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## **Health benefits of xylitol consumption - a literature review**

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**Abstract**

**Introduction and purpose:**

Throughout the years xylitol has become a commonly used sugar substitute. Presenting similar level of sweetness to sucrose, it serves as a much healthier alternative. The aim of this article is to expand knowledge about the beneficial impact of xylitol on human health mainly focusing on aspects regarding oral health.

**Materials and methods:**

A thorough analysis of scientific databases such as PubMed and Google Scholar has been undertaken using the key words chosen based on their relevance to the matter in subject. Studies since the year 2017 have been analyzed in order to obtain the most up to date information.

**The state of knowledge:**

Xylitol, being the sweetest of all polyols, has been prevalently used as a sugar substitute due to its various favorable effects on both oral and general health. It may be incorporated into daily oral care regimen as a preventive measure counteracting caries development both in adults and in children. According to the investigated studies, it also acts as a prebiotic, presents low caloric value as well as low glycemic and insulinemic indices.

**Conclusions:**

Xylitol is characterized by its facile availability in various forms such as for example chewing gums, pastilles, toothpastes, wipes and mouth rinses. It is derived either from natural, mainly plant based sources, or it may also be extracted synthetically. Due to those reasons and its favorable properties, it may serve as a prevalent sugar substitute. Used in appropriate doses it

is safe regardless of age and presents multiple advantageous effects on various aspects of human health.

**Key words:** caries, health care, oral health, sugar substitutes, xylitol, polyols

## **1. Introduction:**

Over the years there has been observed an increase in sugar consumption worldwide which may consequently lead to a wide range of health-related issues and foster the development of several diseases such as, for example, metabolic syndrome, obesity, diabetes mellitus as well as complications related to oral health such as dental caries and gingivitis (1)(2). Due to those negative effects, sugar substitutes have gained popularity as healthier alternatives for sweeteners with xylitol among them as one of the most frequently used not only in food products such as sugar-free candies and chewing gums, but also in various pharmaceutical, for instance, oral care products (2)(3)(4)(5). The aim of this review is to expand the knowledge about the impact of xylitol use on health, mainly focusing on oral health related aspects based on thorough analysis of the latest scientific studies.

## **2. The state of knowledge**

### **4.1 Xylitol – structure, definition, sources**

Xylitol, among other frequently used sugar alternatives such as, for instance, erythritol, sorbitol, maltitol, mannitol and isomalt, is classified within the group of polyols (2) (6) . Xylitol was not determined until the late 19<sup>th</sup> century (2) (4) , however it gained a greater popularity during Worl War II in Finland due to a sucrose deficit, as its alternative. In 1960s its use disseminated across Europe and in 1963 it was approved by the United States Food and Drug Administration (FDA) as a nutritional additive (7) (8) . Since those times it had been commonly used as a sugar alternative worldwide (8) . Later in 1986, FDA announced xylitol

as safe for the exploitation and it became registered as “generally safe” for usage in health care and oral care products, foods as well as pharmaceuticals.

Xylitol constitutes a 5-carbon sugar alcohol (9) in the form of a white crystalline carbohydrate (2). Its molecular weight is 152,15 g/mol and its chemical formula presents as C5H12O5 (10). It may be found in a wide range of various edible sources such as, for example, berries, cauliflowers, pumpkins, plums, oats as well as mushrooms (2)(5)(8)(10). What is interesting, a small amount is also produced by the human organism as xylitol is an intermediary during the process of metabolism of carbohydrates (5)(11). In addition, the liver is also capable of producing small amounts of xylitol and moreover it metabolizes it from external sources facilitating the process of glucose, lactate, pyruvate and glycogen production (12). Another source of xylitol production may be fermentation process by lactic acid bacteria during soybean fermentation (12). Moreover, it is also industrially produced from plant materials rich in xylan such as, for instance, birch wood as well as beechwood (2)(13).

Among polyols, xylitol is the sweetest one (9)(14). In comparison to sucrose, it is similar not only regarding sweetness level which is approximately 95% alike (4), but also duration of sweetness intensity sensation (14), therefore it may serve as its alternative without significant differences regarding organoleptic attributes (11).

#### **4.2 The influence of xylitol on oral health**

Xylitol, widely used as a sugar substitute, has been proved to have an impact on oral health in a wide range of aspects (15). Regular xylitol consumption in recommended doses is believed to foster the reduction of dental caries, plaque occurrence as well as reduction of the level of cariogenic bacteria such as *Streptococcus mutans* (MS), therefore its incorporation into anticaries regimen may be beneficial (16)(17). However, xylitol alone is not enough form of prevention, it may be an advantageous adjunct to established hygiene practices, yet it is of the utmost importance to maintain proper oral hygiene by mechanical and chemical biofilm control (11). Xylitol can be administered in several different forms, as an ingredient of chewing gums, pastilles, syrup and wipes (16), as well as mouth rinses (18), tooth pastes (19), candies and beverages (4). Due to its beneficial properties, xylitol is increasingly used in dentistry as a component of preventive strategies aiming to maintain oral health (20) through the following mechanisms:

