

CARIOGENICITY OF VARIOUS FOOD PRODUCTS AND ITS ORAL CLEARANCE –A REVIEW ARTICLE

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Abstract

Dental caries is a disease, the onset of which is dependent on a combination of multiple factors like microorganisms, host i.e, susceptible teeth, diet: fermentable carbohydrate, and time. Research efforts have been made to understand the contribution of each component on the resulting dental caries. Prediction of a food's cariogenicity can be most usefully regarded as a relative assessment of the food's potential, among other foods, to give rise to caries, with other modifying factors held constant.

Keywords: Cariogenicity, Dental caries, Diet

Introduction

Dental caries is one of the most common preventable diseases which are recognized as the primary cause of oral pain and tooth loss. It is a localized destruction of susceptible dental hard tissue by acidic by products from bacterial fermentation of dietary carbohydrates. Thus it is a bacterial driven, generally chronic, site-specific, multifactorial, dynamic disease process that results from the imbalance in the physiologic equilibrium between tooth mineral and plaque fluid (i.e. when the pH drops, net mineral loss results over time). The infectious disease process can be arrested at any point in time (DCNA 2010), provided the decay does not materialize into cavitation (i.e. penetration into dentin). This multifactorial disease process involves the interaction of acidogenic and aciduric microflora on a susceptible tooth surface in a conducive environment, characterized in part by frequent intakes of food containing retentive and rapidly fermentable carbohydrates. These factors are:

1. Host factor (tooth and saliva)
2. Cariogenic Diet (carbohydrates)
3. Plaque and its microorganisms
4. Time

Host factors:

Tooth:

Caries occurs commonly in teeth having deep pits and fissures while shallow grooves, pits and fissures are less susceptible to caries. Malalignment and overlapping of teeth create areas of stagnation for plaque to build up, predisposing to dental caries. Widely spaced teeth have lower caries susceptibility. A full rounded arch form has

lower caries susceptibility because of better cleansing of the teeth by the tongue and cheeks.

Saliva:

Saliva plays a very important role in oral health. Based on the constituents of saliva, it has properties such as lubrication, clearance of unwanted substances, digestion, neutralization of acids or bases, protection against demineralization and also an antimicrobial role.¹ Saliva affects the incidence of dental caries (1) as a mechanical cleansing agent that results in less accumulation of plaque, (2) by reducing enamel solubility by means of calcium, phosphate and fluoride, (3) by buffering and neutralizing the acids produced by cariogenic organisms or introduced directly through diet and by antibacterial activity.² Average baseline pH of saliva is usually 7.26. The critical pH of saliva is 4.5 to 5.5. Saliva has many essential functions. Salivary buffering capacity has been identified as one of the many factors that may affect an individual caries risk. The ability of saliva to buffer the acids is essential to maintain the pH above the critical pH, thus protecting teeth against demineralization.³ Saliva controls the equilibrium between demineralization and remineralization in a cariogenic environment⁴. The increased concentration of bicarbonate diffuses into the plaque, neutralizes plaque acids, increases the pH of the plaque and favors the remineralization of damaged enamel and dentin. Saliva also serves as the host's defense mechanism by repairing the demineralization that occurs when the plaque pH is below 5.5 to 6.0⁵.

Diet:

Diet is also a major aetiological factor for dental caries and enamel erosion. Physical state of food plays a very significant role in its cariogenic potential. Liquid sugars pass through the oral cavity fairly quickly with limited

contact time or adherence to tooth surfaces. Solid and sticky sugars get stuck to the teeth surface due to their property of adherence. The longer the sugar is stuck to the teeth, the longer the bacteria act on sugars and produce acid thus leading to development of dental caries⁶. Oral clearance properties vary from person to person and depend on metabolism by microorganisms, adsorption onto oral surfaces, degradation by plaque and salivary enzymes, saliva flow, and swallowing⁷. Of all the disaccharides, sucrose (table sugar) has been identified as the "arch criminal" in dental caries formation.

