Sugar is back in the news. After decades of struggling with the low-fat paradigm, the Standard American Diet (SAD) and the Fast Food American Diet (FFAD), consumers are again being warned about the health risks of sugar overuse.1

Popular dietary advice and consumer attitudes about sugar can impact dental health. The 1986 Report of the Sugars Task Force published by the United States Food and Drug Administration concluded that high sugar usage contributes significantly to caries experience, and that the consumption of sucrose and fermentable carbohydrates facilitates the development of plaque, dental caries and periodontal disease.

Our dental health perspective should be broadened to include consideration of health effects throughout the body.2 The American Heart Association (AHA) links excessive sugar consumption to disrupted metabolism, obesity and vascular disease. A recent AHA recommendation places an upper limit of added sugars at 25 grams (less than an ounce) per day for women. Just one 12-ounce cola contains nearly 40 grams of added sugars and more than 150 calories.

Many leading health authorities now agree that preventable disease conditions result from frequent and massive overconsumption of sugars in a largely sedentary society. Nearly one-quarter of our calories come from added sugars.

Dentally, a major concern is the frequency of exposures to sugar. For overall health, the key is the total amount of sugars added beyond those encountered in fruits and vegetables. Among proposed solutions are strict sugar restriction or sugar substitution with low-calorie, non-cariogenic sweeteners.

What is Sugar?

Sucrose is common table sugar. The source, cane or beet, does not matter. On food labels, “sugar” means “sucrose.” The term “sugars” refers to all mono- and di-saccharides, with the “-ose” ending.

Glucose and Fructose are both monosaccharides. Sucrose is a disaccharide (Fig. 1). In the oral cavity, glucose and fructose are in themselves cariogenic. Sucrose is potentially even more dangerous. Most dietary sugars are based on a mono-saccharide unit with a six-carbon-atom backbone. The reactive carbonyl (aldehyde or ketone) functional group allows monosaccharides to link together to form disaccharides or polymer chains of oligosaccharides (oligo-“a few”) and polysaccharides (poly- “many”). For example maltose is a disaccharide of two glucose monosaccharides, maltodextrin is an oligosaccharide usually up to 20 glucose units and starch is a glucose polysaccharide that might have more than 1,000 glucose molecules linked together.

The more polysaccharides are processed and cooked, the more readily they break down into component sugar molecules in the oral cavity and are therefore included as “fermentable” (particularly to lactic acid) carbohydrates. There are differences in cariogenic potential of different sugars in a range from highly cariogenic (sucrose) to low cariogenic (lactose) to even non-cariogenic (tagatose, cellobiose). However, the majority of dietary sugars are generally considered acidogenic and potentially cariogenic.

Good or Bad Sweeteners

Realistically, there are no intrinsically good or bad sweeteners because potential benefit or harm depends on so many diverse factors in application and usage in the overall diet. It is helpful to recognize some of the controversies and see how dental and systemic health might be involved.

Dentally, consider the impact on our natural protective factors such as saliva, pH, mineralization and oral flora. Metabolically, it is useful to see how sweeteners affect digestion, blood sugar, energy, lipids and other parameters.

Bulk Sweeteners

Bulk sweeteners are sugars – including ordinary common table sugar – and sugar alcohols. The goal of bulk sweetening is to match or exceed the qualities of sucrose at comparable or reduced cost. Bulk sweeteners provide both sweetness and func-
tions such as volume, texture, “mouth feel,” humectancy, calories and might assist in food preservation.

**Sugar Alcohols**

Sugar alcohols are reduction products of sugars, where the reactive carbon to oxygen double bond carbonyl group is “reduced” by hydrogen to a hydroxyl or alcohol. Sugar alcohols are closely related to sugars but are generally more slowly absorbed, lower in calories, less reactive and less cariogenic than their sugar counterparts. High cost, lower sweetness and possible laxation at higher doses (similar to dietary fiber) limits full substitution for sugars in many products.

**High Intensity Sweeteners**

Intense (high potency) sweeteners are much sweeter than sugar by hundreds or even thousands of times. They can have a cloying or bitter aftertaste with prolonged use or high concentration. High potency sweeteners are considered non-nutritive or non-caloric and contribute only sweetness to a product. They are most popular in liquids where water provides the bulk. Stevia is a plant extract; the others are artificial. Although artificial sweeteners are supposed to help displace caloric and cariogenic sweeteners, caution is advised regarding the overall product. The volume of high intensity sweeteners is so small that tabletop packets require added bulking agents – usually glucose (D-glucose or dextrose on labels) and maltodextrin – which are not safe for teeth. Diet beverages used throughout the day are usually highly acidic which can contribute to erosion and select for acid-tolerant microflora. Also beware that daily consumption of artificially sweetened “diet” soda might double the risk of obesity, and increase vascular events by 50 percent. Despite reduction in

**Intense, High Potency Super Sweeteners**

- Acesulfame Potassium (Ace K) (130x)
- Stevia (steviosides, rebudiosides) (150x)
- Saccharine (180x)
- Aspartame (200x sweeter than sucrose)
- Sucralose (600x)
- Neotame (up to 13,000x)

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calories, some artificial sweeteners have been implicated in appetite stimulation.

