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Original Article

Investigation of the coloring effects of different ground-based coffee types on composite resin materials

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Abstract

Aim: The aim of this study is to investigate the effect of different ground-based coffee types on the color change of nanohybrid and bulk-fill composites.

Methodology: A total of 80 disk-shaped samples were made using Teflon molds (5 mm in diameter and 8 mm thick) and two types of A2 resin with nanohybrid (Tetric N Ceram Ivoclar Vivadent, Schaan, Liechtenstein) and bulk-fill (Filtek Bulk-Fill, 3M ESPE, St. Paul, MN, USA) structures. All samples were finished and polished with four-stage (thick, medium, fine, and superfine) polishing disks (Sof-lex, 3M ESPE, St. Paul, MN, USA) and kept at 37°C for 24 hours. Color measurements of the samples were performed using a spectrophotometer (Vita Easy Shade, Vita ZahnFabrik, Bad Sackingen, Germany) and were divided into subgroups: the control group, filter coffee, Turkish coffee, espresso, and Mırra (n = 8). Distilled water was used as a control. Prepared coffees were added to the microcentrifuge tubes and refreshed daily during the 14-day exposure period. ΔE values were calculated for each material. Statistical analyses were performed using one-way variance analysis and Tukey multiple comparisons (p = 0.05).

Results: There was no significant color change for either the nano-fill or bulk-fill composite groups in the control group samples ($p>0.05$). Filter coffee was found to be the most effective colorant coffee type for both composites ($p < 0.05$). Among the coffee types, Mırra caused the least coloration for both composites.

Conclusion: The consumption of two or more cups of coffee per day, especially filter coffee, can cause color changes in both conventional and bulk-fill composites, and it should be considered an important factor in aesthetic problems with dental restorations.

Keywords: Bulk-fill composite, nanohybrid composite, coffee, composite resin, colorant effect, staining

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Introduction

Composite resins have been widely used as restorative materials for decades. The term composite resin indicates that the material is a mix of organic and inorganic components. The main organic components are the resin, the coupling agent, and the initiator, while the inorganic component is the filler (1). Although the longevity of dental amalgams has been reported to be better compared with composite restorations (2–4), aesthetics and concerns about the mercury content of amalgams have led to the increased use of composite resins. Through significant improvements in their physical and mechanical properties, the use of composite resins in the restoration of large and deep cavities has become routine (2, 5).

To reduce factors such as limited depth of polymerization (6, 7), polymerization shrinkage, and the consequences of shrinkage stress (8), composite resins require a 2-mm thick layering method; the treatment is long-term, and every layer is placed individually (9). Additionally, it also has a number of handicaps, such as failure of interlayer bonding due to the risk of contamination and void formation, and difficulty in layering due to limited accessibility with conservative preparations (10–12). Industrial changes have led to several improvements based on the handicaps of composite resins, such as faster restorations in deep cavities and the elimination of problems caused by the layering technique. Bulk-fill composite resins have several technical advantages, including being massively insertable (9) and light transmission of up to 4 or 5 mm at once (13); thus, they have been used frequently in dental treatments for the past several years. In contrast to conventional nanohybrid composites, bulk-fill composite resins are claimed to have lower polymerization shrinkage stress and increased polymerization depth due to their higher light transmission (14–16).

Certainly, one of the major aesthetic problems of either nanohybrid or bulk-fill composite resins is the color change due to several intrinsic or extrinsic factors in the oral environment. Previous studies have shown that composite resins may present a tendency to discoloration due to several extrinsic factors including insufficient polymerization, water sorption, exposure to adhesive some colorant food and beverages (e.g., tea, coffee, red wine, carbonated drinks, etc.), use of tobacco products and defective oral hygiene (17, 18). On the contrary, the intrinsic color change is claimed to be the result of resin type, and it might be related to the resin matrix involved (19). Accordingly, it was also stated that particle size is crucial, and in this regard, composite resins containing smaller particles were found to have a lesser color change (20). In addition to that, other components of the composite resins, such as initiators (21) and the polymerization reaction itself (22) may affect the color color of the restorative material.

