Review Article

Role of chewing gum in oral hygiene maintenance

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ABSTRACT

Aim and Objective: The aim and objective of this review are to gain knowledge on sugar-free chewing gums in oral hygiene maintenance. **Background:** Dental caries and periodontal diseases have historically been considered the most important global oral health burdens. Hence, the dental care needs to apply strategies for oral health problems. Chewing gum gained interest due to its ability to stimulate salivation and accelerate the clearance of fermentable carbohydrates from the dietary intake. Chewing gum with xylitol has received special attention due to its mechanical cleaning together with saliva stimulation. These actions could lead to a therapeutic and caries lowering action and various other oral health benefits. Xylitol is indeed becoming quite popular, especially in dentistry, and for good reason, it helps to prevent cavities. It is a natural sugar alcohol similar to other so-called sugar alcohols such as mannitol and sorbitol used as sugarless sweeteners. Xylitol also has the added effect of stopping the saliva from becoming acidic so that decay not only does not start but also rather your mouth becomes an environment that favors non-acid producing bacteria. Researchers have found that systematic use of xylitol chewing gum significantly reduces the relative risk of caries when compared to chewing gums containing sorbitol and sucrose. In addition, xylitol gum is more frequently associated with halting the progression of very tiny cavities versus other combination of chewing gum. The use of other products containing xylitol such as mints, candy, and cookies has shown a decreased incidence of dental caries by arresting active decay. **Reason:** This review was done to gain knowledge about the benefits of sugar-free chewing gums which is an excellent way to protect the overall oral health and even prevent cavities.

KEY WORDS: Chewing gum, Dental caries, Mastication, Prevention, Saliva, Sugar free

INTRODUCTION

Despite great achievements in oral health of populations globally, problems still remain in many communities all over the world, particularly among underprivileged groups in developed and developing countries. Dental caries and periodontal diseases have historically been considered the most important global oral health burdens. At present, the distribution and severity of oral diseases vary among different parts of the world and within the same country or region. The significant role of sociobehavioral and environmental factors in oral disease and health is evidenced in an extensive number of epidemiological surveys.[1]

To date, the most dependable mode of plaque control is mechanical cleaning with a toothbrush and other oral hygiene aids.[2] Unfortunately, the majority of people are unable or unwilling to realize the need to spend time to remove plaque adequately from all tooth surfaces.[3] Barnes *et al*.[4] suggested that chewing gum may serve as an effective oral hygiene device when brushing may not be possible. Sugar-free gums are simple, inexpensive and are readily available. Studies have shown that daily chewing-gum has beneficial effects.

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Gum chewing is a common habit among many people as it provides great pleasure; it is also a nemesis for countless parents, school teachers, and building custodians because this sticky intruder is often found in child's hair, under tables, chairs, and desks. However, chewing gum has two characteristics which are important in considering its effect on dental health. First, it has proved possible to replace the "sugar" in chewing gum with sugar substitutes, without diminishing its consumer appeal. Indeed the development of sugar-free gums with optimal taste characteristics has opened up new markets. The second characteristic is that all gums - sugared

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and unsugared - stimulate the saliva flow about 3–10 times higher than resting values. The stimulation of saliva leads to an increase in potentially protective properties. Both of these characteristics of chewing gum could be responsible for the non-cariogenicity of sugar-free chewing gums. Furthermore, if the gum chewing was to be carried out after meals and if the sugar substituted had beneficial properties, these actions could lead to a therapeutic, caries lowering action, and various other benefits.[5]

The use of sugar-free gum provides a proven anticaries benefit, but other oral health effects are less clearly elucidated. Chewing sugar-free chewing gum promotes a strong flow of stimulated saliva, which helps to provide a number of dental benefits: first, the higher flow rate promotes more rapid oral clearance of sugars; second, the high pH and buffering capacity of the stimulated saliva help to neutralize plaque pH after a sugar challenge; and finally, studies have shown enhanced remineralization of early caries-like lesions and ultimately prospective clinical trials have shown reduced caries incidence in children chewing sugar-free gum.

The oral health, particularly caries reducing benefits of sugar-free chewing gums, has been well documented in many studies and reviews.[6-10] In addition, chewing gum is increasingly being viewed as a delivery system for active agents that could potentially provide direct oral care benefits. The purpose of this review is to provide an overview of the use of chewing gum as an adjunct to other oral health prevention strategies.

