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Evidence for biofilm acid neutralization by baking soda

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ABSTRACT

Background. The generating of acids from the microbial metabolism of dietary sugars and the subsequent decrease in biofilm pH below the pH at which tooth mineral begins to demineralize (critical pH) are the key elements of the dental caries process. Caries preventive strategies that rapidly neutralize biofilm acids can prevent demineralization and favor remineralization and may help prevent the development of sugar-induced dysbiosis that shifts the biofilm toward increased cariogenic potential. Although the neutralizing ability of sodium bicarbonate (baking soda) has been known for many years, its anticaries potential as an additive to fluoride dentifrice has received only limited investigation.

Types of Studies Reviewed. There is evidence that baking soda rapidly can reverse the biofilm pH decrease after a sugar challenge; however, the timing of when it is used in relation to a dietary sugar exposure is critical in that the sooner its used the greater the benefit in preventing a sustained biofilm pH decrease and subsequent demineralization. Furthermore, the effectiveness of baking soda in elevating biofilm pH appears to depend on concentration. Thus, the concentration of baking soda in marketed dentifrice products, which ranges from 10% to 65%, may affect their biofilm pH neutralizing performance. People with hyposalivation particularly may benefit from using fluoride dentifrice containing baking soda because of their diminished ability to clear dietary sugars and buffer biofilm acids.

Conclusions. Although promising, there is the need for more evidence that strategies that modify the oral ecology, such as baking soda, can alter the cariogenic (acidogenic and aciduric) properties of biofilm microorganisms.

Practical Implications. The acid neutralization of dental biofilm by using fluoride dentifrice that contains baking soda has potential for helping counteract modern high-sugar diets by rapidly neutralizing biofilm-generated acid, especially in people with hyposalivation.

Key Words. Baking soda; sodium bicarbonate; adaptation; psychological, biofilms; caries prevention products; dentifrices; bacteria; diet; fluoride; xerostomia.

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ROLE OF DENTAL BIOFILM ACID PRODUCTION IN THE CARIES PROCESS

Dental caries is a complex disease in which there are interactions among the tooth structure, oral microbial biofilm formed on the tooth surface, dietary sugars, and, to a lesser extent, starches and salivary and genetic influences.[1] Biofilm bacteria metabolize sugars and produce acids, which over time demineralize tooth enamel and can lead to progressive destruction of the tooth's hard tissues—and if left untreated, pain, abscess, and possible tooth loss. The central role of the interaction between dietary sugars and dental biofilm is well established.[2] However, views on the role of specific organisms, such as *Streptococcus mutans*, in caries causation have changed over time. Several other biofilm microorganism species from the genera *Veillonella*, *Lactobacillus*, *Bifidobacterium*, and *Propionibacterium*; low-pH non–*S mutans* streptococci; *Actinomyces* species; and *Atopobium* species with acid-producing and acid-tolerating properties also have been associated with caries.[3] The emphasis is now on the biofilm as a community of endogenous microorganisms and how ecological conditions, mainly determined by frequent consumption of dietary sugars and low salivary flow (hyposalivation), can shift the biofilm from a healthy state to a caries conducive condition.[4-6] This ecological pressure from biofilm acidification leads to adaptation of the endogenous microorganisms to an acid environment that favors more acid tolerant (aciduric) bacteria and increased acid producing potential.[4]

Dental caries is a dynamic process involving cycles of mineral loss (demineralization) and mineral gain (remineralization).[1,7] The tooth surface is in a healthy state of dynamic equilibrium with the local oral environment (mainly created by saliva and the fluid phase of the biofilm) when demineralization and remineralization

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are in balance. The caries process occurs in oral conditions that favor more net demineralization than remineralization, resulting in sustained net mineral loss. The demineralization phase starts with the formation of organic acids, mainly lactic acid, as an end product from sugar metabolism.[6] As acid builds up in the biofilm, the pH decreases to the point at which conditions become undersaturated with respect to tooth mineral (critical pH is approximately 5.5); the lower the pH, the greater the degree of undersaturation and the greater the rate of demineralization.[8] In conditions in which sugar metabolism is not taking place or acids have been neutralized, the biofilm pH tends to be in the neutral or basic range, and the fluid phase of the biofilm is saturated sufficiently with calcium and phosphate ions so that redeposition of mineral (remineralization) is favored. The presence of low levels of fluoride reduces the net mineral loss during acid challenge and greatly enhances the reprecipitation process, which is considered the main mechanism of action for fluoride.[9]

