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Ancient remedies in modern dentistry: The remineralizing potential of urine and sumac

Amir Shayegan[1]*, Nicolas Jabbour[1]

[1]Dept. of Pediatric Dentistry, Children's Hospital of Queen Fabiola, Université Libre de Bruxelles, Belgium
[2]Dept. of General Dentistry, Université Libre de Bruxelles, Belgium

Abstract

Background: Enamel remineralization restores mineral content and prevents decay. While fluoride is commonly used, concerns about its risks have led to interest in natural alternatives like urine therapy and sumac, both of which have been historically used for oral health. The aim of this study was to assess the remineralizing effects of human urine and sumac on enamel, testing the null hypothesis that neither would show significant effects.
Materials and Methods: Ninety enamel-dentin blocks were prepared from extracted human teeth and divided into nine groups (10 samples each). The blocks were treated daily with distilled water, fluoride varnish, fluoride toothpaste, human saliva, urine, dark chocolate, honey, honey-ginger mixture, and sumac. After demineralization for 7 days, the samples underwent remineralization for one month with daily treatments. Fluorescence loss (ΔF) was measured at five-time points using QLF. Surface changes were observed using SEM. Statistical analysis was performed using descriptive statistics, t-tests, ANOVA, and nonparametric tests, with significance at $p < 0.05$.
Results: The Fluoride varnish, Fluoride toothpaste, Human saliva, and Human urine groups showed significant remineralization. The Human saliva group had the most significant remineralization by T3, which was sustained at T4. The Human urine group also showed partial remineralization, with significant recovery by T4. The Honey, Honey & ginger, Sumac, and dH_2O groups exhibited minimal or no remineralization after one month.
Conclusion: Fluoride treatments and human saliva demonstrated the most significant remineralization, supporting the well-established role of fluoride in enamel repair. Human urine also showed promising remineralization, likely due to its mineral content. In contrast, substances like honey, honey-ginger mix, and sumac showed minimal or no remineralization, suggesting that not all natural substances are effective in enamel restoration. These findings highlight the importance of proven remineralizing agents and suggest further exploration of natural alternatives.

Keywords: Remineralization, Enamel, Fluoride, Urine, Rhus coriaria L.

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1. Introduction

Enamel remineralization is a natural process that maintains oral health. This phenomenon helps restore enamel's mineral content, reversing early signs of decay and strengthening teeth without invasive treatments. By promoting remineralization, cavities can be prevented, tissue integrity maintained, and minimally invasive dental care emphasized.[1]

Since the 1940s, fluoride has become the most effective and widely used remineralizing agent for preventing caries lesions.[2,3] Regular fluoride administration promotes the formation of a protective layer of fluorapatite, which is more resistant to acid attack and thus strengthens tooth enamel.[4] Fluoride can be administered in various ways: via tap water, fluoridated mineral water, fluoride-enriched toothpaste and specific fluoride supplements. Prolonged and intensive use of fluoride is not recommended, as high levels of exposure carry risks, notably the possibility of fluorosis. This concern has increased interest in alternative, less aggressive, and potentially safer treatments.

The popularity of alternative therapies has grown phenomenally since the 1970s. Despite the significant

*Corresponding author: Amir Shayegan
Email: amir.shayegan@hubruxelles.be

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evolution of so-called conventional Western medicine, many reasons have led people to seek a remedy for their ailments, including homeopathy, phytotherapy, acupuncture, and auriculotherapy. These so-called natural medicines have filled a gap left by modern medicine, which, despite its evolution, needs the holistic approach of traditional Chinese, Indian, and broadly Oriental medicine.[5,6]

Recent studies have highlighted the effectiveness of natural products such as honey,[7] ginger,[8] honey-ginger combinations,[9] turmeric,[10] and dark chocolate.[8] These substances, which are rich in antioxidants and have antibacterial properties, have a dual benefit: they prevent the progression of caries lesions while promoting enamel remineralization.

Urine therapy has been used for thousands of years in ancient cultures such as India, China, and Egypt. Its use is documented in the Indian Damar Tantra and Ayurvedic medicine, underscoring its role in traditional healing practices.[11,12] Despite its ancient practice, modern medicine still explores its effectiveness.

Urine therapy is the practice of using one's urine for medicinal or cosmetic purposes, and it is claimed to detoxify the body, enhance immunity, and improve skin health due to the presence of certain minerals and nutrients in urine. However, scientific evidence supporting these claims is limited and controversial.

In ancient times, urine was considered a precious commodity. Rich in minerals such as phosphorus and potassium, the Romans believed it would whiten their teeth and prevent dental loss. As a result, urine was used as both toothpaste and mouthwash.[13]

Sumac is widely used in Mediterranean and Middle Eastern regions for its culinary and medicinal properties. It has traditionally been used as a spice and contains bioactive compounds such as polyphenols, flavonoids, and tannins, which provide potent antioxidants and antimicrobial effects.[14] Several studies have investigated its potential benefits in oral health.[15,16] Research has shown that sumac extract can significantly reduce the activity of matrix metalloproteinases (MMPs) in demineralized dentin matrix.[14] This reduction in MMP activity could prevent the degradation of dentin collagen, thereby contributing to the preservation of tooth structure and health.

This study investigated the potential remineralizing effect of human urine and sumac. The null hypothesis was that neither human urine nor sumac had a remineralizing effect.

2. Materials and Methods

2.1. Ethics

The study was approved by the Ethics Committee of the Children's Hospital of Queen Fabiola, Free University of Brussels (CEH 62/15).

2.2. Sample preparation

A total of 90 enamel-dentin blocks were prepared from extracted human teeth. Each block measured 3 mm × 4 mm × 2 mm (length × width × depth). The teeth were cleaned, sectioned, and embedded in acrylic resin, exposing the enamel surface. The exposed surfaces were then polished using silicon carbide paper and diamond paste to ensure uniformity.

2.3. Experimental groups

The blocks were randomly divided into nine groups, with ten samples in each group, for treatment with the following substances:

1. Distilled water
2. Fluoride varnish
3. Fluoride toothpaste
4. Human saliva
5. Human urine
6. Dark chocolate
7. Honey
8. Honey and ginger mixture
9. Sumac

The groups and their respective preparations are shown in **Table 1**.

