第 48 卷 第 9 期
2021 年 9 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 48. No. 9.
September 2021

Open Access Article

The Impact of Energy Drinks on Surface Roughness, Hardness, and Color Stability of Three Types of Composite Restorations

D.I. Hamadamin[1], D.H. Saeed[2*]

[1] Faculty of Restorative Dentistry, Kurdistan Board of Medical Specialties, Khanzad Training Center, Erbil, Iraq

[2] Department of Conservative Dentistry, College of Dentistry, Hawler Medical University, Erbil, Iraq

Abstract: In the past years, the significant worldwide increase in the consumption of energy drinks has created several dental-related problems. One of these side effects is weakening the mechanical properties of composite resins, which shortens the lifespan of dental composite and fixed dentures. The study aimed to know the impact of energy drinks (Red Bull, Wild Tiger, and Monster energy Ultra sunrise) and distilled water on surface hardness, surface roughness, and color stability of composite resin restorations. The present prospective study was conducted in Khanzad teaching hospital, on 144 flat circular disks with dimensions 2mm in thickness and 12mm in diameter, which was fabricated using three types of composites: Kulzer (Diamond, Classic) and Tokuyama Omnichroma composite resins and each specimen were randomly immersed into four groups of beverages (Monster Energy, Red Bull, Wild Tiger, and Distilled water) for 5 minutes, three times over 24 hours for 28 days period. The present study showed that Wild Tiger Energy drink has the strongest influence on surface Hardness and color stability than the other beverages. Monster energy has the highest impact on surface roughness of the composite resin materials than other media used in this study. Energy drinks negatively impact the mechanical and physical properties of composite restorations; for this reason, a healthy diet should be advised for patients with composite fillings or fixed dentures.

Keywords: composite restoration, roughness, hardness, color stability, Omnichroma.

能量饮料对三种复合修复体表面粗糙度、硬度和颜色稳定性的影响

摘要：在过去的几年里，全球能量饮料消费量的显着增加造成了一些与牙科相关的问题。这些副作用之一是削弱复合树脂的机械性能，从而缩短牙科复合材料和固定假牙的使用寿命。该研究旨在了解能量饮料（红牛、野虎和怪物能量超日出）和蒸馏水对复合树脂修复体的表面硬度、表面粗糙度和颜色稳定性的影响。本前瞻性研究在康扎德教学医院进行，在144个厚度为2毫米、直径为12毫米的扁平圆盘上进行，该圆盘使用三种类型的复合材料制造：库尔策（钻石，经典）和德山全色差复合树脂，每个样本均随机浸入四组饮料（怪物能量、红牛、野虎和蒸馏水）5分钟，24小时内3次，持续28天。目前的研究表明，与其他饮料相比，野虎能量饮料对表面硬度和颜色稳定性的影响最大。与本研究中使用的其他介质相比，怪物能量对复合树脂材料的表面粗糙度的影响最大。能量饮料会对复合修复体的机械和物理特性产生负面影响；因此，对于复合填充物或固定义齿的患者，应建议健康饮食。

关键词： 复合修复、粗糙度、硬度、颜色稳定性、全色差。

Received: May 1, 2021 / Revised: May 6, 2021 / Accepted: July 19, 2021 / Published: September 30, 2021

About the authors: D.I. Hamadamin, Faculty of Restorative Dentistry, Kurdistan Board of Medical Specialties, Khanzad Training Center, Erbil, Iraq; D.H. Saeed, Department of Conservative Dentistry, College of Dentistry, Hawler Medical University, Erbil, Iraq

Corresponding author D.H. Saeed, dara.Saeed@den.hmu.edu.krd

1. Introduction

Energy drinks are soft drinks with vitamins and other chemicals increasing energy for a very short period [1]. These drinks have been developed to increase physical resistance and alertness. In addition, they increase concentration, stimulate metabolism, and help eliminate harmful substances from the body [2]. According to Allied Market Research, the global energy drink market was valued at $53 billion in 2018 and will increase to $86 billion by 2026 [3], [4]

Although the market is growing rapidly, the adverse effects of energy drink consumption raise concerns. Energy drink advertising has been a particular target for criticism due to the marketing of the beverages to minors [5]. Energy drinks are favorites of candidates, college students, and office workers have been a lot of stress cause improve concentration and fatigue effects. They are growing rapidly on domestic and foreign markets [6].

In the oral cavity, dental restorations are exposed to conditions causing a physical and mechanical change of the restorations, such as wear and discoloration. Thus, over time, the quality of the restoration deteriorates, requiring change [7]. In long-term clinical studies, the discoloration and wear of restorative materials are seen as major problems.[8] The size, concentration, and resin formulation of the filler particles are known factors affecting the wear and discoloration of restorative materials [9].

According to Cavalcanti et al. [10], energy drinks have a high erosive potential, as they have low pH and a high non-reducing sugar content.

With the changing concepts in restorative dentistry, developments in the characteristics and composition of materials have gained importance. In dental clinical applications, composite resins are among the most popular restorative materials because of the strengthening quality of their physical and mechanical properties and enhancement of aesthetic properties [11].

With the advancement in filler and polymer technology, aesthetic dental composites with filler sizes range from nano to macro in combinations with different resin polymers available in the market [12], [13]. The available data shows that filler weight content and sizes [14], [15], [16]. The recent development of composite restorative materials known as "Nano-filled" has diminished particle size and higher filler loading, resulting in enhanced optical and mechanical properties [17], [18]. Nano-filled restorative material contains Nanomers and Nanoclusters of zirconia/silica in the range of 5-75 nm and 0.6-1.4 μm, respectively [19].

Hardness is an important surface property for restorative material [20]. Hardness can be a suitable estimate of the clinical life of a composite material. Similarly, the SR of composite material is an important parameter to gauge restorative material's clinical longevity and aesthetics [21]. A rough surface on a dental restoration can predispose to an accumulation of plaque, residues, and stains leading to gingival irritation, secondary caries, diminished gloss, and discoloration of the restoration [22]. The interaction between external colorants and the composite resin materials also results in composite discoloration. The adsorption of external colorants onto the surface and the absorption into the resin matrixes can cause color changes and compromise the aesthetic outcome [23], [24].

2. Materials and Methods

This study is measuring the effect of energy drinks (Red Bull, Wild Tiger, Monster energy) whose compositions are listed in table 1 on three dental composite materials Kulzer Charisma Classic Micro-Hybrid filler composite, Charisma Diamond Nano-hybrid composite, and Tokuyama Omnichroma Supra-nano composite, whose composition are mentioned in table 2.

A total of 144 flat circular disks with dimensions of 2.0 mm thickness and 12 mm diameter were fabricated using dental restorative materials. The disks were made using a circular metallic mold mounted over a glass slide and filled with composite resin material. A second glass slide was placed on the mold, and pressure was used to expel excess composite material. A light-emitting diode (LED) device was used to cure the composite specimens. Before and after, the LED curing light was calibrated to ensure that all samples were cured with the same intensity of light per cubic centimeter.

The specimens were gently removed from the mold and polished starting with coarse and ending with Ultrafine (Coarse – medium – Fine – ultrafine); subsequently, the polished specimens were stored in distilled water for 24 hours before storage in energy drinks, after 24 hours, the specimens were removed from distilled water and dried. Baseline Color, surface roughness, and hardness were measured, then the specimens for each composite (three groups) were randomly divided into 4 sub-groups consisting of 12 specimens in each (n = 12).

Table 1 Composition and manufacturers of tested energy drinks

Solution	**Composition**	**Manufacturer**	**pH**
Red Bull	Carbonated Water, Sucrose, Glucose, Acidifier citric acid, Taurine (0.4%), Acidity regulators (Sodium Bicarbonate, Magnesium Carbonate), Flavors (Natural and Artificial), Colors (Caramel, Riboflavin), Caffeine (0.03%), Vitamins (Niacin, Pantothenic acid, B6, B12).	Red Bull GmbH, Fuschl am See, Salzburg, Austria	3.3

Continuation of Table 1

Monster Energy Ultra Sunrise	Carbonated Water, Flavorings, Lemon Fruit, acid (citric acid), taurine (0.4%), acidity regulators (Calcium Lactate, Sodium citrate), Panax Ginseng root extract (0.08%), preservative (potassium sorbate), antioxidant (ascorbic acid), caffeine (0.03%), sweeteners (Sucralose, acesulfame K), L-carnitine, L-Tartrate (0.015%), Vitamins (B3, B5, B6, B12), Color (Carotins), Sodium Chloride, D-glucuronolactone, Guarana seed extract (0.002%), Inositol.	Monster Energy Limited, South Bank House, Barrow street, Dublin 4, Ireland.	2.7
Wild Tiger	Carbonated water, Sugar, Citric acid, Trisodium citrate, Taurine 0.37%, Caffeine 0.03%, Glucuronolactone 0.24%, B vitamins (B2, B6, B12, Pantothenic acid, Niacin), Colors (Caramel positive E150C), Benzoic acid, and flavorings.	Free Lines for General Trading Co. LLC, Amman, Jordan.	2.7
Distilled Water	Chemically Pure, Free from Soluble, Clear, Colorless and odorless	Erbil, Iraq	7

