ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Current Research in Dental Sciences

Research Article Araştırma Makalesi
DOI: 10.17567/ataunidfd.1069380

Effect of Different Teas on Surface Roughness of Conventional and Bulk-Fill Composite Resins Beverage Effect on Composite Resins

Farklı Çayların Geleneksel ve Bulk-Fill Rezin Kompozitlerin Yüzey Özelliklerine Etkisi

Esra Özyurt[1]
Ayşegül Kurt[2]

[1]Department of Restorative Dentistry, İzmir Training Dental Hospital, İzmir, Turkey
[2]Department of Prosthodontics, Trakya University, Faculty of Dentistry, Edirne, Turkey

ABSTRACT

Aim: The aim of this study was to assess the effect of different teas on surface roughness and surface morphology of a conventional resin and three bulk-fill composite resins.

Materials and Methods: The three bulk-fill (Beautifil, Tetric N-Ceram, Filtek One) composite resin and one conventional (Z250) composite resin material, three beverages (black tea, kombucha tea, and matcha tea), and distilled water were used. For the surface roughness test (n = 10), 160 samples were prepared, and the initial surface roughness values were measured (t0) with a profilometer device. The final surface roughness evaluation (t1) was made after 12 days of beverage immersions. The surface morphology of samples was evaluated for each group by scanning electron microscope(SEM) and atomic force microscopy(AFM) photomicrographs (n = 3). Ten samples of each composite resin were used for the degree of conversion (DC) analysis. For multiple comparisons, data were analyzed with the independent samples Kruskal–Wallis test, and a one-way analysis of variance test was used to compare DC values with respect to composites ($P < .05$).

Results: There was a statistically significant difference in the kombucha groups between the Beautifil bulk-fill composite and the others ($P < .05$). Tetric was affected by the kombucha tea ($P = .012$). The highest DC was obtained from Filtek One; the lowest DC was obtained from the Beautifil ($P < .01$). In this study, Beautifil showed the highest degree of surface roughness.

Conclusions: The acidic beverages affected the surface properties of bulk-fill composite materials negatively in terms of roughness.

Key Words: Beverage, bulk-fill, roughness, SEM, tea

ÖZ

Amaç: Bu çalışmanın amacı, farklı çayların bir geleneksel ve üç adet bulk-fill kompozit rezinin yüzey pürüzlülüğü ve yüzey morfolojisi üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Üç bulk-fill (Beautifil, Tetric, Filtek One) kompozit rezin ve bir geleneksel (Z250) kompozit rezin, üç içecek (siyah çay, kombucha çayı ve matcha çayı) ve distile su kullanıldı. Yüzey pürüzlülük testi (n=10) için 160 örnek hazırlandı ve profilometre cihazı ile ilk yüzey pürüzlülük ölçümleri (t0) yapıldı. Son yüzey pürüzlülüğü değerlendirmesi (t1) 12 gün içeceklerde bekletme işleminden sonra yapıldı. Örneklerin yüzey morfolojisi, her grup için SEM ve AFM fotomikrografi (n = 3) ile değerlendirildi. Dönüşüm derecesi (DC) analizi için her bir kompozit rezinden on örnek hazırlandı. Veriler, çoklu karşılaştırmalar için Kruskal-Wallis testi ile analiz edildi ve DC değerlerini kompozitlere göre karşılaştırmak için tek yönlü varyans analizi (ANOVA) testi kullanıldı ($P < 0.05$).

Bulgular: Beautifil bulk-fill kompozit rezin ile diğerleri arasında kombucha gruplarında anlamlı fark bulundu ($P < 0.05$). Tetric, kombucha çayından etkilenmiştir ($P = 0.012$). En yüksek DC Filtek One'dan elde edildi; en düşük DC, Beautifil'den elde edildi ($P < 0.01$). Bu çalışmada, Beautifil en yüksek derecede yüzey pürüzlülüğü göstermiştir.

Sonuç: Asitli içecek, bulk-fill kompozit rezinlerin yüzey özelliklerini pürüzlülük açısından olumsuz etkilemiştir.

Anahtar Kelimeler: bulk-fill, pürüzlülük, içecek, çay, SEM

Received/Geliş Tarihi: 12.10.2021
Accepted/Kabul Tarihi: 7.02.2022

Corresponding Author/Sorumlu Yazar: Esra ÖZYURT
E-mail: dr.esraozyurt@gmail.com

Cite this article as: Özyurt E, Kurt A. Effect of Different Teas on Surface Roughness of Conventional and Bulk-Fill Composite Resins Beverage Effect on Composite Resins. *Curr Res Dent Sci*. 2023; 33(2): 84-89.

