



REVIEW ARTICLE

ASSOCIATION BETWEEN SUGAR INTAKE AND DENTAL CARIES IN MODERN SOCIETY-A REVIEW

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ABSTRACT

A dynamic relation exists between sugars and oral health. The resultant action of consumed sugars is the beginning of tooth demineralisation. Many factors in addition to sugars affect the caries process, including the form of food or fluid, the duration of exposure, nutrient composition, sequence of eating, salivary flow and oral hygiene. Many modifying factors such as fluoride and dental hygiene came up to reduce the risk of dental caries, but these would not be needed if we tackle the single cause- sugars. So the aim of this article is to provide a narrative view of association between sugar intake and dental caries in modern society and certain dietary recommendations to reduce it.

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INTRODUCTION

Dental caries is caused by the demineralisation of hard tooth structure and occurs when bacteria metabolise ingested sugars, causing organic acids to be produced. The organic acids create a drop in plaque pH, causing calcium to be lost from the tooth surface and subsequent demineralisation occurs (Hayes *et al.*, 2017). Dental caries is, therefore, directly related to diet, as it is dependent on the presence of sugars. Free sugars refers to monosaccharides (such as glucose, fructose) and disaccharides (such as sucrose or table sugar) added to many foods and drinks by the manufacturer or consumer, and sugars naturally present in honey, syrups, and fruit juice (WHO/FAO Expert Consultation, 2003). Increased consumption of these free sugars is recognised as a risk factor for many chronic health problems and the association of dental caries to excessive

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sugar intake has been affirmed by an expert panel of the World Health Organisation (The World Health Organization, 2003). Understanding the roles of diet, eating behaviors, dermatographics, and environmental factors in contributing to increased caries rates is essential to improving their oral health (Roberts, 2008). The nutritional aspects are different from the dietary. The diet is the kind of food that a person habitually eats. "Nutrition" refers to the sum of biological processes as it relates to dietary intake. Diet has a local effect on oral health, primarily on the integrity of the teeth, pH, and composition of the saliva and plaque. Nutrition, however, has a systemic effect on the integrity of the oral cavity, including teeth, periodontium (supporting structure of the teeth), oral mucosa, and alveolar bone. Nutrition may act both systemically and locally in relation to dental caries. The basic science on nutrition and dental caries is simple as refraining from carbohydrates when consumed in solid or liquid form translates into an absence of dental decay (Alvarezk, 1995). Dietary carbohydrates are the necessary fuel for creating dental caries. The fermentation of these dietary compounds by the

cariogenic microorganisms leads to the formation of fermentation end products which may lead to tooth destruction. The engine that produces dental caries stalls when cereals and sugars are withdrawn from the diet. Since the introduction of fluoride, the incidence of caries worldwide has decreased, despite increases in sugars consumption. Other dietary factors (eg, the presence of buffers in dairy products; the use of sugarless chewing gum, particularly gum containing xylitol; and the consumption of sugars as part of meals rather than between meals) may reduce the risk of caries (Riva Touger-Decker, 2003). So the aim is to review of the evidence of an association between sugar intake and dental caries in modern society

Initiation of dental caries: Dental caries is a dynamic process that requires three factors a susceptible tooth, cariogenic bacteria in dental plaque (*Streptococcus mutans* and *lactobacillus*), and a fermentable carbohydrate and it gets initiated at the interface of the enamel surface and the dental plaque (7.https://www.dentalcare.com/en-us/professional-education/cecourses/ce301/dietary-implications-in-dental-caries.). Other considering factors also include absence of fluoride, salivary gland hypofunction, and poor oral hygiene. In this process enamel will start to demineralize when exposed to fermentable carbohydrates if the pH during the bacterial fermentation process is lowered below the critical level of pH 5.5– 5.7. This occurs after consumption of most sugars found in candy, soft drinks, fruit juices, or the sugars added to coffee or tea (Hujoel, 2017).

