Ref: Ro J Stomatol. 2024;70(3)
DOI: 10.37897/RJS.2024.3.3

Effect of different chocolate and candy in enamel surface loss of human permanent and primary teeth, an in vitro study

Baraa W. Alani[1], Aisha A. Qasim[1], Fatima A. Mohammad[2]

[1]Department of PedoOrtho Prevention, College of Dentistry, University of Mosul, Iraq
[2]Al-Salam Hospital, Ninevah Health Directorate, Mosul, Iraq

ABSTRACT

Background. Excessive eating of sweets and chocolate causes enamel surface degradation in both children and adults.

Purpose. The purpose of this study was to investigate the influence of various chocolates and confectionery on enamel surface erosion of human permanent and primary teeth.

Methods. This study included six different types of candies and chocolates. 78 sound human teeth were used in this study. 39 healthy permanent premolars and 39 primary incisor teeth were chosen. We randomly divided the teeth into 36 fluoridated and non-fluoridated groups, keeping 6 as controls. The fluoridated group's enamel surface was swabbed with toothpaste containing fluoride for five minutes twice daily. Each group was separated into 12 clusters of 6 teeth based on the type of chocolate and sweets utilized, such as jelly beans, chocolate beans, milk chocolate, white chocolate, gumballs, and dark chocolate. Enamel microhardness was then measured. The data were analyzed using independent t-tests, paired t-tests, Tukey tests, and ANOVA.

Results. The following chocolates and candy types had the highest impact on the enamel microhardness of permanent and primary teeth in all groups; however, the increase was smaller in the fluoridated group. Jelly beans showed the most enamel surface degradation, while dark chocolate showed the least (224.16±9.17 and 234.16±4.91, respectively) with a significantly differences.

Conclusion. According to this study, chocolate and sweets reduce the microhardness of enamel. Parents are encouraged to have greater influence over what their children and teenagers eat. After eating candy and chocolate, kids should brush their teeth with fluoride toothpaste.

Keywords: chocolate, candy, enamel surface, permanent teeth, primary teeth

INTRODUCTION

In dentistry, dental erosion is a prevalent issue. Enamel loss is a biochemical process that takes place without the involvement of bacteria in which a tooth's tough surface is eroded by acidic processes [1]. Internal and environmental causes, or a mix of them, are likely to be the cause of this disease in children and young people (such as adults) [2]. The recent diet, which includes an excessive amount of juice, acidic beverages, acidic sweets, and some chewing gum with acidic centers, is the biggest risk factor for erosional processes in youngsters [3].

In the beginning, just the enamel is impacted by erosion. When dental hard tissue is subjected to an unsaturated solution, both fluorapatite and hydroxyapatite dissolve, resulting in erosion and injury to the teeth [4]. The mineral in teeth is prone to demineralization when the pH falls below the critical pH of an enamel (pH = 5.5), but they are re-mineralized when the pH rises just above the critical pH level [5,6].

However, when it comes to prevention, there are natural ways to help stop tooth loss. These include avoiding sticky and sweet foods and drinking lots of water; brushing your teeth correctly and using fluo-

Corresponding author:
Baraa W. Alani
E-mail: baraaw@uomosul.edu.iq

Article History:
Received: 10 June 2024
Accepted: 23 August 2024

ride toothpaste; visiting the dentist and getting sealants and fluorides applied topically (if there are deep pits and fissures); and maintaining a diet rich in foods that are good for your teeth, such as low-fat milk, cheese, curd, soy milk, tofu, nuts, eggs, dark green leafy vegetables, lean meat, fish, beans, and chocolates [7]. Chocolates are of three kinds: milk chocolates, dark chocolates, and white chocolates. Dark chocolate is one of many varieties of chocolate. The cocoa bean is the main healthful ingredient in chocolate; nevertheless, not all chocolate varieties are tooth-friendly. Consequently, chocolate is healthier as a result. Numerous nutrients and antioxidants included in cocoa beans are beneficial for the entire body, not just the mouth and teeth. Theobromine is another phenolic substance present in cocoa husk beans. Theobromine is one such main constituent in cocoa beans and is found in higher concentrations in the dark than in milk chocolate [8].

Numerous studies have revealed that these ingredients have anti-cariogenic effects. These substances have been shown to inhibit bacterial adhesion to tooth surfaces, which lowers the number of germs [8,9]. When exposed to liquids containing chocolate or sweets, the tooth enamel's hardness decreased and the surface roughness increased, which led to tooth erosion. Only the candy's pH fell below the critical enamel pH. Families are encouraged to exert more control over what kinds of candies and chocolates their children and teenagers have access to [3].

A further worrisome dimension to the role that sweets play in tooth decay and destruction is the rapid rise in the use of various food acids as flavoring agents, which can be attributed to the introduction and widespread consumption of acidic candies, which are primarily consumed by young adults, teens, and small children [10]. It's intriguing because sour candy contains sizable amounts and varieties of acids, necessitating investigation into how they impact tooth enamel [11]. A noteworthy public health concern is the general increase in acidic (sour) candy consumption among children and teenagers [12].

It's also been noted that some candies degrade tooth enamel more than acidic beverages, but the data is still insufficient to determine how much of an impact candies have [13]. Various food intakes on a daily basis could potentially impact tooth mechanics, shape, and surfaces. Accordingly, we sought to evaluate the effect of different chocolates and candy on the enamel surface loss of human permanent and primary teeth; fluoride is used in the current study as a preventive method.

