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A Comparison of the Effects of Matcha and Green Tea on Enamel Surface Roughness

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ABSTRACT

Background and Objective: The regeneration of dental enamel is not possible. Tooth decay can develop at any point throughout lifetime. Matcha is often acknowledged as the most aromatic type of tea and is considered to have the highest level of quality. It contains a significant amount of minerals, including fluoride. The aim of this study was to compare the effects of matcha and green tea on the surface roughness of artificial caries lesions.

Methods: In this laboratory study, 40 extracted premolars teeth (for orthodontic treatment) were immersed in 0.02% thymol solution, then rinsed and smoothed using pumice without fluoride, the roots were removed using a diamond disc bur at a depth of 2 mm below the cement-enamel junction. Plastic cylindrical tubes were sliced into rings and acrylic resin was poured into them. Teeth were placed in the middle of the ring, with the labial surface visible. A 4x4mm window was prepared for measurements. Samples were randomly divided into 4 groups of 10: Group I: Deionized water (DW); Group II: Sodium fluoride solution (NaF); Group III: Matcha solution; and Group IV: Green tea solution. Remineralization measurements were conducted one week after subjecting the samples to the agents. Teeth were examined using an atomic force microscope (AFM) in three phases: baseline phase, demineralization phase and remineralization phases. The quantitative outcome variable was equal to the arithmetic mean values of surface roughness (Ra). Data were analyzed using SPSS.

Findings: A significant difference was observed between the groups in the remineralization phase. Matcha showed the highest value (176.420±38.944). Sodium fluoride solution was in second place (88.239±35.239), green tea showed the lowest value (5.145±1.612) and then the deionized water group (64.721±20.197) (p=0.000).

Conclusion: The results of the study showed that green tea was significantly better than matcha when it came to tooth enamel roughness.

Keywords: *Matcha, Green Tea, Roughness, Remineralization.*

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Introduction

Demineralization is a process that causes mineral loss from the enamel, thus creating porosities in the enamel (1). Minimal intervention dentistry aims to extend the longevity of natural teeth. It places the nonrestorative approaches as a priority (2). Teeth possess an indispensable characteristic known as roughness, which impacts the adhesion of external substances to their surfaces (3). Surface roughness governs the quality, color, buildup of plaque in the oral cavity (4). The limit of surface roughness above which the bacteria would adhere is debatable. The most commonly reported limit of surface roughness (Ra) is below 0.2 µm for adherence of dental biofilm (5). The roughness of the tooth enamel surface is inclined due to demineralization and promotes the buildup of plaque (6).

Fluoride is one of the preventative techniques used to address tooth erosion (7). However, dental fluorosis occurs when excessive amounts of fluoride are consumed over a lengthy period. In severe cases, skeletal fluorosis can develop (8).

Tea plants are known as Camellia sinensis; the majority of individuals worldwide have a preference for consuming tea. Black and green teas, the two primary variants, are obtained from the same plant (9). Tea leaves mostly consist of polyphenols (10); the health-promoting effects are mainly attributed to this compound (11). Green tea is available in several forms, including loose leaves, tea bags, or powdered form (12). Matcha is a type of powdered tea made from the Tencha variety (13). It has gained increasing popularity in recent years (14). All varieties of tea include minerals, including fluorine, which plays a crucial role in the mineralization processes of hard tissues (15).

The purpose of the present experiment was to test and compare the effect of Matcha tea and green tea on the roughness of artificially demineralized enamel surfaces.

Methods

This research is a laboratory comparative study. Ethical approval was obtained from the scientific and central committee of the College of Dentistry, University of Baghdad according to the Helsinki Declaration (project no. 682322) (16).

Specimen preparation:

Forty sound human permanent premolars were extracted for orthodontic treatment. The criteria for entering and exiting the study were sound crowns with no sign of caries, restorations, cracks, fractures, and white lesions. The teeth were inspected using a 10X magnifying lens (17). Teeth were collected from teenagers at various dental centers (after gaining consent). Teeth were immersed in distilled water and 0.02% thymol solution. They were then rinsed with deionized water and smoothed using pumice without fluoride (18). The roots were removed from crowns using a diamond disc bur of double-ended type (Nti, Germany) with an adequate quantity of water at a depth of 2 mm below the cement-enamel junction (19).

