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Effect of Different Natural Herbal Products on Roughness of Eroded Enamel Surface (An in Vitro Study)

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Abstract

Aims: The current study aimed to evaluate and compare the effects of the herbal medicaments (Neem, Ginger, Green tea, Clove oil, and peppermint oil) and traditional fluoride gel on the surface roughness of the eroded enamel samples of permanent teeth in vitro study. **Materials and methods:** A total of (80) sound maxillary permanent first premolars were used in the study. Enamel blocks were prepared and divided into eight groups: Negative control group (C-ve) (n=10) not exposed to Pepsi drink. The remaining samples exposed to Pepsi drink then subdivided into (7) subgroups: Positive control group (C+ve) (Pepsi group), the remaining groups representing different experimental remineralizing agents used as follows: Group 3 (NaF gel), Group 4 (Neem), Group 5 (Ginger+ Manuka honey), Group 6 (Green tea), group 7 (Clove oil) and group 8 (Peppermint oil). The Roughness of enamel surface blocks was measured before and after the PH cycle by using a measurement machine. **Results:** The surface roughness of all study groups was increased after eroding by Pepsi drink due to the demineralization, then decreased after treatment with remineralizing agents but the highest decrease of the surface roughness measurements belonged to the NaF group followed by Neem and Ginger +manuka honey groups, while the control negative group of deionized water which not exposed to Pepsi drink had no change in the surface roughness measurements. **Conclusions:** NaF gel group was significantly better than other groups against demineralization and preserving enamel roughness.

الخلاصة

الاهداف: ان الهدف من الدراسة هو لتقييم ومقارنة تاثير المواد العشبية (النيم , الزنجبيل , الشاي الاخضر, زيت النعناع, زيت القرنفل) و الفلورايد جيل على خشونة سطح مينا الاسنان الدائمية مختبريا. **المواد و طرائق العمل:** تم الاختبار باستخدام (80) عينة من الاسنان الضواحك العلوية الدائمية السليمة والتي قلعت لاسباب التقويم , تم تحضير عينات اسطح المينا وتقسيمها عشوائيا الى 8 مجاميع: مجموعة السيطرة السالبة متمثلة بالماء منزوع الايونات (10عينات) , مجموعة السيطرة الموجبة متمثلة بالعينات المعرضة للبيبسي فقط (10عينات),مجموعة صوديوم فلورايد جيل (10عينات) ,مجموعة النيم (10عينات), مجموعة الزنجبيل و عسل المانوكا (10عينات) مجموعة زيت القرنفل (10عينات) مجموعة زيت النعناع (10عينات) ومجموعة الشاي الاخضر (10 عينات) ، تم ادخال العينات الى دورة ازالة واعادة المعادن الى السن وقياس خشونة سطح المينا قبل الدورة و بعد ازالة المعادن و بعد اعادة المعادن عن طريق جهاز قياس الخشونة. **النتائج:** كان هناك اختلاف ذات دلالة احصائية عالية في مجموعات الدراسة بعد دورة ازالة و اعادة المعادن الى السن ، وكان هناك زيادة في خشونة الاسطح في جميع المجموعات بعد تعرضها للبيبسي بسبب فقدان العناصر المعدنية و بعد تعرض العينات لمواد اعادة المعادن للسن فان الخشونة قلت ولكن الانخفاض الاعلى كان في مجموعة صوديوم فلورايد جيل ثم النيم ، الزنجبيل وعسل المانوكا ، الجاي الاخضر ، زيت النعناع واخيرا زيت القرنفل. **الاستنتاجات:** من خلال الدراسة تبين ان مجموعة صوديوم فلورايد جيل هي افضل مجموعة في تقليل خشونة سطح المينا للعينات المعرضة لازالة المعادن منها بواسطة البيبسي.

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INTRODUCTION

Dental enamel erosion is a real dental problem associated with the increase in the consumption of soft drinks, fruit juices, and sport drinks in many countries[1]. Carbonated drinks especially cola are associated with erosion and most likely due to their low pH[2].

