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pH and Erosive Potential of Commonly Used Oral Moisturizers

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Keywords
Dry mouth; erosion; root caries; oral moisturizers.

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Abstract

Purpose: To measure the pH values of commonly used oral moisturizers and to evaluate their erosive potential using a gravimetric analysis.
Materials and Methods: A pH analysis was performed for seven commercially available oral moisturizers using a calibrated pH meter. The pH recording was repeated three times, from three different bottles each of the same product. The gravimetric analysis was performed by submerging human dentin blocks in 5 ml of each of the moisturizers for a total of 2 weeks, with gravimetric measurements made at baseline, 24 hours, 48 hours, 96 hours, 1 week, and 15 days. Tap water was used as positive control and citric acid as the negative control. The erosive potential was descriptively analyzed, and a Spearman correlation coefficient was used to assess the relationship between the erosive potential and the pH values.
Results: The average pH values are as follows: Oasis, 6.3, Bioténe Moisturizing Mouth Spray, 6.1, CTx2 Spray, 9.1, Mouth Kote, 3.0, Thayer's, 6.3, Bioténe Oral Balance, 6.6, Rain, 7.1, tap water 6.99, and citric acid 1.33. The results (% of tooth structure lost) of the gravimetric analysis were as follows: Mouth Kote, 9.6%, Bioténe Moisturizing Mouth Spray, 4.6%, Oasis, 3.2%, Thayer's, 2.0%, Bioténe Oral Balance, 0.0%, Rain, 0.0%, CTx2 Spray, 0.0%, tap water 0.0%, and citric acid 18.8%. There was a significant negative correlation between the pH values and the erosive potential ($r_s = -0.73$; $P \leq 0.0001$).
Conclusions: There is large variation in the composition and pH values of commonly used oral moisturizers, and there is a strong correlation between pH values and erosive potential of commonly used oral moisturizers. *Clinical Significance*: Patients with dry mouth are at increased risk for erosion and root caries. Oral moisturizing agents are often prescribed for patients with hyposalivation to be used as needed for symptomatic relief. This study shows that there is large variation in the pH values and erosive potential of commonly used oral moisturizing agents.

Dry mouth, or hyposalivation, is a multifactorial condition affecting between 15% and 30% of the population.[1,2] Common causes of hyposalivation are side effects of multiple medications prescribed to treat systemic conditions, diseases such as Sjogren's syndrome, head and neck irradiation, and systemic cancer chemotherapy.[3] It has been estimated that 63% of the 200 most commonly prescribed medications in the United States are xerogenic and result in reduced salivary flow rates.[4]

Oral moisturizers are frequently recommended by oral health-care professionals for patients with hyposalivation. Although it is clear that they do not prevent or cure oral disorders, as palliative agents they may significantly improve a patient's quality of life and facilitate improved health in a number of ways.[3]

Patients with hyposalivation have both a subjective and objective reduction in salivary secretions, placing these patients at increased risk for cariogenic activity. Saliva is an amazing substance that reduces the incidence and severity of caries by removing acids by swallowing, by buffering acids created by acidogenic bacteria, and providing calcium and phosphate to aid the remineralization process.[5] With reduced salivary flow rates, patients are at high risk for the development of both root caries and dental erosion.[6,7]

While oral moisturizers can provide comfort to patients with dry mouth, it is important that they do not increase the patient's risk for root caries. One commonly suggested salivary stimulant used with dry mouth patients contains 3% citric acid, which has a pH well below the critical pH for root dentin, and hence would

be erosive and potentially increase the risk for development of root caries. The critical pH for enamel and dentin is the pH at which tooth structure begins to dissolve. The critical pH for enamel ranges between 5.2 and 5.5; however, the critical pH for root dentin is much higher at 6.7.[8] To date, no study has been published that assessed the pH values and erosive potential of oral moisturizing agents.

The purpose of this study was to assess the pH and erosive potential of commercially available oral moisturizers using a pH meter and gravimetric analysis. The null hypothesis is that none of the oral moisturizing agents would have a pH below the critical pH of root dentin or show erosive potential as measured by the gravimetric analysis.

