

X Y L I T O L

The Good Sugar

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Abstract

Xylitol is a natural sugar that provides health benefits. Xylitol impacts plaque biofilm formation, acid production, salivary flow and oral pH providing benefits that prevent dental disease and enhance remineralization. Striving for five xylitol exposures daily can significantly improve oral health by reducing plaque biofilm accumulation and the transmission of *Strep mutans* from mother to child.

The anti-inflammatory aspects of xylitol prevent infection and enhance healing associated with open wounds, ear and sinus infections and aspiration pneumonia. The vast number of xylitol research studies published over the past 30 years in the dental field cover plaque biofilm accumulation, acid production, caries incidence, *Strep mutans* vertical transmission, oral pH and remineralization. Additional research demonstrates the effectiveness of xylitol in controlling biofilm infections in other parts of the body.

Educational Objectives

At the end of this program, participants will be able to:

1. Describe the beneficial characteristics of xylitol
2. Explain the impact of xylitol on plaque biofilm
3. List several ways xylitol can impact dental disease
4. Understand the anti-inflammatory effect of xylitol
5. Describe daily xylitol recommendation
6. Recognize products that are sweetened with 100 percent xylitol

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Introduction

Dental caries is a multi-factorial, pH-related, diet-associated infectious disease that begins with a non-cavitated demineralized enamel lesion.¹ Prevention of enamel demineralization is the foundation of caries prevention. Changes to diet and bacterial levels that impact salivary pH are preventive in nature. Saliva buffering and flow rates are key factors in maintaining neutral or alkaline pH levels. Reducing sugar consumption has been a primary focus in many caries prevention programs by suggesting non-cariogenic alternatives. The caries preventive benefits of many sugarless gums and candies have been attributed primarily to the increase in salivation due to chewing the gum or eating the candy and secondly depriving the oral bacteria of their normal growth substance: sucrose. These passive effects are no doubt important in limiting caries, but xylitol possesses active, specific effects that other non-cariogenic sweeteners do not.² Xylitol will limit caries even in the presence of strong cariogenic challenges with fermentable carbohydrates. The physico-chemical properties of xylitol provide insight as to why it is more effective than other “sugarless” sweeteners in elevating oral pH, reducing plaque, contributing to remineralization and preventing caries.³

Xylitol is a natural sugar; it is not an artificial sweetener. It is considered a carbohydrate and more narrowly categorized as a polyol or sugar alcohol. It is found in tree bark, plants, fruits and vegetables. The human body makes five to 10 grams of xylitol each day in the metabolism of carbohydrates. The most common source today is from corn cobs and corn stalks. Xylitol's crystalline form looks and tastes like table sugar, but contains only 2.4 calories per gram, providing 40 percent fewer calories than other carbohydrates.

Xylitol was discovered in 1891 by chemists Emil Herman Fischer and Rudolf Stahl in Germany and simultaneously in France by chemist M.G. Bertran. It wasn't until the 1960s

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2. Maguire, A., Rugg-Gunn, A., 2003. *Xylitol and caries prevention—is it a magic bullet?* *Br Dent J*, 194, 429-436.
3. Mäkinen, K., 2010. *Sugar alcohols, caries incidence, and remineralization of caries lesions: A literature review*, *International Journal of Dentistry*, 1-23.

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that the benefits of xylitol for those with diabetes were recognized. The glycemic index of xylitol is very low at seven. Xylitol does not use insulin for metabolism, making it ideal for those with diabetes and anyone wanting to reduce sugar consumption.