MATERIALS AND METHODS

In this in vitro study, two distinct sweet types and four distinct chocolate varieties that are often seen in the Mosul market were used. The sample size is determined in the laboratory (sample size: N = (zr / D), N = sample in each group, Z = constant 1.96 for 95% confidence, R = standard deviation 0.41 (from the previous study), and D = precision 0.2 unit). In this in vitro study, six different types of candies and chocolates, two distinct candy types, and four distinct chocolate varieties (jelly beans, white chocolate, gumballs, milk chocolate, dark chocolate, and family milk chocolate with chocolate filling (chocolate beans)) were often used as shown in Figure 1. At

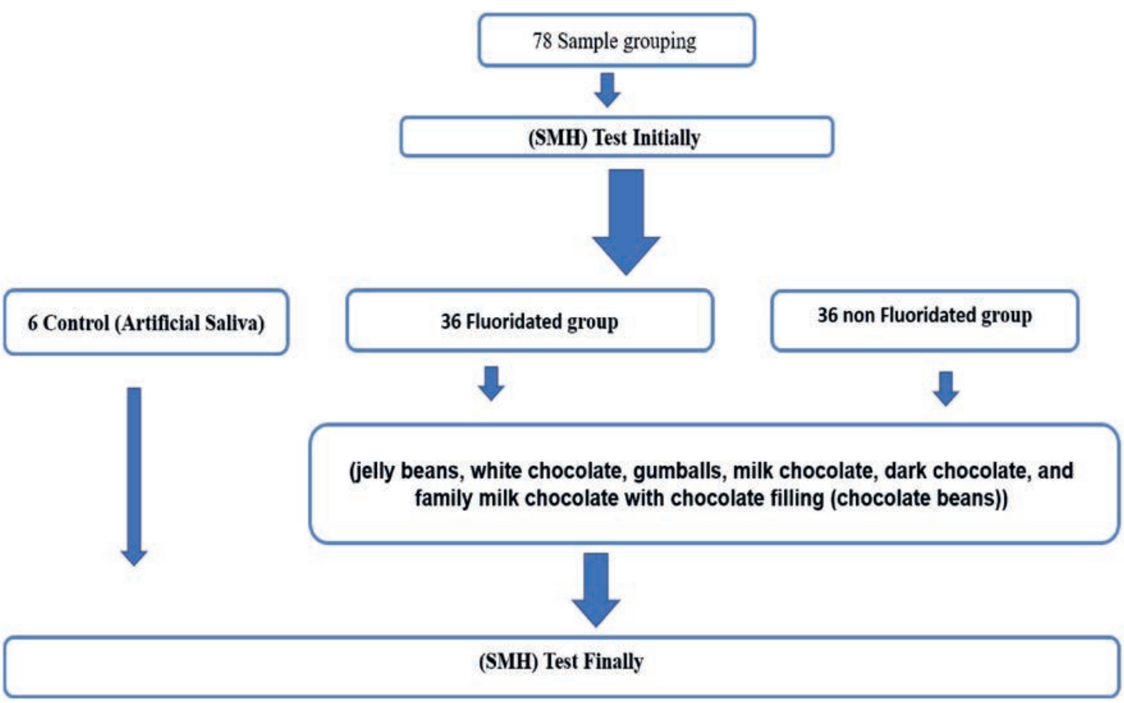

FIGURE 1. Show schematic diagram of the experimental works

that point, their pH was measured with a pH meter (Digital pH-Ion meter, Philips, Japan), and sugar per 100 grams for each kind was recorded in the factory report at room temperature. Seventy-eight healthy permanent premolars for orthodontic reasons and primary incisor teeth were carefully chosen based on the inclusion criteria involving extracted sound permanent premolars and deciduous incisors of less than 3 months post-extraction with intact buccal and labial enamel surfaces. To get rid of any saliva, blood, or even other debris, the teeth were cleaned. After being scrubbed with pumice, they were immersed in normal saline as the experiment began. Using circular molds measuring 10 mm in diameter and 4 mm in depth, enamel blocks of 4 × 4 × 2 mm were created from these teeth and subsequently set in self-curing acrylic resin. The samples were glued to the resin composites so that enamel would appear. After that, sandpaper was used to smooth off the outside of the samples' enamel (600 grit and then 1200 grit).

The 78 final teeth included were divided into two experimental groups randomly: the first 36 teeth to be fluoridated and the last 36 teeth to be non-fluoridated. While the remaining 6 teeth were used as a control group, the composition of artificial saliva per one liter of water was [$CaCl_2$ (15 mg), $MgCl_2$ (5 mg), KCl (0.1 g), KSCN (10 mg), Na_2 HPO4 (40 mg), pH = 7] at room temperature. 3,49 The specimens were then submerged twice in a solution made of 5 grams of chocolate or popping candy diluted in 2 milliliters of artificial saliva for five minutes each time for five days. Following every exposure, samples were washed with distilled water for 20 seconds before the subsequent step of the test, which involved dipping them in the artificial saliva, was replaced every day until the next stage of the test. Using fluoridated toothpaste in the fluoridated group, the enamel surface of each tooth was swabbed with a thin layer of fluoridated toothpaste (Maclean training toothpaste, Glaxo Smith Kline, Brentford, UK) using a fine brush for 5 minutes. procedure was performed twice daily to simulate normal oral hygiene instructions. This procedure was performed twice daily to simulate normal oral hygiene instructions. A thin smear layer of toothpaste was swabbed by the brush and applied over the enamel surface of the immersed hole surface, which was covered by the toothpaste. Then, all the samples were re-immersed in artificial saliva.