Dental erosive wear is the chemical dissolution of the dental hard tissues by acids without the involvement of bacteria. Hydrogen ions from acidic solutions can replace the calcium ions of the enamel, consequently breaking the crystal structure of the enamel and initiating dental erosion and this problem lead to severe impairment of esthetics along with loss of hardness and function of teeth [1]

Many preventive measures have been suggested for the control of dental enamel erosion and the use of fluoride is one of them[2]. Fluoride increases the hardness of the tooth surface and decreases the depth of dental erosive lesions [3].

A topical fluorides system can be used to prevent the progression of dental erosion [4]. The fluoride application remains the best method for remineralizing the early enamel demineralization and it has been well documented. Unfortunately, fluoride could not guide the formation of mineral crystals and failed to form oriented and ordered mineral crystals on the enamel surface [5]. Dental fluorosis and skeletal fluorosis in severe cases result from chronic consumption of a high dose of fluoride [6].

In recent years, attention has been focused on the use of natural products (herbal) as they have both advantages of minimal side effects and being sugar and/alcohol-free, which are the two most common ingredients found in over-the-counter products [5,7].

The purpose of the current study was to evaluate and compare the effects of the herbal medicaments (Neem, Ginger, Green tea, Clove oil, and Peppermint oil) and traditional fluoride gel on the surface roughness of the eroded enamel samples of permanent teeth in vitro study.

MATERIALS AND METHODS

Materials:

The study was approved by the Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference No. UoM.Dent/H.L.31/21. Material used in study table (1) and table (2).

Table (1): Tested material used in study.

Materials	Ingredients
Ginger	Rhizomes are carbohydrates (50–70%), lipids (3–8%), phenolic compounds and terpenes. Terpene components of ginger include β-sesquiphellandrene, zingiberene, β-bisabolene, α-farnesene and α-curcumene, while phenolic compounds include gingerol, shogaol and paradols.
Manuka Honey	Caffeic acid, Phenyllactic acid, Kojic acid, Gallic acid, Isoferulic acid, 4Methoxyphenolactic acid, p-Coumaric acid 5-Hydroxymethylfurfural, 4-Hydrobenzoic acid, 2-Methoxybenzoic acid, Syringin acid, Phenylacetic acid, Quercetin, Methyl syringate, Luteolin, Dehydrovomifoliol, 8-Methoxykaempferol, Leptosin, Pinocembrin, Chrysin, Glyoxal, Isorhamnetin, Methylglyoxal (MGO), Kaempferol, 3Deoxyglucosulose, Galangin, Pinobanksin .
Neem oil	Azadirachtin (azadirachtin A-G and azadirachtin E), limonoids, volatile oils, nimbin, nimbidin, nimbinin, nimbolides, meliantriol, gedunin, and mahmoodin, fatty acids (oleic, stearic, and palmitic), and salannin.
Clove oil	Eugenol, eugenol acetate, β-caryophyllene α-humulene and Caryophylene oxide.
Peppermint oil	Menthol and menthone together with limonene several other minor constituents as menthofuran, menthyl acetate, 1,8-cineole, neoisomenthol, viridiflorol, germacrene-D and β-caryophyllene.
Green tea	Protein, Amino acids, Fiber, carbohydrates, Lipids, Pigments, Minerals, Phenolic compounds, Oxidized phenolic compounds and flavonoids (catechins).
Fluoride gel	Water, O- phosphoric acid (<3%), flavors and fragrances, additives, sodium fluoride Free from aspartame, gluten, saccharine and Xylitol.

Table (2): Other Materials used in the Study.

Materials	Composition
Artificial Saliva	NaCl 0.4 mg/L, CaCl2.2H2O 0.79mg/L, KCl 0.4 mg/L, Na2S9H2O 0.005 mg /L, CH4N2O 1.0 g, distilled water 1 L.
Pepsi (Erbil)	Carbonated water, phosphoric acid, sugar, caramel color, natural flavorings and caffeine.

