THE POWER OF XYLITOL

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Humans have an incredible innate love for sweetness. Unfortunately this has led to the overconsumption of sugars in our Western diet, with all its adverse metabolic consequences, including tooth decay. Early Childhood Caries (ECC) is now a world-wide epidemic costing millions of dollars to treat, let alone the suffering of this vulnerable sector. It's not just about the teeth though, high-sugar diets also lead to metabolic syndrome with its associated morbidity and mortality.

Obviously the answer to these problems is to remove sugar (sucrose) completely from the Western diet. Sugar's deleterious effects have certainly come under the spotlight recently, but it will take time to change. In the meantime is there anything we can do? I have seen the incredible power of xylitol and I think it can be our 'sweet salvation'.

WHAT IS XYLITOL?

Xylitol is a natural sugar widely found in fruits and vegetables (e.g. berries, plums, almonds, lettuce, mushrooms, etc.) as well as our own metabolic pathways. It was originally extracted from the sap of hardwoods, but more recently has been derived from corn cobs. It has a long history, dating back about 2 500 years when used in Chinese medicine for its anti-microbial properties. Native Americans used it to clean their teeth and to make teething rattles for infants. Sugar shortages during World War II in Finland led to the commercial production of xylitol from the bark of local birch trees.

Xylitol acts as a sugar substitute: spoon-for-spoon it tastes like sugar and has the same crystalline appearance. This is where the similarities end. It has 40% less calories than sucrose, with a glycaemic index of only 7. Chemically it is a sugar alcohol, part of a group of polyols, though it does not act as an 'alcohol' in the body. Structurally it is a 5-carbon linear molecule unlike other sugars (glucose, fructose, and sorbitol) which have a 6-carbon ring.

Prof. Kauko Mäkinen, a dental researcher at the University of Turku in Finland, noted that children who consumed xylitol during the war had a reduced incidence of dental caries compared to those who did not. He questioned: could xylitol reduce tooth decay? This initiated the Turku Sugar Studies (1972–1975)[1] in which the control group followed a sucrose containing diet; a fructose group with fructose-based products and a xylitol group with xylitol substitution. The results were astounding. At the end of three years, the xylitol group showed an approximately 90% reduction in caries compared to the control, while fructose provided little benefit over the sucrose group. The other interesting result was that no new caries was initiated in the xylitol subjects. Any insipient carious lesions remineralised. This was the first evidence that teeth could 'heal'.

The Belize Trials in Central America (1989–1997) by Prof. Kauko Mäkinen[2] used sticks of chewing gum intermittently throughout the day and not complete substitution. The trials used mixtures of the polyols xylitol and sorbitol as well as sucrose. The results demonstrated that 100% xylitol-sweetened gum was the most effective, followed by the xylitol-sorbitol mixture. Children chewing xylitol gum developed 73% less tooth decay than those chewing the sorbitol gum.

There have been many subsequent trials using gums, lozenges and 'sweets' which have confirmed xylitol's power in caries prevention.[3] Dr Peter Milgrom at the University of Washington in Seattle has worked with xylitol paediatric syrup for infants who are unable to ingest chewing gum or lozenges. His 2009 trials[4] on babies between 6–15 months of age in the Republic of the Marshall Islands showed for the first time that xylitol is effective for the prevention of decay in the teeth of toddlers. Exposure to xylitol (8 g/day) in twice daily topical oral syrup during primary tooth eruption could prevent up to 70% of decayed teeth.

MOTHER-TO-CHILD TRANSMISSION

Dental caries is a transmissible infectious disease. A neonate's mouth is sterile, but soon becomes colonised, mostly from the mother. Pathogenic strains of *Strep. mutans* are established by three months of age, often long before teeth erupt.[5] One way of targeting these pathogenic strains is during pregnancy using xylitol (gel or chewing gum) for the mother. This should be combined with cleaning the newborn's mouth (from day 1) with a xylitol gel on a disposable sponge.[6] This routine should occur after each main feed. Application of the gel onto pacifiers (dummy) provides the optimal dose and is especially protective when salivary flow is reduced during sleeping.