INTRODUCTION

Resin-based composite materials (RBCs) are chosen because of their ability to adhere to hard dental tissue, their physical and mechanical properties, and their cost-effectiveness.[1] Several new resin-based restorative materials were produced because of the requirement for good esthetics and mechanical properties in dental treatments. The disadvantages of the layering technique (gap or contamination risk between the layers, failure in inter-layer bonding, and time-consuming clinical application) in the clinical application procedure of conventional composites led to the development of bulk-fill RBCs.[2, 3]

Bulk-fill RBC materials are preferred for posterior restoration, as they can fill a single increment of up to 4-5 mm.[4] Bulk-fill RBCs have lower filler amounts and bigger filler sizes, polymer isolator modulators, shrinkage stress relievers, and additional photoinitiator systems.[5, 6] Bulk-fill RBCs have a higher polymerization depth and lower polymerization shrinkage than conventional RBCs.[7] Bulk-fill composites are varied into different types according to their viscosity, filler content, indication, and so on.[2, 8]

A high viscosity bulk-fill giomer (Beautifil Bulk, SHOFU) has been introduced.[9] Giomers are a new resin-based class of glass ionomers containing pre-reacted glass ionomer (PRG) fillers. Giomers do not expose acid-based reactions; thus, they cannot be classified as a compomer. Instead, they are described as a "PRG composite."[10] The PRG fillers ensure fluoride release by ion-exchange in the previously reacted hydrogel. This mechanism makes giomers an alternative to other resin-based restorative materials that release fluoride.[11]

The long-term durability of RBC restoration is subject to the restorative material (the monomer structure, filler size, type and loading, and monomer conversion rate) and the oral conditions. Variables of the oral environment such as thermal changes, masticatory stresses, and chemicals from food and beverages have a significant impact on the restoration.[12] Exposure to saliva, food components, and beverages in the oral environment can degrade the restorations and adversely affect the esthetics and physical properties such as surface roughness, microhardness, and translucency.[13] The surface roughness of dental restoration is an important factor for color stability and esthetics. In addition, plaque accumulation increases on the roughened surfaces, consequently gingival inflammation and recurrent caries occur and wear resistance also decreases.[14]

In recent times, people have become more interested in healthy food and drinks. Kambucha tea is a fermented beverage that is being consumed today and has been reported to have antioxidant and anti-inflammatory properties.[15] Matcha tea is also a tea that has been proven to increase antioxidant properties and cognitive functions, and its consumption is rapidly increasing.[16] Kombucha tea and matcha tea have not been used in any studies concerning dentistry.

Although the bulk-fill composite resin materials are widely used in dentistry, there are limited studies that have evaluated the surface roughness of bulk-fill materials after beverage immersion.[1, 17, 18] An investigation into the mechanical and physical properties of composite materials depending on the oral environment would be of substantial importance to clinicians when choosing the right restorative material. In addition, there have been no studies that have evaluated the giomer-based bulk-fill composite resins' surface properties after beverage immersion. The aim of this study was to evaluate the effect of different teas on surface roughness and surface morphology of a conventional resin and bulk-fill RBCs have different organic matrix, photoinitiator, and filler. The null hypothesis was that the exposure to different teas does not affect the surface roughness.

MATERIALS AND METHODS

The three bulk-fill (Filtek One Bulk Fill, Tetric N-Ceram Bulk Fill, Beautifil Bulk Fill) and one conventional composite resin (Filtek Z250) materials were tested in this in-vitro study. Three beverages (black tea, kombucha tea, and matcha tea) and distilled water were used. Detailed information about the materials is provided in Table 1.

Sample preparation

This study included 40 samples (5 mm Ø, 2 mm thickness) for monomer conversion (*n* = 10), and 160 samples (2 mm thickness, 10 mm Ø) for surface roughness tests (*n* = 10), which were prepared with polytetrafluoroethylene molds and cured for 20 s with a light-curing device (VALO; Ultradent, South Jordan, UT, USA) in contact with the mylar strips. The power density (1500 mW/cm2) of light-curing unit was verified by a radiometer. The prepared samples were polished by using polishing discs (Soflex; 3M ESPE, St. Paul, USA) from coarse to super-fine grain sizes. Sample preparation and application of polishing discs were performed by the same operator to provide the standardization. The polishing discs were used for 10 s each, using a low-speed handpiece with circular movements. The sample surfaces were washed between these discs. The discs were changed after each use. The samples were stored in an incubator at 37 °C for 24 hours in distilled water.