Teeth Samples Collection:

Eighty (80) sound maxillary first premolars were collected from patients aged between (12-18) years extracted for orthodontic treatment from Mosul city.

A tooth with specific criteria: Intact upper first premolar were collected, being free of caries, having no fillings, no developmental anomalies, no enamel hypoplasia, no cracks, wears, or fractures. Also, the enamel surface should be

unaffected by a chemical agent as a bleaching agent or acid etching.

Teeth Samples Preparation:

Before using the teeth, they were cleaned with non-fluoridated pumice and white rubber prophylactic cup using a low-speed handpiece. Then by using a diamond disc bur in the high-speed handpiece the crowns separated from the roots and cooled with water to prevent damaging of enamel and the crown of the teeth collected, figure (1).

Figure (1) : Sound intact teeth sample**.**

All crowns were thoroughly washed with deionized water and kept in a 0.1 % thymol solution in the refrigerator at 4 ºC to maintain the structural integrity of enamel samples until being mounted in a chemical cured resin in plastic rings [8]. Then the crowns were mounted in cylindrical plastic tubes (16 mm diameter ×14 mm depth) with cold cure acrylic resin with the outer buccal enamel surface exposed and polish the teeth specimens by using a fin grit silicon carbide papers 400 and 600 grit to standardize the buccal surface for microhardness test machine [9], figure (2). Lastly, all samples were cleaned with deionized water and kept in a 0.1 % thymol till the beginning of the PH cycle (the erosion in specimens was done by immersing the teeth in Pepsi as a demineralizing agent- PH cycle).

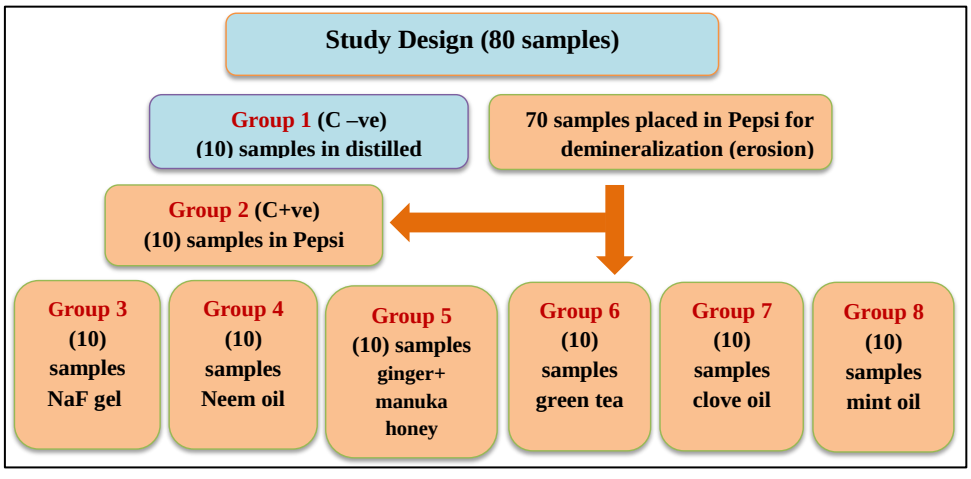

Figure (2): Experimental Design of Study

Experimental Design of Study:

The total number of samples in the main study is (80) samples and randomly divided into 8 groups (10) specimens for each group, figure (3).

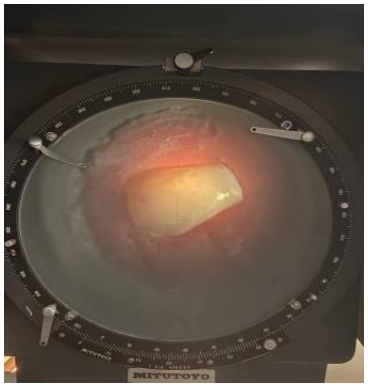

Figure (3): Roughness Profilometer.