TYPE OF CHEWING GUMS[8]

- Medicinal - Chewing gum can be used for a local delivery of therapeutic agents such as sulfonamide, neomycin-gramicidin, miconazole, and nystatin.
- Dental - Fluoride containing, chlorhexidine containing, enzyme containing, mineral salts, carbamide ion, metal ions.

COMPOSITION OF CHEWING GUM

A typical chewing gum consists of powdered cane or beet sugar (50–65%), chewing gum base (18–30%), corn syrup (12–20%), color and flavoring agents (1–2%), and softeners (0.3–3%). Noticeably, more than half of its constituent is sugar, which is responsible to enhance flavor and enrich the texture of gum. Sugar in sugared gum can be sucrose, fructose, or hydrogenated glucose, but sugar-free gum has sugar substitute. Use of term sugar free is somewhat misleading because all carbohydrates provide about 4 Kcal/g, so the amount of calorie provided is the same, but the difference is in the quantity which will depend on the sweetness. Thus, sweeteners can be divided into two groups - bulk sweeteners and intense sweeteners. Bulk sweeteners are almost always carbohydrates and carbohydrate derivatives such as sucrose, fructose, or polyols while intense sweeteners are either synthetic or natural substances such as saccharine, cyclamate, aspartame, and acesulfame-K.[5]

MOST COMMONLY USED SUGAR SUBSTITUTES

Xylitol

The German chemistry professor Emil Herman Fischer and his assistant Stahel separated from breech chips a new compound which was named xylit, the German word for xylitol. Simultaneously with Fischer, the French chemist M.G. Bertrand had managed to isolate xylitol syrup by processing wheat and oat straw. The history of xylitol was indeed quite eventless for the first 50–60 years after its first description in 1891. By the mid 1950s, Dr. Touster's *et al.* concluded that xylitol is formed in the human body. This discovery stemmed from investigation on L-xylulose, the characteristic urinary sugar in essential pentosuria. This is a harmless, rare, recessive genetic disorder initially found in Jews and Arabs. It was recognized that accumulation and excretion of a metabolite which is readily disposed of in normal, but not in pentosuric, individuals. Eventually, the product was isolated and characterized as xylitol.[11] It is a natural "sugar alcohol" similar to other so-called sugar alcohols such as mannitol and sorbitol used as sugarless sweeteners. Xylitol is a sugarless sweetener usually derived from birch trees, and it can be found in gum, lozenges, and candies. Xylitol is a naturally occurring diabetic-safe, low-calorie carbohydrate that is obtained from the bark of birch trees, coconut shells, and cottonseed hulls. It looks and tastes like sugar and is comparable in sweetness.[12] It has an ability to form complexes with certain cations such as Ca, Cu, and Fe and to displace water molecules from the hydration layers of proteins and also from cations. This pentitol occurs widely in fruits (strawberries, plums, and raspberries) and vegetables (lettuce, cauliflower, and mushrooms) and is commercially prepared from coconut shells and birch trees. The absorption of xylitol, while slow and incomplete is greater than that of sorbitol and mannitol. Thus, it is associated with less severe diarrhea. Xylitol is metabolized as a carbohydrate by entering the pentose phosphate pathway through the glucuronic acid cycle. It has been used by diabetics because its metabolism is considered to be insulin independent. The caries-preventive effect of total substitution of dietary sugars by xylitol could be explained by the exclusion of fermentable sugars from the diet. Xylitol is not fermented by dental plaque as the activity of xylitol dehydrogenase in human dental plaque or whole saliva is practically nil. Human oral microorganisms and specifically *Streptococcus mutans* do not have enzymes to utilize xylitol as a source of energy for acid production or for the synthesis of extracellular polysaccharides, and thus, no fall in plaque pH occurs. However, the major disadvantage associated with the use of xylitol is the cost which suggests that it is unlikely to replace more than a small portion of the sucrose intake.[13,14]

