Xylitol

A Sweet for Healthy Teeth and More

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Although xylitol may be technically considered an artificial sweetener because it is manufactured by chemical or biochemical reations, it is actually a naturally occurring sugar alcohol. It occurs in straw, corncobs, oat hulls, cottonseed hulls, and wood. Xylitol is also found in some fruits. German chemist Emil Fischer discovered this white odorless sugar in 1891 (see Figure 1). It has been in use as a sweetener since the 1960s and is now approved in more than 35 countries as an ingredient in foods, such as chewing gum and candies; in pharmaceuticals, such as throat lozenges and cough syrup; and in oral health products, such as toothpastes and mouthwashes.

Xylitol is found in many fruits and vegetables, for example: raspberries, strawberries, yellow plums, and endive. It is also produced in small amounts in the human body. Much of the industrial production of the sugar has been via chemical reduction of the pure wood-sugar xylose (Figure 2) from wood or corncobs. However, more efficient methods have been developed involving fermentation of raw wood hydrolysates by various microorganisms such as *Candida* yeasts.[1]

The use of xylitol as a protection against dental caries stems from research done in Europe in the early 1970s.[2] Much of the early research took place under the direction of Finnish biochemist Kauko K. Makinen, M.S., Ph.D., at the University of Turku. This early research centered on possible mechanisms for the anticariogenic properties of xylitol.[1]

Since the 1970s, further research has suggested other possible benefits of the sugar both in oral health and other areas, including inhibition of otitis media and nasopharyngeal infections and osteoporosis.

Chemistry

Xylitol is a five-carbon sugar alcohol (Figure 1). Although it is listed as being not optically active in *Stedman's Medical Dictionary*,[3] both carbons 2 and 4 are chiral centers. With no aldehydic group, xylitol cannot form a pyranose ring unlike its xylose precursor (see Figure 2).

One of the chemical properties that is sometimes cited as being partially responsible for xylitol's inhibitory effect on bacterial growth is the fact that the xylitol is a five-carbon sugar. The so-called "rule of 5/6" explains that the metabolism of six-carbon carbohydrates is often inhibited by five-carbon carbohydrates. Human nutrition has evolved to use the energy-yielding metabolic pathways associated with the six-carbon D-glucose and its derivatives and copolymers. Xylitol is less able to enter these pathways and so may be shunted into ancillary and, as it happens, into routes that are more beneficial to humans but detrimental to microbes.[4]

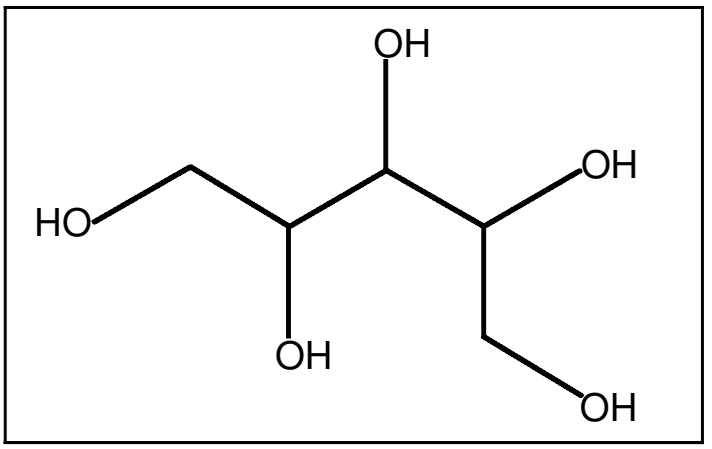

Figure 1. Chemical structure of xylitol.

Preventing Dental Caries

The acid produced as a metabolite of oral bacteria, such as *Streptococcus mutans*, is the principal chemical agency for promoting demineralization of tooth enamel—tooth decay. These bacteria thrive on the carbohydrate-rich substrates and do particularly well with soluble sugars such as sucrose and glucose. Xylitol has long been known to inhibit the cariogenesis of these bacteria,[5] and there is some evidence that this carbohydrate promotes remineralization of decayed tooth surfaces.[6] Most of the research has concluded that using xylitol-sweetened gum or lozenges involving consumption of 4–5 g per day can result in a lower incidence of caries.[7]

Much of the dental research has centered on the influence of xylitol on the development of caries in children[8,9] and some work has shown that there are positive effects on oral health even in elderly subjects.[10]

