EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 69, 1387:1396, April, 2023

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 10-01-2023 • Accept Date :21-01-2023 • Available online: 10-04-2023 • DOI : 10.21608/edj.2023.186362.2405

BEVERAGES EFFECT ON THE FLUORESCENCE OF DIFFERENT CERAMIC MATERIALS

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ABSTRACT

Aim: This study evaluated four beverages' impact on the intensity of fluorescence using three different ceramic materials. Methods: Three ceramic material brands were used; Lava Ultimate, Vita Enamic and Vita Block Mark II. These materials were cut in slices simulating veneers thickness using the isomet machine then were finished using a special kit. Twenty slices of each material were assigned into 4 groups according to the type of staining solution. The immersing solutions were coffee, tea, pepsi and distilled water as a control group. Fluorescence intensity was measured using a spectrofluorometer. All groups were held in an incubator for 30 days and were re-measured after immersion for fluorescence intensity. Results: Data were explored using Kolmogorov Smirnov and Shapiro-Wilk tests. Two-way ANOVA followed by Tukey's post-hoc test was used to compare different groups ($P \leq 0.05$). The results revealed that there was a significant effect of coffee on all groups, followed by Pepsi, while tea had the least effect. As for the materials, Vita block mark II has shown the least change in fluorescence. Conclusion: The ceramic materials and beverages consumed have an impact on the ceramic veneer's final fluorescence intensity.

KEYWORDS: Beverage's effect, Fluorescence, Resin matrix ceramics, Veneers

INTRODUCTION

One of the most difficult and cosmetically rewarding treatments is smile rehabilitation. Due to their excellent durability, aesthetic qualities, and biocompatibility, dental ceramics are widely employed in a range of dental restorations [1]. Tooth discolouration causes a variety of aesthetic issues. Various efforts have been made to make stained teeth seem better [2].

The dentist now needs to be concerned about aesthetics. Expanding services to patients is vital due to evolving dental disease patterns and therapies[3]. A single stained anterior tooth may require aesthetic treatment from a dentist. Bleaching is often the most conservative method, followed by laminates that can hide or lessen the discoloration while preserving the tooth structure [4]. Over the past thirty years, veneering has improved, giving rise to the ideas and materials of today.

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Porcelain laminate veneers are a popular and minimally invasive dental cosmetic repair technique. The use of porcelain laminate veneers to treat diastema and tooth discolouration, especially in the anterior teeth, is a practical choice for the dentist. Clinical research has demonstrated that porcelain laminate veneers can attain acceptable survivability and a long-lasting cosmetic impact [5,6].

Today's use of adhesive technology makes it possible to achieve the patient's restorative objectives and cosmetic preferences while preserving as much tooth structure as is practical [7]. By enhancing a person's character, appeal, and dignity via the use of aesthetic restorative materials like porcelain and resins, we have been able to recapture that mysterious aesthetic appeal [8].

The fabrication of veneers could be made simpler by CAD/CAM (computer-aided design and computer-aided manufacturing) [7]. In manufacturing of CAD/CAM restorations, various types of materials are employed: glass ceramics/ ceramics and resin composites. While resin-composite materials may have important advantages linked to their machinability and intra-oral reparability, glass-ceramics/ceramics generally have superior mechanical and aesthetic qualities. Glass-ceramic/ ceramic materials are preferable to resin-composites in a direct comparison of characteristics. The latter's appeal is based on its simplicity of construction and the potential for a simpler and less obvious intraoral repair of slight faults brought on by function [9].

Recently, CAD/CAM materials with polymer infiltration, ceramic networks (PICN), and materials that may be produced in a single milling step without requiring heating process have been created. PICN materials have mechanical qualities that resemble those of real teeth. Dentin and enamel are closely related in terms of Young's modulus and Vickers hardness, respectively. The crosslinked polymer in the network prevents cracks from forming despite the fact that materials may be machined into thin layers [10].

Enamic (VITA) is feldspathic porcelain made of aluminum oxide, was released in 2014. It mixed porcelain for its ability to withstand wear and abrasion with composite for handling ease. This nanomaterial's goal is to introduce composite particles into ceramic glass. Urethane dimethacrylate (UDMA) and triethylene glycol dimethacrylate were the main polymer components of Enamic (TEG-DMA). Although there is minimal clinical evidence about long-term life expectancy, the ceramic-reinforced polymer network claims to have the advantages of both ceramic and resin [11,12].