Surface microhardness was measured for all specimens using a Vickers microhardness testing machine (OLPERT, Germany) with an applied load of 700 g for 15 seconds via Vickers diamond pyramid indenters, which have a square [1]-based diamond indenter with a 136º angle and a 600x magnification of the microscope. The indentations were made for each specimen at three different locations, and then the average of the three measurements was calculated and obtained as one reading. The indentation result can be seen on the projector screen in the form of a shadow-shaping rhomb; the diagonal length is measured with a micrometer. After indentation was made on the enamel specimen surface, the Vickers hardness number (VHN) was determined from the mean values obtained from three indentations on the surface of each specimen using the formula: HVN = 1.854 × P / d2. The microhardness of the enamel surface was measured before and after the effects of chocolate and candies in each tested group. HVN = sample hardness (kg/mm2), D = measurement result (mm), and P = weight given (kg) [23,33,36]. To analyze the data, Armonk,

TABLE 1. Types, compounds, pH, sugar content, and the manufacturing country of the tested materials.

Materials	Composition	pH	Sugar	Country
A (Jelly beans)	Glucose syrup, sugar, Cider Center 7.5 %, Halal bovine gelatin sourced from Turkey, Citric acid antacid, Natural cola colors, and Polishing agent (Carnauba wax, Beeswax)	4.5	47.3	Turkey
B (White chocolate)	Sugar, cocoa butter, whole milk powder, skimmed milk powder, stabilizer (calcium carbonate), emulsifiers (sunflower lecithin, polyglycerol polyricinoleate), flavoring (vanillin). It May contain hazelnut, pistachio, almond, and wheat).	7.4	50.8	Turkey
C (Gum balls)	Sugar, gum base, glucose syrup, flavors, glycerin, lecithin, citric acid, food color, pectin, and water.	7.0	50.0	Iran
D (Milk chocolate) Family milk chocolate with chocolate filling	Family milk chocolate (70 %), sugar, cocoa butter, cocoa mass, skimmed milk powder, whey powder (milk)fat, mineral (calcium carbonate) emulsifier (sunflower lecithin, polyglycerol polyricinolate), flavoring (vanillin), white chocolate (30 %) (sugar, cocoa butter, whole milk powder, skimmed milk powder, mineral (calcium carbonate), emulsifier (sunflower, lecithin, polyglycerol polyricinolate), flavoring (vanillin). traces: wheat (gluten), almond, hazelnut, pistachio). Cocoa solids in milk chocolate minimum:29%.	7.6	55.3	Turkey
E (Dark chocolate)	Sugar, cocoa paste, cocoa butter, butterfat emulsifier, lecithin's (soya), vanilla extract, and cocoa solids: 50% minimum may contain traces of peanuts, nuts, gluten, and egg	7.2	47.0	Germany
F (Chocolate beans)	Sugar, Cocoa Powder, skimmed milk powder, Hydrogenated Palm kernel oil, listen (E-322), Vanilla, carnauba (E- 903), White Dextrin Food colors (E-110, E-129, E-133, E-155, E-171).	6.8	70.1	Lebanon

New York independent and paired t-tests, the Tukey test, and an ANOVA were utilized [14].

RESULTS

All of the materials evaluated in the current study had PH values higher than 7, except jelly beans and chocolate beans, which had PH values of 6.8 and 4.5, respectively, underneath the critical pH of enamel (5.5). Primary and permanent, as illustrated in Table 2. The results of this investigation showed that the surface hardness value of the enamel of the permanent and primary teeth differed significantly before and after exposure to popping chocolates and candy, respectively (paired t-test, P <0.001). Jelly beans (A), chocolate beans (F), milk chocolate (D), white chocolate (B), gumballs (C), and dark chocolate (E) were the substances that caused the greatest alteration in the surface microhardness of the enamel of primary teeth. On the other hand, there was a general reduction in the surface microhardness values of the treated groups for each tested material used compared with the control group, while surface microhardness was significantly increased in all treated groups with fluoridated toothpaste compared with the untreated groups with fluoridated toothpaste and the control group, as shown in Table 3 and Figure 2 for primary and permanent teeth.

DISCUSSION

Due to the excessive intake of candy and chocolate in recent years, enamel surface loss has increased among children, teenagers, and adults [11-15]. In the current study, all groups saw a reduction in the enamel's surface microhardness after being subjected to sweet or chocolate-flavored beverages. Hardness, a crucial mechanical property of matter, is the ability of a substance or surface to resist piercing or indentation [16]. An increase in hardness improves a material's general resilience to wear, contact, and erosion with other materials. This indicates that enamel with a higher mineral concentration wears less [16]. For the claim that exposure to an acidic solution causes the enamel surface to initially lose its hardness value before enamel tissues degrade and eventually disappear [17].

We assessed the primary and permanent enamel hardness using the Vickers method following the teeth's exposure to chocolate and candy [16]. Any diet with a pH lower than 5.5 may contribute to or enhance enamel surface loss because jelly beans

TABLE 2. Comparison of the microhardness before and after effect of chocolate and candies in each group (n=8) (paired t-test) (primary and permanent teeth)

