Short Communication

The effect of some Mexican citric acid snacks on in vitro tooth enamel erosion

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Enamel erosion is a process of dissolution of the tooth enamel surface dependent upon the pH of the bathing medium, and not due to intrinsic acid production in dental plaque. Pathologic erosion of the dental tissues caused by the consumption of acidic beverages, lemon juice, citric acid, or fruits has been described.[1,2] In South Texas, snacks or candies that contain citric acid, extract of jalapeño pepper, and/or sugar are imported from Mexico and sold in supermarkets and convenience stores in Hispanic barrios. These snacks are increasing in popularity, especially among children and adolescents. The aims of this study were to measure how much softening some of these snack products can cause to dental enamel in a standardized in vitro system, and to compare the effects of these products to each other and to the effects of milk and a carbonated beverage (Sprite™, Coca Cola Co., Atlanta, GA).

Methods and materials

The following products were tested:

1. Lucas powder (A. Matre, S. A. de C.Z.V.)
2. Lucas paste (A. Matre, S. A. de C.Z.V.)
3. Chamoy paste
4. Sprite (regular)
5. milk (whole fat).

Sprite was included as a positive control, and milk as a negative control.

Two-mm-thick sections were cut from 15 extracted human teeth and polished so that the upper and lower surfaces were perfectly flat and free of visible scratches. The microhardness of the enamel on the sections was determined using a Buehler Micromet® Microhardness Tester (Buehler Ltd., Lake Bluff, IL) fitted with a Vickers diamond attachment, under a load of 200 g. The hardness of each sample was tested at three different points on each section prior to and after exposure to the test products. Sections were allocated randomly to treatment groups. Each tooth section was exposed to the products for 20 min, thoroughly rinsed, and then retested for enamel microhardness. The Lucas powder was dissolved in deionized water as a 10% solution. The other products were used undiluted. The sections were placed either in 10 ml of the solutions (Sprite, milk, or dissolved Lucas powder) in glass vials and stirred continuously with a magnetic stirrer, or placed in 5 g of the paste (Chamoy, Lucas paste). The pH of the dissolved test products and controls was measured using a pH combination glass microelectrode.

Data were analyzed by repeated measures ANOVA, followed by Duncan's new multiple range test to determine whether group means were significantly different.

Results

As indicated in the table, all test products caused some softening of the enamel surface, although in the case of milk, this was negligible, and nonsignificant. ANOVA of the before versus after differences in microhardness showed significant ($P < 0.0001$) differences in the extent of softening resulting from the exposure to the different products. Post hoc analysis revealed that Chamoy paste and Lucas powder caused the greatest softening, but were not significantly different from each other. In the case of Chamoy, the de-

TABLE. pH OF PRODUCTS AND MEAN (± STANDARD ERROR OF THE MEAN) VICKERS HARDNESS VALUES FOR TEETH BEFORE AND AFTER EXPOSURE TO TEST PRODUCTS (N=9)

Test product	*pH*	*Vickers Hardness Value* *Before*	*After*	*Difference*	*Percent Difference*
Milk	6.84	401.8 (± 23.8)	371.6 (± 12.8)	30.2 (± 31.3)	-7.5%
Sprite	3.28	393.1 (± 17.0)	274.2 (± 12.8)	118.9 (± 17.4)	-30.2%
Lucas powder	2.04	388.4 (± 14.7)	239.2 (± 19.6)	149.2 (± 27.5)	-38.5%
Chamoy paste	2.18	388.1 (± 20.0)	183.7 (± 5.8)	204.4 (± 18.3)	-52.7%
Lucas paste	2.44	383.2 (± 13.4)	319.0 (± 7.9)	64.2 (± 15.3)	-16.8%

crease in enamel microhardness was greater than 50%. With the exception of the Lucas paste, all of the products caused more softening than did the negative control, milk. Lucas powder caused an equivalent amount of softening and Chamoy significantly more softening than the positive control, Sprite.