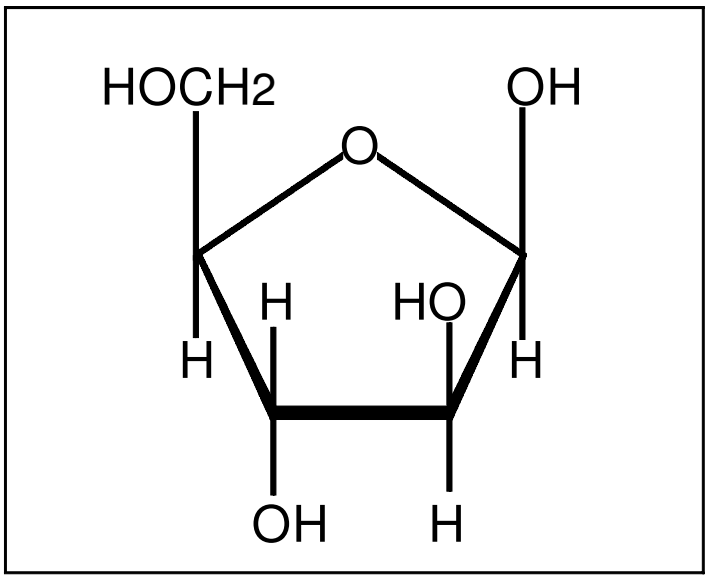

Figure 2. Chemical structure of D-xylose.

The possible mechanism of these effects is complex and not yet completely understood. It may involve levels of action from the purely mechanical to subtle enzymatic inhibitions. Some of these possible explanations are as follows:

- The molecular structure of xylitol and its lack of reducing groups make it a less attractive substrate for oral microorganisms.[11]
- There are few—if any—binding sites for xylitol on dental plaque organisms.[11]
- Oral bacteria lack genes that code for xylitol-utilizing enzymes.[12]
- Xylitol is metabolized by oral bacteria to form sugar phosphate, which inhibits their growth.[13]
- Xylitol inhibits enzymes involved in caries formation.[14,15]
- Xylitol has the ability to increase lactoperoxidase in the saliva.[16]
- Xylitol may strengthen tooth surfaces by enhancing the absorption of glycoproteins.[11]
- Chewing xylitol-sweetened gum induces the washing action of high saliva secretion.[17]

Inhibiting Otitis Media and Nasopharyngeal Infections

The efficacy of xylitol in inhibiting *Streptococcus pneumoniae* and *Haemophilus influenzae* infections has recently been reaffirmed in the literature.[18] One recent clinical study suggested that ingesting from 8 to 10 g of xylitol, in five divided doses per day, is 30–40 percent effective in preventing acute otitis media and markedly reduces the need for antimicrobials for treating infections that do occur.[19]

There have been several clinical studies on xylitol gum and syrup that have shown a positive effect in preventing ear infections in children.[20,21] But a recent report suggested that xylitol is not effective in controlling acute otitis media after the onset of a respiratory infection. [22]

Another form of xylitol that is available is a saline solution nasal spray.[23] There have been no reports in peer-reviewed literature regarding this kind of use.

Possible Protective Action Against Osteoporosis

Recent research in Finland has shown that rats on a diet including xylitol were protected from the weakening of the bone biomechanical properties associated with aging. The experimental animals were separated into two groups; one group was fed a standard maintenance diet and the other group was fed the same diet supplemented with 10 percent xylitol (wt/wt) for 20 months.

After the animals were euthanized, their femurs were tested with various mechanical stressors. Resistance to these stress tests (including bending, torsion, elasticity, recovery and breaking load) was significantly greater in the femurs of the xylitol-treated group of rats than in the standard diet group.[24] The same groups of rats were also tested for tibial bone density and mineral density. The report concluded that dietary xylitol supplementation led to increased bone density and increased bone-mineral content in the long bones of aging rats.[25]

A third report from the same group of researchers described the effect of dietary xylitol on postmenopausal female rats. The rats were divided into three groups of 14 animals each. Two of the groups were ovariectomized and the control group underwent a sham operation. All groups received a standard diet and one of the ovariectomized groups received an additional supplement of xylitol (10 percent wt/wt). Bone density, strength, and mineral content were significantly higher in the xylitol-fed animals than in the rats who were on the standard diet.[26]

Suggestions and Caveats

Dental health and antinasopharyngeal or otitis media infection benefits from xylitol-sweetened gums and candies result from regular use of this carbohydrate. The recommended dosages are from 4 to 5 g per day for promoting dental health and 8–10 g per day for promoting nasopharyngeal health, with the dosage being divided into 1-g amounts spread over the day. Typical xylitol-sweetened gum and lozenge products contain about 1 g per unit, although some products that contain less than 100 percent xylitol may have as little as 300 mg per unit. Animal studies have suggested a potential benefit in protecting against osteoporosis but further studies are needed to ascertain if this will work for human beings.

It should be noted that, like most other antibacterial agents, xylitol's effectiveness is limited by the fact that there are strains of *S. mutans* that are resistant to it. Long-term usage may give rise to such genetically altered organisms[27,28] It is likely that similar resistances could develop in other bacteria that are normally inhibited by xylitol. □

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