Groups	Microhardness	Mean+ SD (primary teeth)	Mean+ SD (permanent teeth)	paired t-test
Control (Artificial Saliva)	before	337.16±11.83	338.0+ 1.58	P<0.001
	after	335.83±20.10	337.20+ 1.30	
(A) With toothpaste	before	330.0±12.64	335.20+1.92	P<0.001
	after	256.66±15.05	264.40+0 .89	
(A) Without toothpaste	before	330.0±12.64	335.20+1.92	P<0.001
	after	224.16±9.17	234.0+0 .70	
(B) With toothpaste	before	333.33±10.32	335.20+0.83	P<0.001
	after	262.50±11.72	266.80+1.30	
(B)Without toothpaste	before	333.33±10.32	335.20+0.83	P<0.001
	after	235.83±13.57	239.60+1.14	
(C) With toothpaste	before	336.66±5.16	337.60+1.14	P<0.001
	after	269.16±22.89	272.0+ 1.58	
(C) Without toothpaste	before	336.66±5.16	337.60+1.14	P<0.001
	after	240.83±11.14	246.0+ 2.54	
(D) With toothpaste	before	333.33±8.16	336.60+ 2.07	P<0.001
	after	265.83±16.25	270.0+ 1.58	
(D) Without toothpaste	before	333.33±8.16	336.60+ 2.07	P<0.001
	after	234.16±4.91	241.60+ 2.07	
(E) With toothpaste	before	335.0±10.48	337.0+1.58	P<0.001
	after	267.50±18.37	272.40+ 1.51	
(E) Without toothpaste	before	335.0±10.48	337.0+1.58	P<0.001
	after	239.16±24.16	245.60+ 1.14	
(F) With toothpaste	before	338.42±10.67	339.60+ 1.14	P<0.001
	after	270.0±11.54	274.80+1.48	
(F) Without toothpaste	before	338.42± 10.67	339.60+ 1.14	P<0.001
	after	238.57±8.99	244.40+1.14	

TABLE 3. Comparison of the effect of candy and chocolate on the microhardness of the primary and permanent teeth enamel groups

Groups	Microhardness (Mean±SD) (primary teeth)	Microhardness (Mean±SD) (permanent teeth)
Control (Artificial Saliva)	1.33±18.34	0.80±0.44
(A)With toothpaste	73.33±20.65	70.80±1.30
(A)Without toothpaste	105.83±14.97	101.20±2.16
(B)With toothpaste	70.83± 14.28	68.40±0 .89
(B)Without toothpaste	97.50±16.65	95.60±0.54
(C) With toothpaste	67.50±22.74	65.60±1.51
(C) Without toothpaste	95.83±13.57	91.60±2.60
(D)With toothpaste	67.50±16.65	66.60±1.51
(D) Without toothpaste	99.16±8.01	95.0±4.12
(E)With toothpaste	67.50±16.65	64.60±2.30
(E) Without toothpaste	95.83±22.45	91.40±1.51
(F)With toothpaste	68.42±20.34	64.80±1.30
(F) Without toothpaste	99.85±15.17	95.20±1.30

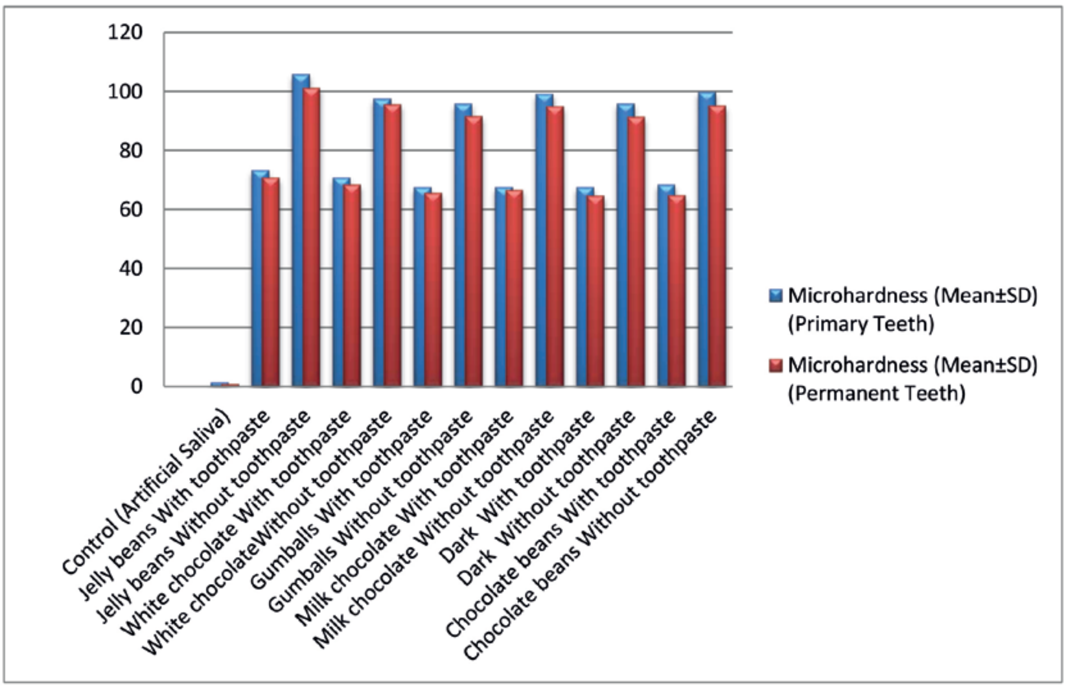

FIGURE 2. Bar Graph for the surface microhardness test for all tested groups of the primary and permanent teeth

have a pH (4.5) that is below the enamel critical pH (5.5), which is thought to be the cause of the high drop in microhardness of the enamel surface. Clinical research has shown, and this is particularly significant, that salivary pH can drop as low as 2.96 minutes after eating candy [11,15]. Dental enamel is affected by variations in the oral environment and decreased pH near the surface of enamel produced by bacterial metabolism. In this case, demineralization is due to the change of the inorganic constituent [$Ca_5(PO_4)_3(OH)$], thus changing physical properties, for example, hardness. When available Ca^{2+} and PO4-ions interrelate with the dental structure, a homeostatic mechanism takes place, improving the physical properties of demineralized tissues [18].

