The Science of Sugars, Part 2

Sugars and a Healthful Diet

Marilyn D. Schorin, PhD, RD, FADA
Kris Sollid, RD
Marianne Smith Edge, MS, RD, LD, FADA
Ann Bouchoux, MSW

Sugars have a long history of safe use in foods. Placed on the Food and Drug Administration's list of foods that are "generally recognized as safe" in 1958, sugars and the health aspects of sugar consumption continue to be evaluated. Recent research has focused on several potential sugars and health relationships, sugar consumption and nutritional quality of the diet, recommendations for sugars or added sugar intake, and the utility of the glycemic index and glycemic load. The data are not clear-cut, although experts generally agree that dietary guidance focusing on calorie control, without singling out one food or nutrient, is essential to addressing the prevalence of obesity. Nutr Today. 2012;00(0):00–00

Much is known about the science of sugars. Part 1 of this series reviewed the food science and technology of sugars as well as the nomenclature of sugars. Consumption data for sugars were also reviewed. Part 2 of this series examines the role of sugars in a healthful diet. It includes an assessment of the association between dietary quality, intake of sugars, and dietary recommendations for sugar. In part 3, the relationship of sugar intake to chronic diseases will be examined. Part 4 will focus on the relationship between sugar intake and dental health as well as the effect of sugar intake on mental performance and behavior.

Marilyn D. Schorin, PhD, RD, FADA, is principal of Schorin Strategies, LLC, in Louisville, Kentucky. Dr Schorin gained extensive experience in scientific, health, and nutrition strategies with more than 20 years working on food and nutrition issues. She currently advises a wide variety of Fortune 500 corporations, identifying emerging nutrition issues and combining communications and regulatory plans to address these topics.

Kris Sollid, RD, is the manager of nutrients at the International Food Information Council (IFIC) and the IFIC Foundation in Washington, DC (http://www.foodinsight.org). He is a registered dietitian dedicated to communicating science-based nutrition information to consumers, health professionals, and other message multipliers that correspond directly with consumers.

Marianne Smith Edge, MS, RD, LD, FADA, is the senior vice president of nutrition and food safety at the International Food Information Council (IFIC) and the IFIC Foundation in Washington, DC (http://www.foodinsight.org). She is a registered dietitian, experienced communicator, strategic planner, and facilitator with more than 25 years of experience working in the healthcare and food industries. Marianne's expertise includes strategic positioning of nutritional products/services and nutrition communications, and she is a nationally recognized speaker in health, wellness, and farm-to-table issues.

Ann Bouchoux, MSW, is the senior director of nutrients at the International Food Information Council (IFIC) and editor of *Food Insight* newsletter for the IFIC Foundation (http://www.foodinsight.org), a nonprofit organization dedicated to the mission of effectively communicating science-based information on health, nutrition, and food safety for the public good.

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Correspondence: Kris Sollid, RD, International Food Information Council, 1100 Connecticut Ave, Suite 430, Washington, DC 20036 (sollid@ific.org).

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DIETARY QUALITY AND SUGAR INTAKE

In its familiar form, cane sugar and beet sugar provide only carbohydrates and are devoid of vitamins or minerals. Similarly, corn syrup, which, like cane and beet sugar, is used in many convenience foods, has no micronutrients. However, sugar and corn syrup are added to numerous foods that do provide essential vitamins and minerals. This raises the following question: Does intake of sugars dilute the nutritional quality of the diet? The data are not clear-cut, but, on balance, they do not support the nutrient dilution hypothesis.

Gibney et al[1] analyzed data from the 1987–1988 US Department of Agriculture (USDA) Nationwide Food Consumption Survey and examined nutrient analysis based on sugar consumption ("low" sugar consumers in the bottom quartile, "high" sugar consumers in the top quartile). They found that high consumption of sugars was not associated with a poorer quality diet.[1] Furthermore, eating low levels of sugars did not necessarily guarantee that an individual's diet met dietary guidelines, nor did high sugar consumption mean a diet of poorer quality.