Table 2 Composites used in the test

Material	**Type**	**Shade**	**Matrix**	**Filler type**	**Filler size (µm)**	**Filler loading (Vol%/wt%)**	**Manufacturer**
Charisma Classic	Micro-Hybrid	A2	Bis-GMA	Barium Aluminium Fluoride glass	0.005-10	61/78	Heraeus Kulzer GmbH, Germany
Charisma Diamond	Nano-Hybrid	A2	UDMA, TECD-DI-HEA	Barium Aluminium Fluoride glass	0.005-20	64/81	Heraeus Kulzer GmbH, Germany
Tokuyama Omnichroma	Supra-Nano	Uni-shade	UDMA, TEGDMA	Zirconia, silica composite filler	0.26	68+/79	Tokuyama Dental, Tokyo 110-0016, Japan

The control specimens of each composite were stored in distilled water. However, the specimens in the experimental groups were immersed for five minutes, three times daily, in respective energy drinks; this immersion represents the medium frequency of energy drink intake. An adequate quantity of energy drink (25ml) was maintained in a petri dish in all the groups during the immersion period. The energy drinks in all groups were regularly changed every 24 hours until the conclusion of the immersion regimen. After exposure to a respective energy drink, the specimens of the experimental groups were stored in distilled water at room temperature between the immersions. The specimens removed from the energy drinks were cleansed using distill water to remove any remanent from the surface. The cleaned composite disks were dried using absorbent paper and underwent the tests (Color stability, surface roughness, and hardness).

2.1. Color Stability Measurement

Color stability of resin composite was measured with VITA Easyshade® Advance 4.0 (Model DEASYAS4, VITA Zahnfabrik, Bad Säckingen, Germany). Before measuring the specimen's color, the VITA Easyshade® was calibrated using its calibration block according to the manufacturer's instructions. The probe tip was then placed perpendicular at the center of each specimen and flushed into the surface of the specimens to obtain accurate measurements. The measurement procedures were repeated three times. All measurements were made on a white background to eliminate background light.

CIE lab* is expressed by the L* coordinate representing color luminosity, varying from white to black, and the a* and b* coordinates representing the chromaticity of the color, with axes varying from green to red, blue to yellow, respectively. The means of the values obtained were calculated. The L*, a*, and b* parameters were determined, the color changes (ΔE*) after one day and after 28 days calculated from the changes in CIE L*, a* and b* values (ΔL*, Δa*, Δb*) as follows:

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

2.2. Measuring Surface Roughness

All the specimens were subjected to roughness testing using a contact profilometer (TAYLOR-HOBSON talysurf 10, R.P.I.LTD, Leicester, England) equipped with a pointed tip stylus was attached to a pickup head. The stylus traversed the surface of the specimen at a constant speed of 0.5 mm/second with a force of 5 mN; each specimen was traced in three parallel locations near the center across the finished and polished surface, with an evaluation length 2.5 mm. Three measurements in different directions were recorded for each specimen. Leveling of all parts of the apparatus was achieved by adjusting the pickup head knob. The device was periodically checked for its performance.

2.3. Measuring Hardness

According to the American dental association specification, all specimens in experimental and control groups were tested for hardness using a durometer hardness tester (shore-d hardness), suitable for resin-based material. The instrument consists of a bluntly pointed indenter (0.8 mm in diameter) present in a cylindrical (1.6 mm in diameter). The indenter was attached to a digital scale that graduated from 0 to 100 units. The usual method was to press down firmly and quickly on the indenter and record the maximum reading as the shore-D hardness. Measurements were taken directly from the digital scale reading. Four measurements were recorded on different areas of each specimen, and an average of these four readings was recorded.

3. Results

Tables 3, 4, 5 and 6 show the mean change in hardness values and *P*-Value of tested restorative materials after immersion in Various Media in different time intervals; two-way mixed ANOVA showed significant change in Hardness in Various immersion media for different restorative materials. Figures 1, 2, 3, and 4 show the changes in hardness in different Media.

Table 3 Hardness - Red Bull

Composite	Time			Test within-Subjects (Time)
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	95.250 (0.767)	95.138 (1.131)	94.972 (0.526)	0.000 (a)
Charisma Diamond	97.007 (0.702)	96.761 (0.612)	95.610 (0.509)	
Tokuyama Omnichroma	95.625 (0.872)	94.944 (1.042)	94.528 (0.315)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred only between Baseline and Day 28 for all composites; b) No Difference occurred between Charisma Classic and Tokuyama Omnichroma; c) No effect of the interaction term has occurred (Time * Composite)

Table 4 Hardness - Tiger

Composite	Time			Test within-Subjects (Time)
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	95.263 (0.345)	94.653 (1.127)	94.362 (0.869)	0.000 (a)
Charisma Diamond	96.904 (0.832)	96.653 (0.583)	95.764 (0.752)	
Tokuyama Omnichroma	95.417 (0.945)	94.750 (1.111)	94.430 (0.605)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred only between Baseline and Day 28 for all composites; b) No Difference occurred between Charisma Classic and Tokuyama Omnichroma; c) No effect of the interaction term has occurred (Time * Composite)

Table 5 Hardness - Monster

Composite	Time			Test within-Subjects (Time)
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	95.333 (1.261)	95.068 (0.733)	94.918 (0.678)	0.002 (a)
Charisma Diamond	97.028 (1.029)	96.307 (0.618)	95.778 (0.863)	
Tokuyama Omnichroma	95.500 (1.054)	94.861 (0.873)	94.708 (1.139)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred only between Baseline and Day 28 for all composites; b) No Difference occurred between Charisma Classic and Tokuyama Omnichroma; c) No effect of the interaction term has occurred (Time * Composite)

Table 6 Hardness - distilled water

Composite	Time			Test within-Subjects (Time)
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	95.306 (1.676)	95.181 (1.635)	94.874 (1.149)	0.031 (a)
Charisma Diamond	97.013 (1.201)	96.499 (0.617)	96.083 (1.062)	
Tokuyama Omnichroma	95.513 (0.782)	95.153 (1.133)	94.875 (0.450)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred only between Baseline and Day 28 for all composites; b) No Difference occurred between Charisma Classic and Tokuyama Omnichroma; c) No effect of the interaction term has occurred (Time * Composite)

