NUTRITION AND YOUR TEETH

ARTICLE 1 Nutrition and Your Child's Dental Health

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How long carbohydrates remain on the teeth is the main culprit that leads to tooth decay.

What diet and nutritional advice can be offered for building strong teeth?

Experts agree that children need food from all the major food groups to grow properly and stay healthy. Too many carbohydrates, sugars (for example, from cake, cookies, candies, milk, fruit juice, and other sugary foods and beverages), and savory foods and starches (for example, pretzels and potato chips) can cause tooth decay. How long carbohydrates remain on the teeth is the main culprit that leads to tooth decay.

Here are some tips for selecting and eating foods that are more healthful to your child's teeth:

- **Keep fruits and vegetables in your house to offer as "healthy snacks" instead of carbohydrates**. Choose fruits and vegetables that contain a high volume of water, such as pears, melons, celery, and cucumbers. Limit bananas and raisins, as these contain concentrated sugar. You should brush immediately after these fruits are eaten.
- **Serve cheese with lunch or as a snack**. Cheese, especially cheddar, Monterey Jack, Swiss, and other aged cheeses, help to trigger the flow of saliva, which helps wash food particles away from teeth.
- **Avoid sticky, chewy foods.** Raisins, dried figs, granola bars, oatmeal or peanut butter cookies, jelly beans, caramel, honey, molasses, and syrup stick to teeth, making it difficult for saliva to wash away. If your child consumes these types of products, have him or her brush their teeth immediately after eating.
- **Serve sugary treats with meals, not as snacks.** If you plan to give your child any sweets, give them as desserts immediately following the meal. There's usually an increased amount of saliva in the mouth around mealtime, making it easier to wash food away from teeth. The mealtime beverage also helps to wash away food particles on teeth.
- **Get your children in the habit of eating as few snacks as possible.** The frequency of snacking is far more important than the quantity consumed. Time between meals allows saliva to wash away food particles that bacteria would otherwise feast on. Frequent snacking, without brushing immediately afterwards, provides constant fuel to feed bacteria, which leads to plaque development and tooth decay. Try to limit snacks as much as possible and to no more than one or two a day. Brush teeth immediately after consuming the snack, if possible.
- **Avoid sugary foods that linger on the teeth.** Lollipops, hard candies, cough drops, and mints all contribute to tooth decay because they continuously coat the teeth with sugar.
- **Buy foods that are sugar-free or unsweetened.**
- **Never put your baby to bed with a bottle filled with milk, formula, juice, or soda.** If your baby needs a bottle at bedtime, fill it with plain water.
- **Offer your child plain water instead of juice or soda.** Juices, sodas, and even milk contain sugar. Water does not harm the teeth and aids in washing away any food particles that may be clinging to teeth.
- **Include good sources of calcium in your child's diet to build strong teeth.** Good sources include milk, broccoli, and yogurt.

Other tips:

- If your child chews gum, encourage him or her to choose xylitol-sweetened or sugar-free gum. Xylitol has been shown to reduce the amount of bacteria in the mouth and the chewing action helps increase the flow of saliva.
- Use fluoride and brush and floss your child's teeth. The best way to prevent tooth decay is to use a fluoride toothpaste every day after the age of 2 or once your child can spit and not swallow toothpaste. Fluoride reverses early decay. Once the tooth is formed, fluoride application remineralizes the surface. This means returning minerals to the teeth. Minerals help keep teeth strong, which, in turn, helps prevent tooth decay. Brush your child's teeth at least twice a day and after each meal or snack if

possible. If brushing between meals is not possible, at least rinse the mouth with water several times. Floss your child's teeth at least once a day to help remove particles between teeth and below the gum line.

- Be sure to brush your child's teeth after giving him or her medicine. Medicines such as cough syrups contain sugar that bacteria in the mouth use to make acids. These acids can eat away at the enamel -- the protective top layer of the tooth.
- Visit the dentist regularly. Your child should make his or her first visit to the dentist by the age of 1 or within 6 months of the first tooth breaking through the gums. Having regular dental checkups will also help catch any developing dental problems early.