1. Control negative group C-ve (Baseline group): ten specimens were placed in distilled water at room temperature throughout the study.

The other specimens were immersed in a beaker filled with 200 ml Pepsi drink at room temperature, which is a demineralizing agent, for 5 minutes, 3 times daily for 6 days. The rate of immersion in Pepsi simulates the rate of acidic drink intake with the daily meals [10]. The Pepsi was changed every day and the specimens were kept in a closed container to complete the demineralization process, after which they were rinsed with distilled water.

2. Control positive group C +ve (Pepsi group): ten of them were taken to represent the (C +ve) group after demineralization by Pepsi drink.

The remaining demineralized specimens were subdivided into six subgroups specimens each representing different remineralizing agents as follows:

3. NaF gel group: Ten of them were brushed with NaF gel for 5 minutes 3 times daily for 6 days by the cotton applicator.

4. Neem group: ten samples brushed with Neem extract oil 10% for 5 minutes 3 times daily for 6 days

5. Ginger+Honey group: The Ginger powder was mixed with Manuka honey (MGO activity of 580) in a ratio of 8mg/ml (w/v) [11]**.**

6. Green tea (Ahmad green tea classic teabag): To prepare green tea, a teabag, was placed in 200 milliliters of boiled distilled water and kept for 5 minutes. The drink was then left to cool until reaching room temperature. After which, the specimens were dipped in a beaker filled with the green tea drink for 5 minutes, 3 times daily for 6 days. They were kept in distilled water between intervals of application.

7. Clove oil group: Oil was applied with an applicator for 5 minutes, 3 times daily for 6 days.

8. Peppermint oil group: Oil will be applied with an applicator, 5 minutes 3 times daily for 6 days.

All materials in the study were prepared newly at each application of remineralization materials. And washed with distilled water perfectly after the end of the time of remineralization cycle and restored in the artificial saliva bath.

Surface Roughness Test:

Using a profile meter (surfatest SJ - 201 p, Mituloyo, Japan) the surface roughness of the enamel surface samples was measured as can be seen in figure (3) with 50x magnification (4). The test was conducted at a technical institute / University of Mosul. Surface roughness was characterized by the arithmetical average of the surface showed minimum and maximum lines drawn at the highest peak and lowest valley found within a central line along the area [12].

Maximum Peak Valley Height (Ry) method of measurement was used as you can see in figure (4) which includes: A section of standard length that was sampled from the mean line on the roughness chart and the distance between the Maximum peak (Rp) and valley (Rv) of the sampled line was measured in the Y direction. The value was expressed in micrometer (μm) [13]

The cut-off value or reference length was adjusted to act at 0.8 mm, three measurements of surface roughness were performed for each sample [14] and the average of these readings was used for the statistical analysis.

Figure (4): Enamel Surface Sample Measured by Using a Profile Projector.

RESULTS

Descriptive statistics of roughness values at baseline, after the demineralization cycle, and after treatment including mean, number, standard deviation, minimum and maximum values are listed in the table (3) for the eight groups.

Table (3): Descriptive Statistics of Roughness Measurements Among Tested Groups at Baseline, After Demineralization and After Remineralization.

Roughness		Mean	N	Std. Deviation	Minimum	Maximum
Control -	Baseline	.5130	10	.10822	.40	.71
	After treatment	.5130	10	.10822	.40	.71
Control +	Baseline	.5440	10	.09107	.41	.70
	After pepsi	1.0230	10	.07056	.91	1.13
	After treatment	1.0230	10	.07056	.91	1.13
Neem	Baseline	.5170	10	.10467	.40	.70
	After pepsi	1.0200	10	.11255	.90	1.18
	After treatment	.6190	10	.06045	.50	.70
Ginger+ Manuka honey	Baseline	.4820	10	.07657	.40	.60
	After pepsi	.9640	10	.06415	.90	1.10
	After treatment	.6240	10	.04971	.52	.70
Green Tea	Baseline	.5570	10	.11046	.40	.64
	After pepsi	.9770	10	.05599	.90	1.09
	After treatment	.8180	10	.06730	.70	.92
NaF	Baseline	.4800	10	.07318	.40	.60
	after pepsi	.9992	10	.09081	.90	1.13
	After treatment	.6140	10	.06484	.50	.70
Clove	Baseline	.4870	10	.09381	.40	.70
	After pepsi	1.0490	10	.08913	.94	1.17
	After treatment	.9220	10	.03736	.85	.97
Mint	Baseline	.5300	10	.11225	.40	.71
	After pepsi	1.0140	10	.07763	.91	1.11
	After treatment	.8980	10	.05308	.81	.97
Total						

