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Concept on Sugar- A Review

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Abstract: Sugars have a long history of safe use in foods. They are common food ingredients that add taste appeal and perform important functions in foods. Besides its pleasant sweetness, sugar performs a host of less obvious and important functions in cooking, baking, candy making and the like. As carbohydrates, sugars are a contributor of calories for the body. The ability to produce solutions of varying degrees of sweetness is important in many food applications, particularly in beverages and confectionery. Low-calorie sweeteners add a taste that is similar to that of sucrose. Intense sweeteners are generally several times sweeter than sucrose. On the other hand, sugar replacers are the bulk and volume providing sweeteners usually less sweet than and different tasting from sugar, commonly used on a one-for-one replacement basis for sugar in recipes. Sugars have been studied extensively for their impact on a variety of issues.

Key words: Sugar, sugar replacer, sweeteners, low-calory

Sugar: Sugars are common food ingredients that are found in many forms. As carbohydrates, they are a contributor of calories for the body. Thus, they are an important energy source. There are no nutritional differences among sugars. The body uses all types in the same way. During digestion, sugars such as sucrose and lactose and other carbohydrates such as starches break down into monosaccharides (single sugars) and then travel through the blood stream to body cells providing energy and helping to form proteins.

Occurrence and types of sugars: Common, refined, white granulated sugar is nearly a pure carbohydrate that occurs naturally in every fruit and vegetable in the plant kingdom. It is a major product of photosynthesis, the process by which plants convert solar energy and atmospheric carbon dioxide into stored food energy, and oxygen. Sugar occurs in greatest quantities in sugar cane and sugar beets. Sugars are found in foods such as fruits, vegetables, flour, cereal products and milk products.Manufacturers also add many of these sugars to foods during processing to perform important functions. Further, sugars are a part of ingredients like fruit juice concentrates, invert sugar, honey, molasses, hydrolyzed lactose syrup, whey protein concentrate and products derived from the hydrolysis of starch such as high fructose corn syrup. Chemically sugar is the disaccharide "sucrose" that results from the biochemical bonding of the naturally occurring monosaccharide molecules "fructose" (also called "levulose" or "fruit sugar") and dextrose (also called "glucose" or "grape sugar"). This bond is relatively strong, but it is commonly broken by heat, acids, and the enzyme " invertase," present in human saliva and digestive tracts (Butchko and Ketsonis, 1991). The process of splitting sucrose into its two components- fructose and dextrose, is alternatively called "inversion" and "hydrolysis." Various types of sugars which are commonly found are discussed below (Butchke and Kotsonis, 1991, Duffy and Anderson, 1998):

World sugar: Unrefined (raw) cane sugar traded at open, public auction on a commodity (futures) exchange is referred to as "world" sugar. Only a small fraction of all the sugar grown and produce, is ever offered for sale at this auction.

White sugars

Baker's Special: An extremely fine-grained (EFG) sugar with several uses, such as: (I) Imparts a delicate texture and high volume in cake products by developing a uniform cell structure, (ii) Retains moisture and improves shelf life of cakes, etc. In dry mixes, it disperses more evenly and with less stratification, than larger-grained white sugars and dissolves faster, especially in cold beverages like iced tea and bar drinks.

Bottler's: Similar to EFG, and meets all standards of the National Soft Drink Association, with respect to: clarity, colour, odour and taste, ash and sediment content; comparative absence of floc-forming substances and microbiological activity.

Coarse: Intermediate grain size sugar designed for easy handling and storage in bulk conveying operations.

Con AA & Con A: Extremely pure, extra-large grain sugars with the following attributes: (I)Exceptionally white, clear and brilliant (ii) Very low ash, colour, turbidity and metallic ion contents (iii) Nearly 100% sucrose in purity (99.9+%). Uses for Con AA & A include: (I) Boiled syrups, boiled-type icings (ii) "Sparkle" topping similar to sanding sugar, but larger crystal size (iii) Candies (especially mints) and fondants where clarity whiteness and brilliance are desirable (iv) Crystallized syrups (v) Cordials and liqueurs where absolute water whiteness is desired. (vi) Cotton candy.

Drivert: The finest-grain of all powdered sugars, used to produce fondants, icings and frostings with no trace of grain or grittiness. These are very fine grain sugar (particles 1/100th the size of regular powdered sugar) that easily mixes with water and produces smooth, creamy icings and frostings with high gloss and little or no grittiness. May contain small amount of invert or maltodextrin.

Gelatin and Gel Grain: Sugar of smaller, exceptionally uniform grain size (60 to 80 mesh), with few "fines." These are used in making gelatins, cookie doughs, cake mixes, quick-dissolving hot and cold beverage mixes, and other dry mixes.

Granulated: Table sugar, commonly called "Fine Granulated" (FG) and "Extra Fine Granulated" (EFG), depending on the refiner's designation.

Manufacturer: Intermediate-grain, agglomerate sugar, resists packing and clumping when dissolved.Usually available in bulk only and are used by bakers, preservers, freezers, canners and syrup manufacturers.

Powder ed: Finely ground granulated sugar to which a small amount (3.0%) corn starch has been added to prevent caking. The fineness to which the granulated sugar is ground determines the familiar "X" factor: 14X is finer than 12X, and so on down through 10X, 8X, 6X (the most commonly used) and 4X, the coarsest powdered sugar.

Raw Sugar: The semi-refined product of plantation mills processing sugar cane. This is the sugar that are extracted from cane juice without any further refining and in which each crystal is coated with a heavy film of low purity molasses.

Sanding: Very pure, clear, large-grained sugar. This sugar adds "sparkle" when sprinkled on candies (gum/jelly goods), cookies, pies, turnovers. In boiled syrups and boiled-type icings, it dissolves uniformly with minimal foaming or discolouring.

Tableting: A directly compressible, granulated sugar or agglomerated powder, used to make tablets and flakes. It consists of mostly sucrose with a small amount of maltodextrin or invert sugar. Tableting sugar is used by pharmaceutical makers as an excipient and by confectioners.

Turbinado: A semi-refined, off-colour sugar containing a higher percentage of sucrose than raw sugar, but less than refined sugar.

Unigran: Pure, uniform, larger-grained sugar containing few "fines." Primarily for use in hot drink dispensing machines.

Brown sugars, molasses

Brown (soft) sugar: This sugar is the commingling of fine grain white sugar and a film of molasses (sometimes called cane sugar syrup). As more and/or darker molasses is present relative to sugar, the grade of brown sugar darkens from light, to medium, to dark, with an accompanying deepening of the caramel and butterscotch flavours so highly prized in the product. Cane brown sugars are produced directly from the dark syrups obtained during the refining process, whereas beet brown sugar is produced by coating white granulated sugar with cane molasses (Duffy and Anderson, 1998). Light (golden) and dark brown sugars are the two major types commercially available, as well as in-between grades. Grades are: (I) Golden C (Light) Brown Sugar (ii) Yellow D (Dark) Brown Sugar (iii) Trademarks of California and Hawaiian Sugar Co.

Brownulated or Free Flowing brown: This sugar is a lower moisture version of ordinary brown. Free flowing brown sugar handles with less clumping and caking, ideal for automated weighing and scaling operations.