2.4. Treatment protocol

The central enamel area of each sample was demarcated using a pencil line to highlight the region for treatment. This central area was left uncoated to undergo the respective demineralization and remineralization processes. The surrounding enamel was coated with a protective layer of varnish to isolate it from the treatments. This approach was designed to create a partially demineralized enamel surface while facilitating accurate monitoring through photo-induced quantitative fluorescence analysis.

All prepared blocks were stored in distilled water in an incubator at 37°C until the beginning and throughout the entire of the experimental procedures.

Each group was treated with the respective substance under standardized conditions. The blocks were immersed in 10 mL of the assigned solution or substance, ensuring complete surface coverage. The treatments were administered twice daily, and measurements were taken every ten days. The total duration of the remineralization treatment was thirty days.

2.5. Demineralization process

The samples were submerged in a demineralizing solution for seven days at 37°C. The solution was composed of 2.2 mmol/L sodium hydrogen phosphate (Na_2HPO_4), 2.2 mmol/L calcium chloride ($CaCl_2$), and 0.05 M hydrochloric acid (HCl). The pH of the solution was carefully adjusted and maintained at 4.4 using sodium hydroxide (NaOH). After the demineralization period, the samples were thoroughly rinsed with distilled water and stored in fresh distilled water at 37°C until the remineralization phase began.

2.6. Remineralization phase

During the remineralization phase, the samples in each group were treated twice daily using a microbrush for 3 minutes. At the end of ten days, quantitative light-induced fluorescence (QLF) measurements were performed to evaluate the progression of remineralization. The treatment was conducted over one month to allow the effects of remineralization.

2.7. Quantitative photo-induced fluorescence (QLF) test

In this study, the quantitative light-induced fluorescence (QLF) technique was used to assess the mineralization of enamel samples. The demineralization and remineralization processes were monitored using the QLF system (Inspektor Research Systems BV, Amsterdam, Netherlands), which captures images by detecting the natural fluorescence of tooth tissue. These images were analyzed to determine the area of lesions (in mm^2) and the depth of demineralization, indicated by the percentage of fluorescence loss (ΔF in %). The lesion depth was quantified as the fluorescence loss, where a more negative value of ΔF represents a greater extent of demineralization.

The mineralization of the samples was assessed at three different time points:

1. Before demineralization: PD (T=0)
2. After demineralization: DEM (T=1)
3. After remineralization: REM (T=2,3,4)

2.8. Scanning electron microscopic (SEM) analysis

For SEM analysis, two representative enamel-dentin blocks were selected from each experimental group. The samples were analyzed under different conditions: untreated, after demineralization, and following treatment in each of the nine groups. The specimens were dehydrated in acetone for 2 minutes, mounted on aluminum stubs, dried under vacuum conditions, and coated with a 20 μm platinum layer. Scanning electron microscopy (Quanta 200; FEI Company, Hillsboro, OR, USA) was used to examine surface changes and evaluate the effects of the treatments on enamel and dentin structures (**Figure 1**).

2.9. Statistical analysis

Data were recorded in an Excel spreadsheet and analyzed using descriptive statistics to summarize the mean fluorescence loss (ΔF) at five-time points: baseline (T0) and post-exposure (T1, T2, T3, T4) for each group. The normality of data was assessed using the Shapiro-Wilk test. For normally distributed data, a paired t-test was performed to compare the values at T0 with those at T1, T2, T3, and T4 within each group. One-way ANOVA was used to compare multiple groups at different time points, followed by Tukey's post hoc test for pairwise comparisons. A Kruskal-Wallis test was used for pairwise comparisons of non-normally distributed data.

Differences between multiple time points were evaluated using the Friedman test, a nonparametric alternative to repeated-measures ANOVA. Dunn's post hoc test was used for pairwise comparisons when significant differences were found. All statistical analyses were performed using GraphPad Prism version 10.1.4 (GraphPad Software, Inc., La Jolla, CA, USA), with statistical significance set at $p < 0.05$.

3. Results

All the results are presented in **Table 2** and **Figure 2** and **Figure 3**. **Table 2** provides a comprehensive overview of the data. At the same time, **Figure 2** and **Figure 3** visually illustrate the comparisons and changes across the different groups at each stage of the experiment, including before demineralization (T0), after demineralization (T1), and after remineralization (T2, T3, T4).

3.1. dH_2O group

The dH_2O group showed significant demineralization from baseline (T0) to T1, with fluorescence decreasing from -2.00 to -8.28 ($p < 0.0001$). This decrease continued at T2 (-8.71), T3 (-10.39), and T4 (-13.51), demonstrating continued demineralization. No significant remineralization occurred at any time point ($p > 0.05$), with T4 showing the most substantial decrease ($p = 0.0281$).

3.2. Fluoride varnish group

Fluoride varnish group showed a significant demineralization at T1 (-9.65). However, notable remineralization was observed at T2 (-6.14), T3 (-3.83), and T4 (-3.24), with T4 showing the greatest recovery ($p = 0.0061$), indicating that fluoride varnish significantly promoted remineralization.

3.3. Fluoride toothpaste group

Significant demineralization was observed in the fluoride toothpaste group between T0 (-3.79) and T1 (-12.70). Subsequent measurements at T2 (-8.80), T3 (-8.50), and T4 (-8.00) revealed statistically significant remineralization ($p < 0.0001$), with consistent recovery across all post-demineralization time points.

3.4. Human saliva group

Human saliva group showed a significant demineralization at T1 (-7.47), followed by substantial remineralization at T2 (0.53) and continued recovery at T3 (0.00), where no further significant changes occurred ($p < 0.0001$). The saliva treatment showed the most significant remineralization by T3, which was sustained at T4.

3.5. Human urine group

At T1, significant demineralization was observed in the human urine group (-7.32), reflecting the effect of the initial acid challenge prior to treatment. Fluorescence values progressively increased at T2 (-4.21) and T3 (-1.78), indicating partial remineralization. By T4 (-1.32), statistically significant remineralization was achieved ($p = 0.0001$), suggesting that human urine may exert a remineralizing effect on enamel under experimental conditions.