Coffee is one of the most consumed beverages both in the world and in Turkey. When compared to other countries according to International Coffee Organization 2021 data, Turkey ranks ninth after the European Union, the United States of America, Japan, the Russian Federation, Canada, the Republic of Korea, Australia, and Algeria (23). Although there are about 100 different species of the coffee tree, two of the most well-known species are Coffea canephora (Robusta) and Coffea arabica, which is Ethiopia originated. The Arabica is the most preferred and consumed coffee type because of its uniqueness and excellence; it thus holds 70% of the global coffee market. On the other hand, the Robusta type is generally preferred in instant coffee production because it is suitable for higher amounts of soluble matter extraction (24). Clearly, coffee has a unique place in Turkish cuisine, tradition, and culture, especially when its historical background is included. Even though Turkish coffee still preserves its situation in traditional consumption, it must be considered that coffee consumption in Turkey is influenced by other brewing techniques used in different countries and the globally popular waves.

As a result of patients' increased aesthetic demands, the color matching and color stability of composite resins have become crucial in dental treatments. Although numerous studies investigating the effects of colorant foods and beverages on composite resins have been conducted, there is still a need for supportive studies with this focus. The present study aimed to investigate the colorant effects of different ground-based coffee types on conventional and bulk-fill composite resins. The null hypothesis of this study is that the tested nanohybrid and bulk-fill composite groups will not make any difference in terms of color changes after soaking in different coffee types.

Materials and Methods

Four types of ground coffee-based beverages (Filter coffee, Turkish coffee, Espresso, and Mırra) were used as colorant agents. Distilled water (Type 1 ultrapure water) was used as the control. Tetric N-Ceram (Ivoclar Vivadent DG, Schaan, Liechtenstein) was used as the conventional composite resin, and Filtek Bulk-Fill (3M ESPE, MN, USA) was used as the bulk-fill composite resin. A total of 80 cylindrical composite samples 5 mm in diameter and 8 mm in height were prepared. In order to eliminate any mistakes, 8 samples were prepared for each group (40 for each material and 80 in total; Table 1). Both sides of the plastic molds were covered with transparent tape and a microscope slide to avoid the formation of surface roughness or air bubbles. Considering the translucency of the materials, the conventional composite was polymerized for 20 seconds on each side, and the bulk-fill composite was polymerized for 20 seconds in total using an LED light source (Hilux 550, Benlioğlu Dental, Turkey). Each material was transferred to a microcentrifuge tube (IsoLab GmbH, Germany) filled with 2 mL of distilled water and kept in the dark at room temperature (Fig. 1). After 24 hours, the first color measurements of the samples were performed using a spectrophotometer (Vita Easy

Shade, Vita ZahnFabrik, Bad Sackingen, Germany). After the samples were dried with a blotter, color measurement was completed in the instrument's L, a, and b modes, and three consecutive measurements were taken from each sample.

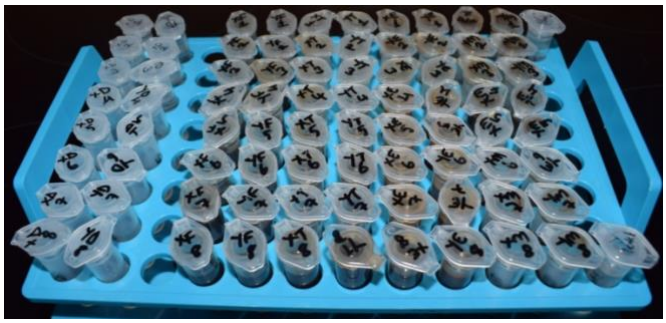

Figure 1. Incubation of the prepared samples in microcentrifuge tubes.

Preparation of coffee

Filter coffee. 200 mL of filter coffee was brewed in a French press for 3 minutes using 8 grams of freshly ground coffee beans.

Turkish coffee. 1 teaspoon of ground coffee was added to 80 mL of water and heated to boiling.

Espresso. 10 grams of ground coffee and 180 mL of water were added to a mocha pot and heated until brewing was completed.

Mırra. 40 mL of Mırra was heated in a pot.