Table 1. Details of the composite resin materials used in the study

Composite	Manufacturer	Type	Composition	Photoinitiator
Beautifil Bulk Fill	Shofu, Tokyo, Japan	Giomer	Monomers: Bis-GMA, UDMA, Bis-MPEPP, TEGDMA Filllers: S-PRG filler based on fluoroboroalumino silicate glass In total: 87 wt%, 74 vol%	Camphorquinone
Filtek Bulk Fill Posterior	3M Espe, USA	Nano-hybrid	Monomers: AUDMA, AFM, DDMA, UMA Fillers: Ytterbium trifluoride (YbF3), zirconia filler, silica filler In total: 76 wt%, 58 vol% 0,004- 0,01 µm	Camphorquinone
Tetric N-Ceram Bulk Fill	Ivoclar Vivadent, Liechtenstein	Nano-hybrid	Monomers: Bis-GMA, UDMA, Bis-EMA Fillers: Barium aluminosilicate glass, prepolymer filler, ytterbium fluoride, spherical mixed oxide In total: 75-77 wt%, 53-55 vol% 0,4-0,7 µm	Camphorquinone Lucirin TPO Ivocerin
Filtek Z250	3M Espe, USA	Micro-hybrid	Monomers: Bis-GMA, UDMA, Bis-EMA, PEGDMA, TEGDMA Fillers: Modified zirconia/silica In total: 82 wt%, 68 vol% 0,01 µm to 3,5 µm with an average particle size of 0,6 µm	Camphorquinone

Table 2. The information about the beverages that were used in the study

Beverage	Manufacturer	pH	Preperation
Distilled Water	-	5.5	-
Tea	Yellow Label Tea 2 g, Lipton, Rize, Turkey	4.9	prepared by one prefabricated tea bag was immersed for 3 min into 200 ml boiled distilled water
Kombucha tea	Kombucha tea, Fermente Mutfağım Yaşayan Gıda, Pendik, İstanbul, Turkey	3.2	-
Matcha tea	Chado Tea, Gurme Gıda, Istanbul, Turkey	5.7	prepared by mixing one tablespoon of tea into 200 ml boiled distilled water and stirred for 30 s

Table 3. Surface roughness (Ra-μm) median of the alteration and min/max values after 12 days immersion

	Distilled Water		Tea		Kombucha		Matcha		
	Median	Min/Max	Median	Min/Max	Median	Min-Max	Median	Min-Max	p
Beautifil	(0.0000	-0.03/0.03)A,a	(0,0000	-0.05/0.13)A,a	(-0.0750	-0.15/-0.03)B,a	(-0.0250	-0.05/0.00)A,B,a	0.000*
Tetric	(-0.0125	-0.03/0.08)A,a	(-0,0250	0.00/0.05)A,B,a	(0.0250	0.03/0.05)B,b	(0.0125	-0.1/0.05)A,B,a	0.012*
Filtek One	(0.0000	-0.03/0.03)A,a	(0,0000	-0.03/0.03)A,a	(0.0000	-0.03/0.05)A,b	(0.0000	0.00/0.03)A,a	0.099
Z250	(0.0000	-0.3/0.03)A,a	(0,0125	-0.08/0.13)A,a	(0.0000	-0.03/0.05)A,b	(-0.0250	-0.08/0.03)A,a	0.072
p	0.237	0.245	0.000*	0.08					

Independent Samples Kruskal-Wallis test
*p<0.05
*Different lowercase letters in columns compare composite resins. Uppercase letters in rows compare beverages.

Table 4. Comparison of DC values according to composites

	Mean	Test Statistic	p
Beautifil	0.70a±0.01	F=171.182	<0.001
Tetric N-Ceram	0.83c±0.02		
Filtek One	0.94b±0.04		
Z250	0.73d±0.02		

F: Variance analysis test statistic, a-d: Different letters in same column mean statistical difference (p<0.05).

Storage agent immersions

Four sample groups were randomly set according to beverages (distilled water as control, tea, kombucha tea, and matcha tea) for evaluating surface characteristics. The manufacturers, pH levels, and preparation methods of beverages were listed in Table 2. The pH levels of the solutions were measured with a pH meter (Benchtop pH meter SevenCompact S220 Basic, Mettler Toledo, Ohio, ABD).

After all the solutions had cooled to room temperature (24 °C) to ensure standardization, the samples were immersed in the solutions for 12 days, which is equal to 1 year of consumption.[19] The solutions were renewed every 2 days to prevent microbial growth. After the solution procedure, the samples were rinsed with distilled water for 10 seconds and dried with absorbent paper.

Surface roughness measurements

For the surface roughness analysis, 10 samples were used for each group. Initial surface roughness measurements (t0) at three points were performed on the top surface of the remaining 10 samples in each group with a profilometer device (Surtronic S128; Taylor Hobson, Leicester, UK) and recorded. The samples were then placed in the indicated solutions. The final surface roughness evaluations were made after 12 days (t1), equivalent to 1 year of consumption.