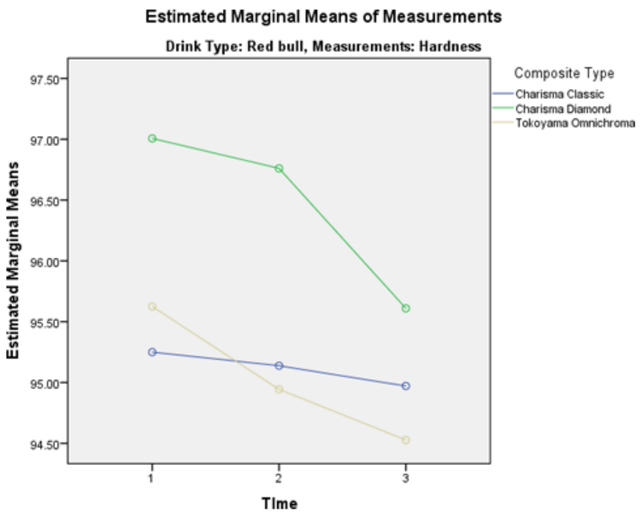

Fig. 1 Changes in the hardness of sample immersed in Red bull media

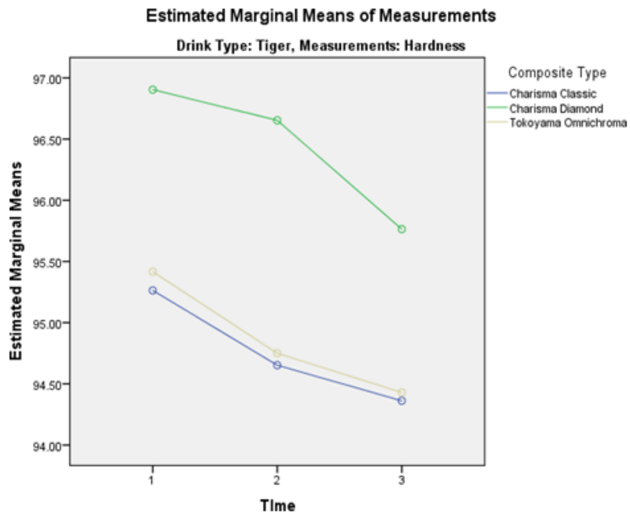

Fig. 2 Changes in the hardness of sample immersed in Tiger media

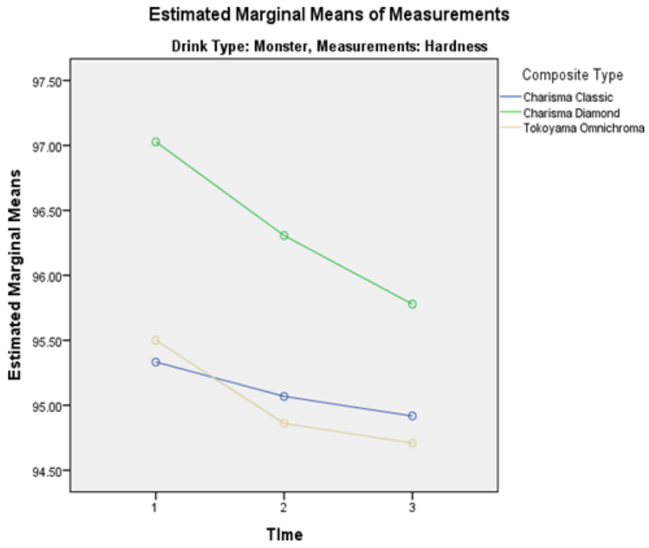

Fig. 3 Changes in the hardness of sample immersed in Monster Media

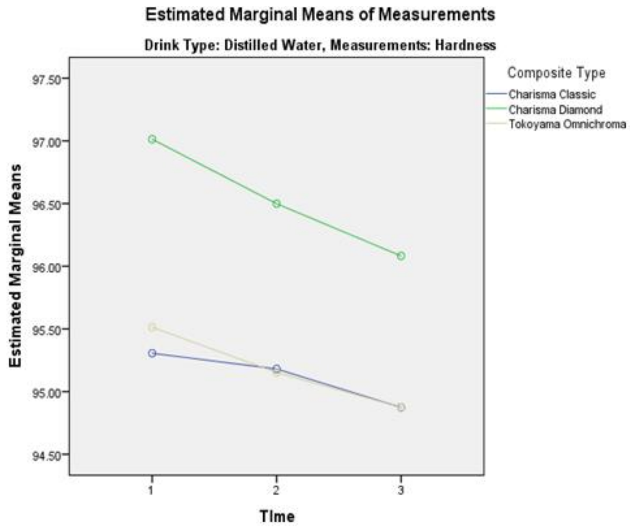

Fig. 4 Changes in the hardness of sample immersed in Distilled water

3.1. Roughness

The present study showed that there is an increase in surface roughness values after a different period of immersion in different media; Tables 7, 8, 9 and 10 shows the descriptive statistics (mean and standard deviation) of the surface roughness values in micrometers for all tested specimens: Figures 5,6,7 and 8 shows the difference in mean surface roughness values among groups represented in Line charts, the results showed that there Is statistically very highly significant ($p > 0.000$) in surface roughness values for all types of composite tested in this study.

Table 7 Roughness - Red Bull

Composite	**Time**			**Test within-Subjects (Time)**
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	0.105(0.024)	0.113(0.034)	0.153(0.015)	0.000 (a)
Charisma Diamond	0.035(0.011)	0.047(0.007)	0.074(0.042)	
Tokuyama Omnichroma	0.050(0.013)	0.071(0.005)	0.117(0.012)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred over all three timelines for all composites; b) Difference occurred among all three composites

Table 8 Roughness - Tiger

Composite	**Time**			**Test within-Subjects (Time)**
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	0.106(0.022)	0.108(0.021)	0.110(0.016)	0.000 (a)
Charisma Diamond	0.038(0.018)	0.045(0.012)	0.094(0.010)	
Tokuyama Omnichroma	0.048(0.013)	0.066(0.006)	0.110(0.017)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred only between Baseline and Day 28 for all composites; b) Difference occurred among all three composites; c) Significant interaction term occurred between time and composited on roughness surface

Table 9 Roughness - Monster

Composite	**Time**			**Test within-Subjects (Time)**
	Baseline Mean (SD)	**Day One Mean (SD)**	**Day 28 Mean (SD)**	**P-Value**
Charisma Classic	0.107(0.020)	0.126(0.031)	0.138(0.024)	0.000 (a)
Charisma Diamond	0.037(0.021)	0.054(0.024)	0.124(0.014)	
Tokuyama Omnichroma	0.049(0.015)	0.064(0.006)	0.117(0.008)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred over all three timelines for all composites; b) No Difference occurred between Charisma Diamond and Tokouama Omnichroma; c) Significant interaction term occurred between time and composited on roughness surface

Table 10 Roughness - distilled water

Composite	Time			Test within-Subjects (Time)
	Baseline Mean (SD)	Day One Mean (SD)	Day 28 Mean (SD)	P-Value
Charisma Classic	0.094(0.024)	0.117(0.010)	0.135(0.012)	0.000 (a)
Charisma Diamond	0.041(0.020)	0.059(0.018)	0.062(0.036)	
Tokuyama Omnichroma	0.055(0.028)	0.061(0.004)	0.109(0.014)	
Test Between Subjects (Composite)	0.000 (b)			

Note: a) Difference occurred over all three timelines for all composites; b) Difference occurred among all three composites; c) Significant interaction term occurred between time and composited on roughness surface

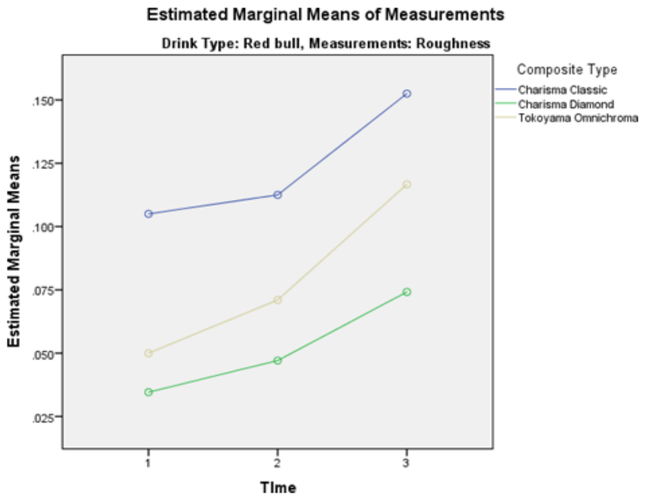

Fig. 5 Changes in the roughness of sample immersed in Red bull

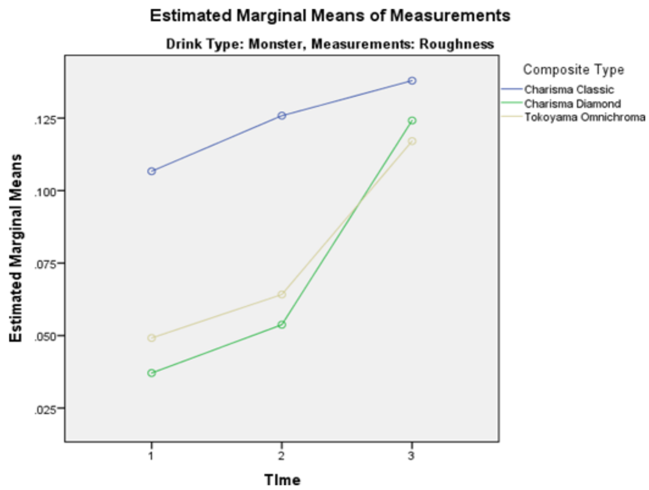

Fig. 7 Changes in the roughness of sample immersed in Monster

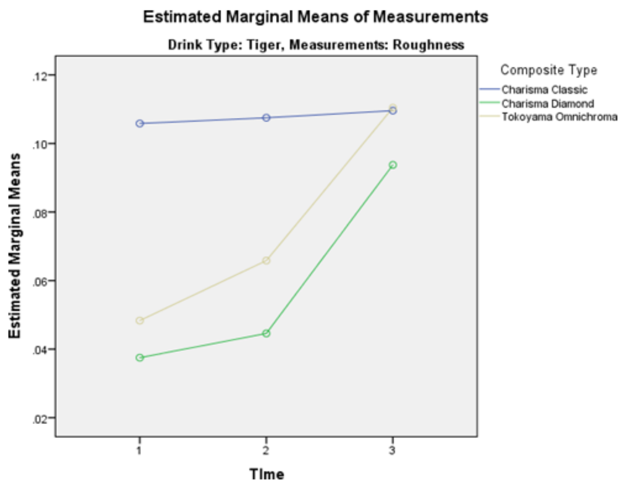

Fig. 6 Changes in the roughness of sample immersed in Tiger

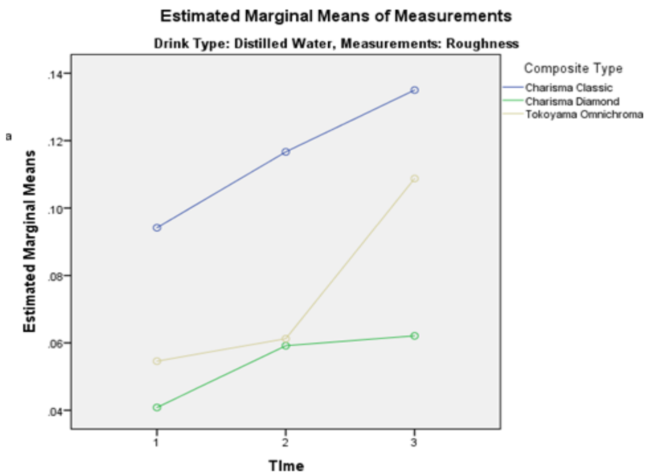

Fig. 8 Changes in the roughness of sample immersed in Distilled water

3.2. Color Stability

The mean of Color change values (ΔE^*_{ab}) for the tested resin composite materials following the immersion in different solutions for one and 28 days are summarized in tables 9 to 12. The figures are presented in graphs 1 and 2.

