-term use of IS-Turkish-c, IS-Filter-c, and I-tea. It was thought that Nano hybrid composite should not be preferred especially in young people with high coffee and tea consumption or necessary warnings should be given if it is to be used.

Keywords: Nano hybrid composite resin, color change, instant sachets

INTRODUCTION

Due to the increasing demand for aesthetic dental fillings in recent years, composite resins have become the first choice for the restoration of anterior teeth in modern restorative dentistry (1). The increasing trend towards natural looks has led to the development of new restorative resins that closely mimic tooth structure, and modifications in fillers have enhanced the mechanical and aesthetic properties of conventional resins (2).

In dental restorative materials, Nano hybrid solutions have combined the strong mechanical properties of hybrid composites with the high polish ability properties

of micro filled composites. Nano hybrid composites have been frequently used in anterior group direct restorations in recent years due to their advantages such as better mechanical and optical properties, better surface gloss, and high resistance to abrasion (3).

Despite the evolving characteristics of composite restorations, discoloration occurring in composite restorations, especially in the anterior region, is one of the main reasons for replacement of restorations (4,5). Discoloration in composite restorations is an aesthetic failure that leads to extra cost and time spent by the physician and the patient (6).

Different internal and external factors play a role in discoloration of composite resins. Internal coloration may occur depending on the size and distribution of fillers, the composition of the resin matrix, and the photo initiators. External discoloration may occur due to insufficient polymerization, heat, UV irradiation, water absorption or absorption of colorants from food and beverages, surface roughness, and insufficient surface polish and finishes. ΔE is a standard measurement established by the Commission Internationale de l'Eclairage (International Illumination) that measures the difference in two colors visible in a product. ΔE is used to ensure that the displayed color is nearly identical to the color perceived by the human eye. The higher the ΔE value, the lower the color accuracy (7-9).

In recent years, the diversification of industrial consumption and the practicality of powdered sachet drinks have increased the use of these beverages in the daily diet. Therefore, the aim of this study was to determine the effect of instant sachets, especially those popular among adolescents in recent years, on the surface discoloration of Nano hybrid composites. The alternative hypothesis (H1) of this study was that the ΔE value of the groups other than the control group would be above the cut-off value.

MATERIAL AND METHOD

Ethics committee approval is not required as the study. All procedures were carried out in accordance with the ethical rules and the principles.

A Nano hybrid composite (Filtek Z550, A2) was used to check the color stability. The properties of this restorative material are presented in **Table 1**. Five different coloring solutions, including sour Cherry-dp, IS-Turkish-c, IS-Filter-c, I-tea, and 3-in-1 Granulated-c, were used as discolorants. DW was used for the control group.

Table 1. Preparation of sachet drink and properties of the restorative material	
Sachet drink types and composite material	Quantities and ingredients
Cherry flavored powdered drink (Cherry-dp) (Nazo; Nazlı food and beverage exporter, İstanbul)	45 grams of powder/ 1 L water
Instant sachet Turkish coffee (IS-Turkish-c) (Shazel; Neon Co., Hatay)	200 mL powder/100 mL water
Instant sachet filter coffee (IS-Filter-c) (Shazel; Neon Co., Hatay)	200 mL powder/100 mL water
Instant tea (I-tea) (Lipton yellow label; Unilever, PLC, England)	200 mL powder/100 mL water
3-in-1 granulated coffee (3-in-1 Granulated-c) (Nescafe 3-in 1; Nestle Co., Sweden)	200 mL powder/100 mL water
Filtek Z550 (Nano hybrid composite resin) (Filtek, St Paul, MN, USA)	Bis-GMA, Bis-EMA, UDMA, PEGDMA, TEGDMA, zirconia silica, silica filler

Preparation of Samples

Teflon molds were used to prepare the samples. The molds were specially prepared with an inner diameter of 10 mm, an outer diameter of 12 mm, and a thickness of 2 mm. A total of 42 Nano hybrid composite materials were placed in molds and smoothed with a mouth spatula. Transparent tape and then glass coverslip were used to remove overflowing excess material. According to the manufacturer's instructions for each sample, composite resins were polymerized from both surfaces with an LED device (Valo Cordless, Ultradent, USA) for 20 seconds. The top and bottom surfaces of all samples were polished with aluminum oxide polishing discs (Sof-Lex TM, Filtek, USA).

Preparation of Solutions

All solutions were prepared according to the manufacturer's instructions. For the cherry flavored beverage solution, 45 grams of cherry powder was poured into 1 liter of water and mixed until dissolved. For teas and coffees, each sachet was poured into 200 ml of boiling water at 100°C (**Table 1**). The tea sachet was shaken gently at 0, 2 and 5 minutes and removed from the water after 5 minutes. While preparing the coffee solutions, the mixture was added to the water and mixed at 0 and 5 minutes.