Molasses: This is the concentrated, clarified extract of sugar cane. It is the end product of sugar refining. Forty to sixty percent of molasses is sucrose and invert sugars and the remainder inorganic non-sugars. Open Kettle Molasses is made by boiling cane juice until a large part of water is evaporated. It is sometimes called unsulfured molasses. Centrifugal molasses results when part or all of the commercially crystallizable sugar is recovered from the concentrated cane juice, often in a series of steps where successive crystallization "strikes" result in molasses with deepening colour and stronger flavour. The resulting types are known as first (light and sweet), second (dark, less sweet) and final (very dark, thick and bitter) molasses. The best grades, first and second, are used for table syrups, gingerbread and so forth. Final, or black strap molasses is considered inedible by some, but is used in yeast breads and baked beans by others. Molasses from sugar beets is not intended for human consumption.

Liquid sugars

Invert sugar : This is the result of inversion (hydrolysis) of sucrose, that is, the splitting of sucrose molecules into their dextrose and fructose components. The degree of inversion can range from slight to great, depending upon the amount of heat, acid or enzyme applied. "Medium Invert" means half of the sucrose molecules present have been split into their fructose/dextrose component and the remaining half are undisturbed sucrose molecules. "Total Invert" means all of the sucrose molecules have been split into their fructose and sucrose components, with consequently no sucrose remaining. Both medium and total invert syrups are commercially available.

Liquid sucrose: This refers to a solution made by dissolving sugar in warm-to-hot water but not so hot as to cause any inversion. It is sold to dairies and food processors in bulk at 67.5 percent sugar solids, a concentration approximately equal to dissolving 1.8 lb. sugar in one pound of water. However, liquid sugar solutions of higher concentrations are routinely made in batch amounts by confectioners.

Cane and beet sugar: There is no difference between the sugar produced from sugar cane or sugar beets. Sugar cane is a giant grass that thrives in a warm, moist climate, storing sugar in its stalk. The sugar beet grows best in a temperate climate, and stores its sugar in its yellow-to-white root. Sugar from either source is produced by nature in the same fashion as all green plants produce sugar; as a means of storing the sun's energy (Duffy and Anderson, 1998). The cane, which contains 10-15% sucrose, is ground to extract the juice, which in turn is boiled until the syrup thickens and crystallizes. The crystals are spun in a centrifuge to produce raw sugar. At a refinery, the raw sugar is washed and filtered to remove impurities and colours, and crystallized, dried and packaged. The beets, which contain 12-18% sucrose, are washed, sliced and soaked in hot water to remove the juice. The sugar-laden juice is purified, filtered, concentrated and dried in a series of steps similar to sugar cane processing.

Rare sugars: The sugars that are unknown or rare and are not abundant in nature, being xenobiotic compounds. Most abundant six carbon sugars in nature are D-glucose, D-fructose, D-galactose and D-mannose. Several studies have been carried out with microorganisms and their enzymes to produce various rare L- and D- sugars from inexpensive carbohydrates. Many aldose-ketose isomerization of free sugars have also been reported. Of the total of eight aldopentoses and four pentitols, three pentoses (D-xylose, L-arabinose and D-ribose) and two pentitols (ribitol and D-arabitol) are common in nature. These rare carbohydrates are difficult to produce and can only be produced by chemical reactions. But recently some of these sugars were produced in laboratory scale by microbial means; such as D-lyxose can be produced from D-glucose, L-ribose from ribitol, etc. (Ahmed *et al.*, 1999a, 1999b and Ahmed, 2001).

Properties of sugar

Solubility of sugar : Sugar is readily soluble in water. The ability to produce solutions of varying degrees of sweetness is important in many food applications, particularly beverages and confectionery. Sugar's capacity to produce a supersaturated solution and then crystallize when cooled is the basis for rock candies. The wonderful variety of confectionery draws from the candy maker's ability to vary sugar concentration, along with temperature and agitation, to produce different crystal sizes and textures.

In solution, sugar has the effect of lowering the freezing point and raising the boiling point of that solution. These are important properties in preparing frozen desserts and candy, respectively. In ice cream, for example, sugar's ability to depress the freezing point slows the freezing process, promoting a smooth, creamy consistency. In shortening-based cakes, sugar raises, delays and controls the temperature at which the batter goes from fluid to solid, which allows the leavening agent to produce the maximum amount of carbon dioxide. The gas is held inside the air cells of the structure, resulting in a fine, uniformly- grained cake with a soft, smooth crumb texture. In food processing, hydrolysis decreases the tendency of sugar to crystallize from thick syrups or jellies. When sugar is heated to a sufficiently high temperature, it decomposes or "caramelizes." Its colour changes first to yellow, then to brown, and it develops a distinctive and appealing flavour and aroma. The melted substance is known as caramel. The brown colour of toasted bread is the result of caramelization. Colour is also produced in cooking when sugars and proteins interact in complex ways. This is known as the browning (Maillard) reaction, important in candy making, baking and other processes. Sugar is consumed by yeast cells in a thoroughly natural process called "fermentation." Carbon dioxide gas is released, and alcohol is produced, reactions vital to bread rising and baking and alcoholic beverage production.

Bodying/Bulking Agent: Sugar imparts satisfying texture, body, mouthfeel and bulk to many processed foods, such as ice cream, baked goods, icings, beverages and candy.

Texture Modification: For example, as sugar is creamed with shortening in baked goods, the irregularities of the sugar crystals help create air pockets that contribute to a uniformly fine crumb structure. In gingersnaps and sugar cookies, the desirable surface cracking pattern is imparted when sugar crystallizes by rapid loss of moisture from the surface during baking.

Preservative: By binding water, sugar acts as a very effective, natural preservative. For example, the high sugar levels in jams, jellies and sauces make them more immune to the microorganism development common in thinner, high-moisture products like commercial applesauce. Sugar is the preferred sweetener in cereal coatings because of its ability to crystallize into a frosty surface forming a hard, continuous glaze. This protects the product from air and moisture, extending its shelf life.

Dispersant: In dry beverage, dessert and bakery mixes, sugar prevents lumping and clumping when the mixture is hydrated.

Whipping aid: In foam-type cakes, such as angel and sponge, sugar enables to create a light foam that serves as the basic structure of the cake.

Humectant: When the sucrose molecule is "inverted", by the application of heat, acids or enzyme, the resulting fructose (especially) and dextrose contribute a moistening property, desirable in such foods as icings, fudge, cakes, marshmallows, soft cookies, and so forth.

Microwave properties: Sugar has unique dielectric properties that enable it to produce desired surface browning and crisping. Sugar can shield lower food layers from heating, as in microwavable ice cream toppings. Sugar can function as a control agent to minimize uneven heating.

Sweeteners and its types

Corn based sweeteners

Corn syrup: This is not a sucrose product at all, but rather a purified, concentrated solution obtained from the hydrolysis of corn starch. There are many corn syrups, of varying viscosity and sweetness, although none is as sweet as a sugar solution of equal solids. Corn syrups perform many roles in foods and beverages, such as: (I) imparting thickness and mouthfeel, (ii) controlling ice crystallization in frozen desserts, (iii) acting as a bulking agent, and so forth. Corn syrups are classified according to their dextrose equivalents (D.E.), a rough measure of sweetness; and Baume', a measure of thickness or solids. The most common corn syrup in commercial use is 42 DE, 43 Baume', and called "regular" confectioners corn syrup.

