

Facts about natural Vs artificial sugars

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ABSTRACT

Sugars are chemically-related carbohydrates, most of which are used in food. On the basis of dietary significance, sugars can be naturally occurring, low-calorie sweeteners or artificial sweetener. Natural sugars being rich in calories can raise blood sugar levels. Added sugars are sweetener added to food during its production/processing. High intake of natural and added sugar consumption may lead to cardiovascular disease, Type 2 diabetes and obesity. Low calories sweeteners are sugar alcohols derived from pentoses and hexoses and have less impact on blood sugar levels. Artificial sweeteners are synthetic sugar substitutes with sweet taste which do not raise the blood sugar levels and are boon to diabetic patients. Glycemic index is a tool that ranks carbohydrates according to their glycemic response. It measures blood sugar response per gram of carbohydrate contained in a food, not per gram of food. Glycemic load is a newer concept which takes serving sizes into account. A diet with a low glycemic index and glycemic load lowers the risk of heart diseases, diabetes and obesity. Therefore, by keeping a check on amount and type of sugar intake one can keep health disorders like obesity, diabetes, cardiovascular disorders at bay.

Key words: Cardiovascular disease; Diabetes; Glycemic index; Glycemic load; Obesity; Sugars

1.0. Introduction

Sugar is the name given to a class of chemically-related soluble carbohydrates most of which are used in food. These are called carbohydrates as are composed of carbon, hydrogen, and oxygen. Sugars can be derived from different sources including plants. Simplest forms of sugars are called monosaccharide for example, glucose (also known as dextrose), fructose and galactose, are made up of only one molecule of simple sugars. Sugars containing two molecules of monosaccharides joined by a glycosidic bond are called disaccharides. Most common example of disaccharide is sucrose (also called table sugar or granulated sugar) which is hydrolysed into fructose and glucose in body to be used as a source of energy. Other disaccharides include maltose and lactose. Polysaccharides are the carbohydrates made up of multiple units of monosaccharides.

2.0. Types of Sugars

Although sugars can be classified on a number of basis but on the basis of dietary significance these can be classified into 3 types (Fig. 1)

- **Naturally occurring sugars**
- **Low-calorie sweeteners**
- **Artificial or no calorie sweetener**

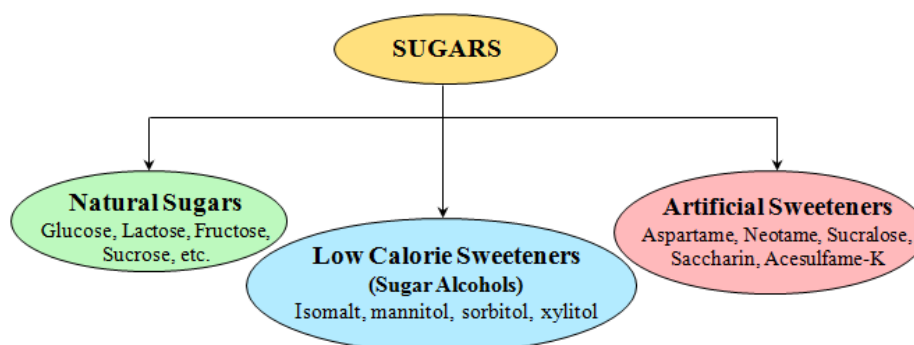


Fig 1: Types of sugar on the basis of dietary significance.

3.0. Naturally occurring sugars

Sugars in diet can be natural or added. Natural sugars occur naturally in foods such as fruit (fructose) and milk (lactose). These, being rich high calories, can raise blood sugar levels. Some of examples include brown sugar, cane sugar, confectioner's sugar, fructose, honey,

jaggery, khand, molasses, Turbinado or “raw” sugar (dehydrated cane juice). These are called natural sugars because firstly these occur on their own; and secondly these are not manipulated by humans. Natural sugars occur in ample amount in fruits and give them sweet and appealing taste. However, some foods are not sweet but contain sugars. Carrots, Beets, cabbage and potatoes contain some of these compounds (Fig 2).

