Nutrition Guideline
Sugar Substitutes

For Professional Reference Only

Applicable to: Nurses, Physicians and Other Health Professionals

Recommendations:

- The research on the health impacts of consuming sugar substitutes is inconclusive because the vast majority of studies are low-quality, short-term and at risk of significant biases.
- The highest-quality evidence shows no definitive risks or benefits for healthy adult populations who consume sugar substitutes.
- Sugar substitutes are not suitable for infants under 12 months of age and are generally not recommended for children and youth under 18 years of age. There is a lack of quality research on the impact of consuming sugar substitutes during growth and development.
- Sugar substitutes are considered safe to use in moderation during pregnancy and breastfeeding.
- Sugar substitutes have little to no effect on blood glucose levels and can be recommended as a component of diabetes management.
- Individuals with phenylketonuria (PKU) need to avoid aspartame.
- Individuals with a fructose metabolism disorder need to avoid d-tagatose.
- Foods and beverages that contain sugar substitutes are often low in nutrients and may have a negative impact on optimal growth and development during infancy, childhood, adolescence and pregnancy.
- The moderate consumption of sugar substitutes in place of sugar may help reduce energy intake and promote short-term weight loss. However, other lifestyle changes – such as healthier diet choices, increased physical activity and healthier food and beverage portions – represent more effective approaches to support and maintain long-term weight loss.
- Replacing sugar-sweetened beverages with a moderate amount of drinks made with sugar substitutes may help reduce overall energy intake. However, water is the beverage of choice because it is the best way to quench thirst and stay hydrated without adding extra calories to the overall diet.

Purpose

This guideline will provide health professionals information on the use and safety of sugar substitutes for healthy infants, children, adolescents, adults and pregnant or breastfeeding women. This guideline also reviews the best research on the link between the consumption of sugar substitutes and the risk of developing certain chronic conditions.

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Key Questions

What is a sugar substitute?

Sugar substitutes include artificial sweeteners and sweeteners extracted from natural sources.[1] They are typically consumed in the form of a tabletop sweetener or an ingredient in various "diet" products, including certain foods (yogurt, baked goods, and chewing gum), beverages (soft drinks and fruit flavoured drinks) and condiments (spreads and salad dressings).[2]

Nutritive and Non-Nutritive Sweeteners

Each sugar substitute is chemically and metabolically distinct, but all of them can generally be classified as a nutritive or a non-nutritive sweetener.[3,4] Nutritive sweeteners, such as sugar alcohols, provide very small amounts of carbohydrate and energy.[3] These sweeteners have much fewer calories than table sugar and have a negligible effect on blood glucose levels.[3] Non-nutritive sweeteners, such as aspartame and sucralose, provide minimal or no carbohydrates and energy.[3] These sweeteners do not have an effect on blood glucose levels.[3] Examples of nutritive and non-nutritive sweeteners are listed in Table 1.

What is the quality of the research on the health impacts of consuming sugar substitutes?

The research on the health impacts of consuming sugar substitutes is inconclusive because the vast majority of studies are low quality, and any higher quality, randomized control trials (RCT) have only measured short-term outcomes. The most common and significant limitations of the large body of research on sugar substitutes include:[5-9]

- A disproportionate amount of research on the impact of each type of sugar substitute since the prevailing focus is on saccharin, aspartame and artificially sweetened beverages (ASB).
- A significant lack of high quality RCTs and little to no long-term RCTs.
- A failure to control for many of the following confounding factors during RCTs and observational research (cohort, cross-sectional, case studies):
  - Dietary habits: diet quality, amount and frequency of food and beverage intake
  - Physical activity level and type of physical activity
  - Pre-existing health conditions: overweight, obesity, cardiometabolic risks, type 2 diabetes, insulin resistance, metabolic conditions, and family history of chronic diseases
  - Smoking or vaping tobacco or nicotine
  - Alcohol consumption
  - Recreational drug use: marijuana, opiates, benzodiazepine and illicit drugs
- A significant likelihood of reverse correlation. Many researchers report an increased incidence or risk of chronic conditions among people who consume greater amounts of sugar substitutes. However, it is highly plausible that most of these individuals actually chose to replace sugar with sugar substitutes to help address ongoing, new or emerging health concerns, such as type 2 diabetes, cardiovascular disease, weight gain, overweight, or obesity.
- A likely and unknown risk of many types of bias including self-selection bias, researcher bias, publication bias, and funder bias.
- Small sample sizes whose outcomes cannot be generalized to the broader, healthy population.
- Large numbers of animal studies whose results may not be as relevant or transferable to humans.
- Substantial heterogeneity across the body of research in this area that is often ignored when studies with inconsistent designs and methodologies are inappropriately compared and contrasted.
- A lack of effective critical appraisal, statistical analyses or weighting methodologies in reviews that compile the results of many independent studies of low or variable quality.