##### **2.2.1. The influence on oral microbiota:**

Xylitol serves as a substance showing antibacterial effect (21). As a sugar substitute, xylitol is considered to promote inhibitory influence on oral pathogens including cariogenic ones such

as, for example *Streptococcus mutans* (22). According to Gasm Benahmed et al. (2) it has demonstrated significant potential in the inhibition and reduction of the growth of oral pathogens which, as El Marakby et al. (13) indicate takes place through starving the bacteria. The authors (13) highlight that xylitol acts via disrupting the process of energy production by *S. mutans* consequently resulting in cell death, and moreover it causes a decrease in acid production potential of the bacteria, as well as it reduces the adhesion of pathogens to the teeth surface. The advantageous property of xylitol regarding its cariostatic effect is that it is neither fermented (21) (23), nor is it used as a substrate by microorganisms including *S. mutans* (23). In contrast, it has been proved to reduce the amount of *S. mutans* in dental plaque and saliva (23)(24), as well as to foster an ecological shift therefore preventing tooth decay and caries development (23). According to El Marakby et al. (13) optimum amounts of xylitol consumption affecting positively the inhibition of *S. mutans* growth are 5-6 g per day divided into three or more portions. However, it should be highlighted that there are some inconsistencies in the literature regarding optimal daily amounts of xylitol consumption, as according to Magacz et al. (25) in order to provide anticaries effect its appropriate intake oscillates between 6-10g per day.

### **2.2.2. Prevention of early childhood caries**

Early childhood caries (ECC) is considered to be a chronic, infectious disease to the development of which *S. mutans* contribute to a large extent (26). It is the most widespread chronic disease in children, which occurs under favorable conditions and is affected by several factors including oral bacteria flora among them (27). *S. mutans* is considered to be one of the most significant bacteria regarding the etiology of dental caries (27) and what is interesting, a positive correlation between the age at which *S. mutans* colonization occurs and the likelihood for children to develop dental caries has been observed (26). Kirthiga et al. (27) have analyzed multiple studies regarding this matter and they have concluded that *S. mutans* presence within the oral cavity at the young age appears to be a significant indicator of dental caries risk regardless of the ethnic group. This stays in correlation with the study by Söderling et al. (16) who also indicate that increased levels of *S. mutans* in dentition appear to be one the most significant risk indicators related to ECC. Hence, it is of the utmost importance to prevent and delay the colonization of *S. mutans* in order to prevent and minimize the development of early childhood caries (26). Xylitol may be a useful substance to achieve this goal, as according to Kayalvizhi et al. (26) the use of xylitol wipes may contribute to the reduction of the level of cariogenic bacteria including *S. mutans* and

therefore should be incorporated into daily hygiene regimen in order to prevent dental caries development in children. Söderling et al. (16) have noticed interesting correlation that maternal consumption of xylitol has been related to a decrease in transmission of *S. mutans* from mother to child. Another association has been described by Xiao et al. (28) who have indicated that both prenatal as well as perinatal xylitol chewing by mothers has resulted in delay of *S. mutans* carriage in children.

### **2.2.3. Reduction of dental plaque**

Dental plaque constitutes a soft deposit including a wide range of various microorganisms that foster the development of both dental caries as well as periodontal disease (29). It should be emphasized that proper biofilm control is vital regarding prevention of development of various oral infections (2). According to Teixeira Essenfelder et al. (30), xylitol may contribute to the reduction of oral biofilm formation within the oral cavity by inhibiting the bacterial  $\beta$ -glucosidase in saliva which is crucial during this process. Wu et al. (10) conducted the study in order to determine whether regular chewing of xylitol containing gum may reduce the level of dental plaque accumulation. They divided 24 medical individuals into two groups – one obliged to chew xylitol containing gum for two weeks (6.2 g of xylitol per day) and the second one serving as a control group. Dental plaque from all teeth has been collected and investigated in terms of weight, pH value as well as microbial composition at the beginning of the study as well as after two weeks period and interestingly the authors have observed a 20% reduction in the accumulation of dental plaque within the research group as well as decreased levels of pathogenic bacteria such as Bacteroidetes, Actinobacteria and Firmicutes concluding that chewing xylitol gum may favor maintaining oral health and reducing bacteria accumulation. This stays in correlation with the observations of Nailis et al. (29) who noted a decreased plaque index score in the group of medical individuals chewing xylitol containing gum. The correlation between the habitual consumption of xylitol and the reduction of the amount of dental plaque have been also described in the study by El Marakby et al. (13). Söderling et al. (16) also indicate the likelihood that habitual chewing of gum rich in xylitol can reduce the level of dental plaque accumulation both in children and adults, not only in short-term, but also in long-term consumption, however the authors highlight the necessity of conducting further studies to explore the matter more meticulously.

