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Biochemical role of sugar-free chewing gum in prevention of dental caries

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Abstract

Sugar chewing gum has been promoted for the maintenance of oral health. It not only prevents halitosis but has a claimed effect of protecting and strengthening the gum and teeth. The sugar-free substitute is usually polyols, the most preferred is xylitol. This xylitol changed the plaque flora mainly inhibited Streptococcus mutants. The chewing process enhances salivary flow rate which increases its buffering power and prevents a fall in salivary ph. These two contributory factors give sugar-free chewing gum its unique role in preventive strategies for dental health.

Keywords: Dental Caries, Polyols, Xylitol, Hydroxyapatite crystal, Streptococcus mutants.

Introduction

Chewing gum is a unique food with low calories and it is expected to influence dental health [1, 2]. Initially, sugar was used as a sweetening agent in chewing gum, which causes dental caries. Now a day, more than 50% of chewing gum sold in Europe is sweetened with sugar substitutes (polyols).

Sugar-free gum is non-cariogenic and even anti-cariogenic. The increased salivary flow during gum chewing due to the gustatory and masticatory stimuli has a protective action against caries. The stimulation causes an increased concentration of bicarbonate from the saliva entering the mouth. As a result, the pH of the saliva increases and its buffering power also. At the same time, there is an increase in salivary phosphate and calcium which prevents a fall in pH, and a greater tendency to favour hydroxyapatite crystal growth. The greater volume and rate of flow of stimulated saliva results from an increased ability to clear sugars and acids from around the teeth hence it has the buffering capacity,

mineral super saturation, cleansing, antimicrobial, and agg lutinating actions. Xylitol as a component of sugar-free gum has a specific effect on oral flora and especially on certain strains of mutant streptococci. Thus, sugar-free Chewing gum has a pronounced effect on oral health.

Sugar-free gum and dental caries

Dental caries is the most prevalent dental disease affecting the human race although the prevalence of dental caries has significantly reduced; it is still a major problem. It is an infectious multifactorial disease. It is due to the fermentation of carbohydrates by cariogenic bacteria producing organic acids. When fermentable carbohydrates are present, the main organic acids produced are lactic, formic, and acetic [3]. These acids coincide with a pH drop in plaque, resulting in demineralization of the tooth [4].) and creating an environment that is advantageous for further growth of Streptococcus mutants [5, 6]. In addition to acid production, mutants streptococci express a wide range of virulence factors that are responsible for the cariogenicity of the dental plaque. The factors influencing dental caries are internal defence factors, such as saliva, tooth surface morphology, general health, nutritional and hormonal status, and several external factors. The main external factors contributing to dental caries are diet, the microbial flora colonizing the teeth, oral hygiene, and fluoride availability.

The main host defence mechanism against these virulence factors is attributed to saliva. The interaction between bacterial virulence factors and host defence affects the balance between de- and remineralization of the teeth. The salivary clearance capacity which measures the flushing and neutralizing effect of saliva is responsible for caries preventive action of saliva [7]. Chewing and taste confer physiologic stimulation to the secretory cells of the salivary glands via autonomic nerve signaling [8]. Usually, low amounts of saliva are secreted (mean 0.2 ml/min) at rest, but chewing and taste stimulation may increase saliva flow more than 10-fold. Elevated secretion is maintained even after extended stimulation. The main component of saliva is water with rinsing and dilution effects. Saliva also contains other components e.g. minerals, mucins, and other proteins and peptides with relevant biological functions, such as buffering of acids, bacteria regulatory effects, lubrication, or crystal formation [9]. As the flow rate increases, the concentration of calcium and bicarbonate in saliva increases, whereas the concentration of many proteins decreases significantly [8]. Salivary factors of possible relevance for "oral health" differ between tissues. For the hard tissues (i.e., enamel, dentin), rinsing off debris, dilution, de- and remineralization, pH neutralization, and regulation of the bacterial community on the teeth are relevant, whereas flushing and innate immunity proteins and peptides, among others, are relevant for soft tissues [8,9]

Reduced salivary flow rate and concomitant reduction of oral defence systems may cause severe caries & mucosal inflammations [10]. Dental caries is probably the most common consequence of hyposalivation [11].