Lava Ultimate, a resin-based block nanocomposite from 3M ESPE in Bad Seefeld, Germany. The blocks are made of nanoceramic particles encapsulated in a highly cured resin matrix that was probably polymerized at different pressure and temperature than Paradigm MZ100 (3M ESPE, St. Paul, MN, USA) which was the first commercial resin-composite for CAD/CAM applications, obtained by the factory polymerization [9].

Natural teeth and some dental restoration materials exhibit fluorescence, an optical signal. Fluorescence is the process through which a material absorbs light and emits it at a longer wavelength [13]. The energy is absorbed at short wavelengths and reemitted at a longer wavelength, which causes the fluorescence of teeth. In other words, because of their inherent fluorescence, teeth serve as a source of blue light. UV radiation promotes teeth whiter and brighter because of the tooth's natural tendency to look yellow and because of their built-in fluorescence characteristic [14,15,16]. As a result, fluorescent materials are frequently employed in glass ceramics and resin composites that serve as tooth-colored materials [17].

The fluorescence characteristics of natural teeth should be replicated in a perfect cosmetic restorative material. Cosmetic restorative dentistry aims to imitate the visual characteristics of natural teeth. However, dental materials for restoration typically ignore the fluorescence of healthy teeth. Fluorescence lengthens a restoration's lifespan and lessens the metameric reaction between restorative materials and teeth under various lighting situations. The fluorescence and other optical properties of natural teeth are attempted to be replicated by modern veneering porcelains and ceramic coping materials [18].

To emulate the fluorescence phenomenon, manufacturers have added specific agents made of metals including cerium, europium, terbium, and ytterbium. In a clinical setting, fluorescence assists in achieving the proper brightness and boosts to the vibrancy of the repair. The degree of fluorescence in various restorative materials varies depending on the manufacturing process or the material's optical characteristics. The substance gets more luminous when the chroma gets lighter [19].

In the last ten years, significant advances have been made in reducing metameric inability [20]. Fluorescent pigments are employed in contemporary composite resins used mostly for anterior tooth restorations to mimic the vivid appearance of natural teeth under all kinds of lighting. Fluorescent particles are frequently found in feldspathic veneering porcelains. All components of the porcelain system [opaquer, dentin, enamel, stains, and even glazing agents] must be fluorescent [21].

Brighter teeth are frequently desired because of advancements in cosmetic dentistry, however, we need to select a material with characteristics like those of natural teeth. Sensi in 2006 [22] asserted that fluorescence "sets natural teeth to seem brighter and more vibrant," hence it is crucial that this feature be included in restorative materials. For patients with demanding aesthetic requirements, particularly those who are regularly subjected to various lighting situations, a restorative material that doesn't match the fluorescence intensity of natural teeth can be a major concern. A greater knowledge of fluorescence improves the restoration's life and beauty, enables manufacturing of restorations to be done with better shade and natural aesthetic adjustment, and reduces the metameric impact between natural teeth and crowns under different lighting situations.

Although research on the effectiveness of ceramic veneers for color matching in natural light has been conducted [23,24], ceramic veneers' ultimate fluorescence has not yet been completely explained. While the fluorescence of teeth and dental porcelain has been evaluated in the past, only a few studies assessed the fluorescence of ceramics during a prolonged period of beverage consumption. The material's resilience is increased by the resin matrix, although its colour stability and fluorescence may be impacted. To better understand how different staining solutions, affect hybrid ceramics over time, this study was done. The diverse ceramic material samples' fluorescence intensities did not substantially vary amongst them, and various staining solutions had no effect on fluorescence, according to the null hypotheses that were sorely examined.

METHODS

I- Preparation of the substrates:

Sixty slices of different machined esthetic restorative material; 20 samples of Lava Ultimate (3M, St.paul, Minnestota, USA), 20 samples of Vita Enamic (Vita Zahnfabrik, Badsackingen Germany) and 20 samples of vita block mark II (Vita Zahnfabrik, Badsackingen, Germany) with dimensions (13mmx13mmx0.5mm). The restorative materials were cut by Isomet 4000 (Buehler, USA) with precision cut micro-saw 4 at cutting speed 2500 rpm using a diamond disc 0.7mm thickness under a water-cooling system in a ratio of 30:1. All slices were measured using a digital caliper (Mitytouo, Germany) by the same operator to standardize the dimensions of all slices.