Materials and methods

pH analysis

A pH analysis was performed for seven commercially available oral moisturizers using a calibrated pH meter (Mettler-Toledo MP230 GLP; Mettler-Toledo, LLC, Columbus, OH). The names of the products, their ingredients and manufacturers are listed in Table 1. Tap water was used as a positive control, and citric acid was used as a negative control.

Three bottles of each moisturizing agent were obtained. For each bottle, the pH recording was repeated five times, resulting in 15 measurements per brand. The pH meter was calibrated with buffer solutions with a pH of 4.00, 7.00, and 10.00 (Fisher Scientific, Fair Lawn, NJ) before a recording from a new bottle was initiated. The pH value was recorded when the pH meter stabilized a measurement. Between each recording, the measuring probe was rinsed with de-ionized water (pH 7.68) and dried, to buffer the glass-electrode. All recordings were made at a temperature of 23°C.

Erosive potential

A gravimetric analysis is the quantitative determination of the mass/volume of a solid after a series of analysis. Forty-five freshly extracted first maxillary molars roots were collected for the gravimetric analysis. Each root was sectioned at the cemento-enamel junction. The coronal and apical portions of the specimens were sealed with a self-etching dentin bonding agent (Clearfil SE Bond, Kuraray America, New York, NY) to avoid influx of the solution into the pulp chamber. The specimens were then thoroughly dried for 1 minute with oil-free air from an air/water syringe and weighed on a calibrated analytical balance (Mettler-Toledo HR-60) to obtain a baseline recording. The specimens were then submerged in 5 ml of solution of each of the moisturizers and control solutions for 24 hours, 48 hours, 96 hours, 1 week, and 2 weeks with measurements performed at each interval after drying the specimens as previously described. The solutions were renewed at each interval.

The erosive potential as indicated by the percent loss from baseline to 2 weeks was analyzed descriptively, and a Spearman correlation coefficient was used to assess the relationship between the erosive potential and the pH of the moisturizers. Level of significance was set at 0.05.

Results

pH analysis

The pH values of the tested oral moisturizers are displayed in Table 2. Five of the seven moisturizers tested had a pH below 6.7. One product (Mouth Kote) had a very low pH of 3.03. Two products (Rain and CTx2 had pHs above 7 at 7.10 and 9.09, respectively. It is clear there is considerable variation in pH values between brands of oral moisturizers.

Erosive potential

The results of the gravimetric analysis are displayed graphically in Figure 1. Three products caused no loss of tooth structure (Bioténe Oral Balance, CTx2 and Rain). Two products (Thayer's Dry Mouth Spray and Oasis) caused moderate loss of tooth structure, 1.99% and 3.23%, respectively. Two products (Mouth Kote and Bioténe Moisturizing Mouth Spray) caused a considerable loss of tooth structure, 9.6% and 4.6%, respectively. Citric acid caused 18.77% tooth structure loss, while tap water caused no erosion at all.

The Spearman correlation between the pH value and the total tooth structure loss after two weeks was statistically significant ($r_s = -0.73$; $P \leq 0.0001$), indicating a negative relationship between average pH of the moisturizers and the total percentage of structure loss (i.e., the higher the pH value, the lower the erosive potential, and the less tooth structure loss).

Discussion

Patients with reduced salivary flow are at high risk for root caries. The data presented in this study provide a sound rationale for recommending specific oral moisturizers for those patients who could benefit from their use; however, it is clear that oral moisturizers differ greatly in their composition, pH, and erosive potential.

Four out of the seven tested moisturizers contain citric acid. Two of the tested products have lemon and lime flavors. It is of great concern that citric acid is added to agents intended for patients with dry mouth. As shown in this study, citric acid caused 18.77% tooth structure loss after 2 weeks of immersion, and three of the four moisturizers that contain citric acid showed varying degrees of erosive potential. While citric acid is indeed a potent salivary stimulant, the addition of citric acid and other acids to food and sweets increases their erosive potential. Wagoner et al studied the erosive effects of sour candies in vitro and found that slurries of candy sweetened with citric, maleic, and fumaric acid caused erosive lesions on enamel.[9] Brand et al found that sour candy had erosive potential in vivo, despite inducing an 8.6- to 13.9-fold increase in salivary flow.[10] These findings, coupled with the findings in this study suggest that adding citric acid to moisturizing agents for patients with reduced salivary flow might potentially be harmful; however, one moisturizing agent containing citric acid (Bioténe Oral Balance) showed no erosive potential, while a moisturizing agent not containing citric acid did. Therefore, the concentration of acid coupled with the complex interplay of other ingredients may have a neutralizing effect.