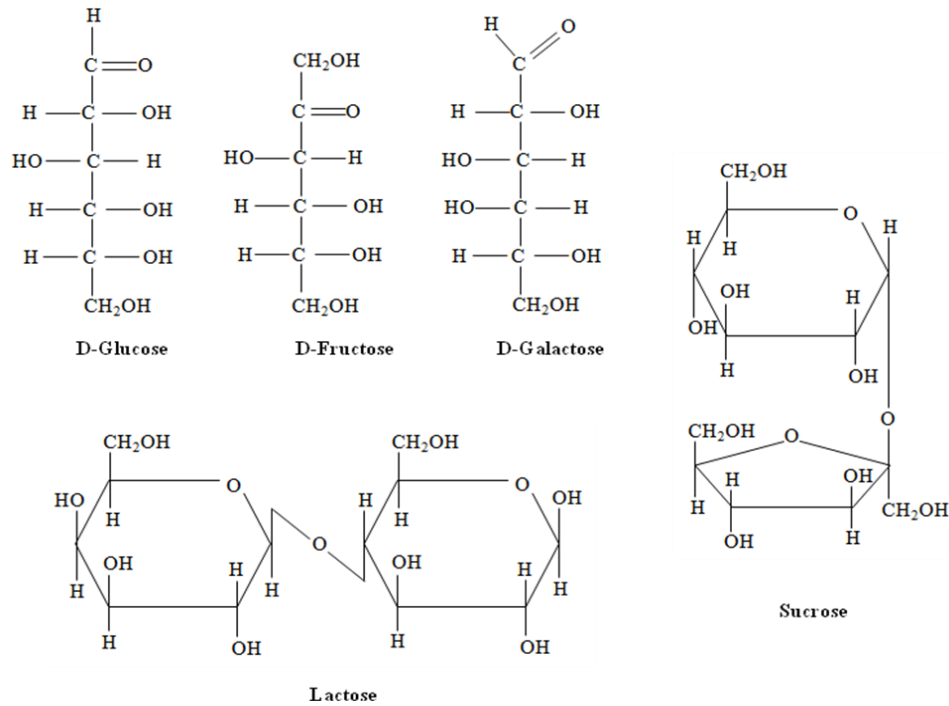


Fig 2: Naturally occurring sugars

3.1. Added sugars

Added sugars refers to caloric sweetener (sugars and syrups) added to foods during its production and processing (Lindsay and Andrew, 2012). It is chemically indistinguishable from natural sugars, but characterized by extra calories with no nutritional value (Welsh, et al., 2011a). These are also known as extrinsic sugars while naturally occurring sugars are known as intrinsic. Consumption of added sugars has been associated with increased risk of heart disease, high blood pressure, type 2 diabetes and obesity (Welsh et al., 2011b). Thumb rule is to avoid products with added sugars; however, the growing use of alternative sweeteners makes it difficult to determine which ingredients count as sugar, because there are multiple sources of sugar with different names. While we sometimes add sugar to food by ourselves, most of it comes from prepared and processed foods, example, breakfast cereals and sweetened beverages. A reduction in added sugar intake can lower the obesity and heart disease epidemics (Johnson et al., 2009). Added-sugar limit should not be more than 100 calories per day (about 6 teaspoons or 24 grams) for women and 150 calories per day (about 9 teaspoons or 36 grams) for men.

3.2. Sugar-sweetened beverages

Soft drinks, the major source of extra calories, can contribute to weight gain and provide no nutritional benefits. Liquid carbohydrates such as sugar-sweetened beverages are less filling than solid ones— causing the feeling of hunger, type 2 diabetes, heart disease, and other chronic conditions (Travis, 2010). An average can of sugar-sweetened soda or fruit punch/juice provides about 150 calories which it is equivalent to 10 teaspoons of table sugar i.e. equivalent to a man's per day need of sugars.