Moreover, oral clearance is much longer for sucrose solution than for carbohydrates from bread, chocolate and Decreased salivary secretion and absence of tongue movements (as during sleep) reduce oral clearance rate.. Distinctions can be made between liquids that are cleared rapidly and adhesive (sticky) foods that vary widely in retentiveness. Particularly high retention rates have been found for products such as sweet biscuits, crackers, and potato chips (crisps)⁸

Plaque:

It is a soft, tenacious biofilm on the tooth surfaces and intraoral appliances exposed to the saliva, harboring a diverse range of bacteria embedded in a matrix of glycoproteins of salivary origin. Microflora of plaque contains species that are acidogenic and demineralize enamel, dentin and cementum, together with proteolytic organisms that hydrolyse the dentin collagen matrix and affect gingival health. The composition of microflora changes as the lesion progresses through the dental tissues due to altered environmental conditions (pH, degree of anaerobiosis, nutritional sources etc). In supragingival dental plaque, the proportion of gram positive facultative acid producing bacteria particularly Streptococci mutans and Lactobacilli has direct relevance to the pathogenicity of the plaque as they tolerate a low pH environment and thrive when the diet is high in cariogenic substrates such as sucrose. Streptococcus mutans and Streptococcus sobrinus produce insoluble extra-cellular polysaccharides from sugars both as a means of forming a dense protective biofilm and as a means for storing surplus substrate.

Time:

The pH of the dental plaque decreases each time the host ingests a snack or meal that contains fermentable carbohydrates; afterwards, the pH returns to the resting level because of salivary flow and clearance of the food components from the oral environment.⁵ The production of acids by microorganisms within the dental plaque continues until the carbohydrate substrate is metabolized. The classic Stephan curve shows the pH changes of dental plaque after rinsing with a sugar solution. Robert Stephan in 1940, shows the fall in pH below the critical level of pH

5.5, at which demineralization of enamel occurs following the intake of fermentable carbohydrates, acidic liquids, or sugar in the presence of acidogenic bacteria. Repeated fall of pH over a period of time leads to more and more mineral loss from the tooth surface and ultimately it presents in unfavorable way resulting in initiation of dental caries. Later, it slowly returns to its original value over a period of 30-60 minutes, approximately.

It is also known that the plaque's pH goes from acidic to normal (or the resting level) within a few minutes and depends on the presence and buffering capacity of saliva, and is due primarily to the carbonate and phosphate pH buffering agents.⁹

Cariogenicity (pH) of common food items and its clearance in the oral cavity

Milk

It is considered as an ideal food for the growing child. It is a more popular form of nutrition. Milk in its physical state shows an alkaline pH. The oral clearance rate of milk is usually 10 minutes. This may be probably due to the physical state of the milk which enables it to clear from the oral cavity soon. Bhat et al compared the acidogenic potential of plain milk, milk with sugar, milk with cornflakes and milk cornflakes with sugar by assessing the salivary pH. He carried out the study on 40 school children of 8 to 12 years; 20 boys and 20 girls. The salivary pH was assessed before and after the consumption of milk; milk and sugar; milk and cornflakes; and milk, sugar, and cornflakes. Baseline unstimulated saliva was collected in sterile plastic tube and the pH was recorded. The change in the salivary pH from the respective groups after consuming the test meal was recorded as follows: (1) after 5 minutes; (2) after 10 minutes; (3) after 15 minutes; (4) after 30 minutes; (5) 120 minutes and concluded the fall in pH in all the groups was not significant to a limit of critical pH. Milk when added with sugar and/or cornflakes as a meal did not pose a threat as there was not significant decrease in pH.³

Milk contains 4%-5% disaccharide lactose, which can be fermented by oral biofilm bacteria. Normally, sucrose lowers the plaque pH to <5.0 while lactose lowers pH to approximately 6.0. therefore under normal conditions, the carbohydrate content of milk confers a low cariogenic potential; however, milk or cheese preserve teeth by counteracting the acidification induced by sucrose in the dental biofilm.¹⁰ Birkhed et al found that milk induced minimal pH reduction compared to fruit juice and sweetened beverages. Milk fermentation leads to the production of lactic acid and the resulting drop in pH inhibits the growth of many pathogenic microorganisms.¹¹ Birkhed et al reported that dental plaque microflora may adapt to lactose in milk, increasing the ability to ferment lactose in the milk following frequent consumption.¹² The

pH increased slightly after 20 minutes due to the peptides and amino acids produced by the hydrolysis of casein, which upon further catabolism, can raise the plaque pH and prevent demineralization. This process of alkaline production may counteract the acid produced from lactose fermentation.¹³