Statistical analysis reveals that the mean roughness values of enamel specimens in all groups increased compared with the baseline values after the demineralization cycle, the roughness of all groups then decreased after treatment protocol compared to the mean roughness values measured after demineralization.

Based on the means values for the tested groups after treatment, Control –ve group, NaF gel group, Neem oil group then Ginger+Manuka honey group had a minimum increase in the roughness of enamel surface. The Green tea group, Peppermint group, and Clove oil group had the maximum increase in surface roughness.

Control +ve group remains high roughness mean value because no remineralization agent applied this group undergo demineralization cycle only.

Table (4) ANOVA test explaining that there was no significant difference for the surface roughness readings existed at $p \leq 0.05$ among tested groups at baseline and after demineralization while there was

a significant difference among tested groups at $p \leq 0.05$ after treatment.

Table (4): Analysis of Variance (ANOVA) Test of Mean Roughness Values for Comparison between the Eight Groups at Every Stage.

Roughness		Sum of Squares	df	Mean Square	F	Sig.
Baseline	Between Groups	.059	7	.008	.893	.516
	Within Groups	.682	72	.009		
	Total	.741	79			
After pepsi	Between Groups	.050	6	.008	1.250	.294
	Within Groups	.424	63	.007		
	Total	.474	69			
After treatment	Between Groups	2.382	7	.340	76.127	.000
	Within Groups	.322	72	.004		
	Total	2.704	79			

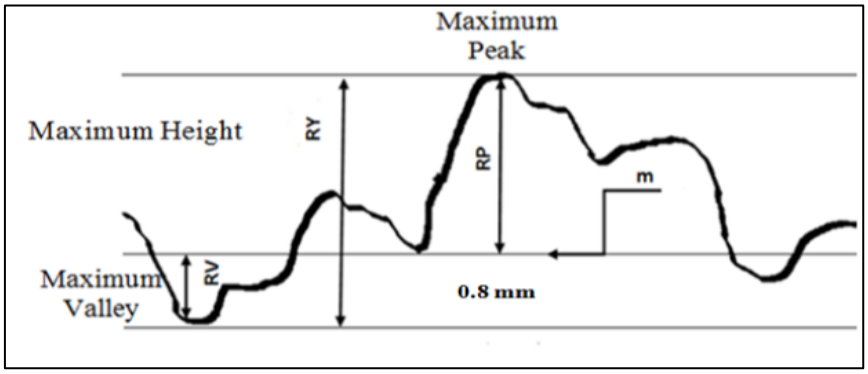

Figure (5): Maximum Peak Valley Height (Ry).

As shown in table (5) of Duncana multiple analysis range test which was done to further explain that there was a highly significant difference among tested groups existed at $p \leq 0.05$. All groups were arranged in nonhomogeneous subsets of data representing the surface roughness means values of each group after treatment at which the control –ve group had highly significant resistance against the increase of surface roughness because not put them on demineralization solution followed by NaF gel group, Neem group and Ginger+ Manuka honey group, and there is no significant difference between them then followed by Green tea group while the least resistance against surface roughness increase belonged to the Clove oil and Peppermint oil groups and with no significant difference between them.