Approximately 2 mL of prepared coffee was added to the microcentrifuge tubes. The solutions were refreshed daily during the 14-day exposure period. Before the refreshment procedure, the samples were washed with distilled water and dried with a blotter. Spectrophotometric measurements were performed on the last day of incubation. The color differences between the two measurements were calculated using L, a, and b values, which were obtained from the first (day 1) and last (day 14) daily values. The formula from (25) is as follows:

$$\Delta E = \frac{(L2^* - L1^*)2 + (a2^* - a1^*)2 + (b2^* - b1^*)2}{2}$$

*2 = data obtained from the last measurement.
*1 = data obtained from the first measurement.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 27 (IBM SPSS Inc., Armonk, NY, USA). Wilcoxon, Kruskal–Wallis, and Bonferroni tests were used for the statistical evaluation of the samples. A value of p <0.05 was considered statistically significant.

Table 1. Properties and specifications of each group

Group	Media	Media obtained from	Labels of Groups
Group 1	Distilled Water	Direct-Q-3 UV Merck Millipore, USA	X*D1, X*D2, X*D3, X*D4, X*D5, X*D6, X*D7, X*D8 Y*D1, Y*D2, Y*D3, Y*D4, Y*D5, Y*D6, Y*D7, Y*D8
Group 2	Filter coffee	Starbucks, USA (From a local café, not grounded)	X*F1, X*F2, X*F3, X*F4, X*F5, X*F6, X*F7, X*F8 Y*F1, Y*F2, Y*F3, Y*F4, Y*F5, Y*F6, Y*F7, Y*F8
Group 3	Turkish coffee	Kurukahveci Mehmet Efendi, TR (Arabica, Grounded)	X*T1, X*T2, X*T3, X*T4, X*T5, X*T6, X*T7, X*T8 Y*T1, Y*T2, Y*T3, Y*T4, Y*T5, Y*T6, Y*T7, Y*T8
Group 4	Espresso	Kurukahveci Mehmet Efendi, TR (Arabica, Grounded)	X*E1, X*E2, X*E3, X*E4, X*E5, X*E6, X*E7, X*E8 Y*E1, Y*E2, Y*E3, Y*E4, Y*E5, Y*E6, Y*E7, Y*E8
Group 5	Mırra	Olabi Oğulları Gıda, TR (Liquid, ready-to-use)	X*M1, X*M2, X*M3, X*M4, X*M5, X*M6, X*M7, X*M8 Y*M1, Y*M2, Y*M3, Y*M4, Y*M5, Y*M6, Y*M7, Y*M8

*: In the group labels, the X indicates the conventional (Tetric N-Ceram) and Y indicates the bulk-fill (Filtek Bulk-Fill) composite resins

Table 2. Comparison of the coloring effects of different coffee types

	Control	Filtered coffee	Turkish coffee	Espresso	Mırra	*p*-value
Tetric	1.05	7.46	5.57	5.68	4.04	0.006
Bulk-fill	1.76	7.98	5.42	5.07	4.46	0.001

Results

The statistical analysis results of the samples are shown in Table 2. Although some color difference between composite types is shown in Figure 2, spectrophotometric measurements revealed no statistically significant difference between the tetric and bulk-fill composites in terms of discoloration ($p > 0.05$ and $p = 0.26$, respectively). There was a statistically significant difference between the experimental groups containing different types of coffee and the control group ($p < 0.05$, Fig. 2). It was observed that all coffee types caused more discoloration than the clinically acceptable limit ($\Delta E > 3.3$). The samples kept in distilled water showed less discoloration than those kept in coffee. Filtered coffee was found to be the most colorant coffee type statistically for both composites ($\Delta E > 3.3$). Although there was less discoloration in the Mırra group, the difference was not statistically significant (Table 2).