Xylitol works by interfering with the bacteria's ability to produce acid and by blocking its stimulus to produce the polysaccharide slime that holds the biofilm together.⁴ Cariogenic bacteria prefer living in a low pH environment and produce the acid that demineralizes enamel. Xylitol is a five-carbon sugar, while most others are six carbons. This makes it easier for a xylitol molecule to pass through the outer membrane of a bacteria, however passing through the next membrane is impossible for xylitol. The bacteria must then use its own membrane pump to move the xylitol molecule back through the membrane to the outside. The bacteria expends energy but does not derive any energy from xylitol the way it can from six-carbon sugars like sucrose and sorbitol.⁵ In the presence of xylitol, the bacteria stop producing acid and the polysaccharide slime that holds the biofilm together and they simply slide off the teeth. In the presence of sugar, bacteria thrive, produce acid and stick to the teeth. Bacterial numbers are significantly reduced in the presence of xylitol.⁶ Xylitol promotes an alkaline oral environment, which is conducive to oral health.

Xylitol maintains a higher pH level in both saliva and plaque fluid in contrast to the acid pH associated with sucrose ingestion.⁷ Sucrose forms complexes with calcium that allows precipitation of calcium out of saliva while xylitol forms complexes with calcium that do not produce acid and maintain a supersaturated calcium level in saliva, important for remineralization of enamel. This is critical when teeth first erupt and are not completely mineralized. The ability of xylitol to maintain high salivary calcium levels as teeth erupt enhances final mineralization of these teeth. The ability of xylitol to bind with calcium is also evident in higher calcium levels measure in plaque when xylitol is present.⁸

There are some minor side effects when xylitol is eaten in large amounts too quickly. Xylitol is digested as a fiber and has the ability to pull fluid out of tissues, which can lead to gas, bloating and diarrhea. It only takes a week for the body to adjust to replacing all sugar with xylitol. In most cases, xylitol is added to the diet but will not replace all sugars so the gastric upset will only be a problem when eating too much too fast, for example, making cookies with xylitol and then eating several because they taste so good.

In the 1970s, the caries prevention benefits of xylitol were recognized, leading to the publication of numerous research studies over the past 40 years. The first dental research using xylitol measured plaque accumulation over a four-day period when xylitol was introduced as a coffee sweetener, in caramels and other food items eaten throughout the day. Plaque accumulation was reduced 50 percent in those eating xylitol-sweetened foods and beverages.⁹ In 1972 this study was repeated with dental students who ate xylitol-sweetened foods and beverages several times each day and refrained from all oral hygiene during the five-day test. Again, plaque accumulation was reduced by 50 percent. This is greater plaque reduction than is evident in many toothbrushing studies. This significant finding, confirming results of the first study completed in 1970, provided a springboard for caries-related xylitol research around the world.¹⁰

After the second plaque accumulation study, the researchers in Finland undertook a serious and expensive study to measure the effects of replacing all sugar in the diet with xylitol. The two-year meal replacement study resulted in an 85 percent reduction in caries activity.¹¹ These findings were exciting, but replacing all sugar with xylitol was a daunting task. Instead of a daily dose of 67 grams of xylitol, researchers next tested a daily dose of 6.7 grams of xylitol-sweetened chewing gum taken after meals and snacks. The results were strikingly similar. This confirmed that not all sugar needed to be replaced with xylitol, but that chewing xylitol-sweetened gum after meals and snacks each day would provide the same caries preventive benefit.

Many more studies followed. Chewing gum comparisons showed that 100 percent xylitol-sweetened chewing gum reduced plaque accumulation significantly better than 100 percent sorbitol-sweetened gum and better than a gum sweetened with both xylitol and sorbitol.¹² Sorbitol can be metabolized by bacteria to produce acid, therefore adding sorbitol to chewing gum sweetened with xylitol will significantly reduce the benefits of xylitol. A three-year study in Hungary among nearly 700 students showed that having xylitol-sweetened candy several times each day reduced the incidence of caries better than fluoridated toothpaste or fluoride in milk.¹³

The classic long-term study was conducted by faculty from the University of Michigan in Belize. This 40-month study, conducted in the early 1990s, included nearly 1,300 students – all the fourth graders in Belize City. Several different chewing gums were tested, with the 100 percent xylitol-sweetened gum provid-