### **2.2.4. Increased salivation**

Saliva fulfills a variety of significant functions in oral health maintenance, having an influence on proper digestion, neutralization of undesired components as well as adequate lubrication of

tissues (31) . Furthermore, the composition of saliva and proper salivation flow are of the utmost importance regarding buffering capacity which enables to neutralize acids produced by cariogenic pathogens and maintain proper pH protecting the enamel of the tooth from dissolving (31) . In addition, saliva performs a cleansing role, protects from infections and maintains the integrity of tissues (31). Due to those reasons, maintaining salivation flow on a proper level is vital, and according to Gasmi Benahmed et al. (2) chewing xylitol containing gum contributes to increased salivary flow, as is the consumption of large tablets rich in xylitol. Such effect of xylitol has been also noticed by Kurkiewicz et al. (32) who distinguish it as one of the anticaries mechanisms related to the consumption of xylitol. The substance contributes to improved salivation yet without an increase in the concentration of acids within dental plaque and therefore it enables to control pH of the environment as well as buffering capacity of the saliva after consumption (11). Increased salivary flow stimulated by chewing gum rich in xylitol has been also observed by Wu et al. (10) which stays in correlation with the observations of Söderling et al. (16) . What is worth underlining is that as Oliveira et al. (12) indicate, due to this effect, xylitol can be used by patients suffering from xerostomia in order to counteract hyposalivation. According to El Marakby et al. (13) increased salivary flow by chewing the gum reach in xylitol promotes mineralization which is another advantageous effect in the context of maintaining oral health. The favorable effect regarding remineralization as a result of an increased flow of the saliva rich in phosphate and calcium has been also described in the study by Gasmi Benahmed et al. (2).

#### **4.3 The variety of health benefits of xylitol:**

The influence of xylitol on oral health has been widely discussed and examined in many studies, however it should be underlined that xylitol being a substance commonly used as a substitute for sugar may be also beneficial for other aspects related to health and general wellbeing due to its wide range of its favorable properties. Among them several should be distinguished including low glycemic as well as low insulinemic indices leading to improved toleration of xylitol especially by diabetics for whom such properties are of the utmost desire (14) (11) (33) . Despite the similar sweetness as in commonly consumed sugars such as sucrose and glucose, xylitol consumption does not result neither in an increase in blood glucose level, nor the level of insulin (14). Its glycemic index is approximately 7 (+- 7) and is significantly lower than in glucose characterized by the value of 100 (11). In addition, xylitol may be also useful in weight control due to its lower caloric value in comparison to sucrose, as 1g of xylitol is an equivalent of approximately 2,4 kcal, while in contrast, 1 g of sucrose contains circa 3,87kcal (11). Moreover, xylitol does not undergo digestion by human enzymes

and circa half of the consumed amount is absorbed in the mechanism of passive diffusion within the small intestine, while the other half enters the colon where it provides the source of carbon and energy further used by the intestinal microbiota, which results in the synthesis of short chain fatty acids that have a significant role in maintaining immune system homeostasis (11). What is interesting is that xylitol is considered to have similar properties as prebiotics which beneficial influence is based on the mechanism of selective use of the substrate by host microorganisms (11). According to Salli et al. (14) xylitol, as other prebiotics, may be used to counteract constipation, however the authors emphasize that further, more meticulous studies need to be conducted to determine its effect on bowel function as well as on the modulation of intestinal microbial composition.

#### **4.4 The adverse effects of using xylitol**

The matter of undesired effects related to xylitol use has been thoroughly discussed indicating that consuming proper, recommended daily dose which is 6g is regarded as entirely safe, whereas noncompliance and consumption of several times increased dose than recommended reaching even 50g per day may result in complications such as, for example, gastric ailments as well as diarrhea (7) (20). The mechanism of such complications has been explained by Geraldo de Siqueira Fraga et al. (11) who indicate that increased xylitol consumption-exceeding 20g per day may lead to the extended concentration of xylitol within digesta and therefore to the increase of osmotic pressure which results in water retention within digesta and laxative effects in consequence. Nevertheless, it should be highlighted that this property of xylitol may be also considered as beneficial during the treatment of constipation (11).

### **3. Conclusions:**

Throughout the years xylitol has gained popularity, becoming widely, prevalently used as a sugar substitute. At comparable level of sweetness, this alternative is considerably more beneficial to human health in comparison to sucrose presenting a wide range of advantageous effects regarding both oral and general health. One of its most favorable impacts is preventing the development of dental caries by reducing the levels of cariogenic bacteria, controlling the biofilm, increasing the salivary flow and promoting remineralization. Positive outcome of xylitol consumption regarding this matter has been observed not only in adults, but also in children indicating that xylitol may be beneficial in prevention of early childhood caries development. Thus, it should be incorporated into daily oral hygiene regimen and promoted by oral care professionals, however with emphasize that mechanical and chemical maintenance by regular brushing using adequate brushing technique, proper toothbrush as

well as tooth paste rich in fluoride are of the utmost importance in order to maintain oral health. Among other advantageous effects, low glycemic as well as low insulinemic indices should be mentioned, along with low caloric value due to which xylitol may be used by diabetics and in weight control. Xylitol is a sweetener widely available in various forms such as, for example, chewing gums, pastilles, sweets, wipes and tooth pastes, therefore one can find the most suitable form of its application, however it ought to be underscored that it is vital to follow appropriate daily dosage in order to obtain desired outcomes without the occurrence of adverse effects resulting mainly from overdose.

**Disclosure:**

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