Acidic ingredients found in sweets include tartaric, malic, phosphoric, citric, oxalic, fumaric, and carbonic acids. This indicates that jelly beans may be more erosive than chocolate, which means they could harm a tooth's enamel more severely. Current study by Sultan et al. (2022) [19] and El-Marakby from 2018 [20]. Additionally, prior research has demonstrated that, similar to gumballs, which have a pH of 6.8, enamel may dissolve at pH ranges of 5.2-2.9% ? and 6.0-6.7, respectively. [21,22] Even though the pH of the other materials under examination fell short of the enamel critical pH, enamel surface loss is still influenced by pH, exposure time, frequency, acid type, acid concentration, and sugars contained, which enhance bacteria to yield acid and lower the pH.23 The results are consistent with other studies [24,26].

Conversely, the least damaging foods for teeth include white chocolate, dark chocolate, milk chocolate, and chocolate beans because they contain another chief good constituent, such as cocoa (Theobroma cocoa), which contains theobromine, cocoa butter, and numerous minerals that harden the tooth enamel and decrease the risk of demineralization and dental erosion [9]. Moreover, those kinds of chocolate have calcium, which is considered an important mineral for tooth remineralization [27]. To this point, samples that were also exposed to water showed signs of demineralization. Deionized water is reportedly very aggressive. This could be explained by the absence of calcium, which serves as a protective agent against erosional attacks [28].

They found in multiple investigations that the demineralization and enamel surface loss of primary teeth are different from those of permanent teeth. The most noticeable differences between primary and permanent teeth are found in their anatomical makeup, with primary teeth having a thinner and more porous enamel layer and being smaller overall. While the enamel prisms of both types of teeth are similar, primary teeth contain prisms that are smaller, more curved, and more widely distributed. Their hydroxyapatite crystals also differ greatly from one another [29]. Crystals of hydroxyapatite, which are imperfect forms found in both permanent and primary enamel, are essentially composed of calcium (Ca^{2+}), phosphate (PO_4^{3-}), and hydroxyl (OH^-) ions, along with some "impurity" ions, such as sodium (Na^+), fluoride (F^-), and carbonate (CO_3^{2-}). These ions are arranged in a crystalline structure with the simplified chemical formula: Ca10–xNax-$(PO_4)_6$–y(CO_3)z$(OH)_2$–uFu. Carbonate (CO_3) is a significant impurity ion that distinguishes permanent enamel from primary enamel [30].

The results of this study showed the greatest alteration in the surface microhardness of the enamel of primary teeth. Numerous studies have shown that permanent enamel is much more erosion-resistant than primary enamel. 31 Conversely, Carvalho et al. (2017) showed that the quantity of surface hardness reduction in permanent teeth and primary teeth was not significantly different [25].

Topical fluoride has had an important effect on decreasing the risk of enamel surface loss and dental caries. The major method recommended for preventing or treating early lesions is the use of various toothpaste types, which are accompanied by mouth rinses and gels with strong active biological components. In addition to other essential elements, several types of toothpaste also contain active compounds. Fluoride is the most prevalent of the altered active composites that support the improvement of enamel remineralization in toothpaste [32]. In 2020, Zanatta et al. released a meta-review just on fluoride composites' capacity to reduce erosive tooth wear [33]. On the other hand, another study assessed the in vivo resistance of dental enamel exposed to acid attack both before and after the use of various fluoride agents, concluding that the treatments created an increased resistance to acid attack. By making enamel harder and more stable and preserving the apatite structure, fluor has an impact on the chemical and physical characteristics of apatite minerals [34]. Evidence suggests that an absence of fluoride can cause tooth demineralization, even if a person takes care of their teeth [34]. Studies showed that, in comparison to untreated teeth, fluoride-treated teeth were much more acid-resistant [17,36].

Comparing human primary and permanent teeth, we discovered that primary enamel released more calcium and phosphate than permanent enamel, both in native samples and during pellicle formation. These observations, while not usually significant, indicate that primary enamel is more easily eroded than enamel from permanent human teeth [37]. In comparison to human permanent teeth, this also shows the lower degree of mineralization of primary enamel, together with higher porosity and susceptibility to erosive enamel flaws. Human primary enamel tended to erode more quickly than permanent teeth, but dentin exhibited the opposite pattern [37-40].

A long-term in vitro erosion study (5–15 days) that exposed primary and permanent enamel to low-pH fruit drinks had similar findings; however, the findings explained by the structural variations in enamel between primary and permanent teeth also validate the greater erosion vulnerability of primary teeth [37]. The findings demonstrated that the microhardness of tooth enamel was significantly reduced by these sweets and chocolates, with the primary teeth seeing a larger drop in microhardness than the permanent teeth. Some distinctions exist between primary and permanent enamel teeth, including variations in mineralization and thickness, which may have an impact on the outcome [38]. Other methods for the detection of enamel surface loss structure defects, such as microhardness, can only examine flat-parallel ground specimens, which precludes the examination of native hard substance specimens. Because of their curved shape and reduced stress, incisors wear down less than molars [37]. Moreover, those kinds of chocolate have calcium, which is considered an important mineral for tooth remineralization [27]. To this point, samples that were also exposed to water showed signs of demineralization. Deionized water is reportedly very aggressive. This could be explained by the absence of calcium, which serves as a protective agent against erosional attacks [28].

When Lazzaris et al. (2015) investigated the acidity and erosive potential of commercially available candies, they also found that jelly beans had a pH lower than the enamel's critical pH and that the pH of the candies varied in flavor [39]. Additionally, this study is compatible with Leelavathi and Chaly's work, which evaluated the pH of lollipops with various tastes. In this study, the effects of candy and chocolate on teeth were examined, and it was shown that jelly beans had a greater drop in microhardness since erosion is also influenced by pH, frequency, exposure duration, and acid type and concentration [40]. Although there hasn't been any particular research on how tooth hardness is affected by dark chocolate, the analysis of theobromine—the main ingredient in cocoa—for enamel and dentin matches those of previous studies that looked into the same topic. Enamel hardness was elevated by theobromine, and the inorganic minerals had a direct impact on this process. When it comes to cocoa powder, milk chocolate has a range of 1.2% to 2.4%, but dark chocolate has a higher theobromine level. Furthermore, unsaturated free fatty acids, such as oleic and linoleic acids, have antibacterial properties against Streptococcus mutans. A medium with anti-carcinogenic capabilities has been developed. Prior research into the mechanism underlying theobromine's anti-cariogenic characteristics has demonstrated the creation of an appetite-structured medium that facilitates the remineralization process, which rehardens the tooth surface [23,42].

