significantly less acidogenic than sucrose and no different than sorbitol.

Maki et al. (Ref. 48) compared acid production in vivo from isomaltulose, sorbitol, xylitol, and sucrose (control) in human dental plaque. Dental plaque was collected from 12 individuals and incubated with phosphate buffer. After endogenous acid production was measured, a 1-percent solution of the test substance in the same buffer was added, and acid production measured again.

The results showed no acid production in the presence of xylitol. Compared to sucrose (100-percent acid production), acid production from sorbitol was 1 percent. The authors noted that the percent acid production from sorbitol may vary considerably among individuals and with the amount of exposure to sorbitol.

Park et al. (Ref. 49) measured interproximal plaque pH in five subjects after consuming one of three snacks alone or one of three snacks followed by a single mint containing sorbitol (94 percent) or a sorbitol and xylitol blend (79 percent and 15 percent, respectively). When mints were used, they were consumed 3 min following ingestion of the sweet snack. Snacks tested included a sandwich cookie, cupcake, and granola bar. A randomized block design was used to administer the test products and mints (see Table 2 for further details). The lowest plaque pH attained after consuming the three test products without mints ranged from 4.02 to 4.16. When the sorbitol mint was consumed following the test product, mean plaque pH values increased and ranged from 4.68 to 5.04. When the sorbitol and xylitol mint was consumed following consumption of the test products, mean plaque pH increased to a range of 5.32 to 5.60. Differences in mean plaque pH values between the mint products differed significantly when the mints were used after the granola bar and cupcake challenges. There was no significant difference in mean plaque pH between the sorbitol (5.04) and the sorbitol and xylitol mint (5.60) products when these products were used after the sandwich cookie challenge.

The results show that consumption of a sugarless mint reduced the acidogenicity of the test snacks, although final pH values remained below pH 5.5 in all but one test. The authors attributed the results of this study to the stimulatory effects on salivary flow by sugar alcohols. Increasing salivary flow increases the buffering capacity of saliva, thus reducing the acidogenic potential of a variety of snack foods. The authors also attributed the additional buffering effects of the sorbitol and xylitol mint to the presence of xylitol and its potential benefits in reducing plaque microbial activity. Without a sucrose-containing mint as a comparison, however, the influence of sugar alcohols on saliva production cannot be adequately assessed.

Söderling and coworkers (Ref. 50) investigated the effect on dental plaque of chewing gums that contained either xylitol, sorbitol, or a mixture of xylitol and sorbitol and compared the results with those obtained with subjects who used sucrose gums. Twenty-one subjects (adults, ages 19 to 35 yr) who were not habitual gum chewers were randomly assigned to chew gum containing either xylitol, sorbitol, or a blend of the two sugar alcohols for 2 wk. Subjects chewed 10 pieces of gum per day for an intake of either 10.9 g xylitol, 10.9 g sorbitol, or 10.9 g xylitol and sorbitol (8.5 g xylitol and 2.4 g sorbitol). The control group was made up of seven habitual sucrose gum users. Subjects maintained their usual diets and oral hygiene except just before to clinic visits. Interdental plaque pH was collected, and the resting plaque pH determined. Plaque pH was measured at 2, 5, 10, 15, and 20 min after an oral rinse containing the same sugar alcohols as used in the gum. Afterward, subjects rinsed with water and chewed a piece of paraffin for 1 min to expedite removal of sugar alcohols from the mouth. Baseline pH was again measured, followed by a mouth rinse with 10 mL of 10-percent sucrose. Plaque pH was again determined.

The results from using gum for 2 wk showed no significant changes in resting plaque pH in the xylitol and xylitol and sorbitol groups, whereas the use of sorbitol gum was associated with a lower pH. Final plaque pH values after use of sorbitol gum were significantly lower than baseline values, but all final values remained above pH 6.0.

Birkhed and Skude (Ref. 51) evaluated, among other tests, the APA from glucose, soluble starch, and Swedish HSH in dental plaque. Eleven adults were instructed to avoid oral hygienic procedures for 2 days. No dietary changes were required. At the end of 2 days, plaque was collected. The APA was determined from 3-percent solutions of glucose, boiled soluble starch, and HSH. The APA was also determined in increasing concentrations (0.003 to 12 percent weight per volume (w/v)) of starch and HSH.

The results showed significantly lower ($p<0.001$) APA from soluble starch (75.7 percent) and HSH (61.5 percent) compared to glucose (99.7 percent). The APA from HSH was also significantly lower ($p<0.01$) than that from soluble starch. The range of optimum acid production for both substrates was 0.03 to 6 percent. The authors noted that Swedish HSH is more fermentable than French HSH, which contains less high molecular weight hydrogenated saccharides than Swedish HSH.

Grenby et al. (Ref. 76) evaluated the dental properties of lactitol compared to five other bulk sweeteners, i.e., sucrose, glucose, sorbitol, mannitol, and xylitol, in vitro using a standardized mixed culture of dental plaque microorganisms. Sweeteners were incubated for 24 hours (h) in media containing a 1-percent solution of one of the six sweeteners. Plaque microorganisms were also incubated in media containing the sweeteners with segments of intact surfaces or with segments of pulverized dental enamel. The demineralization action of the acid produced by microbial fermentation was assayed by calcium and phosphorous analyses.

The greatest amount of acid production and lowest pH (significantly different than the sugar alcohols) were reported with sucrose and glucose (pH of 4.0 to 4.3). Lactitol and xylitol showed only slight changes in pH and acid production over the 24 h (final pH of 6.1 to 6.3); whereas sorbitol and mannitol showed slight changes in pH during the first 12 h ($pH \geq 6$), then gradually decreased to a final pH of 4.6 to 5.1 after 24 h.

The results of the demineralization test showed highly significant differences ($p<0.001$) between sucrose and glucose and the sugar alcohols. The reductions in calcium and phosphorous dissolving in sorbitol was approximately 80 to 85 percent, mannitol 63 to 69 percent, and lactitol and xylitol 94 to 98 percent compared to mineral loss in the presence of glucose.

3. Summary of Evidence Relating Sugar Alcohol and Dental Caries: Long-Term Studies

Möller and Poulsen (Ref. 20) determined the effect of long-term chewing of sorbitol chewing gum on the incidence of dental caries, plaque, and gingivitis. The sorbitol chewing gum contained calcium phosphate which acts as a buffer in saliva to help maintain pH and aid remineralization. Two groups of children, ages 8 to 12 yr of age, from two different schools in Denmark took part in this 2-yr study. Group 1 chewed one piece of sorbitol-containing gum three times a day, after meals. Group 2 chewed no gum and