To make the samples in a uniform design, plastic cylindrical tubes were sliced into identical rings, featuring parallel flat top and bottom edges. Cold cure acrylic resin was poured into rings. In the middle of the ring, teeth were placed, with the labial surface visible and parallel to the base. Nail varnish resistant to acids was used to coat the exposed surface except for the middle third; this area was obscured with tape for adhesion and removal later, creating a 4x4mm window for measurements. This specific area was the focus of analysis (20).

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The roughness was measured at different phases: Baseline, after demineralization, and after immersion in agents' solutions. The teeth were randomly separated into four groups: Group I: Deionized water; Group II: NaF; Group III: Matcha tea; and Group IV: Green tea; Ten teeth in each group. The quantitative outcome variable was Arithmetic average height (Ra) values.

The demineralizing solution was developed to create significant subsurface demineralization similar to enamel caries. A mixture of the indicated materials (50 mM acetic acid, 2.2 mMCa (NO3)2, 2.2 mM KH2PO4, 5.0 mM NaN3, 0.5 ppm NaF) was incubated in a shaker at 37°C and 50 rpm up to 72 hours. The pH of the solution was then adjusted to 4.5 using a portable pH meter (21).

Preparation of aqueous solutions:

NaF solution 0.05%: was prepared by adding 0.05 grams of sodium fluoride powder (M.W. 41.99, Thomas Baker, India) into 100 ml of deionized water (22).

Matcha green tea solution: 2.84 grams of powdered matcha (now Real Tea trademark, USA) was combined with 120 cc of water that had been heated at 82°C and stirred in a zigzag motion until froth and was formed according to the manufacturer's instruction.

Green tea solutions: 8.4 gm of green tea (TWININGS trademark, England) was added to a warm teapot 500 ml. Fresh water boiled to 90°C was poured on it and incubated for 3 minutes according to the manufacturer's instructions.

Demineralization of samples: Samples were stored in a glass beaker with 20 ml of solution that produced demineralization for up to three days. The demineralized solution was replenished daily (23).

Sample treatment: The teeth samples were soaked in 20 ml of the treatment solution for four minutes, followed by a two-minute rinse with deionized water. The processes were performed daily for one week, and the tested solutions were renewed daily (24).

Roughness assessment: The measurements were conducted with an atomic force microscope (NaioAFM 2022 model, Nanosurface AG, Switzerland) testing equipment.

The sample was attached to a double-sided tape. The AFM probe utilized for measurements in tapping mode had been fitted with a gold reflective coating on the tip side of the cantilever (Tap190GD-G), while the detector side was coated with a thin layer of gold measuring 70nm in thickness. The cantilever had a force constant that ranged from 28 to 75 N/m. The probe had the following specifications: beam form, length of 225µm, width of 38µm, and resonance frequency of 190 kHz.

Statistical analysis: Data description, analysis, and presentation were performed using Statistical Package for Social Science (SPSS version -22, Chicago, Illinois, IBM, USA). Statistical analysis included descriptive analysis and inferential analysis: Shapiro test for sample distribution and Levene test for homogeneity of variance. Furthermore, one-way analysis of variance for differences between groups and repeated measure analysis were conducted using Tukey HSD. A p-value less than 0.05 was considered significant.

Results

A significant difference was found after treatment with all tested solutions between the four groups (p=0.000). The super mean value was revealed in Matcha tea, followed by NaF, while green tea represented the lowest mean value, followed by DW groups. The mean, standard deviation and p-values are presented in Table 1.

In addition, a significant difference was found in DW, Matcha tea, and green tea when comparing the demineralization phase to the remineralization phase. At the same time, a non-significant difference was found in NaF when comparing these two phases. All groups show significant differences in remineralization phase when compared to each other except when comparing DW to NaF and DW to green tea.

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Table 1. Descriptive and statistical test of Ra among groups and phases

Groups	Baseline Mean±SD	Demin Mean±SD	Treatment Mean±SD	F	p-value	Effect size
DW	57.98±18.33[a]	108.02±35.57[b]	64.72±20.19[c]	7.149	0.002*	0.290
NaF	67.59±23.72[a]	109.48±33.83[b]	88.24±35.24[c]	4.469	0.019*	0.203
Matcha Tea	43.98±12.48[a]	85.54±25.22[b]	176.42±38.94[c]	35.017	0.000*	0.667
Green Tea	63.32±17.80[a]	51.79±23.12[b]	5.15±1.61[c]	7.055	0.003*	0.287
F	1.875	2.762	17.575			
p-value	0.151	0.056	0.000*			

*Significant at p<0.05

Discussion

The roughness of enamel was assessed in three conditions: sound enamel (baseline measurement), after demineralization, and after remineralization using the examined products. From a statistical perspective, the significant increase in the roughness of the enamel surface following the application of a demineralizing solution suggests the onset of the initial eroded lesion.