ARTICLE 2. Good Oral Health and Diet

Journal of Biomedicine and Biotechnology IMPACT FACTOR 2.44
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1. Introduction

The concept of oral health correlated to quality of life stems from the definition of health that the WHO gave in 1946. Health is understood to be "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity". The programs for the prevention of oral diseases concern teaching about oral hygiene and healthy eating, fluoride prophylaxis, periodic check-ups, sessions of professional oral hygiene, and secondary prevention programs [1]. The term "bionutrition" refers to the important interactions which exist between diet, use of nutrients, genetics, and development. This term emphasizes the role of nutrients in maintaining health and preventing pathologies at an organic, cellular, and subcellular level [2].

There exists a biunique relationship between diet and oral health: a balanced diet is correlated to a state of oral health (periodontal tissue, dental elements, quality, and quantity of saliva).

Vice versa an incorrect nutritional intake correlates to a state of oral disease [3–6].

Go to:

2. Diet and the Development of the Oral Cavity

Diet influences the development of the oral cavity: depending on whether there is an early or late nutritional imbalance, the consequences are certainly different. In fact, an early nutritional imbalance influences malformations most. Moreover, the different components of the stomatognathic apparatus undergo periods of intense growth alternated with periods of relative quiescence: it is clear that a nutritional imbalance in a very active period of growth will produce greater damage [3].

A shortage of vitamins and minerals in the phase before conception influences the development of the future embryo, influencing dental organogenesis, the growth of the maxilla, and skull/facial development [1, 2].

An insufficient supply of proteins can lead to [3, 4] the following:

i. atrophy of the lingual papillae,
ii. connective degeneration,
iii. alteration in dentinogenesis,
iv. alteration in cementogenesis,
v. altered development of the maxilla,
vi. malocclusion,
vii. linear hypoplasia of the enamel.

An insufficient supply of lipids can lead to [5, 6] the following:

i. inflammatory and degenerative pathologies,
ii. parotid swelling—hyposalivation,
iii. degeneration of glandular parenchyma,
iv. altered mucosal trophism.

An insufficient supply of carbohydrates can lead to the following:

i. altered organogenesis,
ii. influence of the metabolism on the dental plaque,
iii. caries,
iv. periodontal disease.

Diet influences the health of the oral cavity, conditioning the onset of caries, the development of the enamel, the onset of dental erosion, the state of periodontal health, and of the oral mucous in general.

Go to:

3. Caries

Caries is a demineralization of the inorganic part of the tooth with the dissolution of the organic substance due to a multifactorial etiology. The demineralization of the enamel and of the dentine is caused by organic acids that form in the dental plaque because of bacterial activity, through the anaerobic metabolism of sugars found in the diet [7].

Demineralization occurs when the organic acids produced increase the solubility of the calcium hydroxyapatite that is present in the hard tissue of teeth (Figure 1).