Color Measurements

Composite discs prepared for color measurement were kept in DW in an incubator at 37°C for 24 hours in the absence of light. The samples were washed with DW and then dried. Initial color measurements were made with a spectrophotometer (Vita Easy Shade Advance 4.0. Germany) with the head of the instrument placed in the middle of the composite samples. Each color measurement was made on a gray background under standard conditions in the dark room with only the illumination of the Fluorescent Daylight Lamp (Master TL-D 90 Graphical 18W965SLV/10, Philips, The Netherlands). Color measurements were repeated three times for each sample and the spectrophotometer was calibrated before each measurement. After the first measurements, the samples were divided into 6 groups (n=7) (Cherry-dp, IS-Turkish-c, IS-Filter-c, I-tea, 3-in-1 Granulated-c, and DW). Prepared solutions were distributed to all groups (5 ml per group) and the samples were completely covered. Between measurements, all samples were kept in the solutions in an incubator at 37°C in the dark. The solutions were changed regularly once a week. Color measurements were repeated on days 1, 7 and 28. The samples were washed with DW for 5 minutes until all beverage residues were removed before each measurement and then dried completely with blotting paper. Each color measurement was made three times for each sample. The color change of the samples was calculated using the formula CIEDE2000 (ΔE_{00}) (10).

$$\Delta E_{00}^* = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2} + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}$$

Equation 1: CIEDE2000

In the CIEDE2000 equation, ΔL', AC' and AH' are the difference in luminance, Chroma, and hue, respectively. RT refers to the interaction between color and hue differences in the blue region (ΔR = RT (ΔC'x ΔH')). SL, SC, and SH are weighting functions that adjust the total color difference in coordinates L*, a*, and b*. KL, KC, KH are correction terms for experimental conditions (11). In the present study, the CIEDE2000 parametric factors difference formula was set to 1. Ethics committee decision is not required as the study was performed on the discs we prepared. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Statistical Analysis

The data were analyzed using the SPSS for Windows 25.0 program. Descriptive statistical methods (mean, standard, deviation) were used while evaluating the data. Conformity to normal distributed was evaluated with the Shapiro Wilk test. Data were analyzed with one-way analysis of variance (ANOVA) and post-hoc Tukey test. p < 0.05 was accepted as statistically significant in all analyses.

RESULTS

Statistical analysis of immersion results for 24 hours, 7 days, and 28 days is shown in **Table 2**. No significant difference was found between any of the composite samples evaluated at 24 hours and on day 7 in terms of color change results (p>0.05). In 28 days, IS-Turkish-c and I-tea caused significantly more coloration compared to Cherry-dp and DW, and IS-Filter-c caused significantly more coloration compared to DW (p<0.05).

There was no significant difference between the results of Cherry-dp, 3-in-1 Granulated-c, and DW at all measurement times (p>0.05). IS-Turkish-c and IS-Filter-c caused significantly more coloration in 28 days compared to 24 hours. I-tea also caused significantly more coloration in 28 days compared to 24 hours and 7 days (p<0.05).

DISCUSSION

The success of aesthetic restorations is directly related to technological developments in composites. Nanotechnology has been incorporated into dental materials to achieve a universal restorative with better mechanical and aesthetic properties (12). The present in vitro study was conducted to evaluate the coloring potential of instant sachets (IS) on Nano hybrid composite (Filtek Z550) material.

Discoloration of composite restorations may occur due to both surface adsorption and absorption of colorants (13). Chemicals in beverages can lead to surface deterioration of composite restorations, causing unaesthetic external pigmentation. The ability of resin composites to absorb water can also be affected by the chemical composition of the beverage (14). In addition, the effect of coloring agents -found in foods and beverages that modernized societies often consume- on composite restorations may be directly related to the amount and frequency of beverage intake (15). IS were preferred in the present study because have become an important part of the daily diet for both practicality and variety.

Visual or instrumental techniques can be used to assess color stability. Color differences below the visual perception threshold can be detected using spectrophotometers (16). In the present study; spectrophotometer was used to evaluate color changes in dental materials because it is more quantitative.

The color stability of the Nano composite resin was evaluated and the numerical values obtained by the spectrophotometer were analyzed with the CIEDE2000 formula. For the evaluation of color stability, CIEDE2000 reported that a modified version of the CIELab system better evaluates color acceptability and perceptibility (17). The most commonly used ΔE cut-off value, which is clinically accepted by most researchers, is 3.3 (15,18). The alternative hypothesis of this study was partially rejected as the ΔE value of sour cherry juice was below the cut-off value. In terms of ΔE values, the cut-off value of 3.3 was measured in the cherry juice and distilled water groups, while the values observed on the 7th and 28th days in the other groups were above the acceptable cut-off value.