Table 9 Color stability - Red Bull

Composite	Time		Test within-Subjects (Time)
	Delta E1	Delta E28	P-Value
Charisma Classic	1.769 (0.881)	2.361 (1.104)	0.000 (a)
Charisma Diamond	1.285 (0.267)	2.104 (0.267)	
Tokuyama Omnichroma	0.596 (0.224)	0.589 (0.238)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta E1 and Delta E28 all composites; b) Statistically significant difference occurred between all three composites; c) Interaction term (Delta Time * Composite) turned to be statistically significant

Table 10 Color stability - Tiger

Composite	**Time**		**Test within-Subjects (Time)**
	Delta E1	**Delta E28**	**P-Value**
Charisma Classic	4.319 (2.611)	4.770 (2.701)	0.000 (a)
Charisma Diamond	1.103 (0.288)	2.097 (0.490)	
Tokuyama Omnichroma	1.534 (2.797)	1.315 (2.901)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta E1 and Delta E28 all composites; b) Statistically significant difference occurred between all three composites; c) Interaction term (Delta Time * Composite) turned to be statistically significant

Table 11 Color stability - Monster

Composite	**Time**		**Test within-Subjects (Time)**
	Delta E1	**Delta E28**	**P-Value**
Charisma Classic	1.950 (0.960)	2.203 (1.125)	0.000 (a)
Charisma Diamond	1.234 (0.374)	2.067 (0.500)	
Tokuyama Omnichroma	0.882 (0.285)	0.842 (0.295)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta E1 and Delta E28 all composites; b) Statistically significant difference occurred between (Classic & Tokuyama) and (Diamond & Tokuyama); c) Interaction term (Delta Time * Composite) turned to be statistically significant

Table 12 Color stability - distilled water

Composite	**Time**		**Test within-Subjects (Time)**
	Delta E1	**Delta E28**	**P-Value**
Charisma Classic	0.231 (0.341)	1.485 (0.775)	0.000 (a)
Charisma Diamond	0.142 (0.051)	0.720 (0.189)	
Tokuyama Omnichroma	0.185 (0.123)	0.948 (0.182)	
Test Between Subjects (Composite)	0.001 (b)		

Note: a) Difference occurred between Delta E1 and Delta E28 all composites; b) No Statistically significant difference occurred only between (Diamond & Tokuyama); c) Interaction term (Delta Time * Composite) turned to be statistically significant

Table 13 Delta B of composites immersed in different media

Delta B - Red Bull			
Composite	**Time**		**Test within-Subjects (Time)**
	Delta B1	**Delta B28**	**P-Value**
Charisma Classic	0.725 (0.341)	1.550 (0.557)	0.000 (a)
Charisma Diamond	0.650 (0.235)	1.708 (0.275)	
Tokoyama Omnichroma	-0.458 (0.116)	-0.367 (0.394)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta B1 and Delta B28 all composites; b) No Statistically significant difference occurred between Charisma Classic and Charisma Diamond composites; c) Interaction term (Delta Time * Composite) turned to be statistically significant

Delta B - Tiger			
Composite	**Time**		**Test within-Subjects (Time)**
	Delta B1	**Delta B28**	**P-Value**
Charisma Classic	0.525 (0.238)	1.342 (0.410)	0.000 (a)
Charisma Diamond	0.208 (0.079)	0.575 (0.290)	
Tokoyama Omnichroma	-0.300 (0.060)	-0.200 (0.226)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta B1 and Delta B28 all composites; b) Statistically significant difference occurred between all three composites; c) Interaction term (Delta Time * Composite) turned to be statistically significant

Delta B- Monster			
Composite	**Time**		**Test within-Subjects (Time)**
	Delta B1	**Delta B28**	**P-Value**
Charisma Classic	0.367 (0.210)	0.617 (0.272)	0.000 (a)
Charisma Diamond	0.200 (0.121)	0.508 (0.108)	
Tokoyama Omnichroma	-0.200 (0.085)	0.100 (0.357)	
Test Between Subjects (Composite)	0.000 (b)		

Note: a) Difference occurred between Delta B1 and Delta B28 all composites; b) No Statistically significant difference occurred between Charisma Classic and Charisma Diamond composites; c) Interaction term (Delta Time * Composite) turned to be not statistically significant

Delta B- Distilled Water			
Composite	**Time**		**Test within-Subjects (Time)**
	Delta B1	**Delta B28**	**P-Value**
Charisma Classic	-0.125 (0.045)	-0.208 (0.067)	0.000 (a)
Charisma Diamond	-0.142 (0.051)	-0.325 (0.062)	
Tokoyama Omnichroma	-0.125 (0.045)	-0.233 (0.065)	
Test Between Subjects (Composite)	0.003 (b)		

Note: a) Difference occurred between Delta B1 and Delta B28 all composites; b) No Statistically significant difference occurred only between (Classic & Tokoyama); c) Interaction term (Delta Time * Composite) turned to be statistically significant

4. Discussion

In this study, the effects of different beverages on the Hardness, Surface roughness, and color stability of three different composite materials were investigated and compared,

Surface Hardness has been measured in many studies, not because it affects the physical properties of composite resin but because it shows the degree of polymerization [25], [26]. Surface Hardness is influenced by different factors, including filler content, distribution, level, surface procedures applied to the filler (silanization), filler matrix interaction, and organic matrix structure [25], [27], [28]; additionally, since better-polymerized surfaces also have harder surface characteristics, consequently they will have more resistance to abrasion and erosion [29], [30].

The hardest values in initial hardness measurements in this study were obtained from the Charisma Diamond specimens; its filler content at 81% by weight may contribute to this High level.

The hardness results obtained in the present study indicate that immersion time in the solution has a critical influence on the surface hardness of the restorative material. In general, regardless of the solution used, all restorative materials demonstrated significantly lower surface hardness values after 28 days evaluation than after 24 hours because liquid absorption will cause deterioration of the materials.

the ingredients present in these energy drinks, especially citric acid, is known to have a damaging effect on the hardness of dental surfaces and resin-based restorative materials, as has been confirmed in previous studies [31, 32].

The surface hardness of the restorative materials tested was reduced after storage in distilled water. It is because "water acts as a plasticizing molecule within the composite matrix [33], softening the polymer resin portion by swelling the network and reducing frictional forces between polymeric chains [34], [35].

The decreased hardness from 24 hours to 28 days obtained from the current study agrees with the results obtained by Al Ghamdi et al. [35]. However, the outcome achieved regarding the decreased hardness of composite stored in distilled water does not agree with the previous studies that demonstrated increased Hardness values of the specimens stored in distilled water [18], [37], [38].

In this study, Wild Tiger has the Highest effect changing the hardness of composites immersed in it; this can be due to the lowest acidity pH=2.7, which is known that more acidity will cause more erosion and will negatively affect on mechanical properties of composite resin. Charisma Diamond showed the Highest change in hardness in all drinks due to its wide particle size distribution range. In contrast, monster energy showed the least effect between the energy drinks used in this study regarding hardness changes despite its pH =2.7, nearly the same acidity as Wild Tiger (pH=2.7). Tokuyama Onmichroma showed an almost identical change in hardness values in all used beverages.

A material's loss of Mechanical properties may contribute to its deterioration in a clinical environment, including loss of anatomical form and discoloration [39]. Furthermore, chemical softening may harm wear and abrasion rates and, consequently, the life span of a restorative material [40].

However, it should be remembered that the experimental conditions do not perfectly mimic the oral cavity testing experience [41]. The function of saliva was simulated in this study by using distilled water. Temperature changes, pH levels, salivary enzymes, and the ionic composition of food or liquids can all influence the properties of restorations in the oral cavity.)