3.3. Cereals and other foods

Whole, unprocessed breakfast foods such as an apple or oatmeal are a great way to avoid additional sugars. Most of the common breakfasts such as ready-to-eat cereals, cereal bars, instant oatmeal (flavoured), and pastries contain high amounts of added sugars. Sweet treats can be enjoyed in moderation with consideration to added sugars elsewhere in diet. The amount of sugar consumption per day should be limited to around 150 calories or approximately 30-40 grams of sugar. According to WHO, one should consume no more than 10 percent of daily calories in form of sugar.

4.0. Low-calorie sweeteners or modified natural sugars

Low calorie sweeteners are the modified form of natural sugars, generally sugar alcohols (also called *polyols*, *polyhydric alcohol*, *polyalcohol*, or *glycitol*). These are named so because of their unique chemical structure, which resembles both sugar and alcohol (Schiweck et al., 2012) and usually their name ends with the letters "-ol". These have general formula $H(HCHO)_{n+1}H$ and are derived from pentoses (five-carbon sugars) and hexoses (six-carbon sugars) that have one OH group attached to each carbon. These sweetens foods, but with half the calories of sugar. Although these can raise the blood sugar levels but their impact is less because these are not completely absorbed by the body (Wolever et al., 2002). Examples of low calorie sweeteners are isomalt, maltitol, mannitol, sorbitol, and xylitol (Islam and Indrajit, 2012). These are the major constituent of sugar-free candy and gum. Some sugar alcohols occur naturally in plants but most of them are manufactured by hydrogenation of sugars using nickel as catalyst. Though sugar alcohols have lesser calories than sugar, most aren't as sweet, so increased amount is required to get the same sweetening effect (Fig. 3) (Table 1).