Corn syrup solids: This is a dried corn syrup, used by food processors who need the functional characteristics of liquid corn syrup in a dry form and are available in a variety of forms.

Fructose: This is a nonsucrose "sugar" which occurs naturally in most plants and fruits, and in honey. It is produced commercially from corn, and is available in crystal and powdered forms. It is a close relative of the liquid sweetener, high fructose corn syrup (HFCS). Fructose is the sweetest of all natural sugars, up to 1.7 times as sweet as sucrose. Also called "levulose" and "fruit sugar." It is used as a sweetener, especially in dietetic foods, because gram-for-gram, it imparts more sweetness than any other natural sweetener. Fructose also has valuable humectant properties.

Dextrose: This is a nonsucrose "sugar" which occurs naturally in many plants, fruits and in honey. In animals, dextrose (also called "glucose" and "grape sugar") is a vital constituent of the blood, and is directly metabolized for immediate energy needs. Dextrose is used in food and beverages as a sweetener (it's about as sweet as sucrose), a browning agent, a humectant, and a fermentation substrate. It is available in liquid (bulk only) and dry forms.

High fructose corn syrup (HFCS): This is an enzymatically modified, crystal clear corn syrup with sweetness (and calories) approximately equal to that of a sugar solution. Although HFCS is not a sucrose product, it performs many of the same functions as sugar, chiefly the "clean" sweetening of beverages, pickles, ketchup, dairy products, baked goods, and a host of food and liquid products. (Nearly every full calorie soft drink produced in the U.S. is sweetened with HFCS). HFCS is usually sold at a price considerably below sugar, hence its popularity.

Maltodextrins : This is similar to, but generally less sweet than, corn syrup solids, commonly used as a bulking agent.

Intense sweeteners: Intense sweeteners possess these characteristics (and differ from Sugar Replacers): (I) Are nonnutritive (noncaloric) (ii) Provide virtually no bulk, only sweetness (iii) Are 150 to 500 times as sweet as sugar (iv) Are mostly artificial/synthetic. Example of some of the intense sweeteners are given below (Lavin *et al*., 1994):

Neotame: It is a versatile, new no-calorie sweetener composed of two elements of protein, the amino acids L-aspartic acid and L-phenylalanine, combined with two organic functional groups, a methyl ester group and a neohexyl group. It is approximately 7,000 to 13,000 times sweeter than sugar and as such captures the "essence of sweetness," with only a very small amount required for use. The chemical composition of neotame makes it stable for use in baking. Aside from its use as a sweetener, another potential application for neotame is as a flavour enhancer. Like other high-intensity sweeteners, although it contributes no sweetness functionality when used at very low levels, it can modify the flavour of a food or beverage.

Alitame: It is another sweetener made from amino acids (L-aspartic acid, D-alanine, and a novel amide [a specific arrangement of chemical bonds between carbon, nitrogen, and oxygen]). It offers a taste that is 2,000 times sweeter than that of sucrose and can be used in a wide variety of products including beverages, tabletop sweeteners, frozen desserts, and baked goods. Only the aspartic acid component of alitame is metabolized by the body. As a result, alitame contains 1.4 kcal/g. Since alitame is such an intense sweetener, however, it is used at very low levels and thus contributes negligible amounts of calories. It is highly stable, can withstand high temperatures in cooking and baking, and has the potential to be used in almost all foods and beverages in which sweeteners are presently used. Alitame has been approved for use in all food products, including beverages, in Australia, Mexico, and New Zealand.

Aspartame: This is an artificial, calorie-free sweetener made by joining two naturally-occurring amino acids (aspartic acid and phenylalanine). Aspartame is about 200 times as sweet as sucrose, and is marketed under various trade names, the best known of which is Nutrasweet. Trademark of Nutrasweet Co

Acesulfame-K: This is an artificial, calorie-free sweetener, about 150 times as sweet as sugar, marketed under the " Sunette," "Swiss Sweet" and "Sweet One" brands.

Cyclamate: This is an artificial sweetener, 30 times as sweet as sugar, long banned in the US, but allowed in Canada and other countries.

Saccharin: This is a white, crystalline artificial sweetener about 300 to 500 times as sweet as sugar. The oldest of nonnutritive sweeteners, its use is allowed in the US but banned in some countries.

Stevia: This is a natural, non-caloric plant extract 200 to 300 times as sweet as sugar, possessing a licorice-like flavour. In the US, FDA prohibits the use of stevia as a sweetener or food additive, but allows it to be sold as a dietary supplement.

Sucralose: This is a white, crystalline powder made from sugar, and about 600 times sweeter than sugar. Marketed under the name "Splenda -- presently available in several countries.

Polyols: Polyols are another type of sweetener used in reduced-calorie foods. They differ from intense sweeteners in that they are considered nutritive; that is, they do contribute calories to the diet. Polyols are incompletely absorbed and metabolized, however, and consequently contribute fewer calories than sucrose. The polyols commonly used in the United States include sorbitol, mannitol, xylitol, maltitol, maltitol syrup, lactitol, erythritol, isomalt, and hydrogenated starch hydrolysates. Most are approximately half as sweet as sucrose; maltitol and xylitol are about as sweet as sucrose. Polyols are found naturally in berries, apples, plums, and other foods. They also are produced commercially from carbohydrates such as sucrose, glucose, and starch for use in sugar-free candies, cookies, and chewing gum. Along with adding a sweet taste, polyols per-form a variety of functions such as adding bulk and texture, providing a cooling effect or taste, preventing the browning that occurs during heating, and retaining the moisture in foods. When consumed in excess, some polyols such as sorbitol may produce abdominal gas and discomfort in some individuals. As a result, foods that contain certain sugar alcohols and that are likely to be eaten in amounts that could produce such an effect must bear the statement "Excess consumption may have a laxative effect."

Other sweeteners

Honey: This is a sweet, thick, supersaturated sugar solution manufactured by bees from floral nectar to feed their larvae and for subsistence in winter. Honey is composed of fructose, glucose, and water, in varying proportions; it also contains several enzymes and oils. The colour and flavour depend on the age of the honey and on the source of the nectar.

Lactose: This is "milk sugar" that occurs naturally in all mammalian milk, including human. Lactose is about 1/6 as sweet as sucrose.

Maltose: This is naturally-occurring non- sucrose sugar found in many plants, principally sprouting cereal grains like barley. Maltose is a disaccharide consisting of two glucose (dextrose) molecules chemically linked. In the human digestive tract, natural enzymes split starches into, among other things, maltose. Maltose has a sweetness about 1/3 that of sucrose.

Maple syrup: This is maple syrup, composed largely of sucrose, glucose, fructose and small amounts of vitamins and minerals, is simply the concentrated sap of 40+ year-old maple trees. This sap, which is only 2-3% sugars, is collected and concentrated, usually through boiling, until the sugar content reaches a critical 66%.