Discussion

This study demonstrated that acid-containing Mexican snack products cause significant damage to dental enamel. The amount of softening caused by the two products was greater than that caused by Sprite. Sprite was chosen as a positive control, because it was found in a similar experiment[3] to cause more enamel softening than other acid beverages tested. Milk was included as a negative control because of its high pH and calcium content, which would inhibit enamel dissolution. Unlike the Lucas powder, the pastes were not diluted in this experiment, following preliminary experiments that indicated that they were not readily soluble in room temperature water at the same 10% concentration. Of the acid snacks tested, the product that caused the least softening was the Lucas paste. Since this is a very thick, viscous product, it is possible that the acid was not able to contact or wet the enamel surface thoroughly, and its diffusion was limited by the viscosity. It is interesting that the Lucas paste (reported composition: sugar, salt, citric acid, chili powder, corn starch, lemon) was not only thicker than the Chamoy paste (composition: starch, salt, sugar, citric acid, chili) but it also contained more sugar. This combination of acidity, stickiness, and sugar could make the Lucas paste potentially more damaging to the teeth, because the retention could allow the acid to stay in contact with the teeth, while the sugar could allow plaque bacteria to form even more acid, causing dental caries and acid erosion.

The inherent pH of a snack or beverage is partially predictive of its erosive potential, but there may be protective factors, such as phosphate concentration, fluoride, and buffer capacity.[3] The contribution of calcium chelation to enamel dissolution has been considered infrequently.[4] It is intriguing that sucrose has been shown to inhibit acid dissolution of enamel,[5-7] while sorbitol has the opposite effect.[4,5] This could also help to explain why the Lucas paste, with a pH lower than that of Sprite, caused no more softening than milk.

Although the enamel sections tested in this study were significantly softened by this short exposure to the acidic products, in vivo there is considerable protection in the form of saliva. Salivary proteins, glycoproteins, and lipids form the acquired enamel pellicle, which has been shown to confer resistance against enamel erosion.[8] The high flow rate of acid-stimulated saliva dilutes and washes away acids, and its elevated buffer capacity would also tend to neutralize the acids. Finally, high salivary concentrations of calcium and phosphate would tend to inhibit dissolution of calcium and phosphate salts from the tooth surface under acid conditions, and promote re-deposition and re-hardening of the damaged enamel as the pH returns to neutral or basic conditions following salivary stimulation. Therefore, normal, infrequent consumption of these acid snacks may not cause extensive enamel erosion.

Patients should be encouraged to limit frequency of consumption of these products and to chew sugar-free gum after using them to increase salivary flow, aid oral clearance of these snacks, and elevate the buffer capacity of stimulated saliva to neutralize both extrinsic and intrinsic (i.e., plaque) acids at the tooth surface. Lastly, salivary stimulation would increase the kinetic driving force for remineralization, or surface repair, by its elevated pH and supersaturated concentrations of calcium and phosphate.

In conclusion, practitioners should be aware that the high erosive potential and patterns of usage of these Mexican snacks may represent a potential dental problem in areas where they are popular.

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1. Asher C, Read MJ: Early enamel erosion in children associated with the excessive consumption of citric acid. Br Dent J 162:384–87, 1987.
2. Grobler SR, Senekal PJ, Kotze TJ: The degree of enamel erosion by five different kinds of fruit. Clin Prev Dent 11:23–28, 1989.
3. Lussi A, Jäggi T, Schärer S: The influence of different factors on in vitro enamel erosion. Caries Res 27:387–93, 1993.
4. Kleber CJ, Putt MS, Muhler JC: Enamel dissolution by various food acidulants in a sorbitol candy. J Dent Res 57:447–51, 1978.
5. Bibby BG, Mundorff SA: Enamel demineralization by snack foods. J Dent Res 54:461–70, 1975.
6. McDonald JL Jr, Stookey GK: Influence of different carboxylic acids on enamel dissolution in the presence and absence of sucrose. J Dent Res 54:187, 1975.
7. Jerushalmi I, Markitziu M, Friedman M, Gedalia I: Enamel dissolution and fluoride uptake from sugar solutions. J Oral Rehabil 11:555–59, 1984.
8. Meurman JH, Frank RM: Scanning electron microscopic study of the effect of salivary pellicle on enamel erosion. Caries Res 25:1–6, 1991.