Table 1 Moisturizing products, ingredients, and manufacturers

Product	Lot numbers	Ingredient(s)	Manufacturer
CTx2 Spray	150811 70113 70113	Purified water, xylitol, glycerin, sodium benzoate, calcium hydroxide, natural flavors, natural colors	Oral Biotech, Albany, OR
Dry Mouth Spray	19CT912 19CT912 9138	Purified water, vegetable glycerin, calcium gluconate, tris amino, citric acid, potassium chloride, natural citrus flavors (derived from oils of lemon and lime)	Thayers Natural Remedies, Westport, CT
Mouth Kote	00513E04113 K0825 K0825	Water, xylitol, sorbitol, yerba santa, citric acid, natural lemon-lime flavor, ascorbic acid, sodium benzoate, sodium saccharin	Parnell Pharmaceuticals, Inc. San Rafael, CA
Oasis	11828	Glycerin, cetylpyridinium chloride, copovidone, flavor, methylparaben, PEG-60 hydrogenated castor oil, propylparaben, sodium benzoate, sodium saccharin, water, xanathan gum, xylitol	Oasis Consumer Health, Cleveland, OH
Biotene Oral Balance	T2M301 1D21C1 T2M301	Hydrogenated starch hydrolysate, purified water, sunflower oil, propylene glycol, whey protein, xylitol, sodium benzoate, flavor, flax-seed oil, xanthan gum potassium sorbate, disodium phosphate, zinc gluconate, citric acid, potassium thiocyanate, lactoperoxidase, lactoferrin, lysozyme, rosemary extract, canola oil, tocopherol	GlaxoSmithKline, Raleigh-Durham, NC
Biotene Moisturizing Mouth Spray	U3B251 U3B251 2B23C1	Purified water, hydrogenated starch hydrolysate, propylene glycol, sunflower oil, xylitol, whey protein, potassium sorbate, sodium benzoate, xanathan gum, flavor, tocopherol, canola oil, lactoperoxidase, citric acid, lactoferrin, lysozyme, disodium phosphate, rosemary extract, potassium acesulfame, potassium thiocyanite	GlaxoSmithKline, Raleigh-Durham, NC
Rain	13129A 13129A 13110A	Purified water, xylitol, aloe vera concentrate, vegetable glycerin, natural spearmint flavoring, calcium glycerophosphate, cellulose gum, grapefruit seed extract	Xlear Inc. American Fork, UT

Some of the ingredients in the moisturizing agents might be of benefit. Six out of seven tested moisturizers contain Xylitol. A recent clinical trial showed a modest, although not statistically significant, reduction in caries incidence among participants who used Xylitol lozenges daily for 33 months, versus the control group that used placebo lozenges.[11] However, when the data from that study were further analyzed, specifically with regard to the incidence of root caries, a 40% reduction was found for the experimental group.[12] That suggests that using oral moisturizers that contain Xylitol might indeed be a beneficial adjunct for patients with dry mouth. One of the Xylitol-containing moisturizers also contains calcium hydroxide, which might be of further benefit in reducing the root-caries risk, and yet another contains calcium glycerophosphate. None of the tested moisturizers contain fluoride.