The recommendations in this Nutrition Guideline are based on strong systematic reviews and meta-analyses[5-7,10-22] to minimize the confounding impact of the limitations and biases among weak or low-quality research.

Is it safe to consume sugar substitutes?

Yes. Sugar substitutes are approved and regulated for use as food additives in Canada under the Food and Drug Regulations.[1,23] Sugar substitutes are generally safe for healthy populations to consume within the acceptable daily intake (ADI) recommended for each sweetener by Health Canada.[1,3,24,25] The ADIs set by Health Canada are recognized internationally and are the same as those established by the Food and Agriculture Organization/World Health Organization (FAO/WHO).[1,26] Table 1 lists the sugar substitutes that are approved for use in food and beverage products or as tabletop sweeteners in Canada within set limits.[1,24] It is important to note that the Food and Drug Administration (FDA) in the United States recommends slightly different ADIs than Health Canada.[27]

Although sugar substitutes are safe to consume, it is worthy to note that:

- consumption of products containing these sweeteners could reduce intake of the nutrient-dense foods and beverages needed to promote general health and to ensure adequate growth and development during pregnancy, infancy, and childhood.[3,28]
- consumers can easily exceed the ADI for cyclamate since it is available in highly concentrated powder, tablet and liquid form because it is significantly less sweet than other sugar substitutes.[29]
- ingestion of more than 10 grams of sugar alcohols per day may result in gas, bloating, upset stomach and diarrhea.[3]
- products made with these sweeteners can still be a significant source of carbohydrate or calories.

Table 1. Sugar Substitutes

Sugar Substitute	Common Brand Names	ADI (mg/kg/day)
Acesulfame-potassium	Sunett®, Equal®	0-15
Advantame	N/A	0-5
Alitame	N/A	0-1
Aspartame	Nutra-sweet®, Equal®	0-40
Cyclamate	Sucaryl®, Sugar Twin®, Sweet N'Low®, Weight Watches Table-Top Sweetener®).	0-11
D-tagatose	N/A	No ADI
Monk fruit extract	N/A	No ADI
Neotame	N/A	0-2
Steviol Glycosides (Stevia)	Truvia®, SweetLeaf®, Sugar Twin Stevia®	0-4
Saccharin	Hermesetas®	0-5
Sucralose	Splenda®, Sugar Twin Sucralose®	0-9
Thaumatin	N/A	No ADI
Sugar alcohols (isomalt, xylitol, lacitol, maltitol, mannitol, sorbitol, erythritol, hydrogenated starch and hydrolysates)	N/A	N/A

Note: ADIs apply to all age groups because they are based on weight, not age.[1,3,24-26,30]

What are the main sources of sugar substitutes in the Canadian diet?

An examination of the data from the University of Toronto's Food Label Information Program indicates that sugar substitutes are primarily found in beverages, followed by desserts, dairy products, fruits, candy, tabletop sweeteners and bakery products.[2] Approximately 1.9% of all prepackaged food and beverage products contain a sugar substitute.[2] The name of each sugar substitute must be included in the ingredient list of all packaged foods and beverages.[24]

Are there any populations who need to avoid sugar substitutes?

Yes. During therapeutic counselling, healthcare professionals can individualize messages about the use of sugar substitutes according to the client's health status, care plan and personal preferences.

Pregnancy and Breastfeeding

While the use of sugar substitutes during pregnancy and breastfeeding is considered safe, there is limited research on both of these populations.[31] For more detail, please refer to the following resources:

- *Nutrition Guideline: Pregnancy*
- *Nutrition Guideline: Diabetes in Pregnancy*
- *Nutrition Guideline: Nutrition for the Breastfeeding Mother*

Infants and Young Children

Sugar substitutes are not recommended for infants under 12 months of age. There is no evidence to show any harmful effects of the occasional consumption of sugar substitutes. However, due to limited research on this population and specific nutritional requirements for normal growth and development in children, foods and beverages containing sugar substitutes are generally not recommended.[32,33]

Refer to *Nutrition Guideline: Healthy Infants and Young Children* for more information.

Phenylketonuria (PKU)

Individuals who have phenylketonuria (PKU) cannot consume high levels of the amino acid phenylalanine, which is a key component of aspartame. Individuals with PKU should avoid all food and beverage products that contain aspartame.[1,3,23] The Food and Drugs Act requires that all food and beverage products with aspartame be labelled as containing phenylalanine.[1,24] The moderate use of other sugar substitutes is considered safe for individuals with PKU.[1,23]

Fructose Metabolism Disorders

D-tagatose is a sugar substitute that is metabolized the same way as fructose in the body.[3] Individuals diagnosed with a fructose metabolism disorder should avoid products containing D-tagatose.[3] The moderate use of other sugar substitutes is considered safe for individuals with a fructose metabolism disorder.[3]

What do we know about the health impacts of consuming sugar substitutes?