	Cherry flavored	Turkish coffee	Filter coffee	Control group	Instant tea	3-in-1 granulated coffee
24 hours	1.86±1.11	2.33±1.64 ^a	2.72±1.19 ^a	1.63±0.89	1.72±0.50 ^a	2.80±2.44
7 days	2.68±1.52	5.43±3.71 ^{ab}	4.62±2.56 ^{ab}	2.08±1.02	4.14±2.45 ^a	4.48±2.32
28 days	3.29±1.36 ^A	8.73±2.51 ^{Cb}	6.96±2.01 ^{Bb}	2.81±1.48 ^A	7.75±3.77 ^{Cb}	5.11±2.72 ^A

a-b: Shows the differences within the same column. A-C: Shows the differences within the same line. * One way ANOVA

Immersion time has an effect on the color stability of composite resins. Color changes become more intense as the immersion time increases. This may be due to increased interaction between chemicals and resin, as well as better penetration of staining agents into the resin. An aqueous environment can affect the properties of composite resins and even lead to hydrolytic degradation over time (19). In the present study, the immersion process of composite samples in beverages was standardized based on previously reported immersion times in the literature. Chowdhury et al. (20) evaluated color change and reported that the lowest values were obtained on the 7th day, followed by the 14th day, and maximum color change was obtained on the 28th day. Based on this study, the samples in the present study were kept in the prepared solutions for 28 days to obtain the maximum results.

For adults, coffee is a frequently preferred beverage in daily life. According to coffee producers, a cup of coffee is consumed by a person in an average of 15 minutes. Average daily consumption of coffee is 3.2 cups per day. There are studies in the literature reporting that the *in vitro* immersion of samples in coffee for 24 hours is equivalent to approximately 1 month of coffee consumption *in vivo* (13,21,22). In the present study, 28 days of immersion simulated almost 2 years of coffee consumption.

The fillers in the structures of composite resins affect their susceptibility to coloration. Inorganic fillers on the surface cause an increase in the surface roughness of the composite by moving away from the resin matrix as a result of clinical use. Since the fillers of Nano hybrid resins are small, lower surface coloration is expected when separated from the surface (3). Color stability of Nano hybrid composites is still a controversial issue in the literature. Villalta et al. (23) and Al Kheraif et al. (24) reported that Nano hybrid composites showed higher discoloration. Özkanoğlu et al. (25). Stated that Nano hybrid composites are resistant to external discoloration.

Similar to the present study, Hasani et al. (26) and Koraç et al. (27) reported that the Filtek Z550 showed more discoloration, especially in coffee. In contrast, Gönülol et al. (28) reported that Filtek Z550 demonstrated high water absorption and the lowest ΔE values in terms of discoloration. In the present study, IS-Turkish-c, IS-Filter-c caused significantly more coloration in 28 days compared to 24 hours. I-tea also caused significantly more coloration in 28 days compared to 24 hours and 7 days ($p < 0.05$). This result indicated that immersion time in the solutions caused an increase in discoloration of Nano hybrid composites.

Darabi et al. (29) and Domingo et al. (30) reported that coffee was the immersion medium that caused the most discoloration on the composite resin tested. There are studies reporting that the high yellow coloring agent in coffee adheres to the composite surface and interacts with the organic phase of the composite resin, resulting in discoloration of the composite (31, 32). In contrast, other studies reported that tea causes more significant discoloration than coffee (33, 34). Nasim et al. (35) reported that the most significant discoloration caused by tea occurred on the 7th and 30th days of immersion. In the present study, immersion in sachet drinks for 24 hours and 7 days did not result in significant color change results, however, IS-Turkish-c, IS-Filter-c and I-tea caused significantly more discoloration in 28 days compared to DW. This was thought to be due to the use of dense extract (tea water) in tea bags for rapid brewing and instant coffees produced from extracts obtained by brewing more concentrated coffee.

Guler et al. (13) reported that cherry juice did not cause a significant color difference in the tested resin composite with the lowest average ΔE value, and the addition of milk powder to coffee reduced the color difference compared to coffee without cream. In the present study, Cherry-dp and 3-in-1 Granulated-c did not result in significant color change compared to DW at all time periods, which is consistent with the results of this study. In our study, it was concluded that adding cream to coffee, especially in 3-in-1 Granulated-c, reduces the concentration of coffee, and milk proteins reduce discoloration by binding polyphenols.

There are certain limitations of this *in vitro* study. In the study, the composite resin material was not constantly exposed to different foods and beverages, did not come into contact with saliva, was not brushed as in the oral environment, and the remineralization environment of saliva was not created. All parameters were measured up to 28 days, but longer clinical studies or studies better simulating the oral environment are needed to confirm the findings.

CONCLUSION

The results obtained in the present study showed that long-term consumption of instant coffee and tea products, which are becoming increasingly popular among young people in modernizing societies, cause discoloration in Nano hybrid composites. Questioning the beverage habits while taking the patient's history may be a criterion in material selection.

ETHICAL DECLARATIONS

Ethics Committee Approval: Ethics committee approval is not required as the study.

Informed Consent: Informed consent is not required as the study.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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