However, in an analysis of the Continuing Survey of Food Intakes by Individuals (CSFII) (1994–1996), Bowman[2] found that individuals consuming more than 18% of their total energy from added sugars did not meet the recommended daily allowance for many micronutrients. Excluded from the analysis were infants younger than 2 years or those who were breast-fed, as well as pregnant and lactating women. Analyzing the same data among children and adolescents (CSFII), Forshee and Storey[3] used a different research design that controlled for all possible sources of energy and reached a different conclusion. They examined micronutrient intake in relation to servings of food in the USDA Food Guide Pyramid. They found the correlation between added sugars and micronutrients inconsistent. For 6- to 11-year-old children, for example, added sugars negatively correlated

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with dairy intake but positively correlated with grains, vitamin C, iron, and folate. Added sugars were not linked to vegetable, fruit, lean meat, vitamin A, or calcium intake among children. Among adolescents, added sugars negatively correlated with fruit consumption and positively correlated with grains, vitamin C, and iron intake.

Calcium and phosphorus intakes of school-aged children and adolescents improved with consumption of sugar-sweetened flavored-milk.[4] Flavored milk drinkers had more milk and fewer soft drinks and fruit drinks, demonstrating that consuming added sugars in nutritious foods such as dairy products may increase intakes of at-risk nutrients such as calcium.

Forshee and Storey[5] also analyzed data from the National Health and Nutrition Examination Survey III for 9 age-gender categories and determined that the association of energy from added sugars with micronutrient intake from that data, like that of CSFII, was inconsistent and small. "We conclude that consumption of added sugars has little or no association with diet quality," they wrote.

Using the recent National Health and Nutrition Examination Survey data (2003–2006), Marriott et al[6] found that intake of added sugars in grams per day has not changed substantially and is comparable with CSFII data from the mid-1990s. More than 87% of the US population had intakes of added sugars between 0% and 25% of total energy intake, which falls within the Institute of Medicine's (IOM's) suggested maximum intake (see below). It is useful to note that, regardless of intake from added sugars, few individuals in the population met recommended nutrient intake.

Other studies have reported that individuals who are high consumers of sugar-sweetened beverages (SSBs) have lower intakes of some micronutrients such as calcium and magnesium.[7,8] Frary et al[8] examined the relationships among nutrient intakes and the major sugar-containing foods and beverages for US children using data from the 1994–1996 CSFII. They found that as intakes of SSBs, sugars and sweets, and sweetened grains (baked goods) increased, the percentage intakes of the Dietary Reference Intakes (DRI) for calcium and iron decreased and saturated fat intakes increased. As the consumption of sweetened dairy products and presweetened cereals mounted, the percentage of the DRI for calcium rose. Among adolescents, as intakes of presweetened cereals increased, the percentage intakes of the DRIs for iron and folate increased. The investigators concluded that consumption of sweetened dairy products and presweetened cereals have a positive effect on nutrient intake, whereas the consumption of SSBs, sugars and sweets, and sweetened grains reduces the intake of key nutrients. Adding sugars to nutritious foods may help increase nutrient intakes.

Rennie and Livingstone[9] conducted a systematic review of published studies, attempting to determine whether added sugar intake was associated with micronutrient intakes and, if so, the magnitude and the direction of the associations. After analyzing 15 studies, the authors found no consistent evidence of micronutrient dilution or a threshold for the effect of added sugar intake for the micronutrients investigated. Further research was recommended to determine which food products might adversely affect micronutrient intake by displacing other food items from the diet.

In the course of exploring various mechanisms by which sucrose could influence behavior, Benton[10] found that, although micronutrient supplementation reduced antisocial behaviors, sucrose intake is not related to micronutrient deficiency. Micronutrient intake is more closely associated with total energy than sucrose intake. In a further review of this topic, Livingstone and Rennie[11] describe the methodological difficulties and conceptual issues that hamper resolution of the micronutrient dilution hypothesis. They question whether it is feasible or necessary to make the distinction between natural and added sugars given that sugars are chemically and physiologically indistinguishable. In fact, the intricacy of measuring added sugars was a topic specifically addressed by the 2010 Dietary Guidelines Advisory Committee (DGAC). According to the 2010 DGAC, means of assessing intake of added sugars vary across studies, and "reliable and standardized measures of exposure to added sugars are necessary to draw meaningful conclusions." Furthermore, accurate evaluation of added sugars "is challenging because no analytical methods exist with which to measure sugars added to foods."[12]

Intervention studies might be the only way to answer questions of micronutrient dilution. Rennie and Livingstone[9] caution: "In the absence of compelling evidence that micronutrient intakes are compromised by a high consumption of added sugars, it may now be appropriate to question the legitimacy of the nutrient dilution hypothesis as it is highly likely that it is oversimplifying more subtle and complex dietary issues."