3.6. Dark chocolate group

In the dark chocolate group, a significant decrease in fluorescence was observed from T0 (-0.58) to T1 (-5.72, $p < 0.0001$). Fluorescence values continued to decrease at T2 (-10.06), but a slight recovery was noted at T3 (-9.62) and T4 (-8.27). The group showed a small but significant remineralization effect at T4 ($p < 0.0001$).

3.7. Honey group

At T1, significant demineralization was observed in the group designated for honey treatment (-7.90), corresponding to the effect of the initial acid challenge prior to product application. Fluorescence values continued to decline at T2 (-10.48), T3 (-12.49), and T4 (-14.95), with no significant remineralization detected throughout the observation period ($p > 0.05$), indicating that honey exerted little to no remineralizing effect on enamel.

3.8. Honey & ginger group

The Honey & Ginger group demonstrated significant demineralization at T1 (-8.22). Fluorescence decreased at T2 (-9.39) and T3 (-10.85), with a further drop at T4 (-14.86). No significant remineralization was observed at T3 or T4 ($p = 0.0277$), indicating limited remineralization in this group.

3.9. Sumac group

At T1, significant demineralization was observed in the Sumac group (-2.23) before treatment application. Fluorescence values continued to decline at T2 (-5.98) and T3 (-6.53), suggesting a limited remineralizing potential of sumac under the tested conditions. However, no significant remineralization was observed by T4 (-7.23) ($p = 0.2028$). The results suggest limited remineralization in this group.

Statistical analysis confirmed that demineralization occurred significantly in all groups after T1. The most significant remineralization was observed in the Fluoride varnish, Human saliva, Fluoride toothpaste and Human urine groups. On the other hand, Honey, Honey & ginger, sumac and dH_2O groups exhibited minimal or no remineralization after one month.

Table 1: Preparation and composition of treatment groups

Group Number	Group Name	Source/Composition	Preparation Method
1	Control Group	Distilled water	No preparation needed
2	Fluoride Varnish Group	Enamelast®, Sodium fluoride 5% (22.500ppm), Xylitol	No preparation needed
3	Fluoride Toothpaste	Elmex® Anti-carie Original Sodium Fluoride (1400 ppm fluoride), Aqua, Silica, Sorbitol, Cellulose Gum, Sodium Lauryl Sulfate, Xanthan Gum, Flavor, Limonene, Sodium Saccharin	No preparation needed
4	Human Saliva	From author	No preparation needed
5	Human Urine	From author	No preparation needed
6	Dark Chocolate	Ethiquable-Nicaragua 98% Dark Chocolate	The dark chocolate (10mg) was melted in a microwave (800Hz) for 1 minute. The melted chocolate was applied to the enamel surface using a microbrush.
7	Honey	Meli-miel (Acacia honey)	No preparation needed
8	Honey + Ginger	Meli-miel (Acacia honey) + Ginger powder (Ducros)	A 50-50 mixture of honey and ginger
9	Sumac	Lebanese Sumac (Rhus Coraria, from the garden)	The sumac was prepared as an aqueous suspension at a concentration of [10mg/mL]

Table 2: Descriptive statistics and normality test results for each time point

Group	Time	Mean	±SD	SEM	P value normality
dH_20	T0	-2.00	3.22	1.02	<0.0001
	T1	-8.28	2.26	0.71	0.3041
	T2	-8.71	2.59	0.81	0.3330
	T3	-10.39	1.89	0.60	0.8218
	T4	-13.51	3.97	1.25	0.0281
Fluoride varnish	T0	-4.60	4.66	1.47	0.0959
	T1	-9.65	3.78	1.19	0.3355
	T2	-6.14	2.54	0.80	0.0530
	T3	-3.83	3.36	1.06	0.0070
	T4	-3.24	3.49	1.10	0.0061
Fluoride toothpaste	T0	-3.79	3.35	1.06	0.0121
	T1	-12.70	4.79	1.51	0.1853
	T2	-8.80	3.89	1.23	0.0001
	T3	-8.50	3.60	1.13	0.0001
	T4	-8.00	3.47	1.09	0.0001
Human saliva	T0	-1.63	3.50	1.10	<0.0001
	T1	-7.47	4.31	1.36	0.0199
	T2	-2.26	3.74	1.18	0.0020
	T3	0.53	1.67	0.53	0.0001
	T4	0.00	0.00	0.00	0.0001
Human urine	T0	-1.73	2.79	0.88	<0.0001
	T1	-7.32	9.42	2.97	0.0172
	T2	-4.21	6.12	1.93	0.0025
	T3	-1.78	3.23	1.02	0.0001
	T4	-1.32	2.29	0.72	0.0001
Dark chocolate	T0	-0.58	1.83	0.58	<0.0001
	T1	-5.72	2.21	0.70	0.0080
	T2	-10.06	2.83	0.89	0.4745
	T3	-9.62	1.73	0.54	0.0448
	T4	-8.27	6.14	1.94	<0.0001
Honey	T0	-3.26	3.49	1.10	0.0042
	T1	-7.90	1.80	0.57	0.2655
	T2	-10.48	2.68	0.84	0.3495
	T3	-12.49	2.53	0.80	0.0918
	T4	-14.95	2.34	0.73	0.0915
Honey & ginger	T0	-6.84	3.48	1.09	0.0462
	T1	-8.22	3.55	1.12	0.0021
	T2	-9.39	2.54	0.80	0.9832
	T3	-10.85	1.62	0.51	0.8984
	T4	-14.86	4.71	1.49	0.0277
Sumac	T0	-0.60	1.89	0.60	<0.0001
	T1	-2.23	3.61	1.14	0.0001
	T2	-5.98	4.26	1.35	0.0065
	T3	-6.53	3.73	1.18	0.0290
	T4	-7.23	4.31	1.36	0.2028