The safety of blends in sweeteners: Individually, each of the approved low-calorie sweeteners has a long history of chemical stability. Additionally, an exhaustive safety database exists on each of these sweeteners. The only known and anticipated interaction between the various blends of sweeteners is the physical interplay with sensory taste buds. Individually, among the low-calorie sweeteners only aspartame is metabolized, and it is rapidly digested and converted into other components that are further metabolized normally. On the basis of the information presented above, health authorities around the world have reasonably concluded that there is no scientific basis to expect any physiological effects to emerge from blended sweetener systems separate and apart from those that occur with the individual sweeteners, and none have been reported. Indeed, the blending of sweeteners further reduces already safe levels of use and dietary intake.

Low-calorie sweeteners and health: The basic equation "calories in equal calories out" still stands as the foundation for successful weight management for human body. If weight loss is desirable, the balance needs to tip in favour of the elimination of calories (e.g., through the ingestion of fewer calories or through more physical activity). The opposite holds true when weight gain occurs. Although dietary fat may have topped the list of diet concerns in recent years, the calorie never really went away. Surveys show that Americans today are paying more attention to the caloric contents of foods, whether their intention is to lighten up or just get healthier. In recent years, there has been a steady and significant increase in consumer demand for low-calorie products. People look to low-calorie foods to help them manage their weight, maintain an attractive physical appearance, and stay in better overall health.

The benefits of low-calorie sweeteners: Low-calorie sweeteners add to foods a taste that is similar to that of sucrose (table sugar). Intense sweeteners, however, are generally several hundred to several thousand times sweeter than sucrose. Most do not contain any calories. Those that do contain calories, such as aspartame, are used in very small amounts because of their concentrated sweetening power. Thus, they also add essentially no calories to foods and beverages. As a result, intense sweeteners practically eliminate or substantially reduce the calories in some foods and beverages such as carbonated soft drinks, light yogurt, and sugar-free pudding. Intense sweeteners also do not affect insulin levels. Hence, they may be used to provide sweet tasting foods and beverages for people who must restrict carbohydrate intake, such as people with diabetes. Because low-calorie sweeteners have different functional properties, the availability of a variety of low calorie sweeteners for use in foods expands the capability to develop reduced-calorie products that better meet consumer needs and desires. Blends of some low-calorie sweeteners in foods and beverages may also act synergistically to produce the desired level of sweetness with smaller amounts of each sweetener. The resulting taste often better meets consumer expectations of a sweetness profile close to that of sugar. The products may also have longer sweetness shelf lives.

Low-calorie sweeteners and weight management: When low-calorie sweetened foods and beverages are substituted for their full-calorie counterparts and no additional food is eaten to replace the calories saved, caloric reduction may be achieved. Pioneering work by Porikos *et al*. (1982) and by other investigators confirmed this effect, showing that study subjects consumed approximately 15 % fewer calories over time when they consumed foods and beverages in which aspartame had been covertly substituted for sugar. Tordoff and Alleva (1990) found a similar effect when comparing the consumption of regular or aspartame- sweetened soda or no soda at all. Individuals who drink low-calorie sodas consumed significantly fewer calories than those who drink regular sodas or no soda. Using U.S. Department of Agriculture nutrition survey data, Smith and Heybach (1988) compared the caloric intake records of persons consuming aspartame-sweetened foods and beverages with the caloric intake records of persons consuming foods and beverages not containing aspartame. Aspartame users consumed an average of 167 fewer calories per day than nonusers. Female aspartame users aged 35 to 50 years consumed 215 fewer calories per day than their study counterparts.

Other research has shown that the use of aspartame may help increase compliance with weight management programs. Kanders *et al*. (1993) measured weight loss, perceived feelings of energy and well- being, and other quality-of-life parameters among 59 free-living obese men and women who were knowingly on a weight-control program for 12 weeks. The experimental group was encouraged to use aspartame, whereas the control group was told to avoid all products sweetened with aspartame. Both groups participated in a weight-loss program that includes support groups, behaviour modification, and exercise instruction.

Facts about low-calorie sweeteners: Here are some of the facts about low-calorie sweeteners and their effects on weight, eating behaviour, and health.

1- Fact: Research shows that people who use foods and beverages sweetened with low-calorie sweeteners consume fewer calories than those who do not. Experts agree, however, that successful weight management requires more than just calorie reduction; it also involves a three-pronged approach of sensible eating, regular physical activity, and behaviour management.

2- Fact: Low-calorie sweeteners do not increase appetite and cravings for sweet foods. Indeed, studies show not only that low-calorie sweeteners do not affect appetite but also that they may even help people be more satisfied with eating plans that help them lose weight and keep it off.

3- Fact: Foods and beverages sweetened with low calorie sweeteners do not cause disease. These ingredients are some of the most closely studied ingredients in the food supply. A wealth of research confirms that they are safe for human consumption.

4- Fact: Pregnant women can safely use low-calorie sweeteners unless otherwise advised by their physician. All Food and Drug Administration-approved low-calorie sweeteners are safe for consumption by pregnant women and children. Because diet and caloric intake are important for both of these groups, however, the advice of a physician or a registered dietitian is recommended.

5- Fact: Low-calorie sweeteners do not cause cancer. Studies show that low-calorie sweeteners do not initiate or pro-mote cancers. Although the level of low-calorie sweetener use has increased in the last several decades, no increase in cancer rates can be attributed to any sweetener.

The role of low-calorie sweeteners in a healthful diet: The growing availability of affordable and palatable foods in combination with an increasingly sedentary lifestyle in industrialized countries under-scores the important role that low-calorie sweeteners can play in achieving a healthful diet that supports healthy weights. Because they do not affect insulin levels, intense sweeteners also play an important role in the diets of people with diabetes. The use of low-calorie sweeteners results in a wide range of food choices that can aid individuals in managing their caloric and carbohydrate intakes. Research shows that intense sweeteners can play a useful role in helping people achieve or maintain a healthy weight by providing good-tasting alternatives to foods and beverages that are typically higher in calories. According to Drewnowski *et al*. (1994) low-calorie sweeteners offer the best method to date of reducing calories while maintaining the palatability of the diet. Although the theory has been put forth that intense sweeteners may have a paradoxical effect and stimulate appetite and hence promote weight gain, a variety of studies both in controlled laboratory environments and with free-living populations do not support this effect.

It is clear, however that intense sweeteners or any food alone cannot make people succeed at weight management or the management of diseases such as diabetes. Such success involves a multidisciplinary approach of diet, physical activity, and behaviour management. However, because they provide the pleasure of sweetness without adding calories or carbohydrates, low-calorie sweeteners can facilitate compliance with restricted eating plans. Within a sensible program for weight or disease management, intense sweeteners can play an important role in helping Americans achieve goals for weight and overall health.

Sugar replacers

Sugar replacers are the bulk- and volume-providing sweeteners usually less sweet than, and different-tasting from sugar, commonly used on a one-for-one replacement basis for sugar in recipes. Sugar replacers have various names: " Polyols," "nutritive sweeteners," "sugar alcohols" and "bulk sweeteners." Sugar replacers are carbohydrates but they are not sugars. Sugar replacers currently approved for use in the US are: Hydrogenated starch hydrolysates (HSH) are- Lactitol, Maltitol, Isomalt, Sorbitol, Xylitol and Mannitol.