The theory that sugars dilute nutritional quality of the diet is overly simplistic.

Some researchers believe that consumption of foods with a high energy density (kilocalories per gram) and a low nutrient density (nutrients per kilocalorie) has the potential to displace needed nutrients in a diet. Others, however, disagree and suggest that the consumption of nutrient-rich foods is independent of consumption of high-energy-density foods. For a modeling study of dietary patterns that satisfy the recommended daily allowance, optimized food patterns exceeded the 2010 Dietary Guidelines for Americans (DGA) in solid fats and added sugars (SoFAS); the model

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patterns had 17% to 33% versus the prescribed 5% to 15% of energy from SoFAS.[13] In terms of communicating dietary guidelines to the public, Murphy and Johnson[14] suggest that it might be more effective to advise choosing foods with a high nutrient density rather than focusing on added sugar content as the source of nutrient displacement.

In 2010, the European Food Safety Authority (EFSA) Panel on Dietetic Products, Nutrition, and Allergies (NDA) issued a Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fiber. With regard to a relationship between sugars and diet quality, the EFSA NDA panel concluded that "Observed negative associations between added sugar intake and micronutrient density of the diet are mainly related to patterns of intake of the foods from which added sugars in the diet are derived rather than to intake of added sugars per se. The available data are not sufficient to set an upper limit for (added) sugar intake."[15]

SUGAR CONSUMPTION AND DIETARY RECOMMENDATIONS

The DGA form the foundation for US nutrition policy. The guidelines are revised every 5 years to ensure that they represent state-of-the-art nutrition science. The wording of the guidelines has evolved over time to reflect both newer scientific knowledge as well as changes in nutrition policy. The 2000 edition of the DGA advised Americans to "Choose beverages and foods to moderate your intake of sugars."[16] In contrast, the 2005 DGA departed from previous editions in that it did not include a message specifically directed toward sugars but advised Americans to "Choose carbohydrates wisely for good health" instead.[17]

The 2010 DGAC reviewed recent science to support the recommendations of the 2010 DGA. The 2010 DGAC report speaks specifically to shifting eating patterns to be more plant-based in composition while addressing both carbohydrates and sugars. Furthermore, unlike past versions of the DGAC, the 2010 report recommends that carbohydrate consumption should vary by activity level. For active people, suggested percentage of total caloric intake for carbohydrates should be at the high end of the acceptable macronutrient distribution range (45%–65%), whereas those who are on low-calorie diets should consume diets at the low end of the acceptable macronutrient distribution range.[12] In addition, sedentary populations, or "most Americans," are advised to reduce consumption of high-energy, non-nutrient-dense carbohydrate sources to aid in calorie control.[12]

Science policy groups have considered the question of whether there is an upper limit to the amount of sugars an individual should consume. This question is based on concerns that overconsumption of sugars may contribute to caloric excess and/or that sugars may dilute the nutrient density of the diet. Based on available evidence, the 2005 DGAC chose not to set a numerical limit for sugar consumption but advised individuals to focus on consuming nutrient-dense foods and diets while treating added sugars, fats, and alcohol as "discretionary calories."[17] The 2010 DGAC moved away from the discretionary calorie concept citing difficulty in educating consumers; they examined the total diet and encouraged consumers to significantly reduce intakes of SoFAS to no more than 5% to 15% of total calories.[12] At present, Americans consume approximately 35% of total calories as SoFAS.