Sorbitol

It is widely distributed in the plant kingdom, in berries, apples, plums, pears, and algae. It was introduced in the diet of diabetics as early as 1929. It is slowly and incompletely absorbed from the intestine which results in osmotic diarrhea. Most microorganisms lack the enzymatic makeup to utilize sorbitol. An important exception is *S. mutans*. However, the fermentation of sorbitol by *S. mutans* is slow, and hence, the drop in the pH of dental plaque is also little. The slow rate of fermentation of sorbitol allows acid to diffuse out of plaque at a rate almost equal to the rate of formation. Nevertheless, the utilization of sorbitol by microorganisms provides them with a substrate that may contribute to their survival but does not directly contribute to their cariogenicity.[13] Due to the results of *in vitro* fermentation experiments and animal studies, concern has been expressed that the oral flora may adapt to sorbitol so that it loses its "safe for teeth" property.[14]

Aspartame

Aspartame was developed by G.D Searle laboratories as nutritious sweetener and flavor enhancer. It is about 180–200 times as sweet as sucrose. It is composed of two amino acids: L-aspartic acid and the methyl ester of L-phenylalanine. Although aspartame has a caloric value of about 4 Kcal/g which is similar to that of proteins and carbohydrates, it is consumed in such a small amount that its caloric contribution is negligible. Due to its relatively greater sweetness, the addition of aspartame to foods can result in sweetness equivalent to that obtained from sucrose and yet reduce calories by over 95%. Aspartame is effective in enhancing acid fruit flavors and extending sweet taste as in chewing gum. If aspartame replaces even some part of the sugar in the diet, it would be expected to reduce caries simply by limiting the amount of frequency of fermentable sugar in the diet. Aspartame reduces caries as might raise plaque pH by forming amines by decarboxylation.

ORAL HEALTH BENEFITS OF CHEWING GUM

Non-specific Benefits of Chewing Suger-free Gum on oral Clearance, Saliva Stimulation, and Plaque pH Neutralization

The major benefits of sugar-free chewing gum are mediated through oral physiology: Stimulation of the salivary glands to produce a strong flow of saliva (a 10–12 fold increase over unstimulated saliva) is elicited by a combination of masticatory and gustatory stimuli.[15] Although saliva flow rates are highest during the 1st 5–7 min of chewing, when the sweeteners and flavor release are maximal, a two-fold increase in flow rate (over unstimulated flow) is maintained for as long as the gum continues to be chewed.[16] One of the immediate short-term effects of this enhanced saliva flow is the increased clearance of sugars and food debris from the oral cavity.[17] The higher flow rate, pH, and buffer capacity of stimulated saliva further help to neutralize acids found in the mouth and, in particular, help to raise the plaque pH, accelerating the recovery phase of the Stephan curve.[18,19] The short-term neutralization of plaque pH out of the demineralization danger zone can also be supplemented by medium-term benefits, as it has been shown that frequent chewing increases baseline (unstimulated) saliva flow rate and increases the resting plaque pH and subsequent ability of the plaque to form acid from sugar.[20,21] Some studies have suggested that chewing gum is better tolerated than artificial saliva for symptomatic relief of xerostomia.[22,23]

EFFECT OF CHEWING SUGAR-FREE GUMS ON BUFFERING CAPACITY OF SALIVA

Solutions containing both weak acids and their salts are referred to as buffer solutions. These solutions have the capacity of resisting changes of pH when either acids or alkalis are added to them. The buffering capacity of human saliva is regulated by three buffer systems - the carbonic acid, phosphate system, and proteins. Carbonic acid rapidly decomposes into water and carbon dioxide which leaves the solution. In contrast to most buffers, the net result is, therefore, not an accumulation of a weaker acid but a complete removal of acid. Phase change for carbondioxide from dissolved state to gas phase is essential for bicarbonate system. The phosphate system also functions similar to bicarbonate except for the fact that no phase change is involved. The salivary proteins are usually not considered to have any significant buffer capacity.[24] Stimulated saliva has an increased bicarbonate concentration and therefore increased buffering capacity in dental plaque while concurrently promoting clearance of fermentable substrate and provides more urea for base production.