Sugar replacers exhibit the following characteristics: (I) Generally do not promote tooth decay (dental caries), (ii) Energy values range from 1.6 to 3.0 cal/g, compared to 3.8 to 4.0 cal/gram for most carbohydrates, including sugar, (iii) Commonly have a cooling effect on the tongue, (iv) Are slowly and incompletely absorbed from the intestine into the blood, (v) Cause only a small rise in blood glucose and insulin levels compared with sugars and other carbohydrates, (vi) Are generally metabolized by biochemical mechanisms that do not depend on insulin, (vii) Do not help restore blood glucose levels due to hypoglycemia (viii) Excess consumption may have a laxative effect for some people.

According to its manufacturer, "Sugaree" brand of D-tagatose is a natural, nonfattening sweetener, derived from whey, that looks, feels, tastes and performs like table sugar. It is not approved for use in the US. Isomalt is a white, crystalline substance made from and resembling sucrose in appearance. Isomalt does not have the cooling effect of some other sugar replacers. Sorbitol is a widely used sugar replacer, sorbitol is technically a polyhydroxy alcohol (polyol or sugar alcohol) derived from dextrose. It is used as a sweetener in sugarless chewing gums, confections, medicines and other products, plus it possesses humectant and other functional properties. It is about 60% to 70% as sweet as table sugar.

Nutritional and energy values present in sugar: It's hard to find anyone who doesn't like the sweet taste of sugars, yet there are many people today who wonder about the effect of that preference on their health. Over the years, questions about the impact of sugars consumption on issues ranging from behaviour to weight to coronary heart disease have made headlines as consumers seek to better manage their diets for health. In fact, sugars rank as one of the most misunderstood components of our food supply. Even though some people believe sugars eating can lead to a host of maladies, extensive research has failed to link sugars to the development or cause of any chronic disease. While dental caries may be associated with sugars consumption, it can also result from eating other carbohydrates including starches. White sugar is a pure carbohydrate (at least 99%) and contains trace amounts of sodium, potassium and iron. Brown sugars contain higher amounts of these minerals, as well as calcium and phosphorus. Like all carbohydrates, sugar contains about 4 calories of food energy per gram. A teaspoon of granulated or brown sugar contains 15 calories, a typical restaurant packet about 10 calories. Powdered sugar contains about 110 calories per quarter-cup.

Sugar and food: Besides its pleasant sweetness, sugar performs a host of less-obvious and important functions in cooking, baking, candy making and the like. Sugar "potentiates," blends and balances flavour components, much like a seasoning. For example, a pinch of sugar added to corn, carrots and peas produces a better-tasting product. In most tomato based products, such as barbecue, spaghetti, and chili sauces, sugar softens the acidity of the tomatoes and blends the flavours.

The appetite stimulation theory first drew widespread media attention when Blundell and Hill (1986) reported that persons who were consuming highly sweetened solutions perceived themselves to be hungrier than when they were consuming water alone. The study, however, relied only on subjects' hunger ratings and did not measure their actual food intake, which is considered essential by psychologists and obesity experts. The impact of having persons consume intense sweeteners in unflavoured solutions instead of in familiar and palatable beverages such as low-calorie sodas has also been questioned. Blundell and Hill (1986) conducted a subsequent study using solutions sweetened with aspartame, saccharin, and acesulfame potassium. Although increased appetite ratings were again observed for all three types of solutions, there were no increases in actual food intakes when they were measured 1 hour later. Subsequent research has failed to confirm that intense sweeteners promote increased food intake. Canty and Chan (1991) found that high-intensity sweeteners did not raise hunger levels or the level of food consumption. Birch *et al.* (1990) found that 2- to 5-year-old children decreased their level of snack consumption 30 minutes after consuming an aspartame- sweetened beverage compared with the level of snack consumption of those who drank water. Anderson *et al.*(1989) found that aspartame consumption did not affect hunger or food intake in 9- to 10-year-old children compared with the effect of sodium cyclamate or sucrose consumption. Several studies with adults have also shown that familiar aspartame-sweetened beverages do not affect short-term appetite or food intake when they are consumed before lunch or with meals compared with the effects of water.

Although Black *et al.* (1990) found that consuming two cans of aspartame-sweetened soft drink significantly reduced appetite ratings but not actual food intake, a follow-up study revealed that the total volume of fluid consumed, not aspartame, was responsible for suppressing short-term hunger in adult males. Mattes found that neither aspartame nor sucrose alone, consumed as part of a breakfast cereal, significantly affected hunger ratings, intake of the next meal, daily calories consumed, or food selections. That study also showed that awareness of the caloric content of the cereal—whether it was the low-calorie or regular cereal—did not significantly affect intake. Similarly, Rolls *et al.* (1990) studied the effect of awareness of the caloric content of regular or low-calorie puddings and gelatins containing sugar or aspartame, with a difference of about 200 calories, on the appetite and intake of nondieting, normal-weight adults. The study showed that awareness did not affect appetite or food consumption at the time of eating, nor did it affect food consumption from a buffet 2 h later. Drewnowski *et al.* (1994) studied the effects of aspartame on caloric intake in both normal-weight men and women and, in a similar study, in obese and lean women. They divided the subjects into four groups, each of which received different breakfast preloads: two provided 700 calories and contained either sucrose or aspartame with maltodextrin, and the other two provided 300 calories and either contained aspartame or were unsweetened. By this method, Drewnowski *et al.* (1994) were able to test both the effect of substituting aspartame for sucrose while maintaining sweetness and the effect of adding aspartame for sweetness. In the study with obese and lean women, there were no significant differences in lunchtime food intakes among the groups that received the different breakfast preloads. In the study with normal-weight subjects, a slight increase in food intake at lunch was recorded for those who consumed the low-energy preloads. However, no overall compensation was observed, so those who consumed the low-energy preloads had lower caloric intakes for the day than those who consumed the high-energy preloads.

The investigators concluded that neither the addition of aspartame nor the substitution of aspartame for sucrose increased overall hunger ratings or food intake. In a comprehensive scientific literature review, Rolls *et al.* (1990) concluded that intense sweeteners have never been found to cause weight gain in humans. Although several investigators have reported increases in rating of hunger associated with aspartame, most have found that aspartame is associated with decreased or unchanged ratings of hunger." It has also been suggested that intense sweeteners may alter food intake not by affecting the sweet taste but by affecting certain hormones involved in appetite regulation. Blundell and Hill (1986) found that subjects who consumed aspartame (235 or 470 mg) in capsules consumed less food than subjects who consumed a placebo capsule. Other studies involving encapsulated aspartame at much higher doses, however, have not replicated such findings. Anderson *et al.* (1989) administered aspartame capsules with water 60 to 105 minutes before lunch and found that they had no effect on food intake or ratings of mood or hunger. Leon and Hunninghake (1989) gave healthy adults aspartame or placebo capsules daily for 24 weeks as part of a long-term aspartame safety study. The body weights of those who took the aspartame capsules did not differ significantly from those at the baseline after 6 months.