Figure (6) show the mean value of surface roughness of eight group at all stage of study (baseline, after demineralization and after treatment), the maximum decrease in surface roughness in NaF gel group followed by Neem then Ginger

+Manuka honey groups. The minimum decrease in surface roughness in Green tea group then Peppermint and Clove oil groups. In control –ve there is no changing occur in roughness of surface because the group not enter in demineralization-remineralization cycle. In control +ve group the mean value of surface roughness stay high because no remineralization agent applied to this group.

Table (5): Duncana Multiple Analysis Range Test for Groups After Treatment.

Groups	N	1	2	3	4	5
Control -ve	10	.5130				
NaF	10		.6140			
Neem	10		.6190			
Ginger+Manuka honey	10		.6240			
Green tea	10			.8180		
Peppermint	10				.8980	
Clove	10				.9220	
Control +ve	10					1.0230
Sig.		1.000	.756	1.000	.425	1.000

Subset for alpha = 0.01

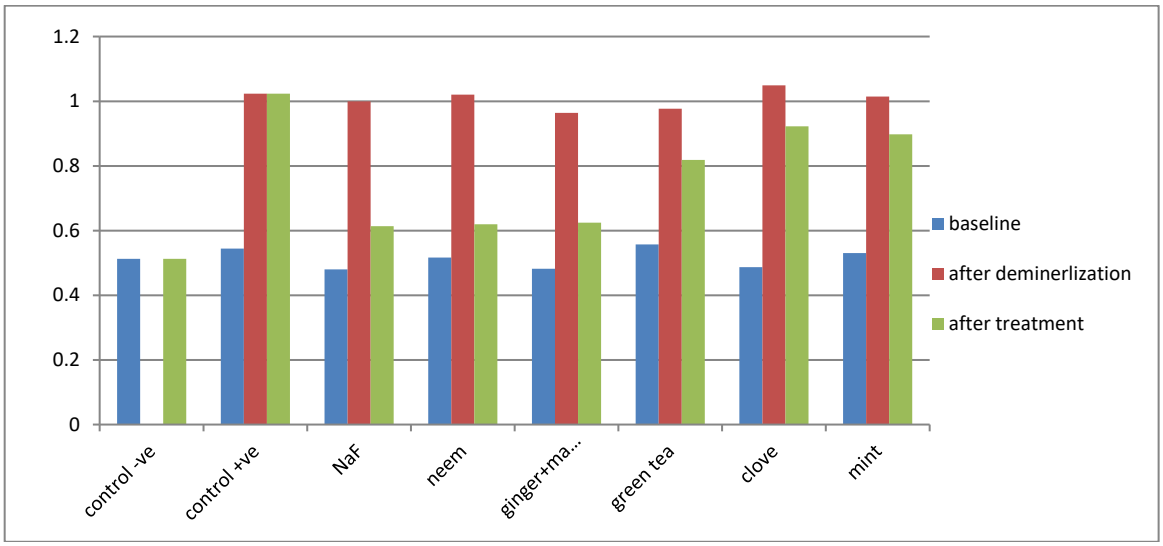

Figure (6): Mean Value of Surface Roughness Measurement for Each Group in Baseline, After Demineralization and After Treatment.

DISCUSSION

Surface roughness is defined as the unevenness of the enamel surface features caused by the process of demineralization [15]. Rough enamel surface contributes to the attachment and maturation of bacteria, also increases absorption of stain. Demineralization is a partial or full tooth mineral loss that happens due to an acidic environment. The demineralization process will increase the enamel surface roughness and maximize the accumulation of plaque whereas the remineralization process will bring back the lost tooth mineral [15]. The

enamel surface roughness could be analyzed by an effective quantitative profilometric method [16] using a roughness profilometer. 0.2 μm is the dangerous roughness threshold beyond which the bacteria will likely stick to the surface [17].