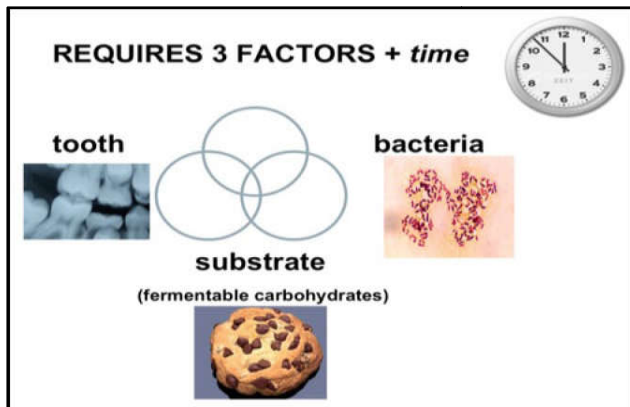


Fig. 1. Depicts the factors involved in initiation of dental caries

Pathologic and Protective factors in caries process

Pathologic factors like reduced salivary function, presence of bacteria and dietary components begins the caries process described as loss of mineral (demineralization) when the pH of plaque drops below the critical pH value of 5.5; the critical value for enamel dissolution is 5–6 (Riva Touger-Decker, 2003). Protective factors from specific foods and diet sequencing may also be utilized in order to reduce the destructive influence of fermentable carbohydrates. Fats and proteins consumed in a meal help coat the tooth surface to protect it from sugars. Consuming dairy products keeps the saliva rich in calcium and phosphorus, offering benefits of remineralization by preventing the pH of the mouth falling below 5.5. Fluoride in both food and water will also help remineralize the enamel. Whether a lesion develops is the outcome of the balance between demineralization and remineralization, in which the latter process is significantly slower than the former (Fig. 2).

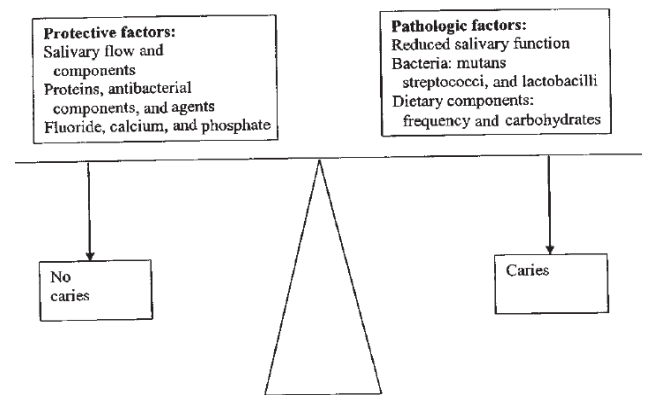


Fig. 2. Schematic diagram of the balance between pathologic and protective factors in the caries process

Nutrition versus Diet: Nutrition is the process of taking in food and its use for growth, metabolism and repair. The nutritional aspects are different from the dietary. The diet is the kind of food that a person habitually eats. "Nutrition" refers to the sum of biological processes as it relates to dietary intake (Hujoel, 2017). But both diet and nutrition may interfere with the balance of tooth demineralization and remineralization in several ways. The "diet" provides sugars and other fermentable carbohydrates, which are metabolized to acids by plaque bacteria and the resultant low pH favors the growth of the acidogenic and aciduric bacteria (*mutans streptococci*). "Nutrition" may affect both the anatomy and function of salivary glands. Chronic malnutrition may reduce the secretion rate of saliva and the buffer capacity of stimulated saliva and adversely affect the volume, antibacterial properties, and physiochemical properties of saliva.

Classification of Sugars: The term *sugar* is generally intended to mean all "dietary sugars," whether added to foods or naturally occurring (Cummings, 2007). The term *added sugars* are all mono- and disaccharides added to food by the manufacturer, cook, or consumer which will therefore include white, brown, raw, manufactured, corn syrups, high fructose corn syrup, and so on, but the definition does not always include honey and natural syrups (e.g., maple syrup). The term *free sugars*, as used by the WHO (2015) in its sugar report, encompasses "all mono and disaccharides added to food by manufacturer, cook or consumer plus those sugars naturally present in honey, syrups and fruit juices and concentrates." So the only difference between the terms *added* and *free* is that the latter includes natural fruit juices and fruit concentrates, honey, and natural syrups, whereas added sugars usually exclude fruit juices and fruit concentrates and sometimes also honey and natural syrups. Then intrinsic sugars are those incorporated within the structure of intact grains, fruit, and vegetables, and sugars from milk are those naturally present in milk and milk products. A further term sometimes used is *fermentable carbohydrate*, which refers to free sugars, glucose polymers, fermentable oligosaccharides, and highly refined starches, but this does not mean that they are fermentable within the mouth by acid producing bacteria in the dental biofilm, given the turnover time of food within the mouth (Sheiham, 2015). Other Dietary Components that may Influence Caries are *Sweetened syrups*. It is not uncommon for infants to be given "comforters" or small "feeders" containing sweetened drinks or sugary vitaminized syrups. The adoption of this practice exposes the deciduous teeth to a potentially cariogenic environment for prolonged periods, and as such is to be deprecated.