Yogurt: The initial fall in plaque pH was due to the acidic nature of the yogurt (4.0-4.5 pH). The increase in pH after 20 and 30 minutes may be due to the buffering capacity of stimulated saliva, and the reduced lactose content of the yogurt due to fermentation.¹³ The increase in pH may also be due to the fact that the natural CPP content present in yogurt is higher than that of milk, due to the proteolytic activity of microorganisms contained in the yogurt, and the peptides and amino acids produced by the hydrolysis of casein. Both of these have a potential to produce a pH rise in plaque upon further catabolism, and prevent demineralization.^{13,14} Milk and milk-based components (without added sucrose) can be used as a substitute for carbohydrate-laden desserts and snacks, which may help reduce the incidence of dental caries.

Pepsi

The beverage market has in recent years seen drastically increased consumption of aerated drink. Teenagers and children are among the largest consumers and account for 65% of total sales.¹⁵ The changes in drinking patterns also have implications for dental health. Soft drinks contain not only sugars but also different organic acids, and they are implicated as an extrinsic cause in the development of dental erosions. A prolonged and frequent use of an acidogenic drink leads to low plaque pH and demineralisation. However, various host factors like salivary flow rate, buffering capacity, and pH, as well as the concentration of calcium and phosphate in saliva and the frequency of fluid intake can influence the extent of dental erosion.¹⁶ The oral clearance rate of soft drink was found to be 13 minutes. This was probably because the liquids tend to clear faster from the oral cavity. This finding of the study was in agreement with the other studies as well in which the oral clearance rate of beverages was found to be in the range of 10 to 15 minutes. Liquid sugars pass through the oral cavity fairly quickly with limited contact time or adherence to tooth surfaces because of their characteristic readiness to flow, little or no tendency to disperse, and relatively high incompressibility.¹⁷

Fruit Drink

Fruits and fruit juices can contain a variety of acids that have the potential to damage the teeth. They may be acidic enough to erode surfaces of the teeth which are not covered by dental plaque. The fruit drink (mango drink), maximum drop in pH took place at 0 minutes (6.08 ± 0.09). It was observed that the mean salivary flow rate was

maximum at 0 minutes (1.88 ± 0.49). The oral clearance rate of fruit drink was found to be 15 minutes.¹⁸

Coffee

Coffee was found to lower the salivary pH but well above the level of critical pH. This might be due to the fact that milk has lactose which has low acidogenicity. Nielsen and Popkin reported an initial rise in pH of saliva after milk consumption.¹⁹ Oral clearance of coffee was found to be within 15 minutes which is in agreement with a study which confirmed rapid clearance of liquids from the oral cavity.²⁰ Ludwig and Bibby who found that clearance of sugar from the mouth was much more rapid when it was consumed in liquid (beverage) rather than in solid form (snacks).²¹

Fibrous foods and caries:

Fibrous plant foods are effective in caries prevention and is more likely to be related to mechanical stimulus of salivary flow than effective plaque removal. The consumption of foods that require a lot of chewing produces a more copious salivary flow with an increased buffering capacity, thereby more effectively neutralizing plaque acids and aiding oral clearance of food debris.²²

Apples

It contains condensed tannins which have anti adhesion properties that may inhibit some bacteria from bonding to each other and producing dental plaque. The acidic nature of the apples stimulated the flow of an alkaline saliva. As the flow-rate increases, the pH of saliva rises and the buffering power is greatly increased.²³

Cranberries and berry fruits in particular are good sources of flavonoids. Preliminary studies have shown that cranberries may lower *S. mutans* count in saliva.²²

Cheese containing meals increase plaque calcium concentrations to a significantly greater level than meals lacking cheese. Cheese delivers high amounts of calcium and inorganic phosphate which result in reduced enamel demineralization by adsorbed proteins, by casein phosphopeptides, i.e., bound calcium and phosphorus.²⁴ Cheese causes stimulation of salivary flow which enhances the food clearance which removes source of fermentable carbohydrates and also results in buffering action which neutralize plaque acids. Cheese also helps in inhibition of plaque bacteria which may reduce bacterial role and thus reduces acid production. Protein present in the cheese extract may prevent caries by adsorbing to the enamel surface and interfering with the ionic diffusion at the plaque enamel interface.²⁵ Cheese produce a rapid rise in plaque pH in vivo, accelerating plaque's pH return to neutrality. Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), which is present in cheese, also may

buffer the plaque pH by adsorbing to the tooth enamel, which reduces enamel solubility and bacterial adherence.