Manufacturers recommend using oral moisturizers as needed throughout the day, and some recommend holding, or even swishing the product in the mouth for several seconds before swallowing it. It is thus clear that there is potential for considerable demineralization over time in patients with severely reduced salivary flow rates. This demineralization could be expressed as root caries or erosion, as erosion is

Table 2 pH of each moisturizer (N = 21), overall mean and standard deviation

	Bottle #1 avg.	Bottle #2 avg.	Bottle #3 avg.	Overall mean	SD
Oasis	6.00	6.50	6.48	6.33	0.28
Bioténe MS	6.15	6.09	6.10	6.11	0.03
CTx2 Spray	9.15	9.07	9.06	9.09	0.05
Mouth Kote	3.06	3.01	3.02	3.03	0.03
Thayer's	6.85	6.02	6.04	6.30	0.47
Bioténe OB	6.47	6.68	6.68	6.61	0.12
Rain	7.10	7.12	7.08	7.10	0.02
Tap water	7.10	6.85	7.03	6.99	0.13
Citric acid	1.41	1.24	1.35	1.33	0.09

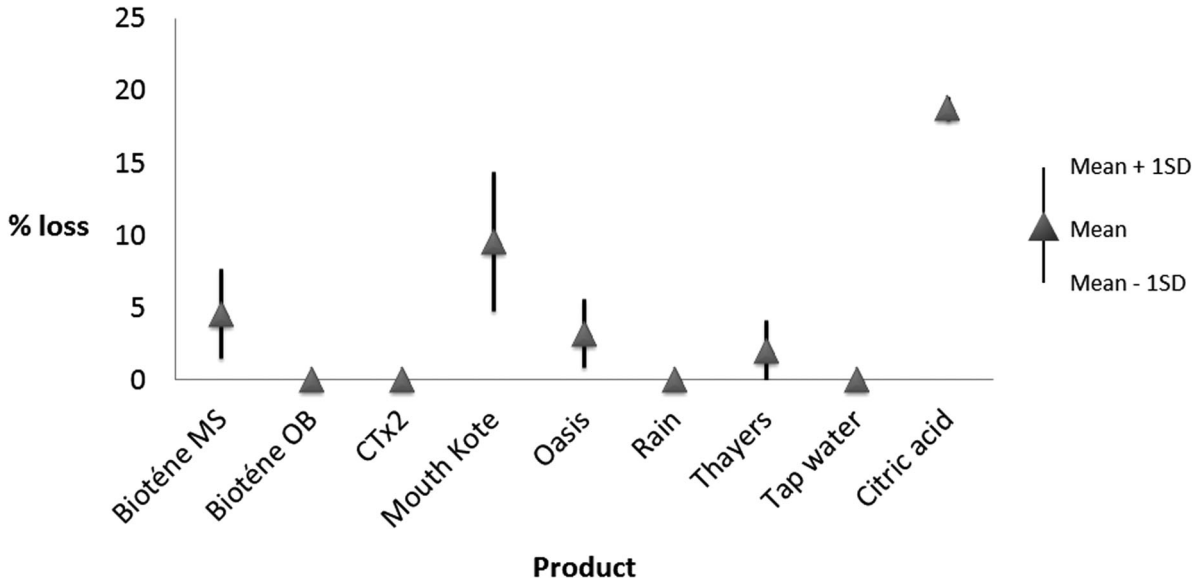

Figure 1 Descriptive statistics for percent tooth structure loss from baseline to 2 weeks.

generally increased in patients with reduced salivary flow rates.[13,14] It would thus seem reasonable to recommend oral moisturizing agents with pH values at or above the critical pH values of enamel and root dentin for patients suffering from reduced salivary flow rates.

Inclusion of oral moisturizers in patients with hyposalivation should be tailored to the individual patient's concerns, preferences, and oral health needs. Most of these products have not been scientifically or clinically tested.[3]

Within the limitations of this study, it is clear that there is considerable variation in composition, pH values, and erosive potential among oral moisturizers. The null hypothesis that no products tested have pH values below the critical values for enamel and dentin and no products tested have an erosive potential is thus rejected. This observation is, however, not a clear depiction of the clinical scenario, since the actual clinical effects will vary from patient to patient as mitigated by the type and amount of saliva and other clinical factors.

Further studies should be conducted to determine if the higher pH moisturizers provide a similar level of relief of the symptoms of dry mouth as the lower pH products. Clinical trials should also be conducted to determine if the incidence of root caries or erosion-related non-carious cervical lesions are affected by use of oral moisturizers.

Conclusion

There is large variation in the composition and pH values of commonly used oral moisturizers, and there is a strong correlation between pH values and erosive potential of commonly used oral moisturizers.

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