Enamel Roughness was measured for sound enamel (baseline measurement), after demineralization, and after remineralization with the tested products. Statistically, a highly significant increase in roughness of enamel surface after pH cycling by Pepsi is an indication of enamel demineralization and the beginning of the initial eroded lesion. After remineralization of enamel samples with the selected products, there was a decline in enamel surface roughness. This may be a sign of integration of ions that reduce porosity and decrease the surface roughness of enamel and this was not seen for samples treated with de-ionized water. On the other hand, the effect of the tested herbal product as remineralizing products on the enamel surface roughness was different from one agent to another this may be associated with the different components of each agent, which is maybe more than one component and has its method in remineralization [18].

So, according to the result of the present study, based on the means values, the preventive effect of NaF gel was better than the herbals and all tested components have a benefit to protect the roughness of the enamel surface of permanent teeth in comparison with the control negative group.

Fluoride ions help in decreasing the roughness of the enamel surface by improving its acid dissolution resistance affecting de- and remineralization and resulting in the formation of CaF_2 – like material on the eroded surface [19].

Despite all the advantages of fluoride, its effect on demineralization is limited. As well, high doses of fluoride are associated with the risk of fluorosis. Therefore attempts are ongoing to discover another remineralizing agent [20].

Studies have focused on the therapeutic properties of plants in terms of dentistry and new oral care products have been developed [21].

In the present study, the variable herbal used have the capability of protecting the eroded enamel via reducing the surface roughness of eroded enamel. The Neem group promoted enamel remineralization and demonstrated one of the good percentage changes in surface roughness compared to the other groups.

The result may be attributed to the composition of Neem, which contains the alkaloid margosine, chloride, fluoride, gum resins, saponins, tannins, silica, sulfur, oils, sterols, flavonoids, and calcium [22, 23].

Also, Neem component may act as a mechanical barrier, tannins and resins theoretically have an astringent effect on the mucous membrane, and they form a layer over enamel, thus protecting the enamel against demineralization [24] as in the study of Prashant, *et al*. (2007) [22]. Because the dental enamel are protected

from acids, abrasion and attrition by the biofilm so this can help in the prevention of tooth wear. On the other hand, tannins ,one of the main phytochemicals of neem, act as an astringent and give Protection to enamel from the adhesion and aggregation of bacteria by coating over the enamel[25].

Similarly, Neem components are nimbin, Nimbidin, nimbinin, alkaloid margosine, nimbolide, nimbidic acid, fluoride, resins, gum, chloride, silica, sulfur, tannins, oils, sterols, saponins, flavenoids, and calcium. Calcium and fluoride are considered important minerals for remineralization of eroded lesions of dental enamel [26].

Reducing the surface roughness has been recorded with the application of ginger and manuka honey extract. An in vitro study has revealed the antimicrobial activity of 10% ethanolic ginger extract against oral microorganisms which were unaffected by to routinely used antimicrobials [27].

A significant antibacterial activity of ginger against streptococcus mutans and Lactobacillus acidophilus. Also, a combination of honey and extracts of ginger was found to be effective against Staphylococcus aureus which is the main pathogen of dental caries [28]. Results were achieved by numerous other studies which as well suggested that a paste of ginger and honey can be effective in teeth demineralization[29, 30]. Honey is theoretically antibacterial agent and studies established that manuka ,type of honey, is likely to be non-cariogenic [31].

The use of Honey and Ginger as herbal medicines will inhibit the deminerlization process and increase remineralization of the eroded enamel established inhibitory effect on demineralization and enhanced remineralization [32].

Moreover, reducing the surface roughness has been recorded with the application of Clove extract. Clove is rich in minerals like calcium, sodium, hydrochloric acid iron, potassium, , phosphorus, and vitamin A and vitamin C [33].

Meanwhile, the results of the current study are varying from those of other previous studies which report that the presence of Clove extract might decrease the roughness of demineralized enamel surface that was attributed to their content of mineral as phosphorus and calcium ions which are the main constituents of hydroxyapatite[34].

As well Clove contains iron, the iron has an effect on the decrease of demineralization of bovine enamel, also on the composition of dental biofilm [35]. The results exhibited that ferrous sulphate decreased the demineralization of enamel and changed the composition of the dental biofilm formed in situ [36].