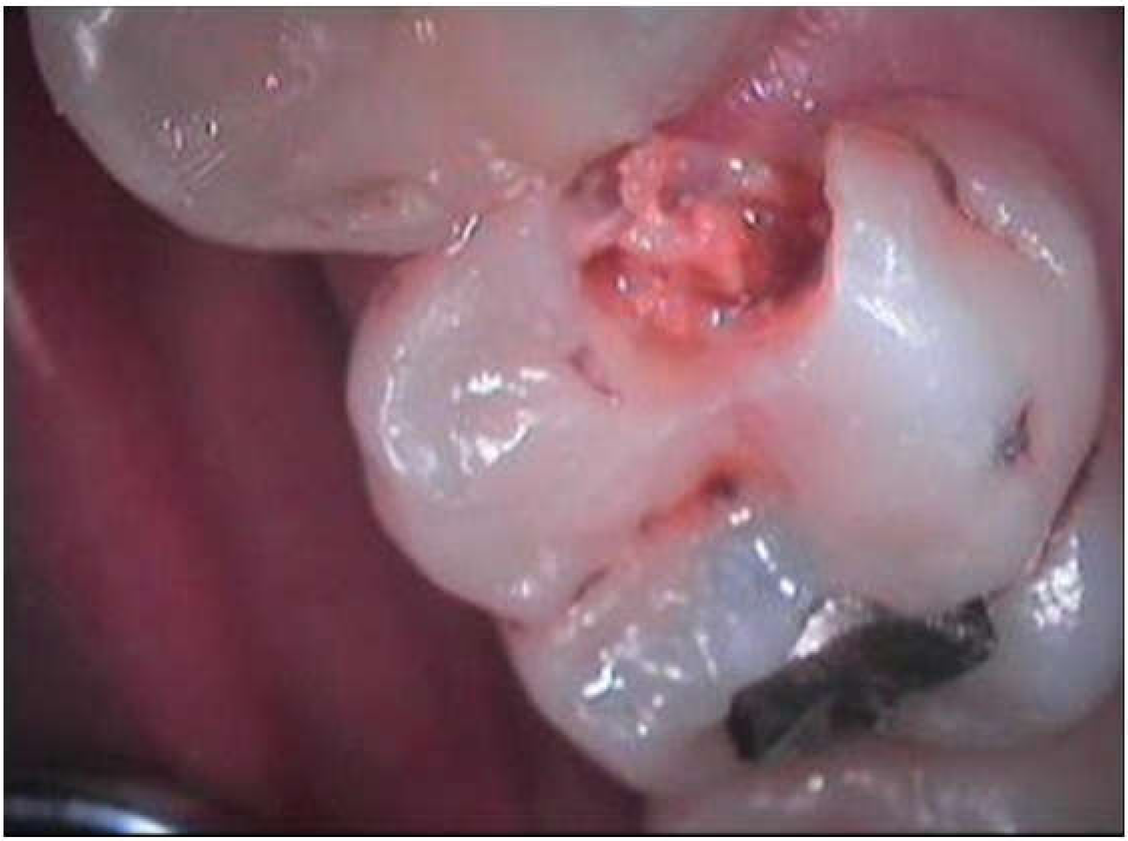

Figure 1

Caries of the teeth.

The development of caries requires the presence of sugars and bacteria but it is influenced by the susceptibility of the teeth, by the type of bacteria, and by the quantity and quality of the salivary secretion.

Saliva is supersaturated with calcium and phosphate with a pH equal to 7, a level that favours remineralization. When acid stimulation is too strongdemineralization prevails until the formation of a carious lesion [8].

Very low levels of dental caries are found in isolated communities with a traditional lifestyle and low consumption of sugars [7–9]. As soon as economic conditions improve and the quantity of sugars and other fermentable carbohydrates increases in the diet, a notable increase in dental caries is noticed. This has been seen in the Inuit of Alaska and in populations in Ethiopia, Ghana, Nigeria, Sudan, and the islands of Tristan da Cunha and Sant'Elena [7–9].

A Vipeholm study in Sweden between 1945 and 1953 in an institute for the mentally ill underlined the correlation between caries and the intake of sugary food of variable viscosity. If the sugar was ingested up to a maximum of 4 times a day only during meals, it had little effect on the increase of caries, even if this occurred in great quantities; the increase in the frequency of consumption of sugar between meals was associated to an increase in caries; when they no longer ate foods rich in sugar, the incidence in the formation of caries diminished [10].

The types of sugar ingested through diet also influence the onset of illness. In fact, studies on the pH of the dental plaque have shown that lactose produces less acidity in comparison to other sugars.

A 1970 Finnish study on a supervised dietary change revealed that, in an adult population, the almost total substitution of sucrose in the diet with xylitol determines a 85% reduction in caries over a 2-year period; its mechanism of action resides in the inhibition of the growth of Streptococcus mutans, the most important microorganism responsible for the formation of caries [11].