Monomer conversion

From each composite resin (5 mm ⌀), 10 samples were prepared and stored in an incubator for 24 hours at 37 °C. The degree of conversion (DC) was determined with Fourier-transform infrared spectroscopy (FTIR- Frontier MIR/FIR Spectrometer, Perkin Elmer, United Kingdom). Absorption spectra of each sample were measured with 32 scans at a resolution of 4 cm^{-1} (within a spectrum of 4000-650 cm^{-1}). The uncured material was determined with the same protocol. The ratio (R) between the peak heights (1637 cm^{-1} and 1608 cm^{-1} band absorptions) for the cured and uncured composites was used to calculate DC according to the formula: DC (%) = $(1 - [R_{cured}/R_{uncured}]) \times 100$.

Surface morphology observation

Three samples from each group that had a mean difference of roughness (Ra) value close to the mean value were chosen for surface topography observations. The sample surfaces were examined using an atomic force microscope (AFM, Nano Magnetic Instrument, Turkey) and a scanning electron microscope (SEM, QUANTA FEG-250, FEI Company, Hillsboro, OR, USA). Four images were taken from each sample prepared for AFM evaluation. Three-dimensional images and surface roughness values were calculated using image analyzer Nano Magnetic software. The surface roughness was calculated in nm as the Ra value.

In each group, qualitative examinations of the three sample surfaces were evaluated with an SEM (QUANTA FEG-250 Field Emission Scanning Electron Microscope, FEI Company, USA). Composite resin material surfaces were gold-sputtered and observed under an SEM. The representative micrographs were recorded at 500x, 1000x, 1500x, and 2000x magnifications.

Statistical analysis

Data were analyzed with SPSS V23 (Chicago, IL, USA). The normality of the data was assessed with the Shapiro–Wilk test. The difference in surface roughness values was subjected to the independent samples Kruskal–Wallis test for multiple comparisons. To compare DC values with respect to composites, one-way analysis of variance was used. Data were analyzed at a significance level of $P = .05$.

RESULTS

The mean and Ra and their SDs are shown in Table 3. There was a significant difference in kombucha groups between the Beautifil bulk-fill composite and the Filtek One, Tetric N-Ceram and Z250 composites ($P = .004$, $P < .001$, and $P = .028$, respectively). There were no significant differences between the other solution groups ($P > .05$).

Among the groups, the observations indicated that Tetric N-Ceram's roughness difference in the kombucha group was different from the distilled water group ($P = .01$). In the Beautifil groups, there was a significant difference between the kombucha tea group and the distilled water and black tea groups ($P = .002$ and