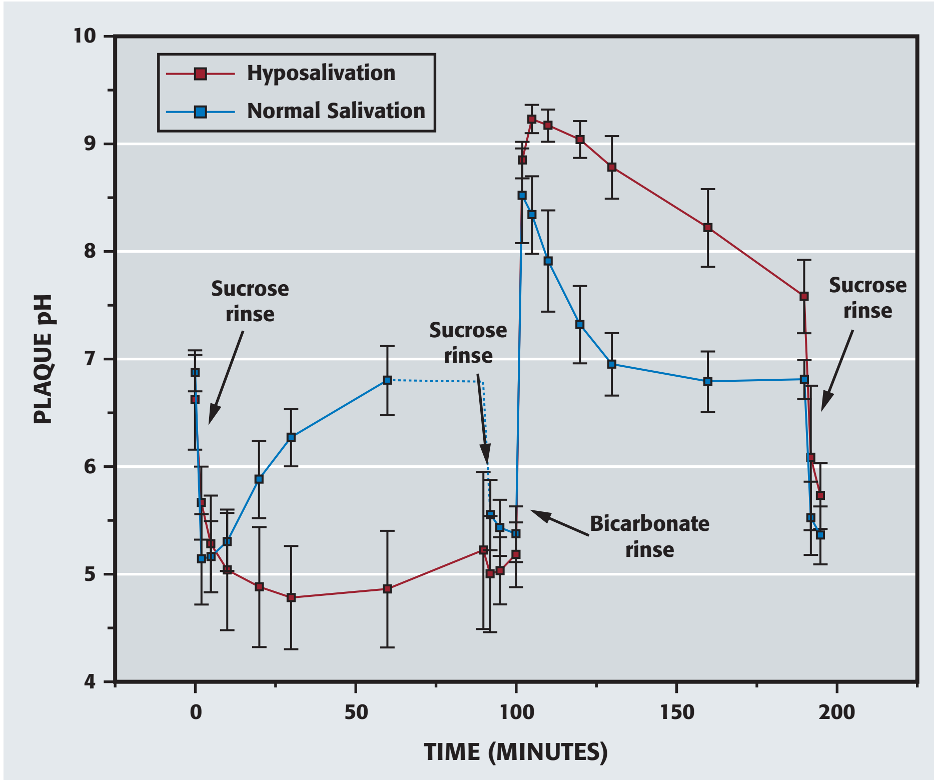

Figure. Mean plaque pH changes in participants with hyposalivation (n = 5) and with normal salivary flow (n = 5) after a one min 10% sucrose rinse, a second one min 10% sucrose rinse, a one minute rinse with 0.1 mol/L $NaHCO^3$ solution, and a third one minute 10% sucrose rinse. Error bars represent standard deviations.

The pH of the biofilm is influenced by many factors, including the concentration of the dietary sugars; the composition, thickness, and diffusion properties of the biofilm; the bicarbonate concentration in the saliva; and the velocity of the film of saliva as it passes over the surface of the biofilm.[1,10] The decrease in pH and subsequent return to neutrality that occurs when the biofilm is exposed to dietary sugars commonly is referred to as the *Stephan curve*.[10] Saliva plays an important role in modifying biofilm pH.[11] Salivary flow rate is the main factor affecting the clearance pattern of cariogenic foods and beverages. Saliva also plays an important role in modifying biofilm pH. In the absence of normal salivary flow, the pH stays at a low level for an extended period after exposure to dietary sugars (Figure). Therefore, saliva is responsible for the recovery of biofilm pH back toward neutrality. Stimulated saliva, because of its higher flow rate (increased volume) and enhanced buffering capacity (bicarbonate buffering system), dilutes and neutralizes biofilm acids.

The greater the acid concentration in the dental biofilm, the greater the driving force for acid to diffuse into the tooth. The 2 important factors that influence the amount of enamel demineralization are the extent of the pH decrease below the critical pH and the extent of time the pH remains below the critical pH. Measures that decrease acid production or elevate the pH through acid neutralization will prevent demineralization and favor remineralization and caries prevention.

DIRECT EFFECTS OF SODIUM BICARBONATE (BAKING SODA) ON BIOFILM pH

The potential of caries intervention strategies directed at the main driver of the caries process—acidification of the dental biofilm below the critical pH—long have been a subject of interest. The rapid alkalization of the biofilm by baking soda is 1 such approach. The author of an earlier review has supported the use of baking soda in dentifrice formulations because of its safety, low abrasiveness, and compatibility with fluoride.[12] The high solubility of baking soda makes it ideally suited to

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