In vitro protection against dental erosion afforded by commercially available, calcium-fortified 100 percent juices

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ABSTRACT

Background. Calcium in acidic beverages can decrease a person's risk of experiencing dental erosion. The authors compared the pHs and titratable acidities of commercially available calcium-fortified and unfortified 100 percent juices, and enamel and root surface lesion depths after they were exposed to different juices.

Methods. The authors measured the pH and titratable acidity of calcium-fortified and unfortified 100 percent juices. They exposed enamel and root surfaces to different 100 percent juices for 25 hours and measured lesion depths. They used the Spearman rank correlation test and the two-sample *t* test to identify associations between the juices' properties and lesion depths and to compare lesion depths between fortified and unfortified juices.

Results. The authors found that fortifying apple, orange and grapefruit juices with calcium prevented enamel erosion and decreased root surface erosion ($P < .01$). They also found that fortifying white grape juice with calcium decreased enamel erosion ($P < .001$) but not root surface erosion. They observed that mean lesion depths were greater in root surfaces than in enamel surfaces after exposure to unfortified orange juice and all fortified juices ($P < .001$).

Conclusions. Calcium concentrations in commercially available, calcium-fortified 100 percent juices are sufficient to decrease and prevent erosion associated with extended exposure to a beverage.

Clinical Implications. People at risk of experiencing erosion could decrease their erosion risk by consuming calcium-fortified juices.

Key Words. Juice; erosion; calcium; fortification.

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Dental erosion is defined as the progressive, chemical removal of mineral from the enamel or exposed root surface of the tooth.[1,2] Erosion differs from caries in that caries is a site-specific lesion associated with bacterial fermentation of carbohydrates. Erosion is classified as extrinsic (that is, from the person's diet) or intrinsic (that is, gastroesophageal) in origin.[1-3] Dental erosion is considered to be a significant oral health concern in European and Middle Eastern countries; however, it has received much less attention in the United States.[4-6]

European investigators have studied acidic foods and beverages to determine if they are risk factors for enamel erosion; most investigations have focused on acidic beverages.[7-9] The pH, titratable acidity (that is, quantity of base required to bring a solution to neutral pH), acid composition and mineral concentrations contribute to the beverage's erosion potential. Danish researchers Larsen and Nyvad[8] reported that in vitro erosion was minimal for beverages with a pH higher than 4.2, but it was more evident for beverages with pHs lower than 4.0. They also found that the extent of erosion was not associated with titratable acidity. In a study in England, Hemingway and colleagues[9] found progressive enamel loss when teeth were exposed continuously to

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a variety of juices and juice drinks. They also found that enamel loss was associated with initial pH but not with titratable acidity. Thus, pH is considered a stronger determinant of erosion potential than is titratable acidity.

The presence of calcium, phosphorous or fluoride in a solution has the potential to prevent or limit the extent of erosion.[10] Larsen and Nyvad[8] reported that calcium and phosphorous supplementation of orange juice prevented in vitro enamel erosion. The addition of calcium citrate or calcium triphosphate to orange juice also has been associated with a lower in vitro erosion potential.[11] Similar to the situation with orange juice, which has a pH of 3.8, the addition of calcium to black currant juice, which also has a pH of 3.8, resulted in a decreased amount of observed erosion both in vitro and in situ.[12]

Although dental erosion has received little attention in the United States, increased consumption of 100 percent juices and juice drinks could increase the potential for erosion. In the United States, some 100 percent juices and juice drinks are fortified with varying concentrations of calcium with the goal of increasing dietary calcium intakes for bone accretion and osteoporosis prevention. We hypothesized that calcium fortification decreases the erosion potential of 100 percent juices. We conducted a study to compare the pHs and titratable acidities of commercially available 100 percent juices with and without calcium fortification and to compare the extent of enamel and root surface erosion after juice exposure.

MATERIALS AND METHODS

Beverage selection. We purchased ready-to-feed 100 percent apple, orange, grape and grapefruit juices with and without calcium fortification from local grocery stores. These 100 percent juices were Mott's Apple Juice (Stamford, Conn.), Minute Maid Apple Juice With Calcium (Atlanta), Tropicana Pure Premium Orange Juice (Bradenton, Fla.), Tropicana Pure Premium Pure Orange Juice With Calcium and Vitamin D, Tropicana Pure Premium Ruby Red Grapefruit Juice, Florida's Natural Grapefruit Juice With Calcium (Lake Wales, Fla.), Welch's White Grape Juice (Concord, Mass.) and Old Orchard White Grape Juice With Calcium (Sparta, Mich.). We stored the juices at room temperature or refrigerated them according to manufacturer's recommendations.

Physiochemical properties. We measured the pH and titratable acidity of each juice by using an automatic titrator (Metrohm E512 analog pH meter, Brinkmann Instruments, Westbury, N.Y.). We measured the titratable acidity of each juice by adding 1 molar of potassium hydroxide (KOH) to 50 milliliters of the juice until the pH reached 7.0. We took measurements three times for each juice.

Tooth preparation. We disinfected 64 extracted, uncavitated molars and premolars. We then removed any soft tissue and debris by scraping the teeth with a razor blade to remove gross debris, sonicating them in water for one to two minutes and brushing them individually with an electric brush. We painted the teeth with fingernail polish, leaving an unexposed 1- × 4-millimeter window of tooth structure on a flat, smooth surface. We prepared the teeth with one enamel or root surface window.

Juice exposure. We suspended the teeth (four enamel surface windows and four root surface windows on the basis of pilot data per beverage) in 250 mL of juice with the windows submerged for 25 hours at room temperature. We stirred the juices by using a magnetic stir bar, and we replaced the juices with fresh juices every five hours. After the teeth were submerged for 25 hours, we removed the teeth from the juice, rinsed them in water and air-dried them.

Measurements. After juice exposure, we mounted the teeth in a mandrel with sticky wax, leaving the window exposed and protruding from the mandrel. We sectioned the teeth through the painted and exposed surfaces by using a microtome (Series 1000 Hard Tissue Microtome, SciFab, Lafayette, Colo.). The sections were 100 to 150 micrometers deep, and we took approximately eight sections per tooth. We removed the sections from the tooth and stored them in water.

We removed the sections from the water and used a polarized light microscope (Olympus BX-50, Olympus America, Center Valley, Pa.) at ×10 and ×5 magnification to visualize the sections to identify any changes in the exposed surfaces. We photographed three representative windows or lesions per tooth surface.

We used image analyses software to measure the depths of both the enamel and root surface

ABBREVIATION KEY. DV: Daily value. **%DV:** Percent daily value. **KOH:** Potassium hydroxide. **NaOH:** Sodium hydroxide.