The IOM's Dietary Reference Intakes (DRI) report recommends that Americans get most of their daily calories from carbohydrates—about 45% to 65% daily calorie intake.[18] Children and adults need a minimum of 130 g of carbohydrates per day for proper brain function. The DRI report reviewed all available evidence on the effects of total and added sugars on chronic disease risk and micronutrient intakes. With respect to chronic disease risk, the report concluded that there was insufficient evidence to set an upper limit for total or added sugars. In its examination of the data regarding sugar and micronutrient intakes, the IOM found that reduced intakes of calcium, vitamin A, and zinc were associated with increasing intakes of added sugars, particularly when added sugars accounted for more than 25% of energy.

A different perspective on consumption is provided by the 2003 independent report of the World Health Organization (WHO) and the Food and Agriculture Organization.[19] Entitled "Diet, Nutrition and the Prevention of Chronic Diseases," the report has raised global awareness of the need to focus on the essential role of both diet and physical activity as key determinants of health. While acknowledging that the recommendation is "controversial," the report proposes a goal that "free sugars" (ie, added sugars) not exceed 10% of total caloric intake. The Academy of Nutrition and Dietetics (AND) commented on the recommendation, noting: "The strategies used in the panel's deliberations encompass their interpretation of a range of epidemiologic, economic, social, and political impacts on the prevention and control of non-communicable diseases. Thus, the proposed 10% intake recommendation may not be based solely on scientific evidence."[20]

Recommended limits on sugar intakes vary among food policy and scientific organizations, although all agree that reducing caloric intake is essential to fight the growing obesity prevalence.

In a recent statement, the American Heart Association (AHA) recommends limiting added sugar intake to one-half

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the discretionary calorie allowance suggested in the 2005 DGA (100 kcal/d for women, 150 kcal/d for men).[21] These amounts are less than the 10% of total calories suggested by the WHO, which would be about 180 kcal for most women and about 250 kcal for most men. The AHA based its recommendations on some studies that suggest that high intake of dietary sugars may be a contributing factor in the rise of obesity and cardiovascular disease. However, the IOM specifically examined the relationship of body mass index (BMI) and sugar intake and found no consistent relationship. Nonetheless, Vartanian et al[22] found a positive association between body weight and soft drink consumption in a meta-analysis of 88 studies. Despite looking at the association between all carbohydrates—not only sugars—and body weight, Gaesser[23] examined more than 100 studies and concluded: "A review of relevant literature indicates that most epidemiologic studies show an inverse relationship between carbohydrate intake and BMI, even when controlling for potential confounders."

The AHA acknowledged that it is "unlikely" that a single food is primarily responsible for obesity, noting that the suggested limits are part of a "multifaceted" approach. "A reduction in added sugars is one means to achieve a reduction in energy density."[21]

A comprehensive review of global dietary recommendations for sugar and added sugar noted the absence of a consensus among the guidelines. After reviewing studies on obesity, nutrient adequacy, metabolic syndrome, attention deficit, dementia, and dental caries, the researchers concluded: "Overall, the available evidence did not support a single quantitative sugar guideline covering all health issues."[24] (See further discussion in the next section: "Sugars and Health.") In addition, the 2010 EFSA NDA panel concluded, "Evidence on the relationship between patterns of consumption of sugar-containing foods and dental caries, weight gain and micronutrient intake should be considered when establishing nutrient goals for populations and recommendations for individuals and when developing food-based dietary guidelines."[15]

To date, no consensus on the upper limit for added sugar intake has prevailed. The diverse recommendations for upper levels of added sugar consumption demand clarification by additional research.

SUGARS AND HEALTH

Sugars have a long history of safe use in foods. They were placed on the Food and Drug Administration's (FDA's) list of foods that are "Generally Recognized as Safe" in 1958. In 1986, Glinsmann et al[25] conducted an extensive review of all the health aspects of sugar consumption. Based on this work, the FDA reaffirmed the Generally Recognized as Safe status of sucrose, corn sugar (glucose), corn syrup, invert sugar, and high-fructose corn syrup (HFCS).[26,27] Since that time, scientists and scientific organizations have kept the science of sugars up to date by periodically evaluating newer research.