REMINERALIZATION AND CARIES REDUCTION

In addition to the pH neutralizing effect, the increased rate of delivery of soluble calcium and phosphate ions from the stimulated saliva helps to remineralize surface enamel lesions, as shown in a number of *in situ* remineralization studies.[25-28] Finally, clinical studies conducted in children who chewed gum at least 3 times daily for 2 or 3 years show that they have significantly lower rates of decay than children who do not chew gum.[29-31] Indeed, the American Dental Association has recently provided clinical guidelines for the use of sucrose-free polyol chewing gums in high caries-risk children and adults.[32]

EXTRINSIC STAIN REDUCTION

Chewing gum can reduce extrinsic tooth stain, either by removing existing stain or inhibiting its formation,[33] while the addition of specific active agents (typically polyphosphates) may provide additional efficacy.[34,35] However, it should be noted that these types of claims are cosmetic and do not directly affect oral health, and the magnitude of the effect is small compared to chair-side or over-the-counter bleaching therapies. On the other hand, accelerated oral clearance of staining agents such as tea or coffee, by chewing gum-stimulated saliva, could conceivably reduce the formation of extrinsic stain over time and help to prolong the benefits of a dental prophylaxis.

EFFECT OF SUGAR-FREE GUM ON DENTAL PLAQUE AND INTERDENTAL DEBRIS

The use of dental floss or inter-proximal brush appears to provide an adjunct effect on inter-dental hygiene when associated with tooth brushing.[36] However, the main problems with all interdental cleaning methods are the individual's manual dexterity and motivation.[37,38] For that reason, there is a tendency to look for other simpler options for cleaning interdental areas.

There is little information in the literature regarding the effect of gum chewing on interdental debris, indicating that this topic remains unexplored. However, one study tried to assess the effect of chewing gum on salivary debris by having volunteers chew liquorice cakes and, after 10 min, collecting saliva samples with and without chewing the gum. A 50% reduction in the wet weight of liquorice debris in the saliva was recorded post-gum chewing.[39] For the chewing-gum studies, the trend has been to study the preventive action[40] of the gum in the absence of tooth brushing and other oral hygiene practices employing a 4 or 5 days' plaque regrowth model.[36,37,41] The results of these studies were disappointing and showed no significant antiplaque effect on the buccal and lingual surfaces. Hence, it was felt that there is a need to study the effect of chewing gum as an adjunct to tooth brushing and also to assess the therapeutic action of the chewing gum on established plaque and interdental debris.

The chewing of gum can stimulate removal of inter-dental debris left after food consumption. Removal is partly not only due to direct attachment of debris to the gum but also due to increased mastication and salivation which aids to wash away debris.[17,42] Since debris left after food consumption often contains fermentable sugars, its removal prevents oral bacteria from producing acids that desorb calcium (Ca2+) and phosphates (PO4 3-) from the enamel,[43,44-47] which constitutes a clear oral health benefit.

REDUCTION OF ORAL DRYNESS

Individuals suffering from xerostomia or the subjective feeling of dry mouth can relief their symptoms by the use of regular sugar-free chewing gum, which is generally preferred by dry mouth patients over the use of artificial saliva.[22] Symptom relief is related to mastication and increased salivation and not to any specific additive incorporated in chewing gums.[48] Importantly, the claim that the chewing of gum reduces dry mouth perception[48,49] is supported by the European Food Safety Authority (EFSA).

INHIBITION OF CALCULUS FORMATION

Calculus formation involves the formation of calcium phosphate mineral salts that calcify and harden oral biofilm. Among many other factors, biofilm pH and salivary calcium phosphate saturation play an important role in the rate of calculus formation.[50,51] Chewing of regular sugar-free gum did not have a pronounced effect on inhibiting calculus formation, and it has even been suggested that calculus formation is promoted by chewing sugar-free gum, due to higher biofilm pH and salivary calcium phosphate saturation.[52-54] Therefore, active ingredients have been incorporated in chewing gums aiming to maintain calcium phosphate deposits in an amorphous state, preventing hardening and facilitating removal. While chewing Vitamin C supplemented chewing gum at least 5 times per day for a duration of 3 months, a reduction in supragingival calculus formation was found.[54]