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	Control	Filtered coffee	Turkish coffee	Espresso	Mırra	*p*-value
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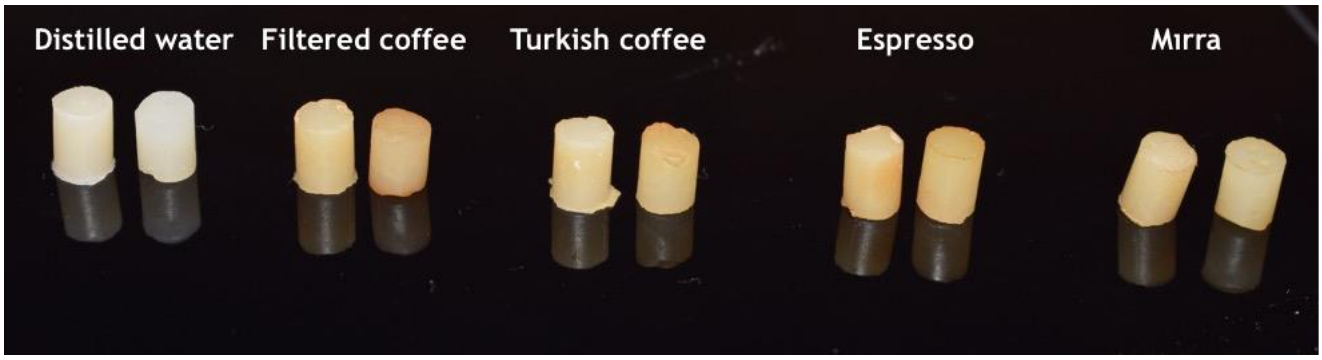

Figure 2. Color change of composite resins after 14 days of incubation (nanohybrid and bulk-fill, respectively)

Discussion

Currently, conventional nanohybrid and bulk-fill composite resins are often preferred in dental treatments due to their advantages compared to other restorative materials, such as dental amalgams. As a result of restorative materials being continuously exposed to dietary colorant agents, aesthetic concerns are becoming a major problem in dental treatments. Although it was clearly stated that the discoloration of composites is affected by exogenous factors, such as oral hygiene, diet, and water sorption (26), experimental studies that focus on each topic specifically are still required. Due to the increasing demand for coffee consumption and third-wave coffee shops in recent years, we aimed to investigate the staining effects of bean-origin coffee types on composite materials.

A study investigating the staining effects of various beverages on composite resins (25) reported that a person's consumption of tea and coffee occurs an average of three times a day for an average of 15 minutes. Considering regional habits, it has been found that in the Turkish population, coffee varieties are consumed less frequently and in lower quantities than black tea. Consumption time was determined to be 10 minutes, on average, and frequency was twice a day. Applying these calculations revealed that exposing restorative materials to coffee varieties for 14 days corresponds to more than 33 months (approximately 2.75 years) of consumption in real life.

Color changes in composite resins can be detected with the naked eye using various scales, or with the help of spectrophotometric devices that give more precise results (27). Therefore, the Vita EasyShade V device (Vita ZahnFabrik, Bad Sackingen, Germany) was used for the spectrophotometric measurements of the composite resins. Since Ruyter et al. reported that the clinically acceptable color change (ΔE) value of the composite resins is ≤ 3.3 (28), a ΔE value > 3.3 was accepted as a statistically significant color change in this study. The results of the samples incubated in coffee showed a statistically significant color change compared to the control group; thus, the null hypothesis of this study was rejected.

Water absorption is crucial for the color change of composite resins. Therefore, water can be considered an agent that carries colorants into the resin matrix. The polyphenolic compounds in coffee (e.g., tannins) can cling to the surface of the restorative material and leave a yellow trace behind, causing aesthetic defects over time. Additionally, it has been noted that coffee-induced discoloration is difficult to remove because the components in coffee have less polarity and therefore penetrate more deeply (25). The findings of the present study are in line with previous studies indicating that samples incubated in coffee revealed significant color changes compared to control groups (25, 29). On the other hand, nanohybrid and bulk-fill composites did not reveal significant color changes, as was previously reported (30).

Interestingly, filtered coffee was found to be the most colorant coffee type of those tested. It was supposed that the reason for this was that filtered coffee is freshly ground and brewed immediately; therefore, the compounds are prevented from oxidation or degradation by other extrinsic factors. Although other types of coffee are much stronger than filtered coffee, it is thought that color changes are not associated with the strength but with the process of making filtered coffee—the coffee beans used in other types are not freshly ground. According to this assumption, the reason Mırra has the bitterest taste among coffee groups but has less coloring effect may be due to the degradation of its compounds during the lengthier preparation process.