Slowly dissolving 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.

Bread

Bread is one of the major contributors of human diet. It is not only caloric but affordable by people. Bread and cereals have the most suggested servings per day in Food Guide Pyramid in individuals with higher daily exercise. Bread is a suitable source of both starches and fibers. Sugars, especially foods containing sucrose, are identified consumables in lowering dental plaque pH and therefore increasing dental caries incidence. Higher levels of demineralization and more *Lactobacillus* colonization were observed when starch added to sugar. Foods with lower acidogenic potential, such as whole meal bread, increased pH even more than baseline.²⁶

Unrefined cereals and nuts:

Taketa and Phillips reported that extracts of oat hulls contained antibacterial factors, partly identified as polyphenols, and assumed that they all possessed water soluble constituents that reduced the solubility rate of enamel.²⁷ Wholegrain foods have protective properties, they require more mastication thereby stimulating increased saliva flow. A number of investigators have reported that inclusion of hulls from oats, rice, cottonseed, and peanuts in diet help in caries reduction. Peanuts and groundnuts are good gustatory flow food and are mechanical stimulants to salivary flow.²⁴

Water

Water, in general, has a neutral pH of about 7.0, which means it's neither alkaline nor acidic. Values less than 7 are considered acidic while greater than 7 pH is considered alkaline. The normal pH of saliva is 6.7 to 7.4 but as bacteria break down the carbohydrates, they release lactic acid, butyric acid, and aspartic acid which bring down the pH of saliva. When the pH level in mouth goes below 5.5 (i.e., the critical pH value), the acids begin to break down the enamel on teeth. The longer the teeth are exposed to a low salivary pH, the more likely the development of dental caries. Regulating the pH in the mouth will also help reduce the bacteria in our mouths, thereby reducing our risk for cavities, gum disease, and tooth decay.

Oral hygiene is one of the most important factors in the maintenance of oral homeostasis and oral health. The mechanical removal of plaque by tooth brushing and flossing can almost completely prevent caries and periodontal diseases. The addition of antimicrobial agents to dentifrices, mouthwashes, and varnishes increases the

effect of mechanical oral hygiene procedures. Antimicrobial agents may assist in protection by reducing bacteria adhesion to the tooth surface, by reducing the growth of microorganisms and plaque accumulation, by selectively inhibiting only those bacteria directly associated with oral diseases, or by inhibiting the expression of virulence determinants, such as acid production or protease activity. Fluoridated toothpastes and mouth rinses are well known for its anti-caries properties. Fluorides inhibit bacterial growth by reducing the sugar transport, glycolytic activity, and acid tolerance of many gram-positive species. It can help stabilize the composition of the microflora by reducing the rate of acid production and the fall in pH during frequent carbohydrate intake. Other agents that have been formulated for commercial toothpastes and/or mouth rinses include chlorhexidine, quaternary ammonium compounds, plant extracts, metal ions, and phenolic compounds. These antimicrobial agents have been shown to reduce dental plaque formation, caries, and gingivitis.

Conclusion

Diet has been associated with the prevalence of dental caries for centuries. It is a major modifiable contributing factor in the aetiology of dental caries. The following conclusions can be made: Firstly, Regularity of main meals can help reduce dental caries prevalence. Adequacy and moderation in diet with appropriate oral hygiene behavior can help further reduce the disease burden of dental caries. Secondly, Caries experience increases when people switch from a dependence on traditional starchy staple food to dependence on refined carbohydrate Thirdly, lower consumption of cariogenic food prevents the development of new lesions while arresting the active carious lesions.

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