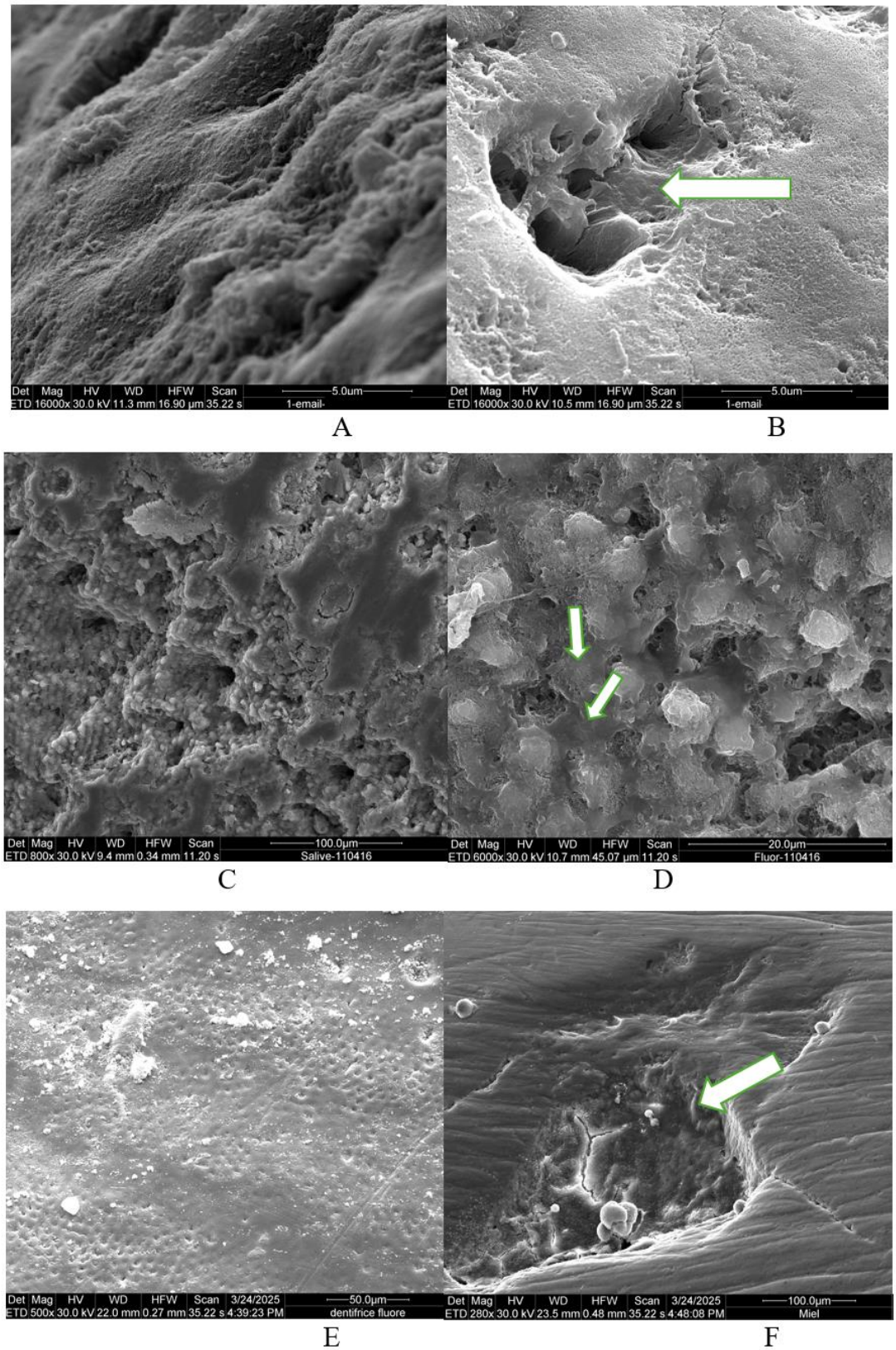

Figure 1: A): Untreated tooth (control), **B)**: Tooth after demineralization; arrow indicates collapsed enamel prisms in demineralized zone, **C):** Human saliva, **D)**: Fluoride varnish; arrows show varnish incorporation into the enamel structure, **E)**: Fluoride toothpaste, **F)**: Honey treatment after 30 days; arrow indicates persistent demineralized area