Diet can be a good ally in the prevention of caries [12].

i. Increase in the consumption of fibres: diminution of the absorption of sugars contained in other food.
ii. Diets characterized by a ratio of many amides/little sugar have very low levels of caries.
iii. Cheese has cariostatic properties.
iv. Calcium, phosphorus and casein contained in cow milk inhibit caries.
v. Wholemeal foods have protective properties: they require more mastication, thus stimulating salivary secretion.
vi. Peanuts, hard cheeses, and chewing gum are good gustative/mechanical stimulators of salivary secretion.
vii. Black tea extract increases the concentration of fluorine in the plaque and reduces the cariogenicity of a diet rich in sugars.
viii. Fluorine.

Fluorine remains a milestone in the prevention and in the control of dental caries. It has a preeruptive mechanism of action (incorporation in the enamel during amelogenesis) and a posteruptive mechanism (topical action). Fluorine reduces caries by 20–40% in children, but it does not entirely eliminate them: even when fluorine is used, the association between the intake of sugars and caries continues to be present all the same [13].

Diet also influences the qualitative characteristics of salivary secretion. The secretive proteins (mucines) represent an important barrier against the reduction of humidity, against the physical and chemical penetration of irritants and against bacteria [14].

The synthesis of glycoproteins requires vitamin A. In an imbalanced diet, there is a reduction in the content of mucines with the consequent risks for oral health (Caries!!).

Go to:

4. Development of the Enamel

Teeth in a preeruptive phase are influenced by the nutritional state. A lack of vitamins D and A and protein-energy malnutrition have been associated to hypoplasia of the enamel and atrophy of the salivary glands, conditions that determine a greater susceptibility to caries. Some hypoplasia and pits on the surface of the enamel correlate to a lack of vitamin A (Figure 2); a lack of vitamin D is associated to the more diffused hypoplastic forms (Figure 3). The structural damage can testify to the period in which the lack of nutrition occurred [15].

Figure 2

Hypoplasia and pits on the surface of the enamel correlate to a lack of vitamin A.

Figure 3

Hypoplasia on the surface of the enamel correlate to a lack of vitamin D.

Go to:

5. Dental Erosion

"Dental erosion is the progressive irreversible loss of dental tissue that is chemically corroded by extrinsic and intrinsic acids through a process that does not involve bacteria…."

Extrinsic Acids Derived from Diet —

They citric, phosphoric, ascorbic, malic, tartaric, and carbonic acids that are found in fruit, in fruit juices, in drinks, and in vinegar.

Intrinsic Acids —

They are derived from serious gastroesophageal reflux [16–18] (Figure 4).

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Figure 4

Dental Erosion.

Go to:

6. Periodontal Disease

Periodontal disease evolves more quickly in undernourished populations: "…the pathology starts in the gum and could interest the periodontal ligament up to the alveolar bone…". The most important risk factor in the development of periodontal disease is represented by inadequate oral hygiene (Figure 5). Data supplied by the National Health and Nutrition Examination Survey 2001/02 underlined that a low level of folic acid is associated to periodontal disease. The serum level of folates is an important index of periodontal disease and can represent an objective that should be pursued in the promotion of periodontal health [19].

Figure 5

Periodontal disease.

Malnutrition and bad oral hygiene represent two important factors that predispose for necrotizing gingivitis. Prevention programs against disease must therefore include a correct evaluation of the immune system and the promotion of nutritional programs. The aim of nutritional support in inflammatory diseases is to provide the right energy and nourishment to respond to the increased demand for protein synthesis in the acute phase, inflammatory mediators, antioxidant defence mechanisms, as well as for the promotion of tissue reparation. Some nutrients have a very important role in the resolution of the inflammatory process. These observations confirm the relationship between diet and periodontal disease [20]. In a recent interview, the president of the American Society of Periodontology, Michael P. Rethman [20], underlined the importance of diet for a healthy smile. In particular, the correlation between the income of calcium and periodontal disease can be due to the role that calcium has in the density of the alveolar bone that supports teeth. Also the intake of vitamin C is fundamental for maintenance and for the activation of reparative mechanisms thanks to its antioxidant properties [20].