Conclusions

It is widely known that coffee has a staining effect on both natural teeth and restorative materials. However, whether composite types differ in discoloration or how different coffee types affect discoloration requires further investigation to improve knowledge. Based on the results obtained in the present study, it was concluded that freshly ground coffees may cause more discoloration due to the richness of their phenolic compounds compared to those varieties sold previously ground. The reason filtered coffee is the most colorant type may be that the coffee is freshly ground from the bean and brewed before its components oxidize. Preparing Mırra requires boiling it for a long time and continuing the process until it separates from its grounds. It is thought that the lower staining effect of Mırra may be related to the way it is prepared.

Providing oral hygiene after coffee consumption (brushing or rinsing with water repeatedly) may be effective in improving the color stability of the composite. Considering the excessive consumption of coffee today, it is recommended that individuals who consume coffee should be advised after treatment about discoloration by their physician.

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References

1. Schricker SR. Composite resin polymerization and relevant parameters. In: Eliades T, Brantley WABT-OA of B, editors. Woodhead Publishing; 2017. p. 153-70. https://doi.org/10.1016/B978-0-08-100383-1.00009-6
2. Van Nieuwenhuysen J-P, D'Hoore W, Carvalho J, Qvist V. Long-term evaluation of extensive restorations in permanent teeth. J Dent. 2003 Aug;31(6):395-405. https://doi.org/10.1016/S0300-5712(03)00084-8
3. Bernardo M, Luis H, Martin MD, Leroux BG, Rue T, Leitão J, et al. Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial. J Am Dent Assoc. 2007 Jun;138(6):775-83. https://doi.org/10.14219/jada.archive.2007.0265
4. Soncini JA, Maserejian NN, Trachtenberg F, Tavares M, Hayes C. The longevity of amalgam versus compomer/composite restorations in posterior primary and permanent teeth: findings From the New England Children's Amalgam Trial. J Am Dent Assoc. 2007 Jun;138(6):763-72. https://doi.org/10.14219/jada.archive.2007.0264
5. Opdam NJM, Bronkhorst EM, Loomans BAC, Huysmans MCDNJM. 12-year survival of composite vs. amalgam restorations. J Dent Res. 2010 Oct;89(10):1063-7. https://doi.org/10.1177/0022034510376071
6. Leprince JG, Leveque P, Nysten B, Gallez B, Devaux J, Leloup G. New insight into the "depth of cure" of dimethacrylate-based dental composites. Dent Mater. 2012 May;28(5):512-20. https://doi.org/10.1016/j.dental.2011.12.004
7. Shortall AC, Palin WM, Burtscher P. Refractive index mismatch and monomer reactivity influence composite curing depth. J Dent Res. 2008 Jan;87(1):84-8. https://doi.org/10.1177/154405910808700115
8. Park J, Chang J, Ferracane J, Lee IB. How should composite be layered to reduce shrinkage stress: incremental or bulk filling? Dent Mater. 2008 Nov;24(11):1501-5. https://doi.org/10.1016/j.dental.2008.03.013
9. Cabadağ ÖG, Misilli T, Gönülol N. Bulk-fill kompozit rezinlere güncel bakış. Selcuk Dent J. 2021;8(1):220-8. https://doi.org/10.15311/selcukdentj.439067
10. Flury S, Hayoz S, Peutzfeldt A, Hüsler J, Lussi A. Depth of cure of resin composites: is the ISO 4049 method suitable for bulk fill materials? Dent Mater. 2012 May;28(5):521-8. https://doi.org/10.1016/j.dental.2012.02.002
11. El-Safty S, Silikas N, Watts DC. Creep deformation of restorative resin-composites intended for bulk-fill placement. Dent Mater. 2012 Aug;28(8):928-35. https://doi.org/10.1016/j.dental.2012.04.038