Nearly all of the systematic reviews and meta-analyses published between 2006 and 2019 report inconclusive results on any positive or negative health impacts associated with the consumption of sugar substitutes.[4,5,8,10-19,21,22,34-42] The following sections review the available research on specific health conditions.

Weight

Weight Loss

The majority of the research has found negligible positive impacts of sugar substitutes on weight loss. Researchers suggest that consuming foods or beverages made with sugar substitutes instead of sugar may help reduce energy intake, prevent weight gain or lead to modest weight loss.[18,21,42] Four strong reviews and one moderate review of RCTs found a weak association between sugar substitute consumption and short-term decreases in body weight in adults.[5,7,15,21,35] A strong review of RCTs found a decrease in weight among overweight or obese adults who consume sugar substitutes but no change for adults whose weight was within the healthy range.[7] One strong review reported a weak link between the consumption of sugar substitutes and short-term decreases in body weight and adiposity in children.[17] However, two strong reviews and three moderate reviews of RCTs found inconclusive results or no association between the consumption of sugar substitutes and weight changes or reduced risk of obesity in adults, children and adolescents.[7,22,34,36,42]

In conclusion, the consumption of food and beverages made with sugar substitutes may not have a sustained effect on weight loss or weight loss maintenance. Other lifestyle changes such as healthier food and beverage choices, consuming healthier food and beverage portions, and increasing physical activity are more effective for weight management. It is also recommended to promote water as the beverage of choice because it quenches thirst, provides no calories, and helps keep the body hydrated. Drinks made with sugar substitutes may be consumed in moderation to reduce energy intake from sugar-sweetened beverages.

Weight Gain

The majority of the research found negligible risks of gaining weight while consuming sugar substitutes.[5,7,15,21] Two strong reviews of observational studies found that the use of sugar substitutes may be associated with long-term weight gain, increased BMI and waist circumference.[5,17] One meta-analysis of RCTs and observational studies found a significant correlation between the consumption of artificially-sweetened beverages (ASB) and an increased risk of obesity and weight gain over time.[20] However, the associations in all of these review articles could likely be the result of reverse causality, where overweight or obese individuals chose to consume more foods and beverages made with sugar substitutes to prevent further weight gain or to promote weight loss.[6] In addition, several researchers hypothesize that the link between sugar substitutes and weight gain is primarily caused by the conscious or unconscious choice to consume greater amounts of sweet or high energy foods after replacing sugar-sweetened beverages with non-caloric drink choices.[6,34] Lastly, many uncontrolled confounding factors may have also impacted body weight outcomes in these studies, particularly changes in physical activity, diet quality, metabolism and pre-existing or new chronic conditions such as obesity, type 2 diabetes and cardiovascular disease.

Blood Pressure

The research findings on the association between the consumption of sugar substitutes and the risk of developing hypertension are inconclusive. One strong systematic review found negligible benefits of using sugar substitutes to lower blood pressure.[7] In the review, three RCTs reported lower systolic and diastolic pressure in adults who used sugar substitutes compared to placebo or sugar, while another RCT found no association between sugar substitute consumption and blood pressure.[7] In contrast, three strong systematic reviews with meta-analyses found that short-term, high intake of sugar substitutes and ASB was associated with an increased risk of hypertension in adults.[10,13,20] One RCT found that the short-term use of sugar substitutes in children had no effect on blood pressure.[7] It is important to note that uncontrolled confounding factors – such as activity level, diet quality, sodium intake, pre-existing cardiometabolic risk and body weight – likely have a greater impact on blood pressure than the consumption of sugar substitutes.[7,13] Long-term RCTs with controlled dietary intake and activity levels are warranted to determine the true impact of sugar substitutes on blood pressure.

Cancer

There is limited research on humans to identify any reasonable link between the use of sugar substitutes and the development of any type of cancer. A strong meta-analysis of case-control and observational studies found no significant risk of developing brain tumours among children or various types of cancers among adults regardless of the frequency or duration of sugar substitute consumption.[7] A strong meta-analysis of observational studies found inconclusive results on whether heavy and prolonged intake of aspartame or saccharin increases the risk of developing bladder or brain cancer.[16] Two weak reviews with a high risk of bias found a slightly greater chance of developing leukemia, lymphomas and myelomas in adults who consume sugar substitutes.[8,37]