ARTICLE 3. SUGARS AND DENTAL CARIES

Riva Touger-Decker Cor van Loveren

SUGARS AND STARCHES IN THE DIET

Intake of sugars and starch

The US *Food Guide Pyramid* (66) and *Dietary Guidelines for Americans* (67) along with the European National Guidelines (34, 68) promote a diet rich in carbohydrates as whole grains, fruit, and vegetables. However, foods within these categories are sources of fermentable carbohydrates. Fruit and select dairy products, vegetables, and starches contain fermentable carbohydrates. A detailed discussion of sources of sugars, dietary guidelines, and terminology regarding sugars may be found in the articles from this workshop by Sigman-Grant and Morita (69) and Murphy and Johnson (70).

Intake of sugars in the United States increased significantly in the latter part of the 20th century; per capita consumption of added sugars increased by 23% from 1970 to 1996 (71, 72). Intake of added sugars increased from 1989–1991 to 1994–1996, representing an increase from 13.2% to 15.8% of total energy intake (73). Despite *The Food Guide Pyramid* (66) and the 2000 *Dietary Guidelines for Americans* (67), which encourage consumers to choose beverages and foods that provide a moderate intake of sugars, intakes of sugars in foods and fluids have increased.

In 2000 the most frequently reported form of added sugars in the US diet was nondiet soft drinks, which accounted for up to one-third of the intake of sugars (70, 74). An increasing availability of added sugars in the diets at home, in restaurants, and even in schools contributes to the rising intake of these foods. The general trend in Europe has been the stable use of sugars (Table 3), ≈34 kg • person^{-1} • y^{-1} (16).

Forms of sugars and starch in the diet

Sugars are a form of fermentable carbohydrate. Fermentable carbohydrates are carbohydrates (sugars and starch) that begin digestion in the oral cavity via salivary amylase. Sugars enter the diet in 2 forms: those found naturally in foods (eg, fruit, honey, and dairy products) and those that are added to foods during processing to alter the flavor, taste, or texture of the food (72) (Table 1). Examples of added sugars include white or brown sugar, honey, molasses, maple, malt, corn syrup or high-fructose corn syrup, fructose, and dextrose (Table 5) (75). Other disaccharides, particularly trehalose, threhalose, and isomaltose, have a lower cariogenic risk than does sucrose. Starches are subsequently digested by salivary amylase to oligosaccharides, which may be fermented by the oral microflora. According to Lingstrom et al (76), only the gelatinized starches are susceptible to breakdown by salivary amylase into maltose, maltotriose, and dextrins.

TABLE 5

Caries-promoting activity and food sources of carbohydrates and sweeteners[1]

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
		Maltose	Yes	Beer
Other carbohydrates				
	Polysaccharide	Starch	Yes	Potatoes, grains, rice, legumes, bananas, cornstarch

Category	Chemical structure	Examples	Caries-promoting potential	Food sources
	Fiber	Cellulose, pectin, gums, beta-glucans, fructans	No	Grains, fruits, vegetables
	Polyol-monosaccharide		Sorbitol, mannitol, xylitol, erythritol	NoFruit, seaweed, exudates of plants or trees
	Polyol-disaccharide	Lactitol, isomalt, maltitol	No	Derived from lactose, maltose, or starch
	Polyol-polysaccharide		Hydrogenated starch, hydrolysates, or malitol syrup	NoDerived 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, modified food starch, pectin, polydextrose, sugar beet fiber, xanthan gum	Unknown	Baked goods, cheese, chewing gum, salad dressing, candy, frozen desserts, pudding, sauces, sour cream, yogurt, meat-based products

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Cariogenic risks of foods and beverages

The focus of this paper is sugars, but sugars are often eaten in combination with starches and many of the same issues arise in determining the cariogenic risk associated with individual foods. Key issues to consider in determining dietary cariogenic, cariostatic, and anticariogenic properties are food form, frequency of sugars consumption and other fermentable carbohydrates, retention time, nutrient composition, the potential of the food to stimulate saliva, and combinations of foods (37, 76). Caries risk also depends on individual host factors. The presence of any individual characteristics—such as low or high salivary pH, genetic predisposition, prior caries history, use of medications, incidence of systemic or local diseases that affect the immune system, and personal hygiene habits—also play a role in the associated caries risks of particular foods.