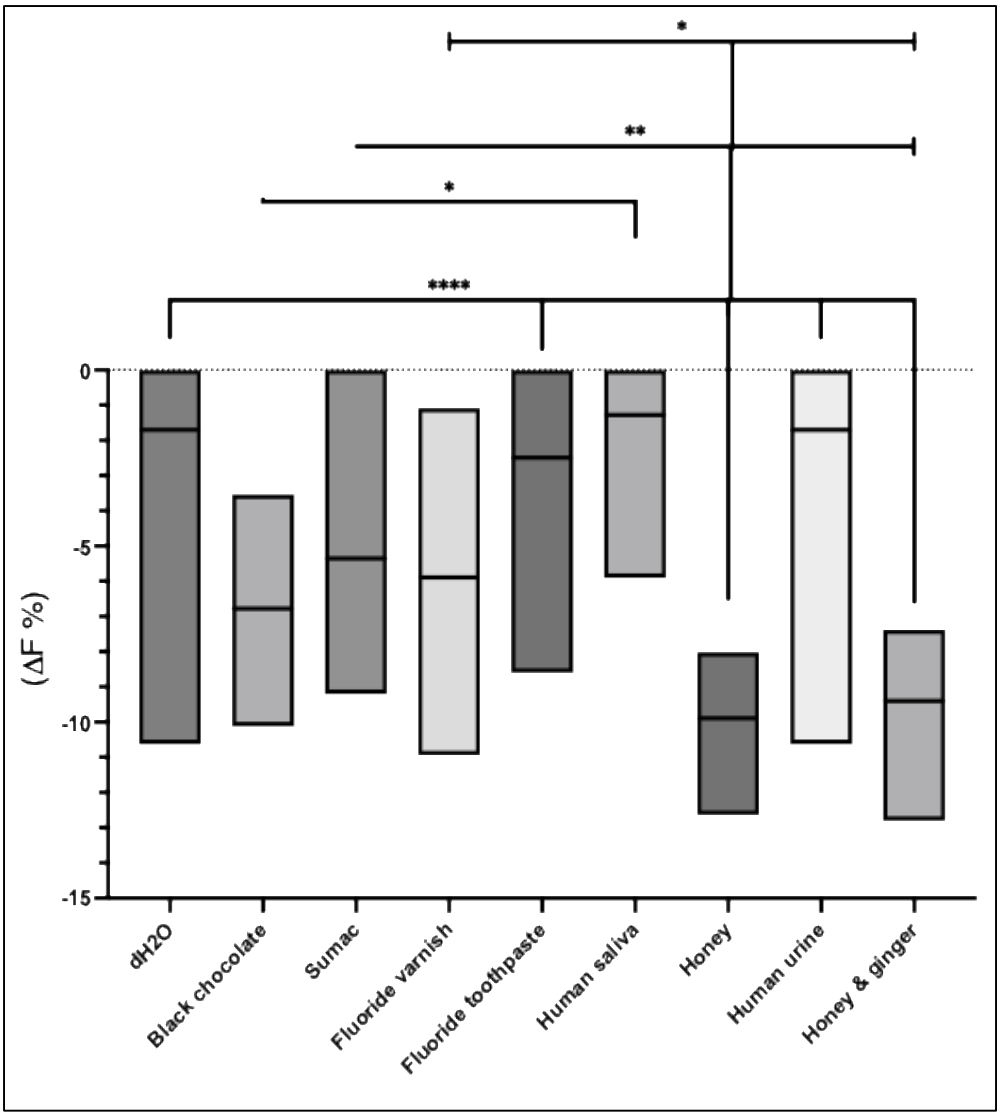

Figure 2: Comparison of demineralization and remineralization effects across the nine groups

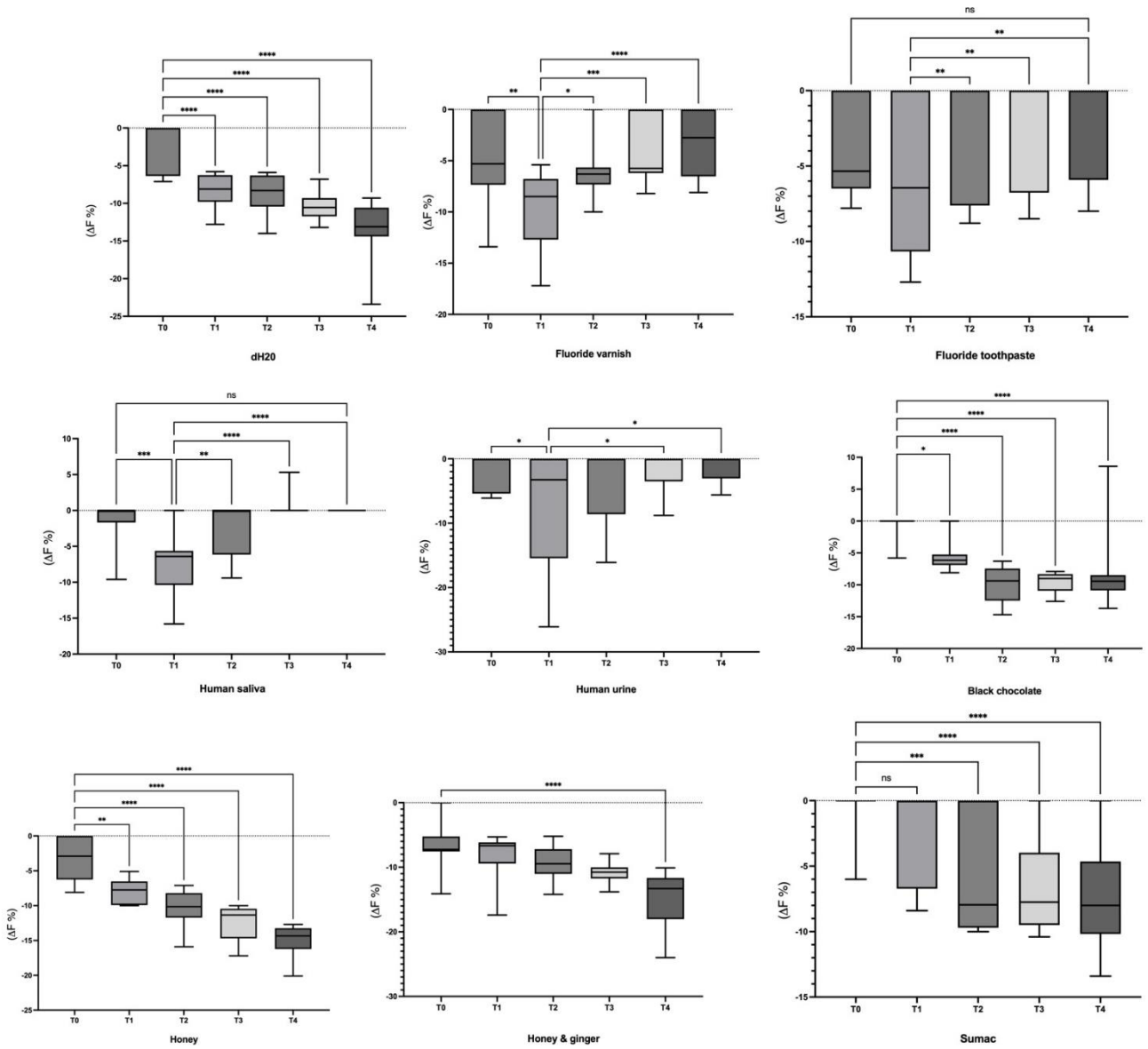

Figure 3: The results were presented for each group before demineralization (T0), after demineralization (T1) and after remineralization (T2, T3, T4)

4. Discussion

The first steps in dental care are educating patients about good oral hygiene and encouraging regular dental visits at least once a year. Today's dentistry focuses on a minimally invasive approach to preserve the integrity of dental tissues. This philosophy emphasizes prevention and early intervention, aiming to treat dental problems in their early stages to avoid more extensive procedures. By prioritizing patient education and conservative treatments, dental professionals strive to promote long-term oral health and reduce the need for invasive procedures.

Beyond traditional prevention, advances in dental research have introduced innovative remineralization techniques that offer non-invasive solutions to strengthen enamel and halt lesion progression. Fluoride-based products, bioactive materials, and novel remineralizing agents provide practical strategies to restore lost minerals and increase tooth resistance.[17-19]

This study aimed to evaluate the remineralization potential of various substances following induced demineralization on enamel-dentin blocks. However, the extent of remineralization varied depending on the treatment applied. The authors chose to apply the remineralizing agent of each group twice a day, in the morning and evening, to match the typical frequency of daily brushing.