In this study, the most important findings revealed that Matcha tea had a significant increase in roughness while the green tea showed the lowest roughness among other materials. However, there has been no research focusing on the enamel surface roughness test after the matcha application, unlike the widely addressed surface roughness test of enamel after green tea application. In a study by Özyurt et al. (25), Matcha shows less roughness compared to other types of tea on composite roughness. This may be attributed to the PH level of 5.7 compared to Kombucha tea, which were 3.2.

The reason behind roughness elevation in the present study may be contributed to the large particle of matcha solution that is deposited on the outer surface of the tooth. The temperature of the water utilized for producing the infusion is a crucial factor that greatly influences the chemical composition of a tea beverage. This pertains to the retrieval of physiologically potent substances and increased motion energy in tea prepared at an elevated temperature (15).

The exceptional antioxidant capacity of Matcha can also be ascribed to the process of grinding. Fujioka et al. established that tea infusions produced by steeping tea leaves contain a reduced amount of polyphenol compared to those created from powdered tea. Therefore, the grinding process itself can expedite the extraction of polyphenolic chemicals (26). All these factors might affect teeth; situations in which teeth experience continuous de- and remineralization and any imbalance in this might result in degradation of tooth structure resulting in roughness rising. However, it is important to acknowledge that this study has certain limitations; the demineralization /remineralization cycle was conducted in a controlled laboratory setting. Following the remineralization process of enamel samples using the chosen products, a reduction in enamel surface roughness was seen in NaF, green tea, and DW.

A study concluded that fluoride ions reduce the roughness of the enamel surface by enhancing its ability to withstand acid dissolution, which affects the processes of de- and remineralization. This leads to the development of a substance similar to CaF2 on the eroded surface (27). However, their preventive action has been reported to be limited, mainly when delivered in solution and dentifrices, due to their low-to-moderate fluoride concentrations (28). The green tea group stimulated the remineralization of enamel. In this study, green tea shows the lowest surface roughness. This result disagreed with the study of Samir et al. (29), which shows more roughness in green tea groups than fluoride groups. This may be attributed to

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the low concentration of fluoride solution used in this study, while Samir et al. used fluoride gel. A study by Kato et al. (30) shows that green tea may potentially reduce dentin erosion by inhibiting Matrix metalloproteinases (MMPs), which could be one of its mechanisms of action. If this statement is accurate, the polyphenols may be the component accountable for this phenomenon. The cell culture studies revealed that green tea polyphenols, particularly epigallocatechin-3-gallate (EGCG), had strong and specific inhibitory effects on MMPs.

A systematic review examined the correlation between green tea consumption and dental degradation. Out of the articles published between 2000 and 2012, only eight were chosen. Among them, seven were laboratory investigations, while just one was a cross-sectional observational study. The findings of the inquiry indicate that sugar-free black or green tea does not cause tooth erosion. However, frozen tea, fruity, floral, and sugary tea have erosive effects (31). The anti-erosion action of green tea can be attributed to its high pH value. Both black and green tea have a pH of approximately 5.7 (32). Results of a study by Abo Baker (32) concluded that green tea was very viable in preventing enamel erosion after using Pepsi beverages through reduction of the enamel roughness and increasing remineralization.

In this study, green tea revealed a minimum effect on the enamel roughness compared to matcha which showed inclination in the roughness. The results cannot be fully extrapolated to an in vivo scenario due to the absence of the inherent defensive mechanisms of the mouth cavity. In addition, more studies are necessary to evaluate the efficacy of Matcha tea with correct methodological design for example testing different techniques for creating an extract of Matcha tea that may decrease the negative effect on the surface roughness of enamel; including solution preparation and concentration. Matcha tea can negatively affect the surface properties of demineralized enamel in terms of roughness while the best effect was shown in green tea.

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

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