The cariogenic potential or associated risk of sugars and other fermentable carbohydrates has been extensively reviewed (37, 60, 76–78). Studies have attempted to estimate the cariogenic potential of foods and beverages on the basis of the decrease in plaque pH caused by food (79). Stephan and Miller (40) published the first research describing the decrease in plaque pH after exposure to fermentable carbohydrates. The cariogenic risk associated with individual foods is challenging to determine in human studies because of the variability in salivary flow and salivary and plaque pH, the eating experience (frequency and food combinations), bioavailability of starch-derived sugars (75), retention time of food in the oral cavity, and potential interactions between starches and sugars. No epidemiologic evidence supports the cariogenic risk associated with select starch products without added sugars, such as rice, potatoes, and bread (80). Luke et al (81), however, showed the caries risk of white bread in the laboratory setting in humans. In a rat study, Mundorff et al (82) showed the potential caries risk associated with French fries. Lingstrom et al (76) concluded that it is premature to consider food starches in modern diets to be safe for teeth.

Food form

The form of the fermentable carbohydrate directly influences the duration of exposure and retention of the food on the teeth. Prolonged oral retention of cariogenic components of food may lead to extended periods of acid production and demineralization and to shortened periods of remineralization. Duration may also be influenced by the frequency and amount of fermentable carbohydrate consumed (76, 77). Liquid sugars, such as those found in beverages and milk drinks, pass through the oral cavity fairly quickly with limited contact time or adherence to tooth surfaces. However, fluid intake patterns can influence the caries risk of the beverages. Holding sugar-containing beverages in the oral cavity for a prolonged time or constant sipping of a sugared beverage increases the risk of caries. Long-lasting sources of sugars, such as hard candies, breath mints, and lollipops, have extended exposure time in the oral cavity because the sugars are gradually released during consumption.

Oral clearance

Oral clearance properties vary by individual person and depend on metabolism by microorganisms, adsorption onto oral surfaces, degradation by plaque and salivary enzymes, saliva flow, and swallowing. Most carbohydrates will be cleared by these simultaneous mechanisms. Luke et al (81) showed this clearance to be relatively slow. Retentiveness of foods is not the same as stickiness. A caramel or jellybean may be sticky, but its retentive properties are fairly low and they are cleared from the oral cavity faster than are retentive foods such as cookies or chips. Luke et al (81) found that after rinsings with 10% solutions, sucrose cleared more rapidly from the saliva than did glucose, fructose, or maltose. Products of sucrose metabolism (ie, glucose and fructose) were not detected after the sucrose rinse in contrast with after the maltose rinse. A test of the salivary clearance of 3 different fermentable carbohydrates (white bread, bananas, and chocolate) showed that the clearance of residual carbohydrates (sucrose, fructose, and maltose) from bananas and chocolate was marginally faster than that from white bread. Carbohydrate residues from the 3 foods were still present in the mouth 1 h after ingestion. Glucose produced by chocolate and bananas was higher initially and cleared more rapidly than that produced by bread, which was initially lower because of the time needed for starch breakdown by amylase.