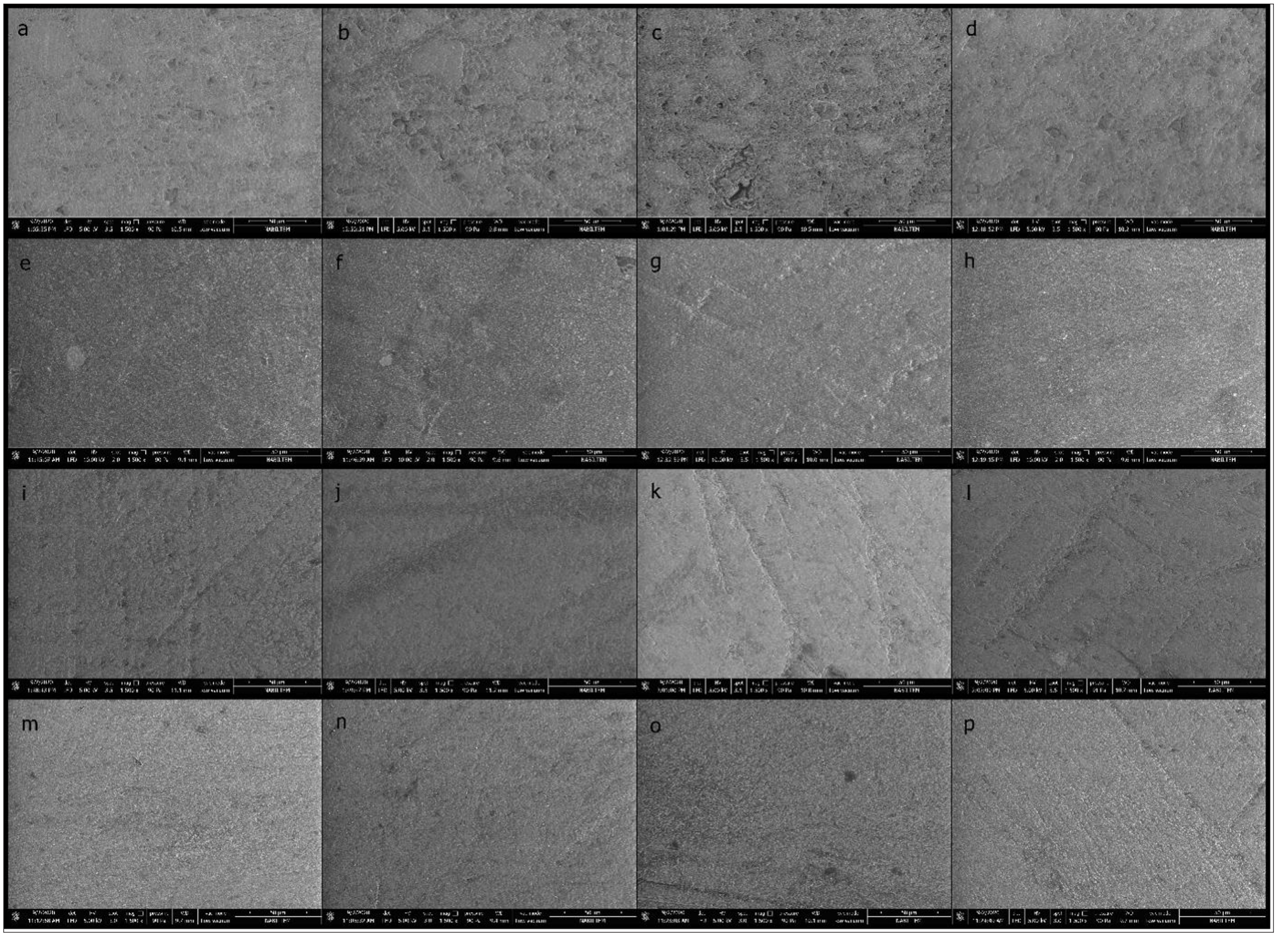

Figure 1.
SEM photomicrographs of the groups after immersions. Beautifil (a,b,c,d, distilled water, tea, kombucha tea, matcha tea respectively), Tetric (e,f,g,h, distilled water, tea, kombucha tea, matcha tea respectively), Filtek One (i,j,k,l distilled water, tea, kombucha tea, matcha tea respectively), Z250 (m,n,o,p distilled water, tea, kombucha tea, matcha tea respectively). (1500x magnification.)

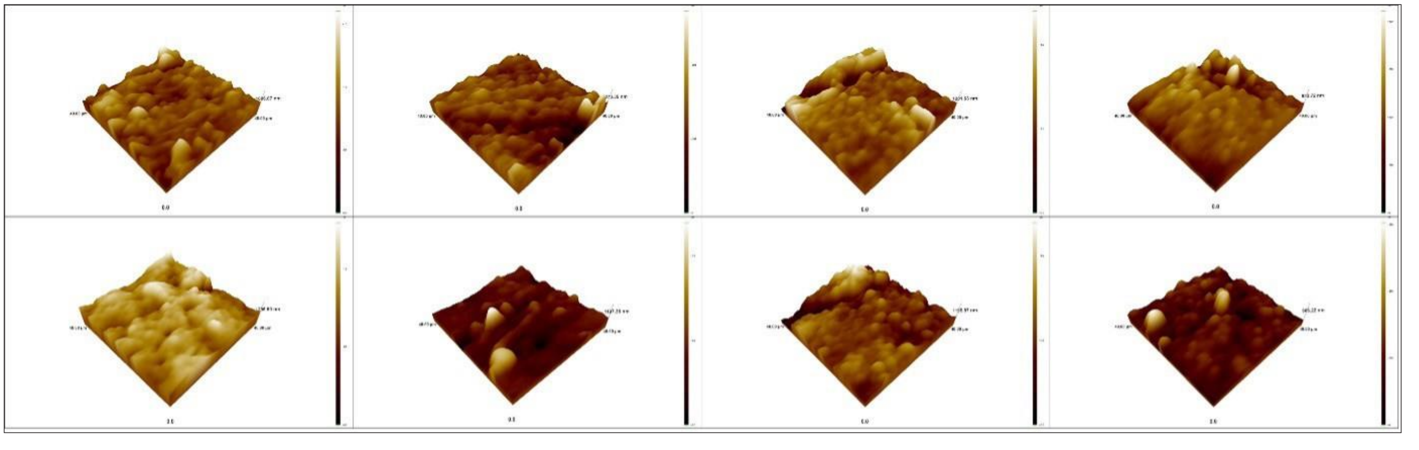

Figure 2.
AFM images of the groups after distilled water (a,b,c,d, Beautifil, Tetric, Filtek One and Z250 respectively) and kombucha tea immersions (e,f,g,h, Beautifil, Tetric, Filtek One and Z250 respectively).

P = .007, respectively). In the Filtek One and Z250 groups, there were no significant differences between the solutions (*P* = .09 and *P* = .07, respectively).

The DC values were statistically different depending on the composites (*P* < .001). Whereas the highest DC was obtained from the Filtek One composite, the lowest DC was obtained from the Beautifil composite (Table 4).