Fluoride is widely acknowledged as the most effective remineralizing agent and is often considered the "gold standard" in dental research. Its well-documented efficacy makes it a valuable reference point for evaluating the remineralization potential of other materials.[1,20] In this study, samples treated with Enamelast fluoride varnish containing 5% sodium fluoride (22,600 ppm) were used as the positive

control group. This varnish is frequently applied in clinical settings to manage dental sensitivity and enhance caries prevention.

The results of our study showed that fluoride-based treatments, such as fluoride varnish and toothpaste, exhibited substantial remineralization effects. Fluoride's ability to enhance enamel resistance to demineralization and facilitate remineralization through the formation of fluorapatite is well established. These results reinforce the effectiveness of fluoride in dental treatments and its importance in preventive oral health care.

Human saliva showed the most significant overall recovery among the tested treatments, underscoring its natural remineralization potential. Saliva contains essential ions, such as calcium and phosphate, and proteins that actively contribute to enamel repair and the formation of a protective layer on the tooth surface.[21] This finding aligns with previous research, which consistently supports the critical role of saliva in maintaining enamel integrity and counteracting acid-induced damage. Furthermore, the buffering capacity of saliva helps neutralize acidic environments in the oral cavity, thereby reducing the risk of demineralization and promoting a balanced pH level. These properties make saliva a vital biological fluid in preventing dental caries and promoting long-term oral health.

Interestingly, human urine also showed a significant remineralizing effect, suggesting the potential presence of mineralizing agents capable of supporting enamel recovery. While the mechanisms underlying this effect require further investigation, this finding opens opportunities to explore alternative remineralizing solutions in dental research. The remineralizing effect of urine can be explained by the presence of mineral and chemical components that may play a role in tooth enamel repair. Urine contains essential ions such as calcium, phosphate, and magnesium, which are known to be involved in remineralization processes.[22] In addition, the ammonia present in urine, due to its alkaline nature, could help neutralize acids in the oral cavity, thereby reducing enamel demineralization and promoting an environment conducive to tooth repair.[23] The exact mechanisms behind this effect remain to be elucidated. Proteins or other organic molecules in urine may interact with the enamel surface to facilitate the incorporation of minerals into tooth structure. Further research is needed to identify and isolate these potential agents and understand their action mechanisms.

However, urine composition is not constant and varies depending on factors such as diet or underlying medical conditions, which could influence its remineralizing potential.[24]

Historically, urine has been used as a dental cleaning agent in ancient cultures, particularly in Roman times, due to its ammonia content, which may have contributed to oral hygiene. Brushing teeth with urine is a common practice among urine therapists. However, caution must be exercised due to the potential risk of infection or underlying medical conditions that may be contraindications to its use. Further studies are needed to assess the safety and efficacy of this practice in a modern dental context.

Today, however, perceptions, often shaped by religious and cultural beliefs, consider urine to be impure and unsuitable for such applications, creating a significant psychological and societal barrier to its potential use in contemporary dentistry.

Our results indicated that dark chocolate exhibited a demineralizing effect on enamel over time. This does not align with previous studies suggesting that theobromine, a compound found in cocoa, can enhance enamel microhardness. A systematic review and meta-analysis reported that theobromine's efficacy in remineralizing white spot lesions is comparable to that of fluoride treatments.[25] Additionally, research has demonstrated that dark chocolate concentrations positively impact enamel and dentine microhardness.[26]

The dark chocolate did not demonstrate a significant remineralizing effect after enamel demineralization. Following acid exposure (T1), the enamel showed a marked loss of mineral content, and despite the repeated application of dark chocolate (T2, T3, T4), no substantial recovery was observed. These findings contrast with previous in vitro studies, which have suggested that theobromine, a key compound in cocoa, may enhance enamel microhardness by promoting apatite crystallization.[26,27] One study on enamel blocks reported increased mineral content following theobromine treatment, indicating a potential remineralizing effect.[28] However, our results did not support this, suggesting that dark chocolate in its natural form may not provide sufficient bioavailable theobromine or other active compounds necessary for enamel repair. The discrepancy between studies may be attributed to differences in experimental conditions, including exposure time, the formulation of the applied product, or the measurement method. Further research is needed to determine whether isolated theobromine, rather than whole dark chocolate, could offer a more effective remineralizing effect under similar in vitro conditions.

Honey did not exhibit a remineralizing effect; instead, the results indicate a continuous progression of demineralization over time. After the initial demineralization step (T1), the enamel lost mineral content despite the repeated application of honey (T2, T3, T4). These findings suggest that honey may have contributed to an acidic environment rather than promoting remineralization or provided fermentable sugars that facilitated further mineral loss. While some studies have suggested honey's potential antibacterial and protective effects,[29,30] its impact on enamel may depend on its specific composition, pH, and interaction

with oral biofilms, which were not present in this in vitro model. In vivo conditions, honey can contribute to dental caries, particularly when misused, such as when parents apply it to a pacifier or bottle nipple to soothe infants. This practice exposes developing teeth to prolonged sugar contact, increasing the risk of early childhood caries.

Similarly, the honey and ginger combination did not prevent demineralization. Instead, the fluorescence values declined over time, indicating ongoing mineral loss. Although ginger is known for its antioxidant and antimicrobial properties,[31] its combination with honey did not appear to counteract the demineralizing effects observed in this study. These results suggest that in an in vitro environment without protective factors such as saliva or fluoride, applying honey-based substances may not benefit enamel integrity and could accelerate mineral loss.

The demineralization process continued progressing in the control group (distilled water), as indicated by the decreased fluorescence values from T1 to T4. After the initial acid challenge (T1), mineral loss persisted despite exposure to dH_2O. These findings indicate that in the absence of remineralizing agents such as fluoride or calcium-phosphate-based compounds, an aqueous environment alone cannot promote enamel recovery. The persistent demineralization observed in the control group aligns with previous reports demonstrating that water exposure, under in vitro conditions, lacks protective and reparative effects on enamel.[32,33] Moreover, it is important to consider that deionized water (dH_2O) is slightly acidic, with a pH ranging from 5.6 to 5.8, which may further contribute to enamel demineralization without buffering systems or remineralizing elements.