Surface roughness is closely related to the material's physicochemical properties. The surface was smoother on the nanohybrid composite resin material immersed in distilled water as compared to those specimens immersed in energy drinks, the particles in resin formulation exhibit significantly harder characteristics; research has shown that roughness is more related to particle dimension and structure than particle hardness [42]. The relatively soft resin matrix exposed to highly acidic beverages is leeched out preferentially, leaving the filler particles protruding from the surface [43]. If initial roughness, Charisma Diamond samples exhibited the lowest roughness values; this may be attributed to different particle size distribution with lowest resin content and highest filler content. The Highest roughness value after immersion in beverages was obtained from Monster energy specimens after immersion for 28 days; this is due to its lowest pH Value (pH=2.7) and highly erosive characteristics. Tokuyama Omnichroma is composed of UDMA and TEGDMA. UDMA has low water absorption and solubility characteristics [44], whereas TEGDMA is a hydrophilic monomer that can absorb water [45]. The storage modulus of TEGDMA-containing composites decreased with immersion time, owing to an increase in water absorption surface hydrophilicity. Hydrophilic groups such as the ethoxy group in TEGDMA are thought to show affinity with water molecules by hydrogen bonding to oxygen [46]; thus, Tokuyama Omnichroma showed the Highest change in surface roughness in Red bull, Wild Tiger, and Distilled water because of surface Hydrophilicity of TEGDMA monomer which increases water uptake. The results obtained in the current study are in accord with the results obtained by Al Ghamdi et al. [36].

Color has an important role in obtaining optimum aesthetics [47]. An increase in the demand from patients for improved aesthetics has resulted in the development of restorative materials with excellent aesthetic properties and their widespread use in dental practice. However, a major disadvantage of resin composites is their tendency to discolor, which may be a major factor in replacing restorations [48], [49]. Therefore, restorative materials should match well the initial shade and preserve the aesthetic semblance over time in the restored tooth [47].

The discolorations of the composite materials were related to the resin filler type, type of resin matrix, and type of staining agent [50]. Resin composite materials that can absorb water can also absorb other fluids with pigments, resulting in discoloration. Water is assumed to be a conductor for the pigment and stain penetration into the resin matrix [51], [52]. Although the resin matrix of the composite materials can absorb water from the environment into the bulk of their structure, inorganic glass fillers cannot absorb water into the bulk of the material but just absorb water on their surface. Excessive water sorption may decrease the life of a resin composite by expanding and plasticizing the resin component, hydrolyzing the silane, and causing micro-crack formation. As a result, the micro-cracks or interfacial gaps at the interface between the filler and matrix allow stain penetration and discoloration [51].

The three tested composite materials in this study revealed statistically significant color changes after 28 days of immersion in the four types of solutions; this obtained result disagrees with the results obtained by Aldharrab [53].

Which stated that the color shift of composite resins immersed in Red bull was statistically insignificant, the color of Charisma Classic showed the highest prone to color change. In contrast, Tokuyama Omnichroma showed the least effect by the immersion; this could be explained by the monomer content in the mentioned restorative materials, as Charisma Classic contains Bis-GMA, which has the Highest water sorption than UDMA and TEGDMA, which are Monomer ingredients of Charisma Diamond and Tokuyama Omnichroma respectively, this result is in accord with the obtained results of Gajewski et al. [50], Tokuyama Omnichroma exhibits the ultimate wide-range color-matching ability by utilizing Smart Chromatic Technology. The Smart Chromatic Technology is achieved by uniformly sized 260nm spherical fillers included in Tokuyama Omnichroma. Structural color is created when various wavelengths of light are intensified or reduced by the structure of a material, resulting in colors that are different from what the material is.

All samples immersed in Wild Tiger showed the Highest color change, then Monster energy, Red bull, and Distilled water. That is because Wild Tiger energy drink has a high content of artificial coloring (E150C).

When comparing the Delta b, which indicates color shift between Blue and Yellow Axis, all composites immersed in Energy drinks showed a statistically significant color shift towards the yellow axis with aging time. The highest value is obtained from samples immersed in the Red Bull energy drink. The lowest is recorded with the Tokuyama Omnichroma tested samples. But samples immersed in Distilled Water showed a statistically significant color shift towards the blue axis, this can be explained by the water sorption of the samples and the lack of any pigmenting material in distilled water.

5. Conclusion

After one month of an in-vitro studying the effect of energy drinks on the surface properties of dental restorative composite materials, the following conclusions were obtained:

- After one month of assessment, the surface hardness values of the composite resin materials were substantially reduced, whether immersed in distilled water or immersed in energy drinks.
- The surface roughness of the composite resin material increased dramatically after one month of evaluation, regardless of whether it was submerged in distilled water or energy drinks.
- With increasing aging time, all energy drink solutions used in this study affected the color stability of tested resin composite materials; however, the impact of energy drink solutions on the color stability of resin composite materials varies depending on the type of solution and the presence of acid in the composition.

Energy drinks negatively impact the mechanical and physical properties of composite restorations; for this reason, a healthy diet should be advised for patients with composite fillings or fixed dentures — the results of this study request further research over a longer period.

Acknowledgments

Gratitude to the ministry of higher education and scientific research, Director of quality assurance accreditation, and higher education council of Hawler Medical University – Erbil

References

[1] LUSSI A., VON SALIS-MARINCEK M., GANSS C., HELLWIG E., CHEAIB Z., and JAEGGI T. Clinical study monitoring the pH on tooth surfaces in patients with and without erosion. *Caries Research*, 2012, 46: 507-512. https://doi.org/10.1159/000339783

[2] BALLISTRERI M. C., & CORRADI-WEBSTER C. M. Consumption of energy drinks among physical education students. *Revisto Latino-Americana Enfermagem*, 2008, 16: 558-564. https://doi.org/10.1590/S0104-11692008000700009

[3] MORDOR INTELLIGENCE. Energy Drinks Market – Growth, Trends, Covid-19 Impact, and Forecasts (2021-2026). *Mordor Intelligence*. https://www.mordorintelligence.com/industry-reports/energy-drinks-market

[4] ALLIED MARKET RESEARCH. Energy Drinks Market

to Garner $86.01 Bn, Globally, by 2026 at 7.2% CAGR, Says Allied Market Research. *Cision PR Newswire*, 2019. https://www.prnewswire.com/news-releases/energy-drinks-market-to-garner-86-01-bn-globally-by-2026-at-7-2-cagr-says-allied-market-research-300873353.html

[5] CURRAN C. P., & MARCZINSKI C. A. Taurine, caffeine, and energy drinks: Reviewing the risks to the adolescent brain. *Birth Defects Research*, 2017, 109: 1640–1648. https://doi.org/10.1002/bdr2.1177

[6] TYAS M. J. Placement and replacement of restorations by selected practitioners. *Australian Dental Journal*, 2005, 50: 81-89. https://doi.org/10.1111/j.1834-7819.2005.tb00345.x

[7] FESTUCCIA M. S., GARCIA L. F., CRUVINEL D. R., and PIRES-DE-SOUZA F. C. Colour stability, surface roughness and micro-hardness of composites submitted to mouth rinsing action. *Journal of Applied Oral Science*, 2012, 20: 200-205. https://doi.org/10.1590/s1678-77572012000200013

[8] TORII Y., ITOU K., ITOTA T., HAMA K., KONISHI N., NAGAMINE M., and INOUE K. Influence of filler content and gap dimension on wear resistance of resin composite luting cements around a CAD/CAM ceramic inlay restoration. *Dental Materials Journal*, 1999, 18: 453-461. https://doi.org/10.4012/dmj.18.453

[9] CAVALCANTI A. L., COSTA OLIVEIRA M., FLORENTINO V. G., DOS SANTOS J. A., VIEIRA F. F., and CAVALCANTI C. L. Short communication: in vitro assessment of erosive potential of energy drinks. *European Archives pf Paediatric Dentistry*, 2010, 11: 254-257. http://dx.doi.org/10.1007/BF03262757

[10] OZKANOGLU S. G., & AKIN E. G. Evaluation of the effect of various beverages on the color stability and microhardness of restorative materials. *Nigerian Journal of Clinical Practice*, 2020, 23: 322-328. https://doi.org/10.4103/njcp.njcp_306_19

[11] WALKER R., & BURGESS J. Comparing resin-based composites. *Compendium of continuing education in dentistry*, 2004. 25(6): 424-428. https://pubmed.ncbi.nlm.nih.gov/15651233/

[12] NAGEM FILHO H., FORTES SOARES D'AZEVEDO M. T., NAGEM H. D., and MARSOLA F. P. Surface roughness of composite resins after finishing and polishing. *Brazilian Dental Journal*, 2003, 14(1): 37-41. https://doi.org/10.1590/s0103-64402003000100007

[13] BERGER S. B., MUNIZ PALIALOL A. R., CAVALLI V., and GIANNINI M. Surface roughness and staining susceptibility of composite resins after finishing and polishing. *Journal of Esthetic and Restorative Dentistry*, 2011, 23(1): 34-43. https://doi.org/10.1111/j.1708-8240.2010.00376.x

[14] AL-SAMADANI, K. H. Effect of energy drinks on the surface texture of nanofilled composite resin. *Journal of Contemporary Dental Practice*, 2013, 14(5): 830-835. https://doi.org/10.5005/jp-journals-10024-1411