SEM and AFM images after being immersed in solutions are presented in Figures. 1 and 2. After exposure to kombucha tea, there were changes in surface properties, especially by Beautifil. The roughest surfaces were observed in the Beautifil group was immersed in kombucha tea (Figure 2).

The Beautifil groups showed a nonhomogenous surface with dislodged fillers and resin loss (Figure 1 a-d). In contrast, the Filtek One and Z250 groups exhibited smoother, more homogeneous surfaces than the Beautifil groups (Figure 1 i-p). In the Tetric groups, a more nonhomogenous surface in the kombucha tea group was seen compared with the other beverage groups (Figure 1 e-h). The gaps that were probably left by the dislodged fillers result in non-homogenous surfaces in the Beautifil kombucha tea group (Figure 1d) compared with all the other groups.

The AFM images of the composite resin surfaces after immersions are shown in Figure 2. In the kombucha tea groups, the Beautifil groups showed irregularities with valleys and peaks (Figure 2 g).

DISCUSSION

It was showed that bulk-fill and conventional composite resins' physical characteristics were affected by the analyzed beverages after 12 days of consumption.[19] Therefore, the null hypothesis was rejected. In the in-group examination, it was observed that an acidic beverage, kombucha tea, caused the highest increase in roughness in the Beautifil composite resin by presenting with the lowest DC. There was a difference between the Beautifil composite and the other resin composites in the kombucha tea subgroups (Table 3). This result was also supported by the SEM and AFM images that evaluated surface morphology.

Kombucha is a fermented tea that contains lactic acid, acetic acid, gluconic acid, and glucuronic acid at different levels.[15] Acidic solutions might permit increases in particle dissolution, which soften the polymer matrices and dislodge the filler particles. This process results from decreases in the load resistance and surface hardness and increases in the roughness of the composite resin materials.[1, 20] Beautifil bulk-fill composite resin is a material with pre-reacted glass ionomer (S-PGR) fillers known as "giomer." The giomer composites release fluoride ions.[21] The giomer material, Beautifil, was found to be significantly degraded by the acidic (pH:3.2) kombucha tea as observed in the SEM and AFM images (Figure 1 and Figure 2). These findings are compatible with the previous studies that examined giomer and conventional composites.[22, 23] This may be explained by fluorosilicate glass fillers' susceptibility to deterioration by weak acids. Furthermore, Gonulol et al.[25] reported that more surface gaps could be observed in giomer composites compared with conventional composites due to the fluoride ion releasing.

In the Beautifil subgroups, Kombucha tea caused the highest roughness difference compared with distilled water and black tea. These results may be caused by acidity as reported in previous studies.[1, 17] Moreover, in the Tetric subgroups, Kombucha tea caused significantly rough surfaces than distilled water. Tetric N-Ceram Bulk-Fill uses ytterbium trifluoride as filler. Ytterbium trifluoride is added to the structure of composite resins because of its radio-opacity and its fluoride-releasing properties.[26] Also, a high degree of conversion provides satisfactory mechanical properties for the composite resin material.[6] Tetric N-Ceram bulk-fill contains ytterbium trifluoride that could be degraded by moisture, and it showed lower %DC value than the other nanohybrid composite Filtek One Bulk-fill, which also contains ytterbium-trifluoride. Thus, Tetric N-Ceram Bulk Fill may have been affected by the acidity of kombucha tea. In the Tetric N-Ceram subgroups, the differences in the roughness of kombucha tea and black tea were not statistically significant, but the difference made by kombucha tea was higher compared with the black tea group.

Surface roughness is related to a combination of factors, such as organic matrix composition; monomer conversion degree; the organic matrix-filler particle bond stability; and the filler particles' percentage, size, and hardness values.[27] The restorative materials used have different organic and inorganic contents (Table 1). When the composite groups are examined in terms of color change, Z250 and Filtek One showed no statistically significant differences in any immersions. Z250 contains Bis-EMA resin monomer, an ethoxylated type of Bis-GMA, which bears reacted hydroxyl groups on the polymer chain, making it highly hydrophobic.[28] It was reported that better mechanical properties with lower solubility in aqueous solutions might be obtained by the Bis-EMA monomer.[22] Furthermore, it was reported that zirconia fillers could be more resistant to an acidic environment than barium glass fillers.[29] In this study, Beautifil and Tetric were affected by the acidic kombucha tea as determined by their increased surface roughness. Beautifil is a giomer-based material and an acidic environment could dissolve the SPRG particles.[22] Tetric N-Ceram has a barium glass filler (Table 1). The other 2 composite materials, Z250 and Filtek One, have zirconia fillers as their inorganic content (Table 1). The difference in filler particles could be caused by the difference in the results of the in-group evaluations.