4. Badet, C., Furiga, A. & Thébaud, N., 2008. Effect of xylitol on an in vitro model of oral biofilm. *Oral Health & Preventive Dentistry*, 6(4), 337-341.
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6. Frostell, G., 1984. Interaction between xylitol and sorbitol in plaque metabolism. *Swed Dent J*, 8 (3) 137-146.
7. Marsh P, 1994. Microbial ecology of dental plaque and its significance in health and disease. *Adv Dent Res*, 8, 263-271.
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11. Scheinin, A., Mäkinen, K., Ylitalo, K. (1976) Turku sugar studies vs. final report on the effect of sucrose, fructose, and xylitol diets on the caries incidence in man. *Acta Odontol Scan*, 34, 179-216.
12. Mäkinen, K.K., 1976. Dental aspects of the consumption of xylitol and fructose diets. *Inter Dent J*, 26(1), 14-28.
13. Scheinin, A., Banoczy, J. Szoke, J. et al., 1985. [Collaborative WHO xylitol field studies in Hungary. I. Three-year caries activity in institutionalized children]. *Acta Odontol Scan*, 43 (6) 327-347.

ing the greatest reduction in tooth decay at 73 percent. At the end of the study, no more xylitol chewing gum was provided for the students. Five years later, researchers from the University of Washington traveled to Belize to evaluate the then fourth graders who were still living in the area. The caries preventive benefit of the xylitol seems to have altered the oral flora providing long-term benefits. The children who had chewed the 100 percent xylitol-sweetened gum still maintained a 70 percent reduction in tooth decay compared to children in the other chewing gum groups.

Numerous published studies report caries reductions from 21 percent to 85 percent, presenting a significant gap between reports. Differences in study outcomes are attributed to many aspects of the study design. Subjects with low caries experience will not demonstrate a large difference. A small study with an insufficient number of subjects will fail to show a difference. Studies using too low of a concentration of xylitol, too short an exposure to xylitol or too few exposures each day will not show significant results. The recommended dose is six to seven grams of xylitol daily, separated into three to five exposures.¹⁴ The gum is chewed for only five minutes, just enough to release the xylitol, no longer.

Babies are born essentially germ-free, quickly acquiring their oral flora from contact with food and loved ones. The mother is generally the primary caregiver and knowingly or unknowingly shares saliva with her infant through kissing, tasting food first to check temperature and sharing food and utensils. As the teeth erupt, *Strep mutans* transmitted from mother to baby will colonize on the non-sloughing tooth surfaces. If the mother has good oral health, low levels of *Strep mutans* and an alkaline oral environment that doesn't promote growth of acid-producing bacteria, the baby is less likely to acquire *Strep mutans*. If children can avoid oral *Strep mutan* colonization past two years of age, they may be able to maintain a healthy, non-acid producing oral microflora.¹⁵ The children of mothers not chewing xylitol gum compared to the children of mothers chewing xylitol gum three to five times daily for two years were five times more likely to experience *Strep mutan* colonization. When the children were five years old, those whose mothers chewed xylitol gum for two years had 70 percent fewer carious lesions when evaluated at age five. Mothers in the two control groups received either fluoride varnish or chlorhexidine varnish twice yearly for the two-year study.

A side effect reported in a xylitol chewing gum study was a 42 percent reduction in ear infections (also known as oti-

tis media).¹⁶ This has led to research confirming the beneficial effects of xylitol nasal rinse in reducing ear infections, allergies, sinus infections and sore throats. Xylitol research has expanded further into the medical arena as a treatment for controlling bacterial biofilm forming on open wounds, specifically on the feet of those with diabetes. In six weeks, open wounds that have been active for many years are converted to healthy sites with the topical use of xylitol applied in dissolved form directly to the open wounds.¹⁷ The potential for xylitol to reduce plaque levels 50 percent presents a means of controlling lingual plaque accumulation for people in long-term care facilities and intensive care hospital wards. Heavy lingual plaque is easily aspirated into the lungs, predisposing lung cells to infection.¹⁸ Ongoing studies will determine if the use of xylitol to control oral bacterial biofilm formation will significantly reduce the incidence of aspiration pneumonia.