A landmark study on reducing mother-to-child transmission was conducted in 2000–2001 by Dr Eva Söderling.[7] Mothers were given four pieces of chewing gum/day (6 g per day) from the time their babies were between six and 24 months of age. The babies did not receive any xylitol. This time covered the eruption of all the deciduous teeth. The researchers monitored the caries rate over a five-year period. Children born of a mother who received the xylitol gum had 70% less caries than those of non-xylitol mothers. The conclusion by the researchers was that xylitol reduces the mother's transmission of *Strep. mutans* by reducing the numbers of these pathogenic bacteria.

This study was the first to understand that xylitol exposure, particularly during tooth eruption, may have a long-term, if not lifelong anti-caries effect. A further ten-year follow-up to the study showed the primary teeth of the xylitol group remained cavity-free. The researchers concluded that xylitol had altered the virulence of the bacterial strains transmitted from the mothers. Xylitol is unique in its remarkable effect on cariogenic bacterial strains.

HOW DOES XYLITOL WORK?

Unlike sugar with a 6-carbon ring, xylitol with its 5-carbon structure cannot be broken down by bacteria for energy. They lack the enzymes ('starvation in the midst of plenty!'). This means no acid is produced. No acid; no demineralisation of enamel. Also this raised pH does not promote the growth of acidophilic bacteria, namely *Strep. mutans* and *Lactobacillus spp*.

Xylitol prevents the establishment of a plaque biofilm. This has been demonstrated *in vitro*; xylitol interferes with its cohesion.[9] Any plaque formed can be easily removed using minimal brushing action. A proposed mechanism is that xylitol interferes with the bacterial lectins (attachment sites) on the *Streptococcus* cell wall which prevents the attachment of the pathogen to the tooth.[9]

HOW MUCH XYLITOL IS NEEDED?

Fortunately total substitution of sucrose by xylitol is not necessary to achieve the profound dental benefits seen in the Turku Sugar Studies. An optimal level of about 10 g, or two teaspoons, per day is needed. However, to be effective, it must be given frequently (preferably five times/day) and consistently (every day) for years (preferably lifelong). A good habit is to chew xylitol gum for five minutes after every meal and snack. Alternatively, apply a smear of xylitol gel to the teeth. The gel must stay in the mouth – no rinsing or spitting out.

IS XYLITOL SAFE?

In 1996 the Joint Experts Committee on Food Additives (JECFA), scientific advisor to the WHO, confirmed the safety of xylitol for human consumption, and gave xylitol an acceptable daily intake (ADI) rating of 'not specified', which is the safest category for food additives. The FDA confirmed this fact. However, some nutritionists have been concerned about the

possible laxative effects of xylitol (and other sugar alcohols) when given in high doses. The xylitol consumption threshold at which gastro-intestinal discomfort may occur in humans appears to fall in the range of 70–200 g daily for adults and 40 g daily for school-aged children. With regular ingestion, the tolerance actually increases. This would translate to a daily consumption of 1 g/kg body weight as safely below the GI tolerance threshold for most adults. Recommended levels for dental prevention (± 6 g/day) will not cause GI discomfort.

XYLITOL IS NOT JUST FOR BABIES

Xylitol gels are excellent 'toothpaste' when teeth appear. They satisfy the role of 'cleaning' the teeth and gums by preventing attachment of *Strep. mutans* with its subsequent plaque. Any 'loose' plaque can be easily removed using a finger brush/toothbrush.

Xylitol, as a food substance, can be swallowed – no need to rinse or spit out. Unlike toothpaste it stays in the oral cavity for the xylitol to 'work'. Fluoride-containing toothpastes are contraindicated for children under one year of age, and with caution under six years,[10] as they do not have a well-developed swallowing reflex. The FDA requires labelling of children's toothpaste with fluoride warnings: "Keep out of the reach of children under six years of age. If more than used for brushing is accidently swallowed, get medical help or contact a Poison Control Centre right away." Although Cochrane's concern is dental fluorosis, the concern is that the ingested fluoride can affect more than the developing tooth enamel.

We all know that children are very poor at complying with oral hygiene instructions. Minimal brushing and no flossing are the norm. Prof. Kauko Mäkinen[11] has shown that five exposures of xylitol/day with no brushing reduced plaque levels by ≥50%, which is far better than anything achieved by conventional means.