In comparable studies of salivary carbohydrate, Edgar et al (83) and Bibby et al (84) found that high-starch foods had slow salivary clearance rates. Kashket et al (77) found particles of food with high contents of starch, such as creme sandwich cookies and potato chips, to be retained on teeth in larger amounts than foods that contained little starch, such as milk chocolate, caramels, and jelly beans. In a subsequent study, Kashket et al (78) showed that the starch particles retained on the tooth surface were hydrolyzed to sugars (maltose and maltotriose), depending on the processing of the food starch. Gelatinization of starches by various degrees of heating enhances the ability of salivary amylase to break down the starches and stimulates a decrease in pH (76, 78). Doughnuts and potato chips processed at the highest temperature gave rise to the highest amount of the sugars compared with the other test foods. The study showed that the longer that foods are retained in the oral cavity, the greater the potential the starch has to break down into sugars and contribute to the caries process. The initial content of sugars was not the culprit; rather, it was the type of starch and extent of starch retention time in the oral cavity that determined the relative cariogenic risk of the food (78).

Frequency

The frequency of consumption seems to be a significant contributor to the cariogenicity of the diet (58, 85–88), although Bowen et al (88) concluded that it is not the frequency of ingestion per se that is related to the development of caries but the time that sugars are available to microorganisms in the mouth. The importance of frequency is clear when caries is regarded as the outcome of the alternation of demineralization and remineralization. Higher frequency means more demineralization and less remineralization. The duration of the decrease in pH after intake of a cariogenic food is an important confounder in this relation. Traditionally, and in many educational models, the decrease in pH lasts 30 min (40). pH telemetry measurements, however, show that after plaque is a few days old, the decrease in pH can last for several hours, unless the site is actually cleared by a stimulated salivary flow or by removal of impacted food (89). These data suggest that local oral factors that influence the accessibility of saliva may modify the cariogenicity of food.

Nutrient composition

Diet and nutrition may favor remineralization when their content is high in calcium, phosphate, and protein. In experiments using processed cheese and sucrose solutions, Jensen and Wefel (90) showed that processed cheese was anticariogenic. Cheese consumption followed by a 10% sucrose solution resulted in a pH of 6.5 compared with a pH of 6.3 for cheese alone and a pH of 4.3 for sucrose alone. When the intakes of sugars and cheese were compared in the Forsyth Institute Root Caries Study, Papas et al (91, 92) showed that, independent of the consumption of sugars, cheese protected against coronal and root caries. These findings, relative to root caries, are particularly important for older adults, many of whom consume a diet rich in simple sugars and are at risk of root caries. Mechanisms proposed to explain the anticariogenic effects of cheeses are as follows: *1*) increased salivary flow and the subsequent buffering effect, which can neutralize plaque acids; *2*) inhibition of plaque bacteria and the effect of that inhibition on reducing the amount of bacteria, thereby reducing acid production; and *3*) intake of increased alkaline substances, calcium, inorganic phosphate, and casein, which decrease demineralization and enhance remineralization (93).

Acid content

The acidity of individual foods can precipitate erosion. The erosive potential, however, depends also on whether the oral buffer systems can neutralize the food. Because the critical pH for enamel dissolution is 5.5, any food with a pH lower than 5.5 may contribute to or stimulate erosion. In persons with adequate saliva and good oral hygiene habits, these fluids and foods pose minimal risk when consumed as part of a balanced diet. Large doses of chewable vitamin C may also cause a decrease in pH because of its citric acid content, which contributes to tooth erosion (80).

Polyphenols

Polyphenols such as tannins in cocoa, coffee, tea, and many fruit juices may reduce the cariogenic potential of foods. In vitro experiments have shown that these polyphenolic compounds may interfere with glucosyltransferase activity of mutans streptococci, which may reduce plaque formation (94, 95). In rat experiments, tea polyphenols reduced caries (95, 96).

Sugar alcohol–based products

Sugar-free gums can stimulate saliva, increasing the clearance of sugars and other fermentable carbohydrates from the teeth and the oral cavity and increasing buffer capacity. Tooth-friendly polyols include sorbitol, xylitol, mannitol, erythritol, and isomalt. However, xylitol—a 5-carbon sugar that oral microflora cannot metabolize—has additional anticariogenic effects attributable to antimicrobial action, stimulation of saliva resulting in increased buffer activity and an increase in pH, and enhanced remineralization (97, 98). Sorbitol-sweetened gums simulate saliva without causing a drop to the critical pH and have been shown to be equal to xylitol gum in terms of caries control (99).