[15] TOPCU F. T., ERDEMIR U., SAHINKESEN G., YILDIZ E., USLAN I., and ACIKEL C. Evaluation of microhardness, surface roughness, and wear behavior of different types of resin composites polymerized with two different light sources. *Journal of Biomedical Materials Research*, 2010, 92(2): 470-478. https://doi.org/10.1002/jbm.b.31540

[16] RUDDELL D., MALONEY M., and THOMPSON J. Effect of novel filler particles on dental composites' mechanical and wear properties. *Dental Materials*, 2002, 18(1): 72-80. https://doi.org/10.1016/s0109-5641(01)00022-7

[17] ERDEMIR U., YILDIZ E., EREN M. M., and OZEL S. Surface hardness evaluation of different composite resin materials: influence of sports and energy drinks immersion after a short-term period. *Journal of Applied Oral Science*, 2013, 21(2): 124-131. https://doi.org/10.1590/1678-7757201302185

[18] MITRA S. B., WU D., and HOLMES B. N. An application of nanotechnology in advanced dental materials. *The Journal of the American Dental Association*, 2003, 134(10): 1382-1390. https://doi.org/10.14219/jada.archive.2003.0054

[19] KHAN A. A., ALKHURAIF A., AL-SHEHRI A. M., and SÄILYNOJA E. Polymer matrix of fiber-reinforced composites: Changes in the semi-interpenetrating polymer network during the shelf life. *Journal of the mechanical behavior of biomedical materials*, 2018, 78: 414-419. http://dx.doi.org/10.1016/j.jmbbm.2017.11.038

[20] ILDAY N., BAYINDIR Y., and ERDEM V. Effect of three different acidic beverages on surface characteristics of composite resin restorative materials. *Materials Research Innovations*, 2010, 14(5): 385-391. http://dx.doi.org/10.1179/143307510X12820854748917

[21] PARAVINA R., ROEDER L., LU H., VOGEL K., and POWERS J. M. Effect of finishing and polishing procedures on surface roughness, gloss, and color of resin-based composites. *American Journal of Dentistry*, 2004, 17(4): 262-266. https://pubmed.ncbi.nlm.nih.gov/15478488/

[22] REN Y. F., FENG L., SERBAN D., and MALMSTROM H. S. Effects of common beverage colorants on color stability of dental composite resins: The utility of a thermocycling stain challenge model in vitro. *Journal of Dentistry*, 2012, 40: e46-e48. https://doi.org/10.1016/j.jdent.2012.04.017

[23] LEPRI C. P., & PALMA-DIBB R. G. Surface roughness and color change of a composite: influence of beverages and brushing. *Dental Materials Journal*, 2012, 31(4): 689-696. https://doi.org/10.4012/dmj.2012-063

[24] TAGTEKIN D. A., YANIKOGLU F. C., BOZKURT F. O., KOLOGLU B., and SUR H. Selected characteristics of an Ormocer and a conventional hybrid resin composite. *Dental Materials*, 2004, 20(5): 487-497. https://doi.org/10.1016/j.dental.2003.06.004

[25] ASMUSSEN E. Factors affecting the quantity of remaining double bonds in restorative resin polymers. *Scandinavian Journal of Dental Research*, 1982, 90: 490-496. https://doi.org/10.1111/j.1600-0722.1982.tb00767.x

[26] HAN L., OKAMOTO A., FUKUSHIMA M., and OKIJI T. Evaluation of flowable resin composite surfaces eroded by acidic and alcoholic drinks. *Dental Materials Journal*, 2008, 27(3): 455-465. https://doi.org/10.4012/dmj.27.455

[27] PEUTZFELDT A. Resin composites in dentistry: the monomer systems. *European Journal of Oral Science*, 1997, 105(2): 97-116. https://doi.org/10.1111/j.1600-0722.1997.tb00188.x

[28] MANDIKOS M. N., MCGIVNEY G. P., DAVIS E., BUSH P. J., and CARTER J. M. A comparison of the wear resistance and hardness of indirect composite resins. *Journal of Prosthetic Dentistry*, 2001, 85(4): 386-395. https://doi.org/10.1067/mpr.2001.114267

[29] MCCABE J. F. *Applied dental materials 7th ed*. Blackwell Scientific Publications, Oxford, 1990.

[30] HAMOUDA I. M. Effects of various beverages on hardness, roughness, and solubility of aesthetic restorative materials. *Journal of Aesthetic and Restorative Dentistry*, 2011, 23(5): 315-322. https://doi.org/10.1111/j.1708-8240.2011.00453.x

[31] TANTHANUCH S., KUKIATTRAKOON B., SIRIPORANANON C., ORNPRASERT N., METTASITTHIKORN W., LIKHITPREEDA S., and WAEWSANGA S. The effect of different beverages on surface hardness of nanohybrid resin composite and giomer. *Journal of Conservative Dentistry*, 2014, 17(3): 261-265. https://doi.org/10.4103/0972-0707.131791

[32] MORAES R. R., MARIMON J. L., SCHNEIDER L. F., SINHORETI M. A., CORRER SOBRINHO L., and BUENO M. Effects of 6 months of aging in water on hardness and surface roughness of two microhybrid dental composites. *Journal of Prosthodontics*, 2008, 17: 323-326. https://doi.org/10.1111/j.1532-849x.2007.00295.x

[33] CATELAN A., BRISO A. L., SUNDFELD R. H., and SANTOS P. H. Effect of Artificial aging on the roughness and microhardness of sealed composites. *Journal of Esthetic and Restorative Dentistry*, 2010, 22: 324-330. https://doi.org/10.1111/j.1708-8240.2010.00360.x

[34] NICHOLSON J. W., GJORGIEVSKA E., BAJRAKTAROVA B., and MCKENZIE M. A. Changes in properties of polyacid-modified composite resins (compomers) following storage in acidic solutions. *Journal of Oral Rehabilitation*, 2003, 30: 601-607. https://doi.org/10.1046/j.1365-2842.2003.01041.x

[35] ALGHAMDI A., ALGARNI A., RAYAN M. ESKANDRANI, and ALAZMI K. F. Influence of Energy and Soft Drinks on the Surface and Mechanical Properties of Nanofilled Composite Resin. *International Journal of Dental Sciences and Research*, 2019, 7(2): 44-48. http://www.sciepub.com/ijdsr/abstract/11023

[36] DE MORAES, R. R., MACHADO MARIMON J. L., SCHNEIDER L. F., COELHO SINHORETI M. A., CORRER-SOBRINHO L., and BUENO M. Effects of 6 months of aging in water on hardness and surface roughness of two microhybrid dental composites. *Journal of Prosthodontics*, 2008, 17(4): 323-326. https://doi.org/10.1111/j.1532-849x.2007.00295.x

[37] YANIKOGLU N., DUYMUS Z. Y., and YILMAZ B. Effects of different solutions on the surface hardness of composite resin materials. *Dental Materials Journal*, 2009, 28(3): 344-351. http://dx.doi.org/10.4012/dmj.28.344

[38] GARCÍA-GODOY F., GARCÍA-GODOY A., and GARCÍA-GODOY F. Effect of APF Minute-Foam on the surface roughness, hardness, and micromorphology of high-viscosity glass ionomers. *Journal of Dentistry for Children*, 2003, 70: 19-23. https://pubmed.ncbi.nlm.nih.gov/12762603/

[39] YAP A. U., LOW J. S., and ONG L. F. Effect of food-simulating liquids on surface characteristics of composite and polyacid-modified composite restoratives. *Operative Dentistry*, 2000, 25: 170-176. https://pubmed.ncbi.nlm.nih.gov/11203812/

[40] HENGTRAKOOL C., KUKIATTRAKOON B., and KEDJARUNE-LEGGAT U. Effect of naturally acidic agents on microhardness and surface micromorphology of restorative materials. *European Journal of Dentistry*, 2011, 5: 89-100. http://dx.doi.org/10.1055/s-0039-1698863

[41] YAP A. U., LYE K. W., and SAU C. W. Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. *Operative Dentistry*, 1997, 22(6): 260-265. https://pubmed.ncbi.nlm.nih.gov/9610323/

[42] BADRA V., FARAONI J. J, RAMOS R. P., and PALMA-DIBB R. G. Influence of different beverages on the microhardness and surface roughness of resin composites. *Operative Dentistry*, 2005, 30(2): 213-219. https://www.researchgate.net/publication/7885041_Influence_of_different_beverages_on_the_microhardness_and_surface_roughness_of_resin_composites

[43] ERTAŞ E., GÜLER A. U., YÜCEL A. C., KÖPRÜLÜ H., and GÜLER E. Color stability of resin composites after immersion in different drinks. *Dental Materials Journal*, 2006, 25: 371–376. https://pubmed.ncbi.nlm.nih.gov/16916243/