Orthodontic patients need all the help they can get when it comes to oral hygiene. How many of us have seen teeth literally 'crumble' under these stagnation-causing devices? It's impossible to clean around these attached brackets. That is why a liberal coating of xylitol gel should be applied last thing at night. A liberal coating of xylitol gel should be applied to the fitting surface of a removable orthodontic device before inserting. The same is true for a bite plate, especially overnight. Prostheses (full or partial) are a particular concern because of *Candida* proliferation under the acrylic. This often leads to angular chilitis if the denture is ill-fitting. Xylitol has anti-fungal properties which reduces the adherence of *Candida spp*.[12][13]

Xylitol is profoundly beneficial for xerostomia patients. By virtue of a reduced salivary flow, they are high-risk for tooth decay. Xylitol is not only a salivary stimulant, it raises the resting mouth pH, thereby promoting remineralisation, not demineralisation. Xerostomia is common in patients on medication, such as antidepressants, antihistamines, decongestants, asthma medications, etc., who may not be aware of this side-effect.

Other conditions for which a xylitol mouth gel is recommended include patients following radiation treatment to the head and neck which leave sensitive mucosal surfaces; oral lesions, including aphthous ulcers, to prevent secondary bacterial infection; and cardiac patients, particularly coronary bypass patients, to keep bacterial levels in the mouth low. Many patients have impaired manual dexterity due to paralysis, stroke, injury, arthritis, aging and special needs. ICU and hospital patients with trachs and feeding tubes would also benefit. Chlorhexidine is commonly used in these situations, but it wipes out the protective bacteria and allows opportunistic pathogens to gain control.

MEDICAL BENEFITS OF XYLITOL

One of the earliest benefits (1950) came from its use to prevent and treat otitis media (middle ear infections).[14] This can be caused by *Strep. pneumoniae* and aligns with xylitol's anti-streptococcal properties. A study showed a 40% reduction in otitis media. Reluctance now by physicians to treat with antibiotics has made xylitol desirable.

Xylitol has been used as part of the diabetic diet since the early 1900s. It has a GI (glycaemic index) of only 7 as it is not digested with other sugars and starches, but passes from the large intestine via the hepatic portal system to the liver. There it is converted to xylulose-5-phosphate. Amo found *in vivo* in rats that feeding xylitol did not cause problems with visceral fat accumulation. In addition, xylitol may have some beneficial effects, such as lower postprandial hyperglycaemia (raised blood glucose after a meal). "These preferable effects show that xylitol intake may be useful to control or prevent humans from obesity, diabetes and other metabolic disorders."[15]

Xylitol has been shown to favour gut health and acts as a prebiotic for digestive health.

XYLITOL IN THE DENTAL PUBLIC HEALTH SYSTEM

In order to have an impact on human health, the use of xylitol needs to be implemented as a public health measure.

In Finland in 1972, the Law on Public Health came into effect and the focus for oral care switched from 'drill and fill' to preventative care. This was progressive policy-making, way ahead of its time. 90% of Finnish kindergartens offer xylitol sweets to all children on a daily basis. This means that school children are introduced to healthy dental habits from a very early age. The Finnish National Institute of Health & Welfare (2013) recommends that all one to six year-olds are given xylitol confectionery after meals. The Ministry of Social Affairs & Health (2013) also recommends that publically-funded xylitol products are provided to children to improve dental health and to decrease the cost of public dental care. More countries should adopt these preventative strategies.

IN CONCLUSION

I remember reading about xylitol in my textbook from dental school. It echoed the results of the Turku Sugar Study: a 90% reduction in tooth decay when xylitol was substituted for sucrose in the diet. I remember feeling ecstatic; we could wipe out tooth decay! It was 1968 and I didn't hear of xylitol for another 30 years, when I saw it in chewing gum. The 'why?' is political, but the sadness is we could all have benefited had it been available. Now we owe it to ourselves and our patients to spread the word on this fascinating substance that is xylitol. The more I learn about it, the more I'm amazed at its benefits. Our health depends on it. ●

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