Because milk chocolate has a lower melting point at body temperature than dark chocolate, it melts more easily on the tongue and has less hardness than dark chocolate due to its combination of cocoa butter and milk fat (milk butter and milk cream) [43]. Theobromine, a substance found in dark chocolate made from Theobroma cacao, is known to increase tooth enamel hardness and reduce the risk of dental cavities [23]. Chemically speaking, theobromine has the formula $C_7H_8N_4O$. It has been shown that theobromine compounds can raise the tooth enamel surface's hardness by encouraging interstitial contacts between hydroxyapatite crystals (HA) and theobromine on the enamel surface [23,42]. Typically, between 50 and 90 percent of the ingredients in dark chocolate are cocoa beans. They are also a rich source of minerals like iron, magnesium, zinc, copper, potassium, selenium, phosphorus, and manganese [23,44], as well as antioxidants like tannins, polyphenols, and flavanols (which include epicatechins, monomers, and catechins) and valuable components like theobromine (1.2-2.4%) [23]. Some earlier research has found that the minerals included in dark chocolate include iron, magnesium, zinc, copper, potassium, selenium, phosphorus, and manganese. These minerals are crucial for creating a stronger tooth structure. Inorganic minerals were directly linked to improving the hardness of the enamel, and theobromine further enhanced its hardness [9,23,42]. Candy is a common product that is enjoyed by both young and old. Its main component, sugar, provides an immediate energy boost. It is typically combined with different colors and flavors to provide a visually appealing and sensual experience. Among the more than 2000 varieties, flavors like caramel, chocolate, peppermint, butterscotch, and vanilla are the most widely consumed [45].

Brand name specifications may not be employed unless the specific brand name, product, or feature is required by the government, and market research shows that similar products from other companies or products without the specific feature, do not meet, or cannot be modified to meet, the needs of the agency. Unfortunately, direct comparisons that evaluate enamel surface loss models by contrasting not just species but also permanent and primary dentition are uncommon, and the experimental criteria used in these comparisons are frequently extremely dissimilar.

When fluoride is applied under acidic conditions, the enamel layer (hydroxyapatite) partially demineralizes and dissolves fluoride's biological effects, including its antibacterial action and a decrease in the attachment of bacteria to fluoridated tooth surfaces [46]. Fluoride may also have chemical actions that contribute to its protective effects. As a result, partial demineralization (partially dissolves) of the tooth enamel (hydroxyapatite) and reprecipitation of fluoride-containing minerals are the chemical effects of fluoride treatment. However, in most situations, there is restricted incorporation of fluoride into the tooth hydroxyapatite to presumably generate fluor-hydroxyapatite, even at very high concentration levels (e.g., fluoride gel; not toothbrushes or mouthwashes). The fluoride treatment reduced the demineralization of the teeth. It has been extensively proven that fluoride has a remineralizing and protecting effect. It is critical to keep in mind that the action of fluoride, which is frequently produced from saliva, depends on calcium and phosphate ions [2], which is followed by the use of fluoride-containing minerals. This fluoride-containing layer thickens with fluoride concentration and is also helped by a low pH level. There is a chance for many hundred nanometers [2, 46]. There have been theories regarding

This study's weakness is that it only looked at the primary and permanent incisors. It is advised that future research examine the impact of the chocolate and candy on the extracted hidden posterior teeth. It is critical to keep in mind that the action of fluoride, which is frequently produced from saliva, depends on calcium and phosphate ions.

CONCLUSION

Chocolate showed the highest enamel surface loss compared to others. Families are encouraged to exercise more control over what children and teenagers eat. It is recommended that they clean their teeth after ingesting the candy and chocolate by brushing the tooth with fluoridated toothpaste, but not directly because the enamel becomes softer when acid is removed without difficulty.

Acknowledgment:
Thanks to the College of Dentistry/University of Mosul for providing support and facilities to accomplish this work.