In 1997, Anderson[28] reviewed sugar-health scientific literature, concluding that except for their contribution to dental caries, sugars are not the cause of chronic or acute disease. The same year, a Joint Expert Consultation of the Food and Agriculture Organization and the WHO reported on "Carbohydrates in human nutrition," finding "no evidence of a direct involvement of sucrose, other sugars and starch in the etiology of lifestyle-related diseases" and recommended that consumers avoid overconsumption of sugars.[29] This topic was again reviewed in 2001 and reaffirmed the FDA's and Anderson's conclusion that aside from dental caries, sugars are not an independent risk factor in chronic diseases.[30]

The IOM's 2002 report on DRIs (commonly referred to as the Macronutrient Report) focused on whether scientific evidence supported setting limits on sugar intake.[18] After reviewing available research on the effects of sugars on chronic disease risk, they found that there was insufficient evidence to set an upper intake level for total or added sugars.

In 2002, the Carbohydrates Technical Committee of the International Life Sciences Institute, North America convened a workshop addressing current scientific issues related to sugars and health. Participants included a group of internationally recognized experts, who reviewed current and emerging scientific research, wrote papers, and critiqued the papers of other participants. Summarizing the proceedings, Lineback and Jones[31] observed: "Available data show that there are few health concerns for which a direct association with sugar can be established."

The AND periodically updates and revises its position paper on the use of nutritive and nonnutritive sweeteners. The 2004 version of this paper reaffirmed the AND's "total diet approach" to communicating food and nutrition information, advising dietetics professionals to "communicate science-based messages about recommendations for added sugar intake with the understanding that all foods can fit into healthful diets, even those high in added sugars. For individual recommendations on intake of added sugars, dietetics professionals should assess food intake within the context of the entire diet and by considering personal health and nutrition goals."[20]

A subsequent review of the sugar-health scientific literature from 1986 to 2006 considered diets of both children and adults.[32] Additional long-term studies across different age groups, ethnicities, and those with chronic diseases were recommended to further define the role of sugars in the diets of average and overweight individuals, as well as in people with diabetes and at risk for cardiovascular disease.

A group of 20 European nutrition, obesity, and dental health expert researchers convened a workshop in 2007,

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"On the Role and Fate of Sugars in Human Nutrition and Health," in which they reviewed the available evidence behind current intake recommendations for sugars, focusing on the strengths and gaps of the scientific evidence available and identifying those areas needing further research.[33] A discussion by Arola et al[34] noted that much of our information about the role of sugars in nutrition and health comes from observational epidemiological studies that do not establish causality and in which carbohydrates in the diet may simply be a marker for other factors. The investigators did not specify the other factors but considered dietary satiety, the complex of obesity–metabolic syndrome–insulin resistance, and other potential regulators of gene expression. The researchers emphasized the need for randomized controlled trials of sufficient size and duration to supplement epidemiological data.

Two recent scientific workshops brought researchers together to discuss the role of fructose-containing sweeteners in the diet and to clarify emerging questions related to metabolic effects and obesity. In 2007, the American Society for Nutrition's Public Information Committee convened a symposium entitled "High Fructose Corn Syrup (HFCS): Everything You Wanted to Know, But Were Afraid to Ask." Symposium research papers were published in a supplement to the American Journal of Clinical Nutrition. Summarizing the presentations, Fulgoni[35] stated that "the data presented indicated that HFCS is very similar to sucrose…, and thus, not surprisingly, few metabolic differences were found comparing HFCS and sucrose." Stanhope and Havel[36] cited evidence that "prolonged consumption of diets high in energy from fructose could lead to increased caloric intake or decreased caloric expenditure, thereby contributing to weight gain and obesity" and that fructose consumption increases blood triglyceride levels. They recommended long-term studies in a variety of populations to investigate the effects of fructose, sucrose, and HFCS on lipid metabolism, glucose tolerance, insulin sensitivity, and the development of obesity.

White[37] stressed that HFCS is not meaningfully different in composition or metabolism from other fructose-glucose sweeteners such as sucrose, honey, and fruit juice concentrates. He emphasized the dissimilarity between pure fructose and HFCS. "Although examples of pure fructose causing metabolic upset at high concentrations abound, especially when fed as the sole carbohydrate source, there is no evidence that the common fructose-glucose sweeteners do the same. Thus, studies using extreme carbohydrate diets may be useful for probing biochemical pathways, but they have no relevance to the human diet or to current consumption." Still, the hypothesis that fructose itself in the diet causes significant health issues continues to be explored.[38,39] It is important to emphasize that White was looking at studies on the effects of fructose in the absence of glucose and noting that these studies may lead to conclusions that are aberrant as the metabolism of fructose is affected by the presence or absence of glucose.