Sumac showed a slower progression of demineralization over time, suggesting that it may have exerted a protective effect on enamel. Although mineral loss was still observed, the fluorescence values declined less steeply compared to the initial acid challenge, indicating that sumac may have influenced the enamel surface in a way that reduced further demineralization. This effect could be attributed to its high polyphenol and flavonoid content, which have been associated with potential enamel-stabilizing properties. Some studies have suggested that polyphenols interact with hydroxyapatite, potentially influencing enamel solubility and modifying mineral dissolution dynamics.

While sumac also contains organic acids, which are typically associated with enamel demineralization, tannins, and polyphenols may have played a role in mitigating mineral loss.[34] Tannins, in particular, have an astringent effect and may interact with proteins or minerals on the enamel surface, potentially forming a protective layer that slows acid diffusion.[35] However, the exact mechanism by which sumac affects enamel remains unclear. Although it appeared to slow down the rate of demineralization, it did not exhibit an apparent remineralizing effect under these in vitro conditions. Further research is needed to determine whether sumac's components influence enamel stability through surface interactions, pH modulation, or other mechanisms and whether its potential benefits could be enhanced when combined with known remineralizing agents.

Although this study provides valuable insights into the remineralization potential of various agents, some limitations should be acknowledged. The experimental conditions may not fully replicate the complex oral environment, where factors such as pH fluctuations, bacterial activity, and dietary habits influence demineralization and remineralization processes. Additionally, long-term effects of these substances on enamel integrity require further investigation through extended clinical studies.

In conclusion, human saliva emerged as the most effective natural remineralizing agent, followed by fluoride-based treatments and human urine. These findings reinforce the established benefits of fluoride in enamel repair and highlight the potential of alternative natural solutions for dental remineralization. Future research should explore the underlying mechanisms of these effects and evaluate their clinical applications in preventing and treating enamel demineralization.

5. Conclusion

However, while remineralizing agents can help restore lost minerals to some extent, the best approach to maintaining healthy teeth remains patient education on proper oral hygiene. Encouraging good oral care practices, such as regular brushing with fluoride toothpaste, flossing, and reducing the consumption of acidic and sugary foods, is essential to preventing demineralization and promoting long-term dental health.

6. Source of Funding

None.

7. Conflicts of Interest

The authors declare no conflicts of interest related to this study.

References

1. Monjarás-Ávila AJ, Hardan L, Cuevas-Suárez CE, Zavala Alonso NV, Fernández-Barrera MA, Moussa C, et al. Systematic review and meta-analysis of remineralizing agents: outcomes on white spot lesions. *Bioengineering (Basel).* 2025;12(1):93. https://doi.org/10.3390/bioengineering12010093.
2. Roberts WE, Mangum JE, Schneider PM. Pathophysiology of demineralization, part II: enamel white spots, cavitated caries, and bone infection. *Curr Osteoporos Rep.* 2022;20(1):106–19. https://doi.org/10.1007/s11914-022-00723-0.
3. Mazzoleni S, Gargani A, Parcianello RG, Pezzato L, Bertolini R, Zuccon A, et al. Protection against dental erosion and the remineralization capacity of non-fluoride toothpaste, fluoride toothpaste and fluoride varnish. *Appl Sci.* 2023;13(3):1849. https://doi.org/10.3390/app13031849.
4. Kim MJ, Lee MJ, Kim KM, Yang SY, Seo JY, Choi S-H, et al. Enamel demineralization resistance and remineralization by various