Function of sugars in foods: Sugars play various function in food, such as: (I) Sweeteners (ii) Reduce water activity (iii) Preservatives (iv) Bulk, density and improved viscosity (v) Fermentable (vi) Nonenzymatic browning. Sugars contain varying degrees of different functional properties, which explains why manufacturers use different sugars in foods. Sugars are used in foods for many reasons that go far beyond the sweet taste they impart. For example, sugars act as preservatives in foods such as jams and jellies. They increase the boiling point or reduce the freezing point of foods, and add bulk and density. Sugars also play important roles in producing quality baked goods. They aid in the fermentation of yeast and the incorporation, retention and stabilization of air in baked products. They also react with amino acids to produce browning and flavour compounds important to the taste and visual appeal of baked goods. In foods with limited moisture such as cookies, sugars provide crispness.

Consumption of sugars: Glucose, fructose and sucrose comprise the major sugars in the diet. The amount of lactose in the diet depends on the consumption of milk and milk products. Lactose, however, is more readily available as a food ingredient today and is used in some foods that are not of dairy origin (Southgate, 1995)). Estimates of sugars intake are often based on food disappearance data, but such information overestimates consumption (Gibney *et al.*, 1995). There is no account for loss and waste during shipping, storage, manufacturing, and at the table.

More precise data comes from food consumption surveys. Although the accuracy of dietary intake data has also been questioned due to potential under reporting by survey respondents, such data can be used to estimate the percentage of energy from sugars (Freudenheim, 1993; Black *et al.*, 1993; Forbes, 1993; Beerman and Dittus, 1993; Eck *et al.*, 1989). It then provides an indicator of the contribution that sugars make to the total diet. Consumption data also allow analysis of the impact of total sugars intake on the nutritional adequacy of the diet and compliance with dietary guidelines. Using dietary intake data from the 1987-88 National Food Consumption Survey (NFCS), Gibney *et al.* (1995) found that for the entire population, total sugars intake remained virtually unchanged since the 1977-78 NFCS. Average daily intake of all sugars was approximately 96 grams per day, or 23% of calorie intake. Intake of total sugars minus lactose averaged 80 gm a day, or 19% of calorie intake. Average total intake of sugars by 1-to-10-year-old children also did not change greatly. Average daily intake of all sugars was 95 gm in 1977 and 96 gm in 1987. Intake of total sugars minus lactose was unchanged at 80 grams per day in 1977 and 1987.

Gibney *et al.* (1995) also found lactose in dairy foods constituted much of the total sugars, although the contribution decreased with age (29.6% for those 1-3 years old, and 15% for males and females between the ages of 10 to 50). Fruits provided significant amounts of sugars at all ages (16.6% for the total population), but particularly for the youngest (22.9% for children 1-3 years old) and oldest (24.6% for males and females over 50) populations. The bread, cereal, pasta and rice group contributed 18.9% of total sugars for the entire population. This included 9.7% from cookies, pies, cakes and pastries. Other foods such as fruit and carbonated drinks and sweet accompaniments like table sugar, honey, syrup and jelly contributed 40.4% of total sugars for the entire population (Gibney *et al.*, 1995).

Sugars consumption and dietary recommendations: The Dietary Guidelines for Americans recommend the use of sugars in moderation, stating that sugars supply calories but are limited in other nutrients (US Dept. of Agriculture, 1990). Indeed, nutritionists worry that people who eat high amounts of sugars may not get enough vitamins and minerals. Yet research indicates the percentage of sugars in the diet does not accurately predict micronutrient intake. Gibney *et al.* (1995) found that moderate sugars consumers (who consumed 27 to 60 grams/1000 kcal/day) had the most adequate micronutrient profiles with diets that better met dietary guidelines, compared to people who consumed lower levels (less than 26 grams/1000 kcal/day) or higher levels of sugars (61 or more grams/1000 kcal/day). Further, eating "low" levels of sugars did not necessarily guarantee an individual met dietary guidelines, nor did "high" sugars consumption mean a diet of poorer quality (Gibney *et al.*, 1995).

Most people who ate high amounts of sugars did tend to consume fewer micro nutrients in total. But this was not always true when daily intakes were compared to the RDA. Depending on age and gender, many people who ate low levels of sugars did not meet at least two-thirds of the RDA for several vitamins and minerals. For example, more 4-to-6-year-old children who ate high amounts of sugars met at least two-thirds of the RDA for thiamin, niacin, vitamin C, iron, zinc and vitamin E than did those who ate low amounts of sugars. Likewise, more women aged 51 and over who were high sugars consumers met two-thirds of the RDA for folacin, vitamin B6, vitamin C and vitamin A than did low sugars consumers their age. Furthermore, more low sugars consumers failed to meet other recommendations for a healthful diet. They tended to eat more than 30% of calories from fat, less than 55% of calories from carbohydrates and more than 300 milligrams of cholesterol.

These findings are similar to those reported by Lewis *et al.* (1992), who found that individuals consuming moderate amounts of added sugars (37-70 g/d) consumed more energy as fat than did high sugars consumers. Nicklas *et al.* (1992) similarly reported 10-year-old children who ate less sugar consumed more fat, both in total amounts and as a percent of calorie intake. Studies in several Europeans countries give more insight into the relationship between sugars and fat consumption. The Dutch National Nutrition Survey showed a clear inverse relationship between percent energy from total fat and that from sugars (Hulshof *et al.*, 1992). That is, the more fat a person ate, the fewer sugars consumed, and vice versa. Further, in comparing the nutrient intakes of the population against the Dutch National Nutrition Guidelines, Hulshof *et al.* (1992) found that the Dutch goals of 35% energy from fat and 10% energy from added sugars are incompatible (Hulshof *et al.*, 1993). It is not generally possible to reduce fat intake to that level and at the same time eat less sugars. Gibney *et al.* (1995) concluded the overall achievability of dietary guidelines should be reappraised on the basis of this study, which showed that only 0.9% of adults met the goal for saturated fatty acid intake (10% of energy) and only 3 in 1000 people met all five Dutch goals.

A survey of food and nutrient intakes of British children showed nutrient intakes were not significantly lower and were often higher in groups with the highest percent energy from sugars (Gibson, 1993). Gibney *et al.* (1995) concluded that the argument that high levels of sugars in the diet will lead to an inadequate micronutrient intake is conceptually naive. Just as some foods with high sugars content contain few micro nutrients, high-fat, low-micronutrient foods also exist. Therefore, sugars can be substituted for substantial quantities of fat without negatively affecting vitamin and mineral intakes.

Sugars and health: Sugars have a long history of safe use in foods (Beauchamp and Cowart, 1987). They were placed on the Generally Recognized as Safe' (GRAS) list of the Food and Drug Administration in 1958. Further, the GRAS status of sucrose, corn sugar (glucose), corn syrup, invert sugar and high fructose corn syrups was reaffirmed in 1986. Many people, however, believe eating sugars can lead to the development of disease. As a result, scientists have extensively explored potential links with a number of diseases and have failed to implicate sugars. Although dental caries may be associated with diet, it is only one factor involved. In 1986 a review of research on sugars intake and safety concluded, "Other than the contribution to dental caries, there is no conclusive evidence on sugars that demonstrates a hazard to the general public when sugars are consumed at the levels that are now current and in the manner now practiced." (Beauchamp and Cowart, 1987).