[44] BAGHERI R., BURROW M. F., and TYAS M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. *Journal of Dentistry*, 2005, 33: 389–398. https://doi.org/10.1016/j.jdent.2004.10.018

[45] ARIMA T., HAMADA T., and MCCABE J.F. The effects of cross-linking agents on some properties of HEMA-based resins. *Journal of Dental Research*, 1995, 74: 1597–1601. https://doi.org/10.1177%2F00220345950740091501

[46] NASIM I., NEELKANTAN P., SUJEER R. and SUBBARAO C. V. Color stability of microfilled, microhybrid and nanocomposite resins – an in vitro study. *Journal of Dentistry*, 2010; 38: 137-142. https://doi.org/10.1016/j.jdent.2010.05.020

[47] AL-NEGRISH A. R. Composite resin restorations: a cross-sectional survey of placement and replacement in Jordan. *International Dental Journal*, 2002, 52: 461-468. https://doi.org/10.1111/j.1875-595x.2002.tb00643.x

[48] CRAIG R. G., & SAKAGUCHI R. *Resin composite restorative materials 12th ed*. Mosby, Maryland Heights, 2006: 189-212

[49] ERDEMIR U., YILDIZ E., and EREN M. M. Effect of sports drinks on color stability of nanofilled and microhybrid composites after long-term immersion. *Journal of Dentistry*, 2012, 40(2): 55-63. https://doi.org/10.1016/j.jdent.2012.06.002

[50] GAJEWSKI V. E. S., PFEIFER C. S., FRÓES-SALGADO N. R. G., BOARO L. C. C., and BRAGA R. R. (2012). Monomers used in resin composites: degree of conversion, mechanical properties and water sorption/solubility. *Brazilian Dental Journal*, 23(5), 508–514. https://doi.org/10.1590/s0103-64402012000500007

[51] BAGHERI R., BURROW M. F., and TYAS M. Influence of food simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. *Journal of Dentistry*, 2005, 33: 389-398. https://doi.org/10.1016/j.jdent.2004.10.018

[52] SCHULZE K. A., MARSHALL S. J., GANSKY S. A., and MARSHALL G. W. Colorstability and hardness in dental composites after accelerated aging. *Dental Materials*, 2003, 19: 612-619. https://doi.org/10.1016/s0109-5641(03)00003-4

[53] ALDHARRAB A. Effect of Energy Drinks on the Color Stability of Nanofilled Composite Resin. *The Journal of Contemporary Dental Practice*, 2013, 14(4): 704-711. https://www.thejcdp.com/doi/pdf/10.5005/jp-journals-10024-1388

参考文:

[1] LUSSI A., VON SALIS-MARINCEK M., GANSS C.,

HELLWIG E., CHEAIB Z., 和 JAEGGI T. 监测有和无侵蚀患者牙齿表面酸碱度值的临床研究。龋病研究, 2012, 46: 507-512. https://doi.org/10.1159/000339783
[2] BALLISTRERI M. C., 和 CORRADI-WEBSTER C. M. 体育学生能量饮料消费情况. 拉丁美洲护理杂志, 2008, 16: 558-564. https://doi.org/10.1590/S0104-11692008000700009
[3] 魔多情报. 能量饮料市场——增长、趋势、新冠肺炎影响和预测（2021-2026）。魔多情报. https://www.mordorintelligence.com/industry-reports/energy-drinks-market
[4] 联合市场研究. 联合市场研究表示, 到2026年, 全球能量饮料市场将获得860.1亿美元的收入，复合年增长率为7.2%。剖腹产美通社, 2019. https://www.prnewswire.com/news-releases/energy-drinks-market-to-garner-86-01-bn-globally-by-2026-at-7-2-cagr-says-allied-market-research-300873353.html
[5] CURRAN C. P., 和 MARCZINSKI C. A. 牛磺酸、咖啡因和能量饮料：审查对青少年大脑的风险。出生缺陷研究, 2017, 109: 1640–1648. https://doi.org/10.1002/bdr2.1177
[6] TYAS M. J. 由选定的从业者放置和更换修复体。澳大利亚牙科杂志, 2005, 50: 81-89. https://doi.org/10.1111/j.1834-7819.2005.tb00345.x
[7] FESTUCCIA M. S., GARCIA L. F., CRUVINEL D. R., 和 PIRES-DE-SOUZA F. C. 经受口腔冲洗作用的复合材料的颜色稳定性、表面粗糙度和显微硬度。应用口腔科学杂志, 2012, 20: 200-205. https://doi.org/10.1590/s1678-77572012000200013
[8] TORII Y., ITOU K., ITOTA T., HAMA K., KONISHI N., NAGAMINE M., 和 INOUE K. 填充物含量和间隙尺寸对计算机辅助设计和制造系统陶瓷嵌体修复体周围树脂复合胶粘剂耐磨性的影响。牙科材料杂志, 1999, 18: 453-461. https://doi.org/10.4012/dmj.18.453
[9] CAVALCANTI A. L., COSTA OLIVEIRA M., FLORENTINO V. G., DOS SANTOS J. A., VIEIRA F. F., 和 CAVALCANTI C. L. 简短交流：能量饮料侵蚀潜力的体外评估。欧洲档案馆小儿牙科, 2010, 11: 254-257. http://dx.doi.org/10.1007/BF03262757
[10] OZKANOGLU S. G., 和 AKIN E. G. 评价各种饮料对修复材料颜色稳定性和显微硬度的影响。尼日利亚临床实践杂志, 2020, 23: 322-328. https://doi.org/10.4103/njcp.njcp_306_19
[11] WALKER R., 和 BURGESS J. 比较树脂基复合材料。牙科继续教育纲要, 2004. 25(6): 424-428. https://pubmed.ncbi.nlm.nih.gov/15651233/
[12] NAGEM FILHO H., FORTES SOARES D'AZEVEDO M. T., NAGEM H. D., 和 MARSOLA F. P. 精加工和抛光后复合树脂的表面粗糙度。巴西牙科杂志, 2003, 14(1): 37-41. https://doi.org/10.1590/s0103-64402003000100007
[13] BERGER S. B., MUNIZ PALIALOL A. R., CAVALLI V., 和 GIANNINI M. 复合树脂在精加工和抛光后的表面粗糙度和染色敏感性。美学与修复牙科杂志, 2011, 23(1): 34-43. https://doi.org/10.1111/j.1708-8240.2010.00376.x
[14] AL-SAMADANI, K. H. 能量饮料对纳米填充复合树脂表面质地的影响当代牙科实践杂志, 2013, 14(5): 830-835. https://doi.org/10.5005/jp-journals-10024-1411
[15] TOPCU F. T., ERDEMIR U., SAHINKESEN G., YILDIZ E., USLAN I., 和 ACIKEL C. 两种不同光源聚合的不同类型树脂复合材料的显微硬度、表面粗糙度和磨损行为的评价。生物医学材料研究杂志, 2010, 92(2): 470-478. https://doi.org/10.1002/jbm.b.31540
[16] RUDDELL D., MALONEY M., 和 THOMPSON J. 新型填料颗粒对牙科复合材料机械和磨损性能的影响。牙科材料, 2002, 18(1): 72-80. https://doi.org/10.1016/s0109-5641(01)00022-7
[17] ERDEMIR U., YILDIZ E., EREN M. M., 和 OZEL S. 不同复合树脂材料的表面硬度评价：运动饮料和能量饮料短期浸泡后的影响。应用口腔科学杂志, 2013, 21(2): 124-131. https://doi.org/10.1590/1678-7757201302185
[18] MITRA S. B., WU D., 和 HOLMES B. N. 纳米技术在先进牙科材料中的应用。美国牙科协会杂志, 2003, 134(10): 1382-1390. https://doi.org/10.14219/jada.archive.2003.0054
[19] KHAN A. A., ALKHURAIF A., AL-SHEHRI A. M., 和 SÄILYNOJA E. 纤维增强复合材料的聚合物基体：保质期内半互穿聚合物网络的变化。生物医学材料力学行为杂志, 2018, 78: 414-419. http://dx.doi.org/10.1016/j.jmbbm.2017.11.038
[20] ILDAY N., BAYINDIR Y., 和 ERDEM V. 三种不同酸性饮料对复合树脂修复材料表面特性的影响材料研究创新, 2010, 14(5): 385-391. http://dx.doi.org/10.1179/143307510X12820854748917
[21] PARAVINA R., ROEDER L., LU H., VOGEL K., 和 POWERS J. M. 精加工和抛光工艺对树脂基复合材料表面粗糙度、光泽度和颜色的影响. 美国牙科杂志, 2004, 17(4): 262-266. https://pubmed.ncbi.nlm.nih.gov/15478488/
[22] REN Y. F., FENG L., SERBAN D., 和 MALMSTROM H. S. 常见饮料着色剂对牙科复合树脂颜色稳定性的影响：体外热循环染色挑战模型的效用。牙科杂志, 2012, 40: e46-e48. https://doi.org/10.1016/j.jdent.2012.04.017
[23] LEPRI C. P., 和 PALMA-DIBB R. G. 复合材料的表面粗糙度和颜色变化：饮料和刷牙的影响。牙科材料杂志, 2012, 31(4): 689-696. https://doi.org/10.4012/dmj.2012-063
[24] TAGTEKIN D. A., YANIKOGLU F. C., BOZKURT F. O., KOLOGLU B., 和 SUR H. 有机改性陶瓷和传统混合树脂复合材料的选定特性。牙科材料, 2004, 20(5): 487-497. https://doi.org/10.1016/j.dental.2003.06.004
[25] ASMUSSEN E. 影响修复树脂聚合物中剩余双键数量的因素。斯堪的纳维亚牙科研究杂志, 1982, 90: 490-496. https://doi.org/10.1111/j.1600-0722.1982.tb00767.x
[26] HAN L., OKAMOTO A., FUKUSHIMA M., 和 OKIJI T.