Table 1. Shows caries-promoting activity and food sources of carbohydrates and sweeteners

Caries-promoting activity and food sources of carbohydrates and sweeteners ⁷				
Category	Chemical structure	Examples	Caries-promoting potential	Food sources
Sugars	Monosaccharide	Glucose, dextrose, fructose	Yes	Most foods, fruit, honey
		High-fructose corn syrup	Yes	Soft drinks
		Galactose	No	Milk
	Disaccharide	Sucrose, granulated or powdered or brown sugar	Yes	Fruit, vegetables, table sugar
		Turbinado, molasses	Yes	
		Lactose	Yes	Milk
Other carbohydrates	Polysaccharide	Maltose	Yes	Beer
		Starch	Yes	Potatoes, grains, rice, legumes, bananas, cornstarch
	Fiber	Cellulose, pectin, gums, beta-glucans, fructans	No	Grains, fruits, vegetables
		Polyol-monosaccharide	Sorbitol, mannitol, xylitol, erythritol	No
	Polyol-disaccharide	Lactitol, isomalt, maltitol	No	Derived from lactose, maltose, or starch
	Polyol-polysaccharide	Hydrogenated starch, hydrolysates, or maltitol syrup	No	Derived from monosaccharides
High-intensity sweeteners	Saccharin	Sweet and Low	No	
	Aspartame	Nutrasweet, Equal	No	
	Aceulfame-K	Sunett	No	
	Sucralose	Splenda	No	
Fat replacers made from carbohydrates		Carrageenan, cellulose gel/gum, corn syrup solids, dextrin, maltodextrin, guar gum, hydrolyzed corn starch,	Unknown	Baked goods, cheese, chewing gum, salad dressing, candy, frozen desserts, pudding, sauces, sour cream, yogurt,

This is not a condemnation of vitamin syrups but of one means of their application. Such preparations doubtless have their value when the diet may be otherwise deficient, but there is no evidence that they have any beneficial effect in reducing the incidence of caries (Hartles, 1975).

Diet and caries –A complex Relationship: Eating dietary carbohydrates does not imply that dental caries will develop. Not only what we eat, but also the behavioural aspects and circumstances related to consumption play a role (Gustafsson *et al.*, 1954). Lately, also sugar frequency has been put into focus and a new understanding of the relationship between sugars and dental caries has been suggested (Moynihan, 2014). The frequency of sugar eaten is the primary factor involved in the caries process. Sugary foods or liquids consumed 20 minutes apart allows for separate opportunities for bacteria to feed and produce acid. When the pH of the dental plaque falls below 5.5, the caries process begins. Form and composition of a fermentable carbohydrate plays a secondary role depending on how long it takes for a food or drink to clear the oral cavity. Liquids clear faster than soft, sticky foods. The total amount of sugar consumed is the least important factor to consider while counseling patients. A food that is 80% sucrose may not be any more harmful than one that is 40% sucrose (Sroda, 2006). The likelihood that a person consuming dietary carbohydrates will develop caries depends also on caries preventive factors, including genetics, which may counteract for negative dietary habits¹⁵. The final outcome is an end result of the balance between caries-promoting and protective factors.

WHO Guidelines: Sugars Intake for Adults and Children: The objective of the WHO (2015) guideline is to provide recommendations on intakes of free sugars to reduce risks of non communicable diseases in adults and children, with a focus on the prevention and control of unhealthy weight gain and dental caries.

The WHO recognized that dental diseases are the most prevalent non communicable diseases globally and that the treatment of dental diseases is expensive, exceeding the entire financial resources available for the health care of children in most lower-income countries. The WHO generated the following recommendations for free sugars intake in adults and children:

WHO recommends a reduced intake of free sugars throughout the life course (*strong recommendation*). In both adults and children, WHO recommends reducing the intake of free sugars to less than 10% of total energy intake (*strong recommendation*). WHO suggests a further reduction of the intake of free sugars to below 5% of total energy intake (*conditional recommendation*). Strong recommendations indicate that “the desirable effects of adherence to the recommendation outweigh the undesirable consequences” and that “the recommendation can be adopted as policy in most situations.” Conditional recommendations are made when there is less certainty “about the balance between the benefits and harms or disadvantages of implementing a recommendation” and when “policy-making will require substantial debate and involvement of various stakeholders for translating them into action” (WHO 2014, 2015) (Sheiham, 2015).

