

# Sweet Facts About Sugars and Health

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 (1). Over the years, questions about the impact of sugars consumption on issues ranging from behavior 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 eating sugars 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.

This issue of IFIC Review takes an in-depth look at sugars and their impact on health and physical and mental performance.

## What Are Sugars?

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.

*\*The term "sugars" as used in this review refers to any free mono- or disaccharide present in foods, such as glucose, fructose, sucrose, maltose or lactose, whether it be naturally-occurring or added to foods. This definition is consistent with that used by the Food and Drug Administration (FDA) for nutrition labeling purposes.*

Sugars include sucrose, glucose, fructose, lactose and maltose and are found in foods such as fruits, vegetables, flour and cereal products and milk products. Manufacturers also add many of these sugars to foods during processing to perform important functions. Further, sugars are 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.

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). These monosaccharides then travel through the blood stream to body cells. There they provide energy and help form proteins.

## Function of Sugars in Foods

- Sweeteners
- Reduce water activity
- Preservatives
- Bulk, density and improved viscosity
- Fermentable
- Nonenzymatic browning

## Functions of Sugars in Foods

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 flavor 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

The amount of sugars consumed in the United States has remained stable since the late 1970s. 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 (2).

Estimates of sugars intake are often based on food disappearance data, but such information overestimates consumption (3). 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 (4-8). 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. found that for the entire population, total sugars intake remained virtually unchanged since the 1977-78 NFCS (3). 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 grams 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 grams in 1977 and 96 grams in 1987. Intake of total sugars minus lactose was unchanged at 80 grams per day in 1977 and 1987.

Gibney et al. also found lactose in dairy foods

### Average Consumption of Sugars USDA Nationwide Food Consumption Survey

|                           | Average Daily Intake, g/day |         | % of Calorie Intake |         |
|---------------------------|-----------------------------|---------|---------------------|---------|
|                           | 1977/78                     | 1987/88 | 1977/78             | 1987/88 |
| Total Sugars              | 96                          | 96      | 21                  | 23      |
| Total Sugars Minus Lactos | 80                          | 80      | 18                  | 19      |
| Total Fructose            | 16                          | 16      | 4                   | 44      |

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 (3).

### 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 (9). 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. 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 (3).

Most people who ate high amounts of sugars did tend to consume fewer micronutrients 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., who found that individuals consuming moderate amounts of added sugars (37-70 g/d) consumed more energy as fat than did high sugars consumers (10). Nicklas et al. similarly reported 10-year-old children who ate less sugar consumed more fat, both in total amounts and as a percent of calorie intake (11).

Studies in several European 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 (12). 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. found that the Dutch goals of 35% energy from fat and 10% energy from added sugars are incompatible (13). It is not generally possible to reduce fat intake to that level and at the same time eat less sugars. Gibney et al. 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 (3).

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 (14). Gibney et al. concluded that the argument that high levels of sugars in the diet will lead to an inadequate micronutrient intake is conceptually naive (3). Just as some foods with high sugars content contain few micronutrients, 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 Physical Performance**

As carbohydrates, sugars are preferred as a metabolic fuel during high-intensity exercise (15,16). 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 glycogen directly affects endurance capabilities, or the time an athlete may effectively perform during an event (17, 18, 19).

For carbohydrate consumption during exercise to improve endurance, the exercise must last longer than 90 minutes and be of moderately high intensity (20). 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 (21,22). Glucose, sucrose, malto-dextrins or high fructose corn syrup during exercise have equally positive effects on endurance (23,24,25).

Adequate carbohydrate consumption immediately after exercise enables multiple activities in a single day and renews carbohydrate stores on a daily basis (26).

## **Sugars, Mental Performance and Behavior**

Contrary to popular belief, sucrose does not cause aggressive or disruptive behavior in children, nor does it negatively affect mental performance (27). Further, no particular group of children reacts to sugars differently from the general population.

Numerous well-controlled studies have searched for a link between behavior 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 behavior was measured, the results consistently show sugars intake does not negatively affect behavior (27).

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 (27). These studies represent over 400 subjects, many of whom were

originally thought adversely affected by sucrose intake.

Most recently, Wolraich, Lindgren and Stumbo looked at the impact of sucrose on the behavior of children aged 6 to 10 years (28). 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 behavior 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

### Definitions

| Sugar   | Sugars                     | Sweeteners                 |
|---------|----------------------------|----------------------------|
| Sucrose | Free mono-or disaccharides | Ingredients for Sweeteners |
|         | Glucose                    | Sugars                     |
|         | Fructose                   | Honey                      |
|         | Sucrose                    | Molasses                   |
|         | Maltose                    | Syrups                     |
|         | Lactose                    | Hydrolyzed Starch          |
|         |                            | Non-Caloric Compounds      |

to calm both children and adults (29). 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.

### Sugars and Health

Sugars have a long history of safe use in foods (30). 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." (30)

*The Surgeon General's Report on Nutrition and*

*Health*, the National Academy of Sciences report *Diet and Health*, and *Healthy People 2000: National Health Promotion and Disease Prevention Objectives* by the U.S. Department of Health and Human Services support these conclusions.

### 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 (30). 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 concluded that sugars in amounts of 50 grams or more, given from 20 to 60 minutes before a meal, decrease the mealtime food intake of adults (31). 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 (32-36).

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 (37). Nor do they eat more sugars than normal-weight persons (38). In fact, evidence suggests that obese persons may consume less sugars (39,40).

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 (41). Further, this reverse association occurred in almost all studies that looked for it (41,42).

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, however, 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) (2). 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 (43). In 1981, Jenkins et al. comprehensively classified foods according to their impact on blood glucose (44). 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.

Brand Miller et al. compared foods prepared with and without refined sugars and saw higher blood glucose and insulin responses only to dairy products to which sucrose had been added (43). 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 (43).

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 (45-48). In people with insulin-dependent diabetes (IDDM), studies show sucrose or starch in calorically-equal amounts affect blood glucose similarly (49-53). Insulin requirements may be higher, however, if sucrose replaces a carbohydrate with a low GI (43).

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 (43). 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 (54, 55, 56).

In recent years, the American Diabetes Association revised its dietary recommendations to approve moderate amounts of sucrose in the diets of persons whose diabetes is well controlled (57). Given their important taste contribution, 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 (58). Persons with high TG and total cholesterol levels and low HDL levels may face additional risk for CHD (59).

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 (60).

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 (61). 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 (62,63,64). 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 (65,66,67). Perrotti et al. 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 (68).

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 (69-83). 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 (84).

## Dental Health

People frequently point to sucrose as a major cause of cavities. They fail to realize that all fermentable carbohydrates, including 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 (85).

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 (85).

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 (86,87). 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 (87,88). In Sweden, Norway and New Zealand, sugars consumption increased between 1982 and 1985, yet the caries rate among children continued to fall (87,89,90).

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 (85). 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 (91).

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 (92,93). But regular removal of plaque, which is necessary to periodontal health anyway, eliminates this indirect risk.

## Conclusion

Sugars are common food ingredients that add taste appeal and perform important functions in foods. Consumption of sugars in the United States has remained stable since the late 1970s, providing approximately 23% of total calories — including milk and fruit sugars — for the entire population.

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 behavior to weight to coronary heart disease. Consumption of sugars does not lead to the development of any chronic disease. Nor does it negatively affect behavior 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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