Fructose-containing sweeteners have been studied by several expert groups; the metabolic effects of pure fructose and high fructose corn syrup are quite different. More research that reflects common human consumption patterns of fructose is needed.

The Agricultural Research Service of the USDA and International Life Sciences Institute, North America convened a roundtable of nutrition and health experts to address "The State of the Science on Dietary Sweeteners Containing Fructose." Research papers from the roundtable were published in a supplement to the *Journal of Nutrition*. The roundtable addressed a wide range of issues including fructose and satiety, trends in fructose consumption, effects of fructose on glucose and lipid metabolism, metabolic syndrome, and diabetes. In a summary of the presented papers, Murphy[40] stated, "…high fructose corn syrup and sucrose are similar and one is not 'better or worse' than the other." Murphy noted that "it does not appear to be practical to base dietary guidance on selecting or avoiding these specific types of sweeteners." Others noted the lack of research information comparing HFCS with other sweeteners[41] but found HFCS no more insidious than other caloric sweeteners. They called for more short-term studies to further explore the relationship.

A detailed analysis entitled "Is Sugar Consumption Detrimental to Health?" reviewed literature from 1995 through 2006. Results from high-quality obesity studies did not suggest a positive association between BMI and sugar intake. The authors found consumption of sugars at 6% to 20% of energy intake could support diet adequacy. Studies on metabolic syndrome reported no adverse effects of sugar in the long-term. In addition, the researchers concurred with other consensus reports that the amount of sugars consumed is not the primary causative factor in dental caries.[24] (See part 4 of this series for more information on sugars and dental health.) More recent scientific opinion from the 2010 EFSA NDA also acknowledges the many variables involved in the formation of dental caries, not only the amount of sugar consumed, but also frequency of consumption, oral hygiene, exposure to fluoride, and various other factors.[15]

GLYCEMIC INDEX/GLYCEMIC LOAD

The glycemic index (GI) was developed to compare the effects of various carbohydrate foods on blood sugar, a useful tool in the treatment of individuals with impaired

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glucose tolerance.[42] According to Jenkins,[43] the GI concept is an extension of the hypothesis that slowly absorbed high-fiber foods may have metabolic benefits in relation to diabetes and to the prevention of coronary heart disease risk. Simply stated, the GI is a measure of the rise in blood glucose level induced by the consumption of a carbohydrate compared to a standard food (white bread or glucose), which is set at 100. It is assessed under laboratory conditions, by measuring blood sugar level after consumption of a set amount of a single food, usually 50 g of digestible carbohydrate.

Glycemic load (GL) represents glucose response or insulin demand produced by total carbohydrate intake. Thus, GL combines both the quality (GI) and quantity of carbohydrate in a meal or diet. Glycemic load is calculated by multiplying the grams of carbohydrate in a serving of food by that food's GI.

In practice, GI and GL cannot always be reproduced consistently among individuals or even in the same individual at different times.[44,45] Many factors affect the consistency and reproducibility of GI calculations, including the ripeness of fruit, the physical form of the food, its temperature, and its processing and preparation.[45] Consumption of carbohydrate foods as a component of a mixed meal may also alter the glycemic response. One Canadian multicenter trial of individuals with non-insulin-dependent diabetes mellitus demonstrated that the higher the sugar intake, the lower the diet's GI[46]; another study found nearly identical GI between sweetened and unsweetened foods.[47]

Using GI/GL in the prevention and treatment of disease has been controversial, as studies have produced inconsistent results, probably due, in part, to inadequate tools to accurately determine these dietary components.[17] Glycemic index is the basis of a number of popular weight loss plans, its popularity fueled by claims that low-GI foods can help control appetite and weight, and may be useful to diabetic individuals. Such claims are based on the theory that high-GI foods raise blood sugar levels, cause excess insulin to be secreted, and lead to the storage of fat.[48] Van Baak and Astrup[49] found some evidence that lower-GL diets may result in lower body weight but stated that "the effect is likely to be small."