Sugars and physical performance: As carbohydrates, sugars are preferred as a metabolic fuel during high- intensity exercise (Koivisto, 1986, Saltin and Kaarlsson, 1977). Further, by consuming adequate amounts of carbohydrate before and immediately after exercise, athletes can maintain body stores of carbohydrate, or glycogen. The amount of muscle glycogens directly affects endurance capabilities, or the time an athlete may effectively perform during an event (Ahlborg *et al.*, 1967; Bergstron *et al.*, 1967; Hermansen *et al.*, 1967). For carbohydrate consumption during exercise to improve endurance, the exercise must last longer than 90 minutes and be of moderately high intensity (Coyle and Coggan, 1984). Further, this improvement is only seen in athletes who are sensitive to a lowering of blood glucose. Seventy percent of cyclists may be so sensitive. Forty to 65 grams of carbohydrate per hour will maintain blood glucose levels and positively affect performance although carbohydrates must be consumed before blood glucose begins to fall (Coggan and Swanson, 1992, Coggan and Coyle, 1987). Glucose, sucrose, malto-dextrins or high fructose corn syrup during exercise have equally positive effects on endurance (Coggan and Coyle, 1991; Murray *et al.*, 1989; Hickey *et al.*, 1994). Adequate carbohydrate consumption immediately after exercise enables multiple activities in a single day and renews carbohydrate stores on a daily basis (Sherman, 1995).

Sugars, mental performance and behaviour: Contrary to popular belief, sucrose does not cause aggressive or disruptive behaviour in children, nor does it negatively affect mental performance. Further, no particular group of children reacts to sugars differently from the general population. Numerous well-controlled studies have searched for a link between behaviour and sugars consumption in children. Despite significant differences in the children tested - normal children, those previously identified as negatively affected by sugars, children diagnosed with hyperactivity or attention deficit disorder, etc. and differences in the type of sugars given, composition of the total diet, and how behaviour was measured, the results consistently show sugars intake does not negatively affect behaviour (White and Wolraich, 1995). For example, findings of 13 published controlled challenge studies do not support the hypothesis that refined sugar affects hyperactivity, attention span or cognitive performance in children (White and Wolraich, 1995). These studies represent over 400 subjects, many of whom were originally thought adversely affected by sucrose intake. Most recently, Wolraich *et al.*(1994) looked at the impact of sucrose on the behaviour of children aged 6 to 10 years. The children were chosen for the study because their parents believed the children reacted negatively to sucrose. Preschool children were also studied. They are often considered sensitive to some foods. The researchers found no differences in the behaviour of the children when they ate higher-than-normal amounts of sucrose compared to when they ate diets low in sucrose. Actually, this and other research suggests sugars tend to calm both children and adults (Glinsmann *et al.*, 1986). This effect could go unnoticed due to other influences, however. For instance, the excitement of a birthday party or holiday could override the calming effect of sugars.

Obesity: Because sugars taste pleasant and humans are born with a preference for a sweet taste, scientists have speculated that eating sugars may lead to overeating and thereby obesity (Beauchamp and Cowart, 1987). Research, however, shows sugars do not interfere with bodily controls for energy balance, nor do they stimulate appetite in normal, healthy adults or children. In a review of the effect of sugars consumption on energy intake, Anderson (1995) concluded that sugars in amounts of 50 gm or more, given from 20 to 60 minutes before a meal, decrease the mealtime food intake of adults. This indicates that adults maintain regulatory controls for energy intake when consuming sugars. Studies also indicate when children eat sucrose before meals, their mealtime intake decreases (Birch and Deysher, 1986; Black and Anderson, 1994; Crombie, 1992; Rolls *et al.*, 1981; Birch *et al.*, 1989). Further, both survey and experimental data reveal that obese people are no different from normal-weight individuals regarding preference for and ability to detect sweet tastes (Grinker *et al.*, 1986). Nor do they eat more sugars than normal-weight persons (Campbell *et al.*, 1971). In fact, evidence suggests that obese persons may consume less sugars (Pliner, 1973; Hill and Prentice 1994). A study of over 11,000 Scottish men and women found significantly more obesity among people who ate lower amounts of sugars than there was among those who ate the greatest amounts of sugars (Bolton and Woodward, 1993). Further, this reverse association occurred in almost all studies that looked for it (Bolt on and Woodward, 1993; Nelson, 1991). Conventional treatment for obesity advises reducing fat and sugars intake. But this research suggests moderate amounts of sugars in the diet may be useful to weight management by providing a pleasant taste without significantly increasing calorie intake. Consequently, satisfaction with the diet may be higher and lead to greater adherence to the diet.

Diabetes mellitus: It has been clear for many years that sugars do not cause diabetes mellitus. The effect of sugars on the condition has been less well understood. Simple sugars were once thought to be more rapidly digested and absorbed than complex carbohydrates, and thus raise blood glucose levels to a greater extent. It is now known, that the absorption rates of sugars depend on the form in which they are consumed, including the food matrix (whether sugars are in free solution or contained within plant cells or emulsions or foamed structures of processed foods) (Southgate, 1995). Whether foods are eaten cooked or raw, the amount of fiber in the food, the size of the food particle in the gastrointestinal tract and the presence of fat all impact digestion and absorption. Once absorbed, the dietary source of sugars has little significance. Contrary to popular opinion, research also shows that refined sugars are no more likely than naturally occurring sugars or cooked starches to negatively affect blood glucose in both healthy subjects and people with diabetes (Wolever and Brand, 1995). Jenkins *et al.* (1981) comprehensively classified foods according to their impact on blood glucose. They showed many foods containing sugars, such as ice cream and candy, raised blood glucose levels less - or had a lower glycemic index (GI) – than foods such as white or whole grain bread. Wolever and Brand (1995) compared foods prep ared with and without refined sugars and saw higher blood glucose and insulin responses only to dairy products to which sucrose had been added. They concluded that the effect of adding sucrose to a food depends on the GI of the unsweetened food.

In addition, they found no rebound hypoglycemia after eating foods containing refined sugars. On the basis of this study, which included a very large number of foods, Wolever and Brand Miller suggest that many foods containing simple sugars, whether refined or naturally occurring, impact blood glucose less than most starchy foods in the western diet (Wolever and Brand, 1995). The previous studies looked at the effect of foods on blood glucose in healthy persons. Studies of people with non-insulin dependent diabetes (NIDDM) also show substituting sucrose for starch in equal amounts of calories, and at moderate intake levels in a mixed meal of common foods, does not significantly affect blood glucose or insulin levels (Slama *et al.*, 1984; Bornet *et al.*, 1985; Cooper *et al.*, 1988 and Peterson *et al.*, 1986). In people with insulin-dependent diabetes (IDDM), studies show sucrose or starch in calorically-equal amounts affect blood glucose similarly (Forlani *et al.*, 1989; Vaaler *et al.*, 1980; Steel *et al.*, 1983 and Bantle *et al.*, 1983 and Chantelqu *et al.*, 1985). Insulin requirements may be higher, however, if sucrose replaces a carbohydrate with a low GI (Wolever and Brand, 1995). In summary, the blood sugar level following a meal depends on many factors, including the source of the sugar or starch, its method of preparation and the composition of the total meal (Wolever and Brand, 1995). Cooked starches, such as bread, rice and potato, raise blood glucose in amounts similar to, or only slightly less than, glucose and frequently the same or greater than sucrose (Crapo *et al.*, 1976; Jenkins *et al.*, 1981; Mann and Truswell, 1972). In recent years, the American Diabetes Association (1987) revised its dietary recommendations to approve m oderate amounts of sucrose in the diets of persons whose diabetes is well controlled. Given their important taste contrbution, sugars in the diets of persons who must restrict fat intake, such as people with diabetes, may offer important benefits in terms of satisfaction with and ultimate adherence to prescribed diets.