Type 2 Diabetes

The majority of the research reported a negligible effect of sugar substitutes on the risk of developing type 2 diabetes or impaired glucose metabolism. One strong review and two weak reviews of cohort, observational and epidemiological studies found no statistically significant association between the consumption of ASB and developing type 2 diabetes among adults.[8,19,37] Two strong meta-analyses reported a moderate association between the intake of ASB and the risk of developing type 2 diabetes in adults.[6,12] There is a significant possibility that reverse causality may also be in effect when examining the impact of sugar substitutes on the risk of developing type 2 diabetes.[6] Researchers hypothesize that people who have diabetes or who are at risk for developing diabetes may consume larger amounts of sugar substitutes or ASBs to prevent high blood sugars or further weight gain, or to promote weight loss.[6]

Since sugar substitutes have a negligible effect on blood glucose levels, clients with diabetes can consume a moderate amount of sugar substitutes as a way to help manage the condition. Sugar substitutes may help increase the flexibility in a meal plan, reduce carbohydrate intake from sugar, or support a weight management strategy.[3]

Refer to *Nutrition Guideline: Diabetes* for more information.

Blood Lipid Profile

The majority of the research found a negligible association between the use of sugar substitutes and changes in blood lipid profiles. Some RCTs found greater high-density lipoprotein (HDL) cholesterol levels among participants who consumed aspartame compared to controls who did not use sugar substitutes.[21] A strong review and a weak review found no effect of sugar substitutes on blood lipid profiles in adults.[22,37]

Chronic Kidney Disease

Two strong meta-analyses of cohort, cross-sectional and case-control studies found no associated risk of developing chronic kidney disease with the consumption of ASBs or sugar substitutes.[7,11]

Mental Health and Cognition

One strong and one weak review found a negligible association between consuming sugar substitutes and impacts on mental health status or cognitive functioning.[7,37] A small cohort study found a slight increase in the risk of developing depression among adults who use sugar substitutes.[7] The same study observed no differences among adults and children who do or do not consume sugar substitutes with regards to negative impacts on mood, behaviour or neurocognition.[7] Two observational studies found no significant neurological effect on children with epilepsy or hyperactivity who also use aspartame.[37]

Appetite Regulation and Food Intake

Researchers hypothesize that sugar substitutes may affect hunger signals and appetite control because intestinal cells contain receptors that respond to sweetness and stimulate the release of gastrointestinal hormones that regulate satiety.[40,41] Two strong reviews show inconclusive results regarding the link between consuming sugar substitutes and changes in appetite or food intake.[7,19] Three RCTs found no association between the use of sugar substitutes and changes in the serum concentration of appetite-regulating hormones.[19] Two RCTs found no difference in the energy intake and self-reported appetite between adults who use or do not use sugar substitutes, and a negligible decrease in energy intake among children who use sugar substitutes.[7]

Dental Health

One RCT found no change in tooth plaque volume in children who drank water with stevioside (stevia) compared to those who drank plain water.[7] However, more research on other types of sugar substitutes is necessary to determine the unique impact of each type of sweetener on dental health.

Gastrointestinal Health

Gut Function

The research on the effect of sugar substitutes on gut function is very limited and low quality. Two weak reviews on animal and human studies found no association between the use of sugar substitutes and rates of gastric emptying or the release of gastrointestinal hormones.[40,41] Many more long-term RCTs are warranted to draw stronger conclusions on the impact of different sugar substitutes on gut function.

Microbiome

There is limited, low-quality research on the impact of consuming sugar substitutes on the human microbiome. Much of the microbiome research focuses on animals whose enteroendocrine cell function differs significantly from humans.[40,41] Limitations of animal studies also include small sample sizes, short study durations, extreme high dosages of sugar substitutes for body weight, and uncontrolled amounts and types of food intake.[4,38-41] Thus, the results from animal studies may not be transferrable or relevant to the human population. In addition, the limitations of the few cross-sectional human studies include small sample sizes, short study durations, self-reporting biases and no diet controls.[38,39]

Two weak reviews on multiple animal studies and two human studies found inconclusive results on the intake of different types and dosages of sugar substitutes and changes in the gut microflora.[38,39] It is important to note that uncontrolled and confounding diet factors – including the amount of complex carbohydrate, fermentable fibres, saturated fat and sugar – may have a greater impact on the gut microbiome than sugar substitutes alone.[4,39] Longer RCT studies on humans with different types and dosages of sugar substitutes are needed to elucidate the effect on the gut microbiota.

Are there any resources on sugar substitutes that I can use with my clients?

Online Resources

Health Canada [The Safety of Sugar Substitutes]: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/food-additives/sugar-substitutes.html

Dietitians of Canada [Facts on Artificial Sweeteners]: http://www.unlockfood.ca/en/Articles/Food-technology/Facts-on-Artificial-Sweeteners.aspx

Diabetes Canada [Sugars and Sweeteners]: https://guidelines.diabetes.ca/docs/patient-resources/sugars-and-sweeteners.pdf

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