**Complex Carbohydrates**

An earlier term complexed carbohydrates referred to carbohydrates present in unprocessed whole foods. The current definition of “complex carbohydrates” is based on molecular weight of polysaccharides, but provides no functional meaning for metabolism, ability to raise blood sugar, or cariogenicity. Differences in how even the same sugars are molecularly linked can make a big difference in digestion and metabolism. Glucose polymer (as starch, maltodextrin) can be broken down rapidly to cariogenic sugars, or (as cellulose, polydextrose) can be resistant to digestion and function as dietary fiber. Likewise “simple sugars” such as xylose can be non-cariogenic.

Insoluble fiber such as bran is metabolically inactive but assists regular elimination. Soluble dietary fiber forms a viscous gel that can be broken down by bacteria in the colon. Soluble fiber is known as “prebiotic” favoring healthy intestinal flora. Adequate consumption is associated with reduction in colon cancer, stabilizing blood sugar and improving heart disease markers.

**Sucrose is Special (Dentally)**

The disaccharide sucrose is readily digested to its monosaccharide components, and is metabolically similar to equivalent loads of glucose and fructose.

In the oral cavity, glucose and fructose are by themselves cariogenic, but sucrose is potentially even more dangerous. Acidogenic bacteria such as the mutans group of streptococci cleave the disaccharide bond for energy, and use the resulting glucose and fructose residues for more energy and lactic acid production. During times of sugar availability, remaining glucose and fructose molecules are reassembled into intracellular polysaccharide for energy storage, and extracellular glucans and fructans (branched glucose and fructose polymer) that form much of the sticky, protective matrix in biofilms. Frequent sucrose exposure leads to plaque that is abundant, adhesive, acidic and irritating to the tissues.

**Glucose**

Glucose is absorbed rapidly by active transport and quickly raises blood sugar levels (high glycemic). Glucose is the monosaccharide that can be utilized for energy throughout the body. Excess glucose can be stored as glycogen, a glucose polysaccharide known as “body starch.”

**Glycemic Index**

The Glycemic Index (GI) was developed in the early 1980s to measure the effect on blood sugar of the same amount of various carbohydrates. Some early surprises confirmed that different carbohydrates have widely different glycemic impact. For example, plain white bread topped the chart, whereas some sweet fruits like cherries and plums registered very low, even less than barley. The confusion and controversy over the reliability and utility of the GI continues.

It should be apparent from scanning GI lists that many polysaccharide “complex carbohydrates” such as cooked starch are rapidly broken down to monosaccharides. This agrees with dental researchers who warn that starchy carbohydrate foods are acidogenic.

Cardiologists Dr. William Davis and Dr. Frederick Vagnini point out the dangers of a high-glycemic diet rich in sugars and starches. Processed starch, even whole wheat bread, raises blood sugar more than pure sucrose sugar. Those fluffy fast food hamburger buns are even worse.

Repeatedly or persistently high blood glucose triggers correspondingly high insulin levels promoting efficient fat storage. The cycle progresses as more fat accumulation causes inflammation leading to insulin resistance, poor lipid control and tissue damage of the pre-diabetic and diabetic states.

**High Fructose Corn Syrup (HFCS)**

Some looked at the early GI data and concluded that sugar is no worse than starch for glycemic control, so go ahead and enjoy! The focus was locked on calories and fat. It was noted that perhaps the very low GI of fructose would have a metabolic advantage, particularly for diabetics. Fructose was rapidly gaining popularity since an enzyme process began commercial production in 1975. Corn starch polysaccharide is first broken down (with water, heat and acid) to glucose syrup, and then some of the glucose is enzymatically converted to fructose. The result is a high fructose corn syrup consisting of 58 percent glucose and 42 percent fructose which has the same sweetness as sucrose, or could be concentrated to 45 percent glucose and 55 percent fructose. The HFCS 42 could easily be incorporated into processed foods, and the HFCS 55 is commonly used in beverages at lower costs than sucrose. Being even sweeter than sucrose HFCS 55 allows manufacturers to mask diuretics such as caffeine and sodium to encourage more consumption. By now HFCS seems to be in most processed foods, including baby foods and infant formula.