INFLUENCE OF LIFE SPAN ON CARIES RISK

Caries patterns in children, adults, and elderly vary, as do eating patterns. In all age groups, eating frequency, retentive and nutrient properties of food, and oral hygiene habits play a role in determining caries risk. Infants and children are particularly susceptible to early childhood caries (3). Caries in early childhood typically occurs when bedtime or naptime habits include lying with a bottle filled with formula, juice, milk, or another sweetened beverage. Although the content of sugars in the diet plays a pivotal role in caries patterns, adoption of good oral hygiene habits, a balanced diet, and limited intake of high-sugar between-meal snacks will reduce the risk of caries. Root caries are more prevalent in the elderly than in other age groups (91, 92). Papas et al (91, 92) showed that elderly persons whose sugar intakes were in the highest quartile had significantly more root caries than did persons whose sugar intakes were in the lowest quartile. Persons with a sugar intake in the highest quartile consumed approximately twice as many sugars in the form of liquids (sweetened coffee or tea) and sticky sugars (92).

DIETARY RECOMMENDATIONS FOR REDUCING THE RISK OF ORAL INFECTIOUS DISEASE

The primary public health measure for reducing oral infectious disease, from a dental perspective, is the use of topical fluorides (as toothpastes) and water fluoridation at appropriate levels of intake (100). The primary public health measure, from a nutrition perspective, is dietary balance and moderation in the adherence to dietary guidelines, food guides, and dietary reference intakes (101). Dietary habits regarding the consumption of naturally occurring and added sugars, including the frequency of eating, the form of the sugars-containing food, the sequence in a meal, the presence of buffers such as calcium, and the duration of exposure greatly affect caries risk and should be addressed in dietary recommendations. Likewise, the use of fluoridated toothpaste and water greatly affects caries risk. Persons at high risk should be attentive to their consumption patterns, moderate their intakes of sugars (naturally occurring or added) and other fermentable carbohydrates, and use fluoridated toothpaste. A diet void of naturally occurring sugars and fermentable carbohydrates is not feasible, and a diet void of added sugars would be difficult to achieve and maintain. Maintaining a moderate use of added sugars and sweets is a prudent recommendation found in the US *Dietary Guidelines* for *Americans* (67).

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 (1, 2, 58, 75):

1. 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.
2. 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.
3. 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.
4. chew sugarless gum between meals and snacks to increase salivary flow.
5. drink, rather than sip, sweetened and acidic beverages.
6. moderate eating frequency to reduce repeated exposure to sugars, other fermentable carbohydrates, and acids.
7. avoid putting an infant or child to bed with a bottle of milk, juice, or other sugar-containing beverage.

SUMMARY AND CONCLUSIONS

The relation between sugars and oral health is dynamic. Although sugars, both naturally occurring and added, and fermentable carbohydrates stimulate bacteria to produce acid and lower the pH, several dietary factors affect the caries risk associated with fermentable carbohydrates. Topical fluoride in toothpaste and fluoridated water supplies have had a significant effect on reducing caries risk globally. 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.

Further research is needed to determine anticariogenic strategies to reduce risks posed by sugars and other fermentable carbohydrates, explore the use of sugar alcohols and dairy products to prevent caries, and determine the cariogenicity of different starches and starch-sugar combinations. The effect of sugars on plaque pH and decay patterns in mixed diets merits additional human studies. Longitudinal studies are needed to explore caries risk over time in persons with different sugar and meal-snack consumption patterns. Educational and behavioral research is needed to determine strategies to moderate the frequency of added sugars and to increase compliance with the *Dietary Guidelines for Americans* and the dietary reference intakes.

Sugars and oral health are integrally related. Dietary guidelines for the prevention and management of dental caries provide a framework for consumers and health professionals to use in managing the intake of sugars.

The authors had no conflict of interest.