Conflict of interest: none declared

Financial support: none declared

REFERENCES

1. Widiya U, Rosa A, Al Supartinah S. The relationship between tooth loss and pre-elderly nutritional status and quality of life. *Dent J.* (Majalah Kedokteran Gigi). 2023;56(2):80-6. https://doi.org/10.20473/j.djmkg.v56.i2.p80-86.
2. Yakop, Hussein S, Sarmad S. Salih Al Qassar, Mahmood Ahmad Hamood Aljoubory. Assessment of the influence of metal ions released from the fixed orthodontic appliances on the static friction and surface topography of stainless steel and I archwires: An in-vitro study. *J Orthod Sci.* 2023;(12):1. http://doi.org/10.4103/jos.jos_58_23
3. Alkasso IR, SalihAlQassar SS, Taqa GA. Durability of different types of Mouthwashes on the Salivary Buffering system in Orthodontic Patients. *Dent 3000.* 2021;9(1):178-92. http://doi.org/10.5195/d3000.2021.121
4. Khedir R, Taqa G, Al Qassar S. Evaluating the Systemic Effect of Magnesium Oxide on Gene Expression of Osteocalcin and Vitamin D Receptors in Rabbits with Orthodontic Teeth Movement. *Egy J Veter Scie.* 2023;54(1):71-86. http://doi.org/10.21608/EJVS.2022.155237.1377
5. Mohammed RE, Al Qassar SSS, Taqa GA. Clinical and histological evaluation of the effect of magnesium oxide administration on relapse after orthodontic teeth movement (Rabbit Model Study). *J Ortho Sci.* 2023;12(1):19. http://doi.org/10.4103/jos.jos_80_22.
6. Ebru A, Cansu OS, İzzet Y, İsmet RT. Saliva analysis in children with active caries before and after dental treatment. *Dent J.* 2022;55(3):120-4. http://doi.org/10.20473/j.djmkg.v55.i3.p120-124.
7. Adiba SH, Effendy R, Zubaidah N. Fluoride Varnish Effect on Dental Erosion Immersed with Carbonated Beverages. *J Int Dent Med Res.* 2018;11(1):299-302.
8. Melaku TA. Dietary Protein. *Acta Sci Pharm Sci.* 2022;6.(3):01.
9. Lakshmi A, Vishnurekha C, Baghkomeh PN. Effect of theobromine in antimicrobial activity: An in vitro study. *J Dent Res.* 2019 Mar;16(2):76.
10. Nimbulkar G, Parida R, Chhabra KG, Deolia S, Reche A, Patel S. Dark Chocolates: Friend or Foe – A Review. *Eur J Mol Clin Med.* 202022;7(07):2020.
11. Aarti K, Rachel JK, Nehaa K, Charlotte S, Piyasree M, Erika R, Karen SG. Maternal–child consumption of ultra-processed foods and sugar-sweetened beverages in informal settlements in Mumbai India. *J Health Popul Nutr.* 2023;42:142. http://doi.org/10.1186/s41043-023-00486-z
12. dos Reis Oliveira PR, Amaral FLB, França FMG, Basting RT, Turssi CP. Prevalence of dental erosion in Brazilian children and adolescents. *Pesqui Bras Odontopediatria Clin Integer.* 2018;18(1):3866. http://doi.org/10.1111/j.1752-7325.2010.00194.x
13. Lesley SN, Stanley CO, Nelisha M, Karin P, Shenuka S. Evaluating the erosive effect of sour candy on human. *J Dent Oral Hyg.* 2020;12(2):27-34. http://doi.org/10.5897/JDOH2019.0243
14. Alkhayat ZI, SalihAlQassar SS, Qasim AA. The effect of the static magnetic field on some of the mechanical properties of glass ionomer cements. *Rom J Stomatol.* 2023;69(4):224-29. http://doi.org/10.37897/RJS.2023.4.9.
15. Khan HS, Sarmin NM, Zahid MF, Hashim NA. The effect of different milk products on enamel hardness: an in vitro study. *Compendium of Oral Science*. 2022;9(1):67-79. http://doi.org/10.24191/cos.v9i1.16909
16. Naidoo LS, Onwubu SC, Murugan N, Singh S. Examining the effect of exposure time on the erosive potential of sour candy. *S Afr Dent J.* 2021;76(2):72-7. http://dx.doi.org/10.17159/2519-0105/2021/v76no2a2
17. Gabriela Monteiro BX, Aila Silva DA, Alexandra Gabrielly de SB, Issae SS, Cecy MS, Jesuína Lamartine NA. Assessment of the Erosive Potential of Mineral Waters in Bovine Dental Enamel. *Open Dent J.* 2022;16. http://doi.org/10.2174/18742106-v16-e2208180
18. Irianti AN, Kuswandari S, Santoso AS. Effect of formula milk on the roughness and hardness of tooth enamel. *Dent J.* 2021;54(2):78-81. http://doi.org/ 10.20473/j.djmkg.v54.i2.p78–8
19. Barrera Ortega CC, Araiza Tellez MA, Garcia Perez AL. Assessment of Enamel Surface Microhardness with Different Fluorinated Compounds under pH Cycling Conditions: An in Vitro Study. *J Clin Diagnostic Res.* 2019;13(8). http://doi.org/10.7860/JCDR/2019/41054.13057
20. Sultan FG, Fatma K, Ersin A. Organic acid, phenolic acid and flavonoids of medlar during different maturation stages. *Akademik Ziraat Dergisi.* 2022;11(2):207-12. http://dx.doi.org/10.29278/azd.1061365
21. El-Marakby AM, Saber M, Alammary AT, Gad NA. Surface hardness assessment of tooth substrates and different esthetic restorative materials after immersion in different acidic media. *Int J Dent Oral Heal.* 2018;4(11):178-83
22. Mariana M, Carla A, Joana C, José JM, Ana CM. pH analysis of still and carbonated bottled water: Potentialinfluence on dental erosion. *Clin Exp Dent Res.* 2022;8:552-60. http://doi.org/10.1002/cre2.535
23. Robert PS, Michele EB, David M P, Megan A, Adrian L. Effects of Calcium and Phosphate on Dissolution of Enamel, Dentin and Hydroxyapatite in Citric Acid. *Swiss Dent J.* 2023;133(7-8).
24. Niaz HH, Intesar ST, Adil OA, Shakhawan KK. Assessing the Impact of Varied Dark Chocolate Concentrationson Enamel and Dentine Microhardness. *Appl Sci.* 2024;14:382. http://doi.org/10.3390/app14010382
25. Constanza EF, Ana Carolina SB, Eloá CB, Atair Antoninha DC, Jaime AC, Livia M.AT. Effect of pH and titratable acidity on enamel and dentine erosion. *Clin Oral Investig.* 2022;26(Suppl 1). http://doi.org/10.1007/s00784-022-04544-4.
26. Carvalho TS, Schmid TM, Baumann T, Lussi A. Erosive effect of different dietary substances on deciduous and permanent teeth. *Clin Oral Investing.* 2017;21:1519-26. http://doi.org/10.1007/s00784-016-1915-z
27. Valenzuela MJ, Waterhouse B, Aggarwal VR, Bloor K, Doran T. Effect of sugar-sweetened beverages on oral health: a systematic review and meta-analysis. *Eur J Public Health.* 2021;31(1):122-9. https://doi.org/10.1093/eurpub/ckaa147
28. Lončarević I, Milica S, Biljana P, Ivana N, Jovana P, Branislav Š, Danica Z. Blueberry juice encapsulated on maltodextrin: The impact on the properties of white chocolate. *Food Feed Res.* 2023;50(2):77-89. http://doi.org/10.5937/ffr0-46552
29. Onwubu SC, Mdluli PS, Singh S. Evaluating the buffering and acid-resistant properties of eggshell–titanium dioxide compo-site against erosive acids. *J Appl Biomater Funct Mater.* 2019;17(1):1-7. http://doi.org/10.1177/2280800018809914