Coronary heart disease: Dietary advice to help reduce risk for coronary heart disease (CHD) includes reducing total and saturated fat intake to 30% and 10% of calories, respectively. At the same time, it is recommended to increase carbohydrates to approximately 55% of calories . In a small number of "carbohydrate-sensitive" individuals, however, these dietary modifications have been reported to elevate blood triglycerides (TG) and decrease HDL-cholesterol levels (Frayn and Kingman, 1995). Persons with high TG and total cholesterol levels and low HDL levels may face additional risk for CHD (Kris, 1990). Because the recommended dietary changes also decrease total and LDL- cholesterol levels, the ultimate impact on risk for CHD for these carbohydrate-sensitive individuals is not clear. In persons with established diabetes, however, sugars consumption does not appear to affect blood lipids, even when very high amounts are eaten. Further, TG are not elevated in populations that habitually consume a high-carbohydrate diet (The American Dietetic Association, 1993). It also appears that the type of fat eaten may affect TG levels. TG and total cholesterol levels were higher in people fed a diet containing 34% of calories as sucrose if the fat (30% of calories) was mainly saturated (Mann *et al.*, 1973). Similarly, in people who already had high levels of various blood lipids, a diet containing 40% of calories from sucrose raised TG and cholesterol levels only if the dietary fat was mainly saturated (Little *et al.*, 1970; Birch wood *et al.*, 1970 and Antar *et al.*, 1970). If the fat was primarily polyunsaturated, blood lipid levels dropped and the sucrose had no effect.

In individuals with IDDM, research shows fructose does not negatively affect blood TG or cholesterol levels in individuals whose diabetes is reasonably well-controlled (Buysschaert *et al.*, 1987; Bantle *et al.*, 1992; Pelkonen *et al.*, 1972). Perrotti *et al.* (1984) also found no effect on fasting lipid levels in IDDM patients on a 60% carbohydrate diet that included a simple sugar intake identical to those on a 41% carbohydrate diet. Long-term feeding of fructose or sucrose to people with NIDDM does not affect blood lipids, even in those fed up to 220 grams of sugars a day (Emanuele *et al.*, 1986; Crapo *et* *al.*, 1986; Buysschaert *et al.*, 1987; McAteer *et al.*, 1987; Osei *et al.*, 1987; Abraira and Derler, 1988; Cooper *et al.*, 1988; Grigoresco *et al.*, 1988; Koh *et al.*, 1988; Anderson *et al.*, 1989; Osei and Bossetti, 1989; Thorburn *et al.*, 1989; Bantle *et al.*, 1992; Koivisto and Yki-Jarvinen, 1993; Coulston *et al.*, 1987). Further, one study found male patients with NIDDM consuming lower-carbohydrate diets over four years had higher fasting plasma TG levels than those consuming higher intakes of carbohydrates (Gallagher *et al.*, 1987).

Dental Health: People frequently point to sucrose as a major cause of cavities. They fail to realize that all fermentable carbohydrates, induding cooked starches and sugars in fruits, are potentially caries-promoting. Cavities occur when bacteria in dental plaque break down starches and sugars to form acids that destroy tooth enamel, dentine and/or cementum (Konig and Navia, 1995). The degree to which sugars and starches enhance the cavity-producing action of plaque bacteria depends on a number of factors. The factors include the concentration of sugars, how long they remain in the mouth, and how frequently sugars are eaten. Further, the action of saliva in diluting the mouth contents, converting starch to fermentable sugars, or neutralizing acids plays a role. Sugars do not produce significant amounts of acids when plaque is absent or present only in thin layers (Konig and Navia, 1995). Thus, good oral hygiene contributes significantly to reducing caries risk; an adequate fluoride intake is equally important. This is seen in the experience of Swiss school children after World War II (Buttner, 1991 and Konig, 1990). Before and after the war, there was an unlimited supply of sugars, poor oral hygiene and no fluoride available, and the percentage of caries-free 7-year-old children was 2 to 3%. Wartime restriction reduced sugars supply from about 40 to 16 kg/person/year, and the number of caries-free children increased to about 15%. But the improvement was even greater after 1962 when water supplies were fluoridated, oral hygiene instructions began to be given at school and fluoride dentrifices became available. Although sugars consumption rose after the war, and has been about 45 kg per capita for the last 40 years, the number of caries-free school children 7 to 15 years of age has risen to 65% in 1989. In The Netherlands, caries prevalence has fallen rapidly within the last 25 years, although sugars consumption has remained stable (Konig, 1990 and Truin *et al.*, 1993). In Sweden, Norway and New Zealand, sugars consumption increased between 1982 and 1985, yet the caries rate among children continued to fall (Konig, 1990; Birkhed *et al.*, 1989; Rolla and Ogaard, 1987). Experts today emphasize a comprehensive approach to preventing caries. The approach recognizes the need for an adequate diet containing nutrients important to tooth development. In addition, it emphasizes better oral hygiene, the appropriate use of fluoride and sealants, and enhancement of saliva function. Periodontal health depends on preventing chronic inflammation of the gingiva, the periodontal connective tissues and the supporting alveolar bone (Konig and Navia, 1995). Regular removal of dental plaque by tooth brushing ranks as a primary method for protecting periodontal health. Emerging evidence suggests an individual's immune response may also play a key role (Enwonwu, 1994). Sugars consumption is not directly related to periodontal disease. Animal studies do indicate the frequent eating of sugars may stimulate the energy metabolism of plaque bacteria, increase plaque volume and thereby indirectly increase risk to periodontal health (Hoeven, 1974; Savoff and Rateitschak, 1980). But regular removal of plaque, which is necessary to periodontal health anyway, eliminates this indirect risk.

Sugars are common food ingredients that add taste appeal and perform important functions in foods. Consumption of sugars providing total calories - including milk and fruit sugars. While some nutritionists often worry that eating sugars may negatively affect the micronutrient adequacy of the diet, research shows moderate sugars consumers better meet the RDAs than those who consume high or low amounts of sugars. Further, low sugars consumers tend to eat more fat and cholesterol and less carbohydrate than recommended. Indeed, dietary recommendations to reduce fat to 30% or less of calories and added sugars to 10% or less may be incompatible. Sugars have been studied extensively for their impact on a variety of issues ranging from behaviour to weight to coronary heart disease. Consumption of sugars does not lead to the development of any chronic disease. Nor does it negatively affect behaviour or mental performance in children. In some situations, such as weight management or diabetes, a moderate amount of sugars in the diet may increase the acceptability of and adherence to prescribed diets.

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