The solubility of tooth hydroxyl apatite crystal increases as pH drops. They are very resistant to dissolution at neutral ph. Typically, the critical pH for dental enamel is around 5.5, and for dentin 6.2. Buffering of acids (i.e., pH normalization) and limiting the duration of periods of pH drop resulting from metabolic acid production by saccharolytic bacteria at carbohydrate exposure may decrease the incidence of dental caries.

Sugar-free gums sweetened with xylitol have been shown to reduce cavities & plaque. It inhibits streptococcus mutants, bacteria that are significant

contributors to tooth decay [12]. However, it has been observed that chewing sucrose gum causes a moderate fall from plaque [13]. Rugg-Gunn and Nunn [14] have stated that results of clinical trials of sugar-free gum show that chewing helps to prevent caries- probably by encouraging healing of very carious lesions through increased salivary flow. Moreover, there dose-response relationship, since the carries-preventative effect increases as the frequency of chewing gum per day increases.

1. Remove food debris and plaque from teeth [15], keeping gums and teeth healthy and strong.
2. By increasing the salivary flow rate [16],
3. by raising plaque pH [17],
4. enhancing remineralization [18],
5. reducing oral dryness

However, it may hurt TMJ [19]

Composition of sugar-free chewing

It is a type of gum-made gum base, non-sugar sweetener (polyol), flavouring, and aromatic agents. The characteristic components of chewing gums are the gum base, which may comprise a complex mixture of elastomers, natural and synthetic resins, fats, emulsifiers, waxes, antioxidants, fillers, and sweetening and flavouring agents [17]. The common characteristic of sugar-free chewing gums is the absence of fermentable carbohydrates [2]. The most common and beneficial polyol used nowadays is xylitol.

Role of xylitol in caries prevention

Xylitol is a natural sugar alcohol derived from the pentose sugar xylose which is used as a sugar substitute. It has sweetness equal to that of sucrose and is not fermented by plaque bacteria to form acid. In vitro, it has bacteriostatic properties. Along with bacteria, it forms an inhibitory phosphorylated intermediate. [20, 21]

Sugar-free gum sweetened with xylitol has been shown to reduce cavities and plaque [22]. The sweetener sorbitol has the same benefit but is only about one-third as effective as xylitol [22]. Xylitol is specific in its inhibition of Streptococcus mutants, bacteria that are significant contributors to tooth decay [23]. Xylitol inhibits Streptococcus mutants in the presence of other sugars, except fructose [24]. Daily doses of xylitol below 3.44 grams are ineffective and doses above 10.32 grams show no additional benefit [25]. Calcium lactate added to toothpaste has reduced calculus formation [26]. One study has shown that calcium lactate enhances enamel remineralization when added to xylitol-containing gum [27], but another study showed no additional remineralization benefit from calcium lactate or other calcium compounds in chewing gum [28]. Chewing sugarless gum increases saliva flow considerably and thus fast-flowing saliva with its high pH and high concentration of calcium and phosphate aids remineralization of dental enamel and resists caries development. In the trial studies, it has been observed that on consuming xylitol-containing gums, cariogenic bacteria become less frequent in the plaques. Hence it has been suggested that xylitol has a unique, positive role in preventing dental caries [29, 30]. However, some research workers refute xylitol's unique action suggesting that the caries-preventive effects of xylitol chewing gum can be explained adequately by the favourable action of chewing gum alone [31].

Xylitol is not fermented by dental plaque [32, 33]. The non-specific effect is a result of non-ferment ability not encouraging bacterial growth [34]. The specific effect of xylitol is first due to the effect on mutants streptococci resulting in the development of mutant xylitol-resistant strains which may be less virulent in the oral environment [35]. Secondly, the concentrations of

ammonia and basic amino acids increase when plaque is exposed to xylitol, resulting in the neutralization of plaque acid [36]. Third, in-various studies have shown some strains of oral streptococci take up xylitol and convert it to xylitol 5 phosphate resulting in the development of Intracellular vacuoles and degraded cell membrane in mutants and sobrinus streptococci, and through this mechanism, xylitol is acting in a bacteriostatic way [37]. Lastly, some streptococcal strains take up xylitol which participants in what is termed the futile metabolic cycle' [38]. Much evidence from well-controlled clinical studies indicates that xylitol decreases the growth of plaque compared with sugar and other polyols [39].