II- Finishing and polishing:

All slices were then finished using a special finishing and polishing kit (Vita, North America) according to the manufacturer's instructions. First Coarse wheel, then medium rubber tool and finally fine rubber tool was used using a straight handpiece attached to an electric motor with the direction of rotation forward. As for polishing, soft 15 mm bristle brush was used with a low-speed handpiece and a polishing agent (3M, Deutshland GmbH) applied by a brush moving in one direction till they attained a smooth surface on both sides. Samples were then cleaned for 180 seconds with distilled water in an ultrasonic cleaner (Misr-Sinai company (M.C.S)/ Egypt) and dried with oil-free air.

III- Samples grouping:

The specimens were assigned into 3 groups (20 samples each) according to the type of ceramic material used and then each group was subdivided into 4 subgroups (5 samples each) according to the type of solution that the specimens will be immersed in. The solutions used were coffee (Nescafe Espresso, Nestlé S.A., Switzerland), tea (Lipton yellow label Unilever, Canada), Pepsi (PepsiCo, New York) and distilled water.

IV- Immersion in different solutions:

Preparation of solutions:

According to the manufacturer's instructions, 2 packets (3.6gm) of coffee powder were dispersed in 300 ml of boiling water used for coffee. The mixture was stirred for ten minutes before filtering using filter paper. While for tea, immersing two prefabricated tea bags into 244 ml of boiling water with stirring for 2 minutes. The 20 specimens of each material were subdivided into 4 groups each 5 samples were immersed in one of the selected solutions (Coffee, Tea, Pepsi and Distilled water) in a plastic container and stored in an incubator (Genlab General Purpose Incubator - Mini Digital) which was set at 37oc for 4 weeks. The solutions were changed every 48 hours to help prevent bacterial infection.

The specimens were measured for fluorescence before staining. The samples were stained for 4 weeks before being washed under rushing water for 5 minutes and left to dry with tissue paper and re-measured for fluorescence measurement.

IV- Fluorescence measurement:

The fluorescence of the 60 specimens was measured before and after staining using Spectrofluorophotometer (Shimadzu RF-5301 PC, Shimadzu Corporation, Kyoto, Japan). It works following the scheme in (Fig.1). When a sample was mounted to an acrylic cuvette and put within a spectrophotometer chamber with slits emission openings of 2.5 mm, the center of the sample was illuminated by light from an excitation source that first went through a filter or monochromator. The excitation beam's wavelength was 380 nm, which corresponds to the wavelength at which the tooth's fluorescence output reaches its maximum intensity as mentioned by Catelan A. et al [25]. The sample captured a fraction of the incident light. All directions were filled with fluorescent light. A part of this fluorescent light made it to a sensor, which was often positioned at a 90° angle to the incident light beam to reduce the possibility of incident light being received or reflected accessing the detector. All measurements of emission intensity between 420 and 600 nm were collected on a computer connected to the fluorescence spectrophotometer in graphical form. Between 420 and 470 nm in wavelength, fluorescence units (FUs), the peak pick unit of fluorescence intensity, were recorded. These bands of fluorescence exhibited a blue-white look, which is characteristic of fluorescence from natural teeth.

Statistical Analysis

The results were collected and statistically analyzed. By examining the distribution of the results and computing the mean and median values through using Kolmogorov-Smirnov and Shapiro-Wilk tests, the data were analyzed for normality. Two-way ANOVA followed by Tukey's post-hoc test were used to compare different groups. The cutoff for significance was chosen at $P \leq 0.05$. With IBM SPSS Statistics Version 20 for Windows, statistical analysis was carried out.

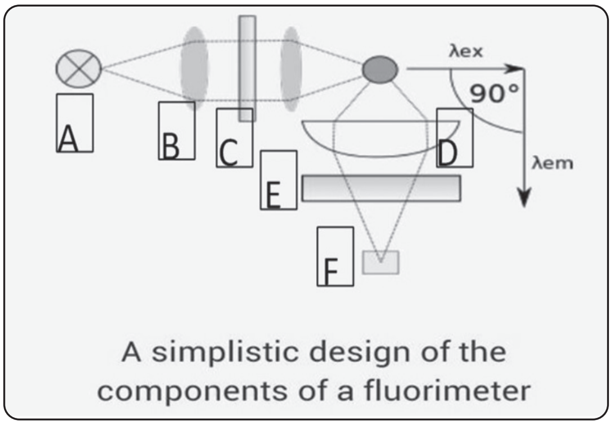

Fig. (1) Fluorometer: (A) light source (B) slit (C)primary monochromator (D) sample (E) secondary monochromator (F) detector

RESULTS

For each group, the mean and standard deviation values were determined. Using the Kolmogorov-Smirnov and Shapiro-Wilk tests, the normality of the data was examined, and a parametric (normal) distribution was found.