DC% affects the surface properties of the composite resins.[19, 25, 30] The high rate of polymerization could reduce the amount of residual monomer and cause the structure of the composite resins to be nonporous. In this study, Filtek One had the highest DC value and the high DC value may have prevented Filtek One from being affected by beverages in terms of surface roughness.

This study does not reflect the oral conditions entirely, as it is an in vitro evaluation. Saliva has a neutralizing pH effect in the oral environment and distilled water, as control solution may not mimic the oral conditions. Also, oral hygiene routines could cause the acidity of beverages to be decreased or even eliminated. It would be appropriate to address the effects of brushing and oral hygiene materials, such as toothpaste or mouthwashes, and evaluate the color stability in future studies. Besides, further in-situ and in-vivo studies are necessary to confirm these drinks' long-term effects on restorative materials. In addition, it is necessary to evaluate the effects of frequently consumed beverages such as coffee, coke, and wine on the surface properties of composites. In further studies, these limitations should be considered.

CONCLUSIONS

It can be concluded that:

- Monomer conversion degree is important in the mechanical properties of composite resins.
- Acidic beverages could negatively affect the surface properties of bulk-fill composite resins.
- The giomer-based Beautifil composite resin showed more surface degradation and a higher roughness value than the other bulk-fill composite resins.

Ethics Committee Approval: No need to ethical approval for this study. No human subject were used for the study.

Informed Consent: Written informed consent was obtained from patients/patients' parents/ the parents of the patients/patient who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - E.Ö.; Design- E.Ö., A.K.; Supervision- A.K., Resources - E.Ö.; Materials - E.Ö.; Data Collection and Processing- E.Ö., A.K.; Analysis and/or Interpretetion - E.Ö.; Literature Search - E.Ö.; Writing Manuscript - E.Ö; Critical Review- A.K.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: This study was supported by the Scientific Research Fund of Trakya University, Turkey (project no. TUBAP 2019/234).

Etik Komite Onayı: Bu çalışma için etik komite onayına gerek duyulmamıştır. Çalışmada hasta kullanılmamıştır.

Hasta Onamı: Yazılı hasta onamı bu çalışmaya katılan hastalardan/ hastanın ailesinden/hastadan

Hakem değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir - E.Ö.; Tasarım- E.Ö., A.K.; Denetleme - A.K., Kaynaklar - E.Ö.; Malzemeler - E.Ö.;Veri Toplanması ve/veya İşlemesi - E.Ö., A.K.; Analiz veya Yorum - E.Ö.; Literatür Taraması - E.Ö.;Yazıyı Yazan - E.Ö; Eleştirel İnceleme- A.K.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Finansal Destek: Bu çalışma Trakya Üniversitesi Bilimsel Araştırma Fonu tarafından desteklenmiştir (proje no. TUBAP 2019/234).