12. Abbas G, Fleming GJP, Harrington E, Shortall ACC, Burke FJT. Cuspal movement and microleakage in premolar teeth restored with a packable composite cured in bulk or in increments. J Dent. 2003 Aug;31(6):437-44. https://doi.org/10.1016/S0300-5712(02)00121-5
13. Ilie N, Keßler A, Durner J. Influence of various irradiation processes on the mechanical properties and polymerisation kinetics of bulk-fill resin based composites. J Dent. 2013 Aug;41(8):695-702. https://doi.org/10.1016/j.jdent.2013.05.008
14. Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Oper Dent. 2013;38(6):618-25. https://doi.org/10.2341/12-395-L
15. Ilie N, Stark K. Curing behaviour of high-viscosity bulk-fill composites. J Dent. 2014 Aug;42(8):977-85. https://doi.org/10.1016/j.jdent.2014.05.012
16. Kim RJ-Y, Kim Y-J, Choi N-S, Lee I-B. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. J Dent. 2015 Apr;43(4):430-9. https://doi.org/10.1016/j.jdent.2015.02.002
17. Kleverlaan CJ, Feilzer AJ. Polymerization shrinkage and contraction stress of dental resin composites. Dent Mater. 2005 Dec;21(12):1150-7. https://doi.org/10.1016/j.dental.2005.02.004
18. Patel SB, Gordan V V, Barrett AA, Shen C. The effect of surface finishing and storage solutions on the color stability of resin-based composites. J Am Dent Assoc. 2004 May;135(5):587-94; quiz 654. https://doi.org/10.14219/jada.archive.2004.0246
19. Barutcigil Ç, Barutcigil K, Özarslan MM, Dündar A, Yilmaz B. Color of bulk-fill composite resin restorative materials. J Esthet Restor Dent [Internet]. 2018 Mar 1;30(2):E3-8. https://doi.org/10.1111/jerd.12340
20. Fontes ST, Fernández MR, de Moura CM, Meireles SS. Color stability of a nanofill composite: effect of different immersion media. J Appl Oral Sci. 2009;17(5):388-91. https://doi.org/10.1590/S1678-77572009000500007
21. Janda R, Roulet J-F, Kaminsky M, Steffin G, Latta M. Color stability of resin matrix restorative materials as a function of the method of light activation. Eur J Oral Sci. 2004 Jun;112(3):280-5. https://doi.org/10.1111/j.1600-0722.2004.00125.x
22. Barutcigil C, Harorli OT, Yildiz M, Ozcan E, Arslan H, Bayindir F. The color differences of direct esthetic restorative materials after setting and compared with a shade guide. J Am Dent Assoc. 2011 Jun;142(6):658-65. https://doi.org/10.14219/jada.archive.2011.0249
23. International Coffee Organization. ICO [Internet]. 2021. Available from: https://www.ico.org/prices/new-consumption-table.pdf
24. Farah A, Ferreira dos Santos T. Chapter 1 - The Coffee Plant and Beans: An Introduction. In: Preedy VRBT-C in H and DP, editor. San Diego: Academic Press; 2015. p. 5-10. https://doi.org/10.1016/B978-0-12-409517-5.00001-2
25. Yamanel K. Farklı İçeceklerin Diş Rengindeki Restoratif Materyallerin Renk Stabiliteleri Üzerine Etkisi. Süleyman Demirel Üniversitesi Sağlık Bilim Derg. 2018;9(2):26-31. https://doi.org/10.22312/sdusbed.409547
26. Ardu S, Duc O, Di Bella E, Krejci I. Color stability of recent composite resins. Odontology [Internet]. 2017;105(1):29-35. https://doi.org/10.1007/s10266-016-0234-9
27. Chittem J, Sajjan GS, Varma Kanumuri M. Spectrophotometric Evaluation of Colour Stability of Nano Hybrid Composite Resin in Commonly Used Food Colourants in Asian Countries. J Clin Diagn Res. 2017 Jan;11(1):ZC61-5. https://doi.org/10.7860/JCDR/2017/22919.9193
28. Ruyter IE, Nilner K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. Dent Mater. 1987 Oct;3(5):246-51. https://doi.org/10.1016/S0109-5641(87)80081-7
29. Reddy PS, Tejaswi KLS, Shetty S, Annapoorna BM, Pujari SC, Thippeswamy HM. Effects of commonly consumed beverages on surface roughness and color stability of the nano, microhybrid and hybrid composite resins: an in vitro study. J Contemp Dent Pract. 2013 Jul;14(4):718-23. https://doi.org/10.5005/jp-journals-10024-1390
30. 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 Oct;107(4):507-12. https://doi.org/10.1007/s10266-019-00421-x