The material had a substantial impact, according to a two-way ANOVA and a significant effect of solution type over fluorescence, also there was a significant effect of interaction between material and solution type. Collective data of fluorescence was collected in (Table 1).

TABLE (1) Statistical analysis of the effect of ceramic material and solution type on fluorescence

Variables	Vita Enamic Mean ± SD		Lava Ultimate Mean ± SD		VitaBlock Mark II Mean ± SD		*P value*
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	
Coffee	57.89 ± 2.00	34.13±4.66	148.86±57.63	51.07±5.39	57.44±4.24	39.98±4.52	0.001*
Tea	46.37 ± 8.13	36.04±1.74	125.44±33.60	64.44±5.38	52.40±1.58	41.61±4.24	0.1
Pepsi	58.51 ± 9.02	39.94±1.33	159.50±54.92	81.33±9.50	51.10±4.27	41.93±9.66	0.01*
Distilled Water	60.66 ± 3.42	47.02±4.43	171.58±50.29	134.94±39.34	54.71±1.38	46.46±5.19	0. 3
P-value	<0.05*		<0.05*		<0.05*		

Mean with different letters in the same column indicate a statistically significant difference *; (p<0.05)

Effect of coffee on the three ceramic materials:

Fluorescence intensity (FUs) greatly decreased regarding Vita Enamic samples (pre 57.89 ± 2.00) after immersion in coffee (post 34.13 ± 4.66) with statistical significance difference (p>0.05). There was a statistically significant difference (p>0.05) in Lava ultimate samples before (148.86 ± 57.63) and after (51.07 ± 5.39) immersion in coffee denoting a reduction in fluorescence strength (FUs) after immersion. For vita block mark II material ,there was a substantial drop in fluorescence intensity (FUs) (p>0.05) before (57.44 ± 4.24) and after (39.98 ± 4.52) immersion in coffee.

One-way ANOVA followed by Tukey's post-hoc test was used to illustrate how coffee affects the three materials. Lava ultimate showed the highest difference in fluorescence intensity (FUs) in all groups followed by vita Enamic. Vita block mark II was the least affected material.

There was a statistically significant difference between (Lava Ultimate/Coffee) (-97.79 ± 24.14) and (VitaEnamic/Coffee) (-23.76 ± 15.71) also there was a statistically significant difference between (Vita BlockMarkII/Coffee) (-17.46 ± 8.37) and (Lava Ultimate/Coffee) (-97.79 ± 24.14) where (p>0.05). However, no statistically significant difference was discovered between (VitaEnamic/Coffee) (-23.76 ± 15.71) and (VitaBlockMarkII/Coffee) (-17.46 ± 8.37) where (p<0.05).

Effect of tea on the three ceramic materials:

Fluorescence intensity (FUs) of vita Enamic (pre- immersion 46.37 ± 8.13) was slightly decreased after immersion in tea (post- immersion 36.04 ± 1.74). No statistically significant difference was found with (p >0.05). Fluorescence intensity (FUs) of lava ultimate (pre- immersion 125.44 ± 33.60) was greatly decreased by immersion in tea (post-immersion 64.44 ± 5.38). A statistically significant difference was found with (p >0.05). The fluorescence intensity (FUs) of vita block (52.40 ± 1.58) was slightly decreased by immersion in tea (41.61 ± 4.24). With (p <0.05), no statistically significant change was discovered. There was no statistically significant difference between the three Ceramic materials, as determined by One-way ANOVA and Tukey's post-hoc analysis (Vita Enamic, Lava Ultimate and Vita Block MarkII).