The decalcification prevention of the test appears distinctive like that of fluoride treatment. Although the use of 0.05% clove oil, eugenol as well as eugeyl

acetate inhibit the dissolution of calcium by the apple juices after swishing [37] .

On the other hand, the green tea group stimulated remineralization of enamel but revealed one of the least percentage variations in microhardness in comparison with the other groups. Also, the group of green tea display decrease in roughness in comparison with control group but it less than the effect of fluoride and this agreed with Jaâfoura *et al.* (2014) [38] who showed that the anti-erosion effect of sugar-free green tea could be clarified by its high pH value. The PH of green tea is about 6.3. They as well found that alteration of green tea by the addition of calcium, phosphate or fluoride ions could improve the anti-erosion effect. Green tea contains around 5-7% minerals, mainly calcium potassium, magnesium and phosphorus along with small quantities of zinc, copper, and manganese as well it contains vitamins, chlorophyll pigments and carotenoids [39].

The result of the present study may be caused by even though tea plants gathered fluoride in their leaves at a level comparable to that recommended in preventive dentistry [40,41] there was only remineralization of surface area, i:e incomplete re-mineralization. This can be clarified that only a low level of fluoride is necessary to trigger the mechanism of remineralization, elevating the level of fluoride dose not cause greater degrees of mineralization i.e only free exchangeable one can react with calcium ion [42]. This draws the attention to discover a way to make much fluoride in any tea in its reactable state to get the best benefit or to inhibit the competition of different ions in the single solution to get a reaction with the appetite crystals.

Results of Abo Baker and Moawad, (2019) [43] study concluded that the use of green tea was very effective in preventing the enamel erosion that occurred by Pepsi beverages through reduction of the enamel roughness and increasing the remineralization.

The result of the current study is in agreement with another study that concluded that the green tea group enhanced enamel remineralization but showed one of the least percentage variations in roughness in comparison with the other remineralizing groups [44].

Then again, the Peppermint group promoted enamel remineralization but demonstrated one of the least percentage changes in surface roughness compared to the other groups. The constituents of mint oils differ with plant maturity, geographical region, variety, and processing conditions [45]. There is information on the effects of mint extracts on oral bacterial [46, 47].

The prevention of plaque buildup indirectly aids in tooth enamel remineralization. When the mouth is free of harmful bacteria, enamel has the chance to remineralize, meaning teeth are strengthened and protected [48].

Tsai *et al.*, (2013) [49] study showed the two mint essential oils contain more alcohol and terpene and the menthol was

the major compound and it is a rich source of minerals and vitamins. mint is a gift from nature loaded with multivitamins and minerals such as vitamin C, vitamin B6, vitamin A, riboflavin and folate. These are essential for periodontal health and they all contribute to healthy bone mass, this includes teeth, mint can strengthen the density in the skeletal system, jaws and teeth. After all, contain minerals such as calcium, potassium, magnesium, manganese iron and phosphorus which are required for the formation and maintenance of teeth and oral bone density. Additionally, the entire skeletal system and jaws need this mineral to function properly. The vitamins and minerals in mint work together to reinforce the enamel and strengthen the gums.

Phosphorus plays important role in dental health because it naturally protects and rebuilds the enamel. In the same way, calcium and phosphorus have an important role in process of remineralization of enamel surface and also in the conflict between demineralization and remineralization processes [50, 51].

Finally, when different studies were examined, successful results were achieved when the herbal products were compared with the products which are considered as the gold standard. Though herbal components are assumed to be more harmless than those containing heavy chemicals, more studies are required to study the biocompatibility and safety of their use. If their bio-reliability is confirmed, they can be used very effectively in the battle against pathogenic bacteria in the field of dentistry [21].

CONCLUSIONS

The herbal products have the capability of protecting the eroded enamel via reducing the surface roughness. So, the Neem oil was significantly better than other herbal groups against demineralization and preserving enamel roughness but the NaF gel was better than Neem oil group.

Declaration of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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