Dietary recommendations for Reducing the Risk of Dental Caries: A diet history concerning food intake patterns, diet adequacy, consumption of fermentable carbohydrates (including naturally occurring and added sugars), and the use of fluoridated toothpaste is a strategy for health professionals to use to determine the diet related caries risk habits of persons. Diet recommendations for oral health are as follows (American Dietetic Association, 2003; Department of Health and Human Services, 2000; Konig, 1955; Mobley, 1998; Mobley *et al.*, 2009):

- Eat a balanced diet rich in whole grains, fruit, and vegetables and practice good oral hygiene particularly the use of fluoridated toothpastes to maximize oral and systemic health and reduce caries risk.
- Eat a combination of foods to reduce the risk of caries and erosion; include dairy products with fermentable carbohydrates and other sugars and consume these foods with, instead of, between meals; add raw fruit or vegetables to meals to increase salivary flow; drink sweetened and acidic beverages with meals, including foods that can buffer the acidogenic effects.
- Rinse mouth with water, chew sugarless gum (particularly those containing sugar alcohols, which stimulates remineralization), and eat dairy product such as cheese after the consumption of fermentable carbohydrates.
- Chew sugarless gum between meals and snacks to increase salivary flow.
- Drink, rather than sip, sweetened and acidic beverages.
- Moderate eating frequency to reduce repeated exposure to sugars, other fermentable carbohydrates, and acids.
- Avoid putting an infant or child to bed with a bottle of milk, juice, or other sugar-containing beverage.
- Educational protocols need to be established to advise pregnant women about healthy diets and provide guidance on infant feeding, emphasizing the value of breast feeding and the necessity of restricting nighttime bottle feeding to decrease caries risk.
- Family demographics, cultural/ethnic practices, and food related environmental issues should be routinely taken into consideration to tailor education and counseling to the unique needs of a family.
- Multidisciplinary teams including dental professionals, pediatricians, nurses, registered dietitians, family practice physicians, and other allied health care professionals should be trained to screen, educate, and counsel children and families to access care and seek medical and dental homes with active health promotion programs that include diet, nutrition, and dental education resources. Awareness among primary care providers of the potential association between obesity and caries can lead to early interventions and improved health status for all children.

Recent advancements

Phenotype of Dental Caries: Aside from diet and oral microbiota, the host itself plays a role in dental caries. Host behavior contribute to the disease like the patient's dietary preferences may contribute. For example, taste preferences may influence dietary behavior, which in turn may influence whether or not a patient develops caries. Studies have shown some taste genes to be associated with caries. There are also a range of enamel formation genes such as amelogenin, enamelin, tuftelin, and ameloblastin, which exhibit variation and association to dental caries. So to identify the risk factors for dental caries phenotype along with diet and nutrition can eventually translate to better prevention strategies (Weber *et al.*, 2018).

Predictors of Dental Caries: Various studies are going on to access the association between dental caries with BMI, age and gender considering these to be the strong predictors of dental caries (Hassan, 2018).

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Conclusion

Dental caries is a diet-mediated disease. There is extensive scientific evidence that free sugars are the primary necessary factor in the development of dental caries. Acid-producing bacteria and other factors facilitate the development of dental caries, but free sugars are the necessary dietary cause of caries, with consistent evidence for a markedly sensitive log-linear dose-response increase in caries from 0.1% sugars intake to 2% to 3%. A 10% sugars intake was noted by the WHO (2015) as inducing high caries rates despite fluoride use in drinking water and toothpaste. Eating patterns, nutrient composition, duration of exposure, food form, saliva, and supplemental use of fluoride in drinking water, toothpastes, and other agents all interact and affect caries development. Integration of oral hygiene instruction into diet and oral health education will help to reduce caries risk. Health professionals, particularly dental and nutrition professionals, must recognize the relation between oral health and diet and manage patients accordingly.

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