Effect of Pepsi on the three ceramic materials:

Fluorescence intensity (FUs) decreased in vita Enamic samples (pre immersion 58.51 ± 9.02) after immersion in pepsi (post- immersion 39.94 ± 1.33) with statistical significance (p>0.05). As for lava ultimate (pre-immersion 159.50 ± 54.92) there was a significant decrease in fluorescence intensity (FUs) after immersion in Pepsi (post immersion 81.33 ± 9.50) with statistically significant difference where (p >0.05). Fluorescence intensity (FUs) of vita block mark II (pre-immersion 51.10 ± 4.27) showed a slight decrease after immersion (post immersion 41.93 ± 9.66) in pepsi with (p <0.05). One-way ANOVA followed by Tukey's post-hoc test were used to compare all groups. Lava ultimate has shown the greatest decrease in fluorescence intensity (FUs) followed by Vita Enamic. A statistically significant difference was found between (LavaUltimate/Pepsi) (-78.16±27.39) and (VitaEnamic/Pepsi) (-18.57±12.17) where (p>0.05). Moreover, there was a statistically significant difference between (VitaBlockMarkII/Pepsi) (-9.17 ± 7.76) and (Lava Ultimate/Pepsi) (-78.16 ± 27.39) where (p>0.05). No statistically significant difference was found between (VitaEnamic/Pepsi) (-18.57±12.17) and (Vita Block MarkII/Pepsi) (-9.17±7.76) where (p<0.05).

Effect of distilled water on the three ceramic materials:

Distilled water showed a slight decrease in the fluorescence intensity (FUs) (pre-immersion 60.66±3.42)of vita Enamic (post-immersion 47.02 ± 4.43 with (p< 0.05). Fluorescence intensity (FUs) of lava ultimate (pre-immersion 171.58 ± 50.29) was slightly decreased (post-immersion 134.94 ± 39.34) after immersion in distilled water with (p< 0.05). Fluorescence intensity (FUs) of vita block mark II (pre-immersion 54.71 ± 1.38) was slightly decreased by immersion in distilled water (post immersion 46.46 ± 5.19) with (p <0.05). No statistically significant difference was found between the three Ceramic materials (Vita Enamic, Lava Ultimate and Vita Block MarkII).

The Fluorescence of the three Ceramic materials regardless of the type of solution:

One way ANOVA showed that the interaction of all variables had a statistically significant difference between (LavaUltimate) (68.40 ± 42.81) and (VitaEnamic) (-16.57 ± 11.74) where (p=0.001) there was also a statistically significant difference between (Vita Block MarkII) (-11.47 ± 9.21) and (LavaUltimate) (-68.40 ± 42.81) where (p>0.05). While no statistically significant difference was found between (VitaEnamic) (-16.57 ± 11.74) and (Vita Block MarkII) (-11.47 ± 9.21) experimental groups where (p<0.05) (Fig. 2).

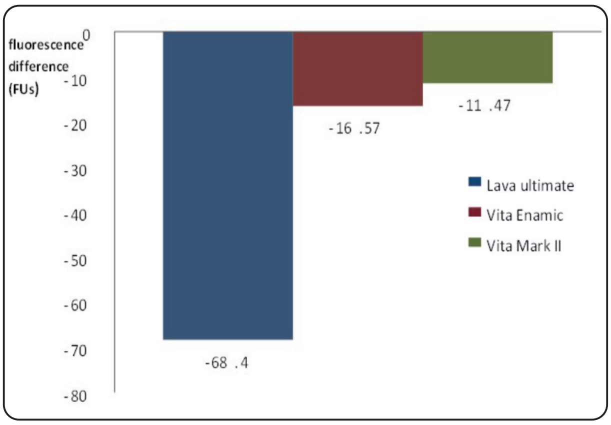

Fig. (2) Bar chart showing the Fluorescence difference of all groups regardless of the type of staining solution

DISCUSSION

When reconstructing anterior teeth, laminate veneers are an extremely aesthetic option to full crowns. The materials used in this study were Resin nano ceramic (RNC) and Hybrid ceramic (HC) materials. For tooth rebuilding, understanding the visual characteristics of these aesthetic restorative materials is essential. Fluorescence intensity is considered one of the special parameters for the restorative procedures of anterior teeth. Different methods are used to evaluate the stability of the optical properties of restorative materials. One of these methods is by immersion in different staining solutions for a certain time and then measuring the changes that occurred in their optical properties. In this study, staining solutions used were coffee, tea and Pepsi. These stains were chosen because they are the most popular drinks and have a high likelihood of discoloring tooth-colored restorative materials [26,27]. Also, the Espresso type of coffee was used as it causes the greatest change in color [28]. The null hypothesis was rejected, as the results indicated a statistically significant difference that the ceramic and beverages could influence the fluorescence intensity of ceramic veneers.