EFFECTS ON BACTERIAL ADHESION TO ORAL SURFACE

Adhesion of planktonic bacteria to oral surfaces is the first step in the formation of oral biofilm and is mediated by attractive forces between oral surfaces and adhering bacteria. Accordingly, the properties of the oral surfaces play a major role in the development of these adhesion forces and changing the forces may impact the amount and composition of oral biofilm formed.[55,56] Chewing a gum containing polyphosphates made adsorbed salivary conditioning films more hydrophilic and more negatively charged as compared with other gums. Since most oral bacterial strains are negatively charged,[57,58] this implies weaker adhesion of oral bacteria and polyphosphates may even promote detachment of bacteria from salivary conditioning films on enamel surfaces.[59]

EFFECTS ON BIOFILM FORMATION, COMPOSITION, AND REMOVAL

Chewing of regular sugar-free gum dislodges loosely bound bacteria from the oral mucosa[60] and inhibits regrowth and maturation of oral biofilm on occlusal surfaces.[40] Nonetheless, biofilm regrowth was not inhibited on smooth lingual and buccal surfaces and a relationship between complete biofilm removal directly after a single gum chew has not been established[40,61] not even when abrasive agents were included in the gum.[62] Therefore, the EFSA concluded that the claim that the chewing of regular sugar-free gum "reduces plaque formation" is unsubstantiated,[41] so direct and clinically relevant biofilm reduction is not a supportable claim for chewing gum without active ingredients, although it is possible that gum chewing could modify the biofilm composition to a less cariogenic state.

Chlorhexidine is the most effective antimicrobial for the chemical control of oral biofilm.[63] Its antimicrobial properties are based on disturbing the bacterial cell membrane, and its binding to intraoral surfaces ensures substantive action.[63] Chlorhexidine tastes bitter, alters long-term taste perception,[64] and causes (reversible) tooth stain.[64] Antimicrobial effective chlorhexidine containing chewing gums with acceptable taste can be made, but consumer hesitance remains to exist, and in certain countries, chlorhexidine-containing chewing gums are likely to only be available on prescription.[65,66] Application of chlorhexidine in chewing gum not only reduces planktonic levels of *mutans* streptococci directly after chewing[67] but also reduces oral biofilm formation. Incorporation of chlorhexidine in chewing gum inhibited oral biofilm growth in a 4 days' study when only two pieces of gum were chewed per day in the absence of other oral hygiene measures.[66]

Similar to chlorhexidine, xylitol also resulted in a reduction of salivary *mutans* streptococcal numbers when used for 5 weeks, but this was too short to result in a change in the composition of oral biofilm.[68,69] Furthermore, in combination with regular brushing, no effects of xylitol-containing gum on biofilm and gingivitis scores were observed compared to chewing gum base only.[70] 6 months chewing of xylitol-containing gum caused a decrease in the acidogenicity of oral biofilm,[71] indicative of a change in biofilm composition. In general, oral health-care benefits of xylitol on oral biofilm are still subject to debate, and it is not clear whether effects of xylitol-containing gum are solely due to increased salivation or to the addition of xylitol as well.[65,72,73]

POTENTIAL NEGATIVE EFFECTS OF CHEWING GUM

It is worth acknowledging that there are some concerns over chewing gum use, including its potential to be a choking hazard in young children, be subject to littering, exert a laxative effect, and to contribute to temporomandibular dysfunction (TMD). Therefore, consumers should be reminded not to give gum to children younger than school age and to dispose of chewed gum, responsibly. Despite limited evidence that chewing gum is a causative agent of TMD or jaw muscle pain,[74] the prudent practitioner should probably avoid recommending chewing gum for patients suffering from these conditions.

CONCLUSION

As mentioned earlier, the scientific evidence supporting the non-specific benefits of chewing sugar-free gum has been reviewed. Over the past decades, chewing gum developed from a candy toward an oral health promoting nutraceutical to be used as an adjunct to regular oral hygiene. The basic beneficial effects of the chewing of gum on oral health have been well documented and are officially approved by the EFSA. Conventionally, preventive dentistry has focused on sugar restriction, plaque removal/oral hygiene, fluoride usage, fissure sealants, and education. More recently, these approaches have been modified by improved diagnostic methods to allow early identification of disease, together with an accurate assessment of disease activity. There is an opportunity for chewing gum to be considered as another preventive modality to provide an additional layer of prevention by helping to maintain the oral ecology in high and lower risk individuals and populations.

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