fluoride-releasing dental restorative materials. *Materials (Basel).* 2021;14(16):4554. https://doi.org/10.3390/ma14164554.
5. Janakiram C, Venkitachalam R, Fontelo P, Iafolla TJ, Dye BA. Effectiveness of herbal oral care products in reducing dental plaque & gingivitis - a systematic review and meta-analysis. *BMC Complement Med Ther.* 2020;20(1):43. https://doi.org/10.1186/s12906-020-2812-1.
6. Saikia A, Sivasubramanian A, Muthu MS, Ganesh A, Chandrasekaran K, Kirubakaran R. Herbal dentifrices for prevention of dental caries in children and adolescents: a systematic review. *Int J Clin Pediatr Dent.* 2024;17(2):229–36. https://doi.org/10.5005/jp-journals-10005-2780.
7. Cherian TS, Subramaniam P, Gupta M. Erosive effect of milk, honey, cereal porridge, and millet porridge on enamel of primary teeth: an in vitro study. *Indian J Dent Res*. 2020;31(1):129–33. https://doi.org/10.4103/ijdr.IJDR_224_18.
8. Çelik ZC, Yavlal GO, Yanıkoğlu F, Kargul B, Tagtekin D, Stookey GK, et al. Do ginger extract, natural honey and bitter chocolate remineralize enamel surface as fluoride toothpastes? An in-vitro study. *Niger J Clin Pract.* 2021;24(9):1283–8. https://doi.org/10.4103/njcp.njcp_683_20.
9. Kade KK, Chaudhary S, Shah R, Patil S, Patel A, Kamble A. Comparative evaluation of the remineralization potential of fluoride-containing toothpaste, honey ginger paste and ozone: an in vitro study. *Int J Clin Pediatr Dent.* 2022;15(5):541–8. https://doi.org/10.5005/jp-journals-10005-2445.
10. Shayegan A, Arab S, Makanz VM, Safavi N. Comparative evaluation of remineralizing efficacy of calcium sodium phosphosilicate, ginger, turmeric, and fluoride. *Dent Res J (Isfahan).* 2024;21:55.
11. Hörl WH. The medicinal use of urine. *Am J Nephrol.* 1999;19(2):111–3. https://doi.org/10.1159/000013436.
12. Savica V, Calò LA, Santoro D, Monardo P, Mallamace A, Bellinghieri G. Urine therapy through the centuries. *J Nephrol.* 2011;24 Suppl 17:S123–5. https://doi.org/10.5301/JN.2011.6463.
13. Lentini R. Tooth pastes and oral hygiene in the Roman world. Med Secoli. 1995;7:351-65.
14. Alsamri H, Athamneh K, Pintus G, Eid AH, Iratni R. Pharmacological and antioxidant activities of Rhus coriaria L. (Sumac). *Antioxidants (Basel).* 2021;10(1):73. https://doi.org/10.3390/antiox10010073.
15. Salman BN, Gheidari MM, Nejad AY, Zeighami H, Mohammadi A, Shabestari SB. Antimicrobial activity of silver nanoparticles synthesized by the green method using Rhus coriaria L. extract against oral pathogenic microorganisms. *Med J Islam Repub Iran.* 2022;36:154. https://doi.org/10.47176/mjiri.36.154.
16. Kacergius T, Abu-Lafi S, Kirkliauskiene A, Gabe V, Adawi A, Rayan M, et al. Inhibitory capacity of Rhus coriaria L. extract and its major component methyl gallate on Streptococcus mutans biofilm formation by optical profilometry: potential applications for oral health. *Mol Med Rep.* 2017;16(1):949–56. https://doi.org/10.3892/mmr.2017.6674.
17. Walsh T, Worthington HV, Glenny A-M, Marinho VC, Jeroncic A. Fluoride toothpastes of different concentrations for preventing dental caries. *Cochrane Database Syst Rev.* 2019;3(3):CD007868. https://doi.org/10.1002/14651858.CD007868.pub3.
18. Hsu SM, Alsafadi M, Vasconez C, Fares C, Craciun V, O'Neill E, et al. Qualitative analysis of remineralization capabilities of bioactive glass (NovaMin) and fluoride on hydroxyapatite (HA) discs: an in vitro study. *Materials (Basel).* 2021;14(14):3813. https://doi.org/10.3390/ma14143813.
19. Wang X, Megert B, Hellwig E, Neuhaus KW, Lussi A. Preventing erosion with novel agents. *J Dent.* 2011;39(2):163–70. https://doi.org/10.1016/j.jdent.2010.11.007.
20. Creeth J, Smith G, Franks B, Hara A, Zero D. Remineralisation of enamel erosive lesions by daily-use fluoride treatments: network meta-analysis of an in situ study set. *Clin Oral Investig.* 2024;29(1):28. https://doi.org/10.1007/s00784-024-06107-1.
21. Farooq I, Bugshan A. The role of salivary contents and modern technologies in the remineralization of dental enamel: a narrative review. *F1000R*es. 2020;9:171. https://doi.org/10.12688/f1000research.22499.3.
22. Hesse A, Classen A, Knoll M, Timmermann F, Vahlensieck W. Dependence of urine composition on the age and sex of healthy subjects. *Clin Chim Acta*. 1986;160(2):79–86. https://doi.org/10.1016/0009-8981(86)90126-9.
23. McNabb FM, McNabb RA. Proportions of ammonia, urea, urate and total nitrogen in avian urine and quantitative methods for their analysis on a single urine sample. *Poult Sci*. 1975;54(5):1498–505. https://doi.org/10.3382/ps.0541498.
24. Alwis US, Haddad R, Monaghan TF, Abrams P, Dmochowski R, Bower W, et al. Impact of food and drinks on urine production: a systematic review. *Int J Clin Pract.* 2020;74(9):e13539. https://doi.org/10.1111/ijcp.13539.
25. da Silva A, Gonçalves RD, Catão MHdV. Theobromine for remineralization of white spot lesions on dental enamel: a systematic review and meta-analysis. *Oper Dent*. 2024;49(4):376–87. https://doi.org/10.2341/23-153-LIT.
26. Kargul B, Özcan M, Peker S, Nakamoto T, Simmons WB, Falster AU. Evaluation of human enamel surfaces treated with theobromine: a pilot study. *Oral Health Prev Dent*. 2012;10(3):275–82.
27. Farooq I, Khan AS, Moheet IA, Alshwaimi E. Preparation of a toothpaste containing theobromine and fluoridated bioactive glass and its effect on surface micro-hardness and roughness of enamel. *Dent Mater J*. 2021;40(2):393–8. https://doi.org/10.4012/dmj.2020-078.
28. Hamasaeed NH, Toma IS, Abdullah AO, Kadir SK. Assessing the impact of varied dark chocolate concentrations on enamel and dentine microhardness. *Appl Sci.* 2024;14(1):382. https://doi.org/10.3390/app14010382.
29. Brudzynski K, Sjaarda CP. Colloidal structure of honey and its influence on antibacterial activity. *Compr Rev Food Sci Food Saf.* 2021;20(2):2063–80. https://doi.org/10.1111/1541-4337.12720.
30. Boekema BKL, Chrysostomou D, Ciprandi G, Elgersma A, Vlig M, Pokorná A, et al. Comparing the antibacterial and healing properties of medical-grade honey and silver-based wound care products in burns. *Burns.* 2024;50(3):597–610. https://doi.org/10.1016/j.burns.2023.10.009.
31. Mathai K, Anand S, Aravind A, Dinatius P, Krishnan AV, Mathai M. Antimicrobial effect of ginger, garlic, honey, and lemon extracts on Streptococcus mutans. *J Contemp Dent Pract.* 2017;18(11):1004–8. https://doi.org/10.5005/jp-journals-10024-2165.
32. Carey CM. Remineralization of early enamel lesions with apatite-forming salt. *Dent J (Basel).* 2023;11(8):182. https://doi.org/10.3390/dj11080182.
33. Ghisi AC, Kopper PMP, Baldasso FER, Stürmer CP, Rossi-Fedele G, Steier L, et al. Effect of superoxidized water and sodium hypochlorite, associated or not with EDTA, on organic and inorganic components of bovine root dentin. *J Endod*. 2015;41(6):925–30. https://doi.org/10.1016/j.joen.2015.01.039.
34. Batiha GE-S, Ogunyemi OM, Shaheen HM, Kutu FR, Olaiya CO, Sabatier J-M, et al. Rhus coriaria L. (Sumac), a versatile and resourceful food spice with cornucopia of polyphenols. *Molecules.* 2022;27(16):5179. https://doi.org/10.3390/molecules27165179.
35. Hertel S, Pötschke S, Basche S, Delius J, Hoth-Hannig W, Hannig M, et al. Effect of tannic acid on the protective properties of the in situ formed pellicle. *Caries Res.* 2017;51(1):34–45. https://doi.org/10.1159/000451036.

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