Opinions differ on the clinical utility of the glycemic index and glycemic load concepts in the United States and Canada.

Other investigators found support for reduced-GI diet on maintenance of weight loss.[50] Nonetheless, the EFSA NDA concluded in 2010 that "although there is some experimental evidence that a reduction of the dietary glycaemic index and glycaemic load may have favourable effects on some metabolic risk factors such as serum lipids, the evidence for a role in weight maintenance and prevention of diet-related diseases is inconclusive."[15] The 2010 DGA was more definitive: "Strong evidence shows that glycemic index and/or glycemic load are not associated with body weight; thus, it is not necessary to consider these measures when selecting carbohydrate foods and beverages for weight management."[12]

In the past, diabetes treatment involved restricting sugar consumption because of its expected hyperglycemic effect. That advice has been modified as the glycemic impact of starchy and sugary foods has been documented. Numerous studies have demonstrated the beneficial effects of using GI/GL in treatment of individuals with type 2 diabetes,[47,51,52] although it is not universal.[44,53,54]

Use of GI/GL may permit more sugar in the diets of people with diabetes. Even with a normal distribution of GI values in this group, those consuming a low-GI diet are apt to consume more simple sugars than low-GI starchy foods, according to Wolever et al.[46] A low-GI diet also produced better glycemic control (hemoglobin A_{1c} and fasting glucose) than did one emphasizing cereal fiber.[55]

Use of GI/GL is acknowledged but not universally accepted as a tool for diabetes management. The Canadian Diabetes Association advises that "the Glycemic Index (GI) is a useful concept for the management of blood glucose in those affected by diabetes."[56] Diabetes Australia, in conjunction with the University of Sydney and the Juvenile Diabetes Research Foundation, endorsed a program for labeling food with its GI value, provided that (*a*) the food meets specified nutritional criteria and (*b*) the GI testing is performed by an approved laboratory.[57] A position statement from the American Diabetes Association concluded that "there is not sufficient, consistent information to conclude that low-glycemic load diets reduce the risk for diabetes."[58] However, it advises that "the use of glycemic index and load may provide a modest additional benefit over that observed when total carbohydrate is considered alone."

Even experts who support the clinical utility of the GI caution that it should not be the only criterion by which to judge a food.[59] Other factors to consider include a food's fat content and nutrient density. When discussing GI, it is important to consider that sugars are moderate to low in both GI and GL. Sugars have a lower GI than do many starchy or starch-containing foods.[30]

As an alternative to the GI, Segal and colleagues[60] propose the use of a fructose index to categorize foods. Fructose index is defined as the percentage of energy of a food item derived from fructose, and fructose load is the amount of fructose present in a single serving. They hypothesize that eating foods that induce insulin resistance increases risk for obesity and cardiovascular disease, as opposed to eating foods that stimulate insulin secretion. Evidence-based trials to test this hypothesis are suggested.

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Several professional groups in the United States advise caution and further research before supporting the use of GI to make dietary recommendations for the general population or for the prevention and treatment of disease.[61,62] The AND advises: "There is insufficient research to show that the GI of a food or a meal has any effect on weight loss or gain."[63] In the United States, prevailing nutrition perspective is represented by the 2010 DGAC report, which declares, "When selecting carbohydrate foods, there is no need for concern with their glycemic index or glycemic load. What is important to heed is their calories, caloric density, and fiber content."[12]

SUMMARY

Three key concerns prevail in the investigation of sugars and dietary quality. First, the need to obtain adequate intakes of vitamins and minerals, which is what drove the IOM analysis. They noted that micronutrient intake was affected by sugar intake exceeding 25% of calories. Specific micronutrient relationships were clarified by other research groups.

Second, the effect of all carbohydrates, including sugars, on blood sugar propelled the creation of the GI and concept of GL. The utility of the index remains controversial in that similar glycemic control can be achieved by monitoring the type and amount of carbohydrate consumed.

Third, calorie control and obesity dominate concerns of several professional organizations, who advocated varying limits on free or added sugars. Despite disagreement on specific limitations for sugar or added sugar, there is consensus that total caloric intake must not exceed caloric expenditure.

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