Xylitol has proved to be the most superior polyol exhibiting dental health benefits. In addition, xylitol-specific effects on oral flora and especially on certain strains of mutants streptococci add to its caries-preventive profile and give it a unique role in preventive strategies for dental health.

Salivary flow rate and remineralization

Saliva stimulation by gum chewing is beneficial for tooth crystal de- and remineralization balance [40]. Saliva has a lubricating effect on the oral mucosa, protecting effect on the tooth and oral mucosal surface, and an antimicrobial effect in the resting phase. The main component of saliva is water, with rinsing dilution effects. It also contains other components (e.g., minerals, mucins, and other proteins and peptides) with relevant biological functions, such as buffering of acids, bacteria regulatory effects, lubricants, or crystal formation [9]. As the flow rate increases, the concentration of calcium and bicarbonate in saliva increases, whereas the concentration of many proteins decreases significantly [8].

It has been observed that on chewing gum by healthy subjects, the flow of saliva increases from the resting value of 0.40-0.5ml/min, to approximately 5-6ml/min. After around 5 minutes, it falls to 2ml/min, and slowly thereafter to 1.2-1.5 at 20ml/min. Stimulation of saliva results in the flushing effect and clearance of oral derbies and noxious agents. Saliva is the flushing and neutralizing effect, commonly referred to as "salivary clearance" or "oral clearance capacity" [7]. In general, the higher the flow rate, the faster the clearance [41] and the higher the buffer capacity [42]. Salivary factors of possible relevance for 'oral health' differ between tissues. For the hard tissue (i.e., enamel, dentin) rinsing of debris dilution and remineralization, pH neutralization, and regulation of the bacteria community on the teeth are relevant. For soft tissue flushing and innate immunity proteins and peptides are relevant.

Moreover, stimulated saliva is known to promote remineralization of early caries lesions due to its mineral supersaturation concerning dental hard tissue, immediately after eating, plaque acids can attack the tooth and initiate the demineralization of the tooth surface, which can weaken the tooth and lead to decay over time. Chewing sugar-free gum increases the production of saliva which can help neutralize plaque acid, wash away food particles and remineralize tooth enamel to strengthen teeth. Chewing sugar-free gum for 20 minutes after meals and snacks have been proven to help reduce tooth decay and increased saliva flow leads to the reduction of oral dryness.

Effect of chewing gum on salivary ph

By stimulating saliva production, chewing sugar-free gum can be an important defence mechanism to help protect teeth. Here, the graph indicates chewing sugar-free gum for about 10 to 20 min [43]. After a meal neutralizes the salivary pH and maintained it posts

postprandial. A study based on chewing one stick of sugar-free gum three times daily after each main meal reduces the acidogenic challenge induced by the snack foods. When the recommendation to chew sugarless gum following food ingestion is used as an adjunct in caries prevention, it should start within 5 minutes after food ingestion, the sooner the gum chewing is initiated the better – and should continue for at least 15 minutes to obtain the maximum benefit.

Summary

Hence, chewing sugar-free gums prevents dental caries.

1. The chewing process increases the salivary flow rate.

2. Xylitol, the polyol, used as a non-carbohydrate sweetener is non-cariogenic and anti-cariogenic.

The non-cariogenic effect of xylitol is contributed due to its non-carbohydrate nature while it is anticarcinogenic because of its effect on oral flora especially streptococci mutants.

Conclusion

Sugar-free chewing gum after every meal can certainly be recommended or even promoted and they are "Tooth-friendly". Tooth-friendly means that the product is neither cariogenic nor erosive. Chewing gum is effective mainly because the component xylitol has non-cariogenic and anti-cariogenic properties. It mechanically removes food residues from the teeth during the chewing process and increases the salivary flow rate. The saliva flow thus induces support natural realization and neutralization of the acid produced by plaque bacteria from sugar which prevent dental caries.

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