酸性和酒精饮料侵蚀的可流动树脂复合材料表面的评价。牙科材料杂志, 2008, 27(3): 455-465. https://doi.org/10.4012/dmj.27.455
[27] PEUTZFELDT A. 牙科树脂复合材料：单体系统。欧洲口腔科学杂志, 1997, 105(2): 97-116. https://doi.org/10.1111/j.1600-0722.1997.tb00188.x
[28] MANDIKOS M. N., MCGIVNEY G. P., DAVIS E., BUSH P. J., 和 CARTER J. M. 间接复合树脂的耐磨性和硬度比较。修复牙科杂志, 2001, 85(4): 386-395. https://doi.org/10.1067/mpr.2001.114267
[29] MCCABE J. F. 应用牙科材料第 7 版。布莱克威尔科学出版物, 牛津, 1990.
[30] HAMOUDA I. M. 各种饮料对美容修复材料硬度、粗糙度和溶解度的影响。美学与修复牙科杂志, 2011, 23(5): 315-322. https://doi.org/10.1111/j.1708-8240.2011.00453.x
[31] TANTHANUCH S., KUKIATTRAKOON B., SIRIPORANANON C., ORNPRASERT N., METTASITTHIKORN W., LIKHITPREEDA S., 和 WAEWSANGA S. 不同饮料对纳米杂化树脂复合材料和焦聚体表面硬度的影响。保守牙科杂志, 2014, 17(3): 261-265. https://doi.org/10.4103/0972-0707.131791
[32] MORAES R. R., MARIMON J. L., SCHNEIDER L. F., SINHORETI M. A., CORRER SOBRINHO L., 和 BUENO M. 在水中老化 6 个月对两种微混合牙科复合材料硬度和表面粗糙度的影响。口腔修复学杂志, 2008, 17: 323-326. https://doi.org/10.1111/j.1532-849x.2007.00295.x
[33] CATELAN A., BRISO A. L., SUNDFELD R. H., 和 SANTOS P. H. 人工时效对密封复合材料粗糙度和显微硬度的影响美学与修复牙科杂志, 2010, 22: 324-330. https://doi.org/10.1111/j.1708-8240.2010.00360.x
[34] NICHOLSON J. W., GJORGIEVSKA E., BAJRAKTAROVA B., 和 MCKENZIE M. A. 在酸性溶液中储存后多元酸改性复合树脂（复合体）的性能变化。口腔康复杂志, 2003, 30: 601-607. https://doi.org/10.1046/j.1365-2842.2003.01041.x
[35] ALGHAMDI A., ALGARNI A., RAYAN M. ESKANDRANI, 和 ALAZMI K. F. 能量和软饮料对纳米填充复合树脂的表面和机械性能的影响。国际牙科科学与研究杂志, 2019, 7(2): 44-48. http://www.sciepub.com/ijdsr/abstract/11023
[36] DE MORAES, R. R., MACHADO MARIMON J. L., SCHNEIDER L. F., COELHO SINHORETI M. A., CORRER-SOBRINHO L., 和 BUENO M. 在水中老化 6 个月对两种微混合牙科复合材料硬度和表面粗糙度的影响。口腔修复学杂志, 2008, 17(4): 323-326. https://doi.org/10.1111/j.1532-849x.2007.00295.x
[37] YANIKOGLU N., DUYMUS Z. Y., 和 YILMAZ B. 不同溶液对复合树脂材料表面硬度的影响[J].牙科材料杂志, 2009, 28(3): 344-351. http://dx.doi.org/10.4012/dmj.28.344
[38] GARCÍA-GODOY F., GARCÍA-GODOY A., 和 GARCÍA-GODOY F. 酸性磷酸氟化物微泡对高粘度玻璃离聚物的表面粗糙度、硬度和微观形态的影响。儿童牙科杂志, 2003, 70: 19-23. https://pubmed.ncbi.nlm.nih.gov/12762603/
[39] YAP A. U., LOW J. S., 和 ONG L. F. 食品模拟液对复合材料和多元酸改性复合材料表面特性的影响。牙科手术, 2000, 25: 170-176. https://pubmed.ncbi.nlm.nih.gov/11203812/
[40] HENGTRAKOOL C., KUKIATTRAKOON B., 和 KEDJARUNE-LEGGAT U. 天然酸性试剂对修复材料显微硬度和表面微观形貌的影响。欧洲牙科杂志, 2011, 5: 89-100. http://dx.doi.org/10.1055/s-0039-1698863
[41] YAP A. U., LYE K. W., 和 SAU C. W. 使用不同抛光系统抛光的牙齿色修复体的表面特征。牙科手术, 1997, 22(6): 260-265. https://pubmed.ncbi.nlm.nih.gov/9610323/
[42] BADRA V., FARAONI J. J, RAMOS R. P., 和 PALMA-DIBB R. G. 不同饮料对树脂复合材料显微硬度和表面粗糙度的影响牙科手术, 2005, 30(2): 213-219. https://www.researchgate.net/publication/7885041_Influence_of_different_beverages_on_the_microhardness_and_surface_roughness_of_resin_composites
[43] ERTAŞ E., GÜLER A. U., YÜCEL A. C., KÖPRÜLÜ H., 和 GÜLER E. 树脂复合材料在不同饮料中浸泡后的颜色稳定性。牙科材料杂志, 2006, 25: 371–376. https://pubmed.ncbi.nlm.nih.gov/16916243/
[44] BAGHERI R., BURROW M. F., 和 TYAS M. 食品模拟溶液和表面光洁度对美学修复材料染色敏感性的影响。牙科杂志, 2005, 33: 389–398. https://doi.org/10.1016/j.jdent.2004.10.018
[45] ARIMA T., HAMADA T., 和 MCCABE J.F. 交联剂对甲基丙烯酸2-羟乙酯基树脂某些性能的影响。牙科研究杂志, 1995, 74: 1597–1601. https://doi.org/10.1177%2F00220345950740091501
[46] NASIM I., NEELKANTAN P., SUJEER R. 和 SUBBARAO C. V. 微填充、微混和纳米复合树脂的颜色稳定性——一项体外研究。牙科杂志, 2010; 38: 137-142. https://doi.org/10.1016/j.jdent.2010.05.020
[47] AL-NEGRISH A. R. 复合树脂修复体：约旦放置和更换的横断面调查。国际牙科杂志, 2002, 52: 461-468. https://doi.org/10.1111/j.1875-595x.2002.tb00643.x
[48] CRAIG R. G., 和 SAKAGUCHI R. 树脂复合修复材料第12版。莫斯比，马里兰高地, 2006: 189-212
[49] ERDEMIR U., YILDIZ E., 和 EREN M. M. 运动饮料对纳米填充和微混复合材料长期浸泡后颜色稳定性的影响。牙科杂志, 2012, 40(2): 55-63. https://doi.org/10.1016/j.jdent.2012.06.002
[50] GAJEWSKI V. E. S., PFEIFER C. S., FRÓES-SALGADO N. R. G., BOARO L. C. C., 和 BRAGA R. R. (2012). 树脂复合材料中使用的单体：转化度、机械性能和水吸附/溶解度。巴西牙科杂志, 23(5), 508–514. https://doi.org/10.1590/s0103-64402012000500007
[51] BAGHERI R., BURROW M. F., 和 TYAS M.

食品模拟溶液和表面光洁度对美学修复材料染色敏感性的影响。牙科杂志, 2005, 33: 389-398. https://doi.org/10.1016/j.jdent.2004.10.018
[52] SCHULZE K. A., MARSHALL S. J., GANSKY S. A., 和 MARSHALL G. W. 加速老化后牙科复合材料的颜色稳定性和硬度。牙科材料, 2003, 19: 612-619. https://doi.org/10.1016/s0109-5641(03)00003-4
[53] ALDHARRAB A. 能量饮料对纳米填充复合树脂颜色稳定性的影响。当代牙科实践杂志, 2013, 14(4): 704-711. https://www.thejcdp.com/doi/pdf/10.5005/jp-journals-10024-1388