30. Nouran SM, Reham AE, Asmaa Ali EA. Effect of lactoferrin on enamel characteristics of primary an d permanent teeth: an in-vitro study. *BMC Oral Health.* 2023;23(1). http://doi.org/10.1186/s12903-023-03709-1
31. Thiago SC, Adrian L, Nadine S, Tommy B. Diferences in susceptibility of deciduous and permanent teeth to erosion exist, albeit depending on protocol design and method of assessment. *Sci Rep.* 2022;12:4153. http://doi.org/10.1038/s41598-022-08116-0
32. Zheng L, Peng J, Zheng J, Liu D, Zhou Z. Surface properties of eroded human primary and permanent enamel and the possible remineralization influence of CPP-ACP. *Wear.* 2017;376:251 8. http://doi.org/10.1016/j.wear.2017.01.055
33. 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. http://doi.org/10.4012/dmj.2020-078
34. Zanatta RF, Caneppele TM, Scaramucci T, El Dib R, Maia LC, Ferreira DM, Borges AB. Protective effect of fluorides on erosion and erosion/abrasion in enamel: a systematic review and meta-analysis of randomized in situ trials. *Arch Oral Biol.* 2020;120:104945. http://doi.org/10.1016/j.archoralbio.2020.104945
35. Abdulhaddi A, Al Qassar SSS, Mohammed AM. Assessment of the mechanical properties and antimicrobial efficiency of orthodontic adhesive modified with Salvadora Persica oil. *Ro J Stomatol.* 2024;70(2):153-9. http://doi.org/10.37897/RJS.2024.2.14
36. Al Qassar SSS, Alkhayat ZI, Al Mallah MR. Bond Integrity and Microleakage of Orthodontic Bands Cemented by Glass Ionomer Cements Stored in Static Magnetic Field. *J Adv Oral Res.* 2024: On line. http://doi.org/10.1177/23202068241247630
37. Salih AlQassar SS, Ahmed MK, Al-Mallah MR. Estimation of the shear bond strength and adhesive remnant index of orthodontic adhesives stored in static magnetic field. *Clin Invest Orthod.* 2023;82(4):204-11. http://doi.org/10.1111/cid.12703
38. Qasim AA, Alani BW, Salih AlQassar SS. Effects of fluoridated tooth paste on medically erosive enamel in bonded primary teeth during maxillary arch expansion in cleft palate patient: An in vitro study. *J Orthod Sci.* 2021;10:1-17. http://doi.org/10.4103/jos.jos_1_21
39. Lazzaris M, Farias MM, Araújo SM, Schmitt BH, Silveira EG. Erosive potential of commercially available candies. *Pesqui Bras Odontopediatria Clin Integr.* 2015;15(1):1-6.
40. Leelavathi L, Chaly PE. Erosive potential of various commercially available lollipops. *J Oral Health Comm Dent Sci.* 2015;9:126-31. http://doi.org/10.5005/johcd-9-3-126
41. Jayakumar P, FelsyPremila G, Muthu MS, Kirubakaran R, Panchanadikar N, Al-Qassar SS. Bite force of children and adolescents: a systematic review and meta-analysis. *J Clin Pediatr Dent.* 2023;47(3):39-53. http://doi.org/10.22514/jocpd.2023.022
42. Chire-Fajardo GC, Valdivia-Arrunategui RA, Orihuela-Rivera CA, Ureña-Peralta MO. Assessment of physical and physicochemical quality of main chocolates traded in Peru. *Acta Agron.* 2017;66(2):164-71. http://doi.org/10.15446/acag.v66n2.53779
43. Rekha K, Prasad R, Jyoti S, Harshal A. Herbal Candies: A Potential Source of Health Benefits. *Curr Nutr Food Sci.* 2023;20(9):1039-48. http://doi.org/ 10.2174/0115734013250026231016140631
44. Al Qassar SSS, Qibi H, Qasim AA, Dawood HM. Evaluation of antiseptic mouthwashes protocol against SARSCoV-2 on orthodontic appliances (an in vitro study). *Braz Dent Sci.* 2024;27(2):e4196. http://doi.org/10.4322/bds.2024.e4196
45. Prabhakar PK, Akhilesh K, Srivastav PP. Flow and Deformational Behaviour of Dark, Milk and Plain Chocolate Used for Ice-Cream Coating. 2015:27-8.
46. Kirsch J, Hannig M, Winkel P, Basche S, Leis B, Pütz N, Kensche A, Hannig C. Influence of pure fluorides and stannous ions on the initial bacterial colonization in situ. *Sci Rep.* 2019;9:18499. http://doi.org/10.1038/s41598-019-55083-0