HFCS has displaced sucrose in many applications, especially in soft drinks. Metabolically, it does not seem to make much difference if these sugars are ingested as monosaccharides or disaccharides. Dentally, the disaccharide sucrose is more harmful.

**Fructose**

Evidence is accumulating that excess consumption of fructose is particularly harmful. Although fructose is sometimes promoted for a small glycemic impact, it is absorbed fairly rapidly.
Unlike glucose, most fructose is processed in the liver. A rush of fructose overloads a processing bottleneck in the liver, where excess fructose is efficiently converted to triglycerides and fat.

Dr. Robert H. Lustig, UCSF professor of pediatrics in the division of endocrinology and Dr. Richard Johnson, University of Colorado interview with Dr. Joseph Mercola and point out potentially devastating effects. Compared to glucose, isocaloric loads of fructose have greater effect on:

- Increased appetite
- Increased triglycerides
- Induced insulin resistance
- Impaired glucose tolerance
- Decreased leptin and insulin (satiety) signaling
- Dyslipidemia (high LDL, low HDL)
- Pro-inflammatory markers
- Increased oxidative stress
- Damage to pancreas beta cells
- Increased blood pressure
- Increased uric acid

Chronic sugar, particularly fructose overconsumption might contribute to:

- Obesity
- Premature aging
- Metabolic syndrome (prediabetes, eventually diabetes)
- Vascular disease
- Heart disease
- Fatty livers (non-alcoholic fatty liver disease)
- Kidney disease
- Gout

Maillard Reaction

Carbohydrate group of sugars can also link with amino acids. The Maillard reaction is a familiar non-enzymatic “browning” that occurs in cooking where sugars react with proteins. Non-enzymatic implies “uncontrolled” reactions in the body. Sugars build up on and crosslink these glycated proteins. This leads to the formation of “AGEs” — Advanced Glycation End products — which are useless molecules that clog up normal pathways. Eventually there is loss of function, elasticity and structural support (think of browning toast, age spots, gingival recession, wrinkles and accelerated aging).

Persistently high blood glucose (can be determined by measuring glycated hemoglobin in the HbA1c blood test) and fructose cause more AGE formation. Fructose is particularly dangerous, as it is up to seven times more likely to glycate than glucose. Persistently high blood glucose (can be determined by measuring glycated hemoglobin in the HbA1c blood test) and fructose cause more AGE formation. Fructose is particularly dangerous, as it is up to seven times more likely to glycate than glucose.

How Much is Too Much?

Close to half of our sugar is in the form of fructose. Overall consumption of sugars is now almost 140 pounds per person per year, in spite of all the intense sweeteners that were supposed to depress sugar demand. About one-third of adult Americans are already obese, and the rest of the world is catching up. It is variously estimated that our ancestors normally consumed only about one ounce of sugars or about 15 grams of fructose naturally in fruits and vegetables daily. Very physically active individuals can usually tolerate higher amounts. In times of abundance that amount could be much higher. Fat storage then was a survival mechanism for lean times. But, most consumers now are regularly getting many times those amounts. Access to sugars is just too easy, and the products are just too enticing.

Although fructose is associated with fruit, consumption of moderate amounts of fruit is almost universally considered healthy. The amount of fructose in berries and most fresh fruit is modest – generally less than 10 grams per serving. Fruit contains fiber along with many valuable nutrients and contributes to favorable potassium to sodium balance. However, dried fruits, fruit juice and sweetened fruit-flavored beverages can quickly add to the overall fructose burden.

The Trend is to Blend

The large manufacturers are already beginning to respond to public awareness concerns about sugar overload. Watch for more selections of “low sugar” or “reduced sugar” in packaged product introductions. The trend is to replace some, but not all, sugar with combinations of polyols and intense sweeteners. Additional claims for reduced calories go along with using less sugar. If “resistant” starch and “resistant” maltodextrin are incorporated, a fiber claim might also be made. Such products, even those that tout “no sugar added,” should be evaluated individually, as they might still contain acidogenic sugars and poly saccharides.

Another trend is to go back to using sucrose instead of HFCS. Some consumers are influenced to perceive “pure natural cane sugar” is superior to HFCS. The corn syrup lobby is fighting back, insisting that there is no difference metabolically. Their contention might be valid, and sucrose might actually make the product more harmful dentally.

Sugars can be problematic dentally and metabolically. What steps can we take to enjoy the sweet benefits and minimize the damage?

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