REFERENCES

1. Tanthanuch S, Kukiattrakoon B, Eiam-O-Pas K, et al. Surface changes of various bulk-fill resin-based composites after exposure to different food-simulating liquid and beverages. *Journal of Esthetic and Restorative Dentistry* 2018; 30: 126-135. **[Crossref]**
2. Chesterman J, Jowett A, Gallacher A, et al. Bulk-fill resin-based composite restorative materials: a review. *British dental journal* 2017; 222: 337-344. **[Crossref]**
3. ÖZGÜL BM, BOSTANCI GB, TİRALİ RE, et al. EFFECT OF CURING UNITS AND ADHESION STRATEGIES ON MICROLEAKAGE OF BULK-FILL COMPOSITES: AN IN VITRO STUDY. *Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi*; 29: 74-79.
4. Diab RA, Yap AU, Gonzalez MAG, et al. Impact of light-curing distance on the effectiveness of cure of bulk-fill resin-based composites. *The Saudi Dental Journal* 2021. **[Crossref]**
5. Czasch P and Ilie N. In vitro comparison of mechanical properties and degree of cure of bulk fill composites. *Clinical oral investigations* 2013; 17: 227-235. **[Crossref]**
6. de Araújo-Neto VG, Sebold M, de Castro EF, et al. Evaluation of physico-mechanical properties and filler particles characterization of conventional, bulk-fill, and bioactive resin-based composites. *Journal of the Mechanical Behavior of Biomedical Materials* 2021; 115: 104288. **[Crossref]**
7. Garoushi S, Vallittu P, Shinya A, et al. Influence of increment thickness on light transmission, degree of conversion and micro hardness of bulk fill composites. *Odontology* 2016; 104: 291-297. **[Crossref]**
8. Yap AUJ, Pandya M and Toh WS. Depth of cure of contemporary bulk-fill resin-based composites. *Dental materials journal* 2016; 35: 503-510. **[Crossref]**
9. Ilie N and Stawarczyk B. Evaluation of modern bioactive restoratives for bulk-fill placement. *Journal of dentistry* 2016; 49: 46-53. **[Crossref]**
10. Kooi T, Tan Q, Yap A, et al. Effects of food-simulating liquids on surface properties of giomer restoratives. *Operative Dentistry* 2012; 37: 665-671. **[Crossref]**
11. Ikemura K, Tay FR, Endo T, et al. A review of chemical-approach and ultramorphological studies on the development of fluoride-releasing dental adhesives comprising new pre-reacted glass ionomer (PRG) fillers. *Dental Materials Journal* 2008; 27: 315-339. **[Crossref]**
12. DA SILVA MAB, Vitti RP, Sinhoreti MAC, et al. Effect of alcoholic beverages on surface roughness and microhardness of dental composites. *Dental materials journal* 2016; 35: 621-626. **[Crossref]**
13. Badra VV, Faraoni JJ, Ramos RP, et al. Influence of different beverages on the microhardness and surface roughness of resin composites. *Oper Dent* 2005; 30: 213-219.
14. Dede DÖ, Şahin O, Koroglu A, et al. Effect of sealant agents on the color stability and surface roughness of nanohybrid composite resins. *The Journal of prosthetic dentistry* 2016; 116: 119-128. **[Crossref]**
15. Villarreal-Soto SA, Beaufort S, Bouajila J, et al. Understanding kombucha tea fermentation: a review. *Journal of food science* 2018; 83: 580-588. **[Crossref]**
16. Dietz C, Dekker M and Piqueras-Fiszman B. An intervention study on the effect of matcha tea, in drink and snack bar formats, on mood and cognitive performance. *Food research international* 2017; 99: 72-83. **[Crossref]**
17. Meenakshi CM and Sirisha K. Surface quality and color stability of posterior composites in acidic beverages. *Journal of Conservative Dentistry: JCD* 2020; 23: 57. **[Crossref]**
18. Karadaş M and Demirbuğa S. Evaluation of color stability and surface roughness of bulk-fill resin composites and nanocomposites. *Meandros Medical and Dental Journal* 2017; 18: 199. **[Crossref]**
19. Alberton Da Silva V, Alberton Da Silva S, Pecho OE, et al. Influence of composite type and light irradiance on color stability after immersion in different beverages. *Journal of Esthetic and Restorative Dentistry* 2018; 30: 390-396. **[Crossref]**
20. Borges MG, Soares CJ, Maia TS, et al. Effect of acidic drinks on shade matching, surface topography, and mechanical properties of conventional and bulk-fill composite resins. *The Journal of prosthetic dentistry* 2019; 121: 868. e861-868. e868. **[Crossref]**
21. Francois P, Fouquet V, Attal J-P, et al. Commercially Available Fluoride-Releasing Restorative Materials: A Review and a Proposal for Classification. *Materials* 2020; 13: 2313. **[Crossref]**
22. Kazak M, Tiryaki M, Basaran ET, et al. Evaluating the effects of different beverages with daily consumption habits on the wear of restorative materials. *Odontology* 2020: 1-10. **[Crossref]**
23. Cabadag ÖG and Gönülol N. The Effects of Food-Simulating Liquids on Surface Roughness, Surface Hardness, and Solubility of Bulk-Fill Composites. *Journal of Advanced Oral Research* 2021: 2320206820988451. **[Crossref]**
24. Wa C. Influence of oral fluid on composite resin and glass-ionomer cement. *The Journal of prosthetic dentistry* 1984; 52: 182-189. **[Crossref]**
25. Gonulol N, Ozer S and Sen Tunc E. Water sorption, solubility, and color stability of giomer restoratives. *Journal of esthetic and restorative dentistry* 2015; 27: 300-306. **[Crossref]**
26. Iazzetti G, Burgess J, Gardiner D, et al. Color stability of fluoride-containing restorative materials. *Operative dentistry* 2000; 25: 520-525.
27. Lepri CP and Palma-Dibb RG. Surface roughness and color change of a composite: influence of beverages and brushing. *Dental materials journal* 2012; 31: 689-696. **[Crossref]**
28. Yazici AR, Celik C, Dayangaç B, et al. The effect of curing units and staining solutions on the color stability of resin composites. *Operative dentistry* 2007; 32: 616-622. **[Crossref]**
29. Loomans B, Cardoso M, Opdam N, et al. Surface roughness of etched composite resin in light of composite repair. *Journal of dentistry* 2011; 39: 499-505. **[Crossref]**
30. Lauvahutanon S, Shiozawa M, Takahashi H, et al. Discoloration of various CAD/CAM blocks after immersion in coffee. *Restorative dentistry & endodontics* 2017; 42: 9-18. **[Crossref]**