Many chewing gums contain some xylitol, but also contain sorbitol, sucralose, aspartame, Ace K or mannitol. Adding these artificial sweeteners to chewing gum containing xylitol will reduce the benefits of xylitol. To achieve results similar to those reported in the research, products should be sweetened with 100 percent xylitol. Xylitol delivery has most often been through chewing gum, but there are many other proven delivery systems available: candy, mints, toothpaste, mouthrinse, dry mouth spray and oral gel. Dr. Catherine Haynes was quoted in a 2001 edition of the *Journal of Dental Education* on the benefits of xylitol: "Since the evidence suggests a strong caries protective effect of xylitol, it would be unethical to deprive subjects of its potential benefits."

Note: Never assume that what is safe for you to eat is also safe for your pets. Xylitol should not be fed to pets, just as chocolate, raisins and grapes should not be fed to pets. Undernourished dogs are the most likely to experience severe reactions to xylitol. Keep xylitol out of the reach of dogs. ■

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16. Vernacchio, L., Mitchell, A., 2007. Xylitol to prevent acute otitis media. *Ped Infect Dis J*, 26(9), 863-864.
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Author's Bio

Trisha O'Hehir is currently the editorial director for Hygienetown.com and Perio Reports. She received her education at the University of Minnesota and her four-decade career has included roles as clinician in the USA and Zurich, Switzerland, faculty at the Universities of Minnesota, Washington, Arizona and Louisville, international speaker, writer, instrument designer, inventor and entrepreneur. Trisha currently resides in Arizona, where she is a past-president of the Arizona State Dental Hygienists' Association.



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1. Health benefits of xylitol use include:
 - a. Reduced plaque and reduced caries.
 - b. Increased salivary flow and increased oral pH.
 - c. Reduced open wound biofilm.
 - d. All of the above
2. Xylitol was discovered:
 - a. in 1891 in both France and Germany.
 - b. 10 years ago in milk products.
 - c. in China by agricultural researchers.
 - d. by NASA scientists.
3. Xylitol is:
 - a. a crystalline carbohydrate.
 - b. found in tree bark, plants, fruits and vegetables.
 - c. made by the body in small amounts.
 - d. All of the above
4. Xylitol interferes with bacterial function by:
 - a. killing bacteria.
 - b. breaking the cell wall of bacteria.
 - c. interfering with sugar metabolism by the bacteria.
 - d. making the tooth surface slippery.
5. Xylitol can benefit dental patients by:
 - a. reducing plaque volume.
 - b. reducing pH in the mouth.
 - c. preventing acid production by the bacteria.
 - d. All of the above
6. The ideal percentage of xylitol-to-sweetener chewing gum is:
 - a. 100%
 - b. 80%
 - c. 75%
 - d. 50%
7. Xylitol prevents otitis media by:
 - a. opening the Eustachian tube.
 - b. increasing biofilm formation.
 - c. a direct effect on the ear drum.
 - d. reducing biofilm formation blocking the Eustachian tube.
8. New uses for xylitol include:
 - a. reducing global warming.
 - b. healing and closing open wounds.
 - c. sweetener for soda pop and other cold drinks.
 - d. replacement for topical fluoride.
9. Xylitol reduces bacterial biofilm levels by:
 - a. reducing bacterial acid production and making bacteria slippery.
 - b. lowering the pH of the biofilm.
 - c. increasing extracellular matrix in the biofilm.
 - d. increasing the number of bacteria in the biofilm.
10. Xylitol is dangerous when consumed by:
 - a. children.
 - b. adults.
 - c. dogs.
 - d. All of the above

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