In this study, fluorescence intensity was less detected after immersion in the staining solutions for the three restorative materials. This result is compatible with the finding of Gawriolek M et al [29] where they discovered that fluorescence diminished by up to 40% after being exposed to staining beverages. Additionally, they discovered that composite materials' luminescence diminishes more quickly after staining than does ceramic materials. If the dye materials deposited at the specimen surface and in the bulk are what's causing the changes, then luminescence stability should be associated to colour stability, which is what really occurs.

In contrast, our results could be caused by the absorbed colorant's attenuation of both the input excitation photons and the fluorescent photons that were released, rather than any particular energy-transfer events between the fluorescent dental materials and the absorbed dye stuffs .i.e. no fluorescence quenching has occurred. Since lava ultimate had absorbed more colorants than vita Enamic and Vita block mark II, the absorbed energy was greatly affected causing a decrease in the intensity of the emitted energy which in turn caused an obvious decrease in fluorescence after immersion in the staining solutions.

Colorants have different polarities, lower polarity components (like those in coffee) are eluted at a later time so it has time to penetrate the structure of the material [30]. Polar colorants in the case of coffee are absorbed and adsorbed. So, part of the colorants is absorbed on the surface while the less polar colorants have entered deeper into the material causing intrinsic discoloration [31]. This colorant adsorption and penetration into the materials' organic layer was described by the authors [30] likely a result of the polymer phase's compatibility with the coffee's yellow coloring agents. This may explain the reason why coffee caused decrease in fluorescence intensity in comparison to all beverages used in this study.

Concerning tea, insignificant difference between the three materials in fluorescence measurements. Discoloration by tea may be attributed to yellow colorants mainly tannin. These colorants have different polarities [8]. Higher polarity components (those in tea) that's eluted first has no time to enter deeper into the material. Therefore, discoloration by tea was due to adsorption of polar colorants onto the surface of materials without penetration into deeper layers as that in coffee which make it easier to be removed by cleaning under running water.

Results of groups immersed in Pepsi have shown significant difference in all groups in fluorescence difference. In comparison to coffee, pepsi has shown lesser effect on fluorescence difference. This conclusion is consistent with Hatim NA, Al-Tahho OZ [32] where they reported that coffee caused higher discoloration than Pepsi. Although, Pepsi has the lowest pH (2.7) compared to other staining solutions (Coffee=5.01, tea=5.38) [25] which might have damaged the surface integrity of the materials, it did not produce decrease in fluorescence as coffee. The reason for this may be because the lack of a yellow colorant in Pepsi and the low polarity of colorants in coffee which made it easy to be absorbed deep into the material.

Results, however, showed that pepsi caused the intensity of fluorescence to drop more than tea. Cola, a dark carbonated beverage, gets its colour from the caramel that is added. The process of making caramel involves boiling sugar or glucose in the presence of an alkali or mineral acid, and the resulting hues range from the palest yellow to the darkest brown. In addition to its staining potential, cola drinks have been shown to have an erosional (corrosive) impact on teeth structure and enamel, with Pepsi's pH being substantially lower than tea. This may have harmed the surface's integrity, weakening the matrix because of the loss of structural ions. Meanwhile, tea colorants' were absorbed on the surface and might have been removed during cleansing under running water before measurements have taken place.

Although this study was done in vitro for the purpose of standardization and optimization of the surrounding condition, some limitations exist in this study. This study's in vitro design, which allowed for staining on both sides of the material, had certain limitations. In a therapeutic setting, the substance is attached to a tooth structure and is only partially exposed to solutions and light. The clinical relevance of immersing ceramic discs in the same solution for 30 days is considered another limitation in this study as in the oral cavity saliva washes part of the stains also the frequency of exposure to staining beverages is less. Although the staining effects of the solutions are accelerated in the laboratory, clinical investigations considering saliva and temperature cycling might offer more clinical insight. Also, cementation of different layers of enamel and dentin, different microstructure reacts differently to light. Clinical studies should be used to support the study's findings. The vulnerability of hybrid dental ceramic and resin nano-ceramic materials to coloring by other liquids and nutrients and their impact on fluorescence require more clinical and in vitro investigations [33].

CONCLUSIONS

Within the limitations of this study, colorants in different consuming beverages can affect the fluorescence intensity of esthetic dental materials. Coffee was the most effective beverage in causing a decrease in fluorescence intensity compared to other beverages. Resin matrix ceramics showed a significant change in fluorescence.

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