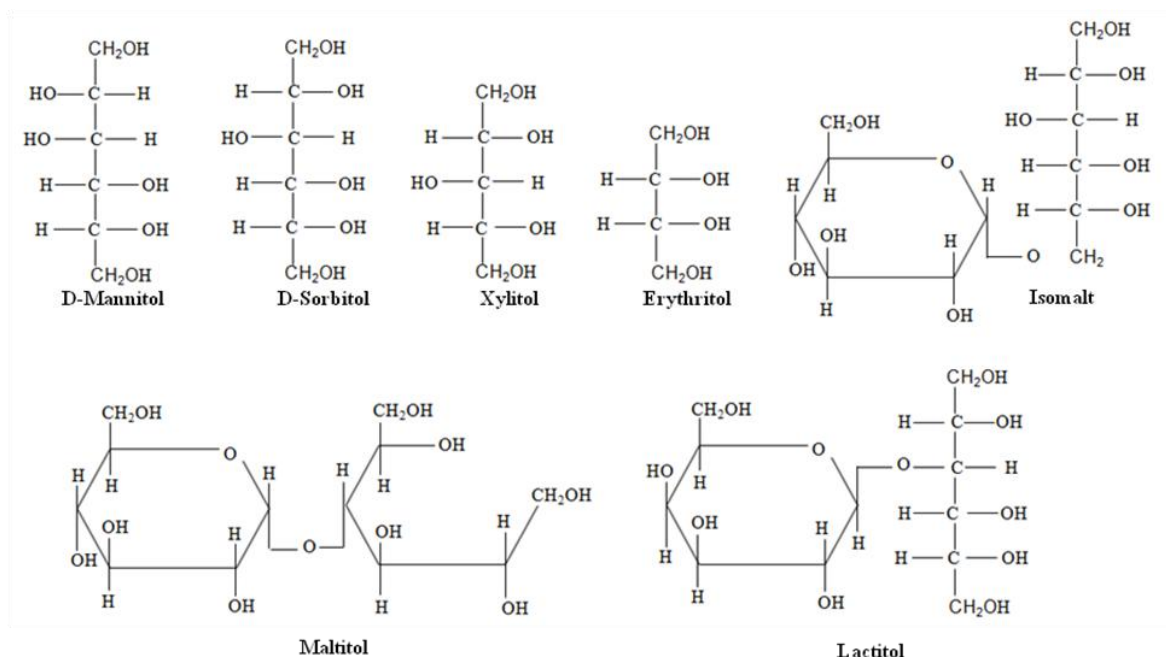


Fig 3: Sugar alcohols: Low calorie sweeteners

4.1. Types of sugar alcohols

- **Mannitol** is present naturally in pineapples, olives, asparagus, sweet potatoes, carrots and seaweed. It is 50-70 % sweet as compared to sucrose and more amounts must be added to deliver similar sweetness. Mannitol remains in the intestines for a long time and may cause bloating or even diarrhoea (Kearsley and Deis, 2006).
- **Sorbitol** occurs naturally in fruits and vegetables. It is only 50-70 percent sweet as compared to sucrose (Kearsley and Deis, 2006). It has a lower tendency to cause diarrhoea as compared to mannitol.
- **Erythritol** also occurs naturally in fruits, certain mushrooms and other fungi, wine and soy sauce. It has 60-80 percent of sweetness of sugar and has a cooling effect in mouth. It is used in baking, where it also has tenderizing effects of sugar.
- **Xylitol** (wood sugar) is present naturally in straw, corncobs, fruit, vegetables, cereals and mushrooms. It has same relative sweetness as sucrose.
- **Lactitol** is often used in sugar-free products. Although it is only 30-40 percent sweet as compared to sucrose but has similar taste and solubility profile.
- **Isomalt** is 45-65 percent as sweet as sucrose and is heat resistant. It absorbs very little water and hence used in hard candies, toffee, cough drops and lollipops.
- **Maltitol** is used in sugar-free candies, chewing gum, chocolate-flavored desserts, baked foods and ice cream because it gives a creamy texture. It is 75 % as sweet as sucrose.

- **Hydrogenated starch hydrolysates (HSH)** are manufactured by partial hydrolysis of corn. It provides only 25-50 percent sweetness of sucrose.

Table 1: Low Calorie sugar alcohols and their properties

Type	Calories per gram	Sweetness (sucrose =100%)	Food Applications
Sorbitol	2.6	50 - 70%	Sugar-free candies, chewing gums baked foods, frozen desserts
Xylitol	2.4	100%	Chewing gum, hard candy, toothpastes, mouthwashes, throat lozenges, cough syrups, chewable multivitamins
Maltitol	2.1	75%	Hard candies, chewing gum, chocolates, baked goods and ice cream
Isomalt	2.0	45 - 65%	Candies, toffee, lollipops, wafers, cough drops, throat lozenges
Lactitol	2.0	30 - 40%	Chocolate, cookies and cakes, hard and soft candy, frozen dairy desserts
Mannitol	1.6	50 - 70%	Dusting powder for chewing gum, ice cream and confections
Erythritol	0 - 0.2	60 - 80%	Bulk sweetener in low calorie foods
Hydrogenated Starch Hydrolysates (HSH)	3	25 - 50%	Mouthwashes, Bulk sweetener in baked foods, confections

5.0. Artificial Sweetener: No calorie sweeteners

Artificial sweeteners are not sugars but chemically-different substances which have a sweet taste (Lyn, 2011). These do not occur naturally but are synthesized in laboratories and are considered as "sugar free foods". These have generally little to no calories or other nutrients and used as lower-calorie substitutes for sugar (Mattes and Popkin, 2009). These do not raise the blood sugar levels and are considered boon for diabetic patients (Mattes and Popkin, 2009). Common examples of artificial sugars are "Aspartame", "Sucralose", Neotame, Sucralose (Butchko et al., 2002) (Daniel et al., 2000) (Fig. 4).

5.1. Types of Artificial Sweeteners for Diabetic Patients

International Council of Dietary Association has approved some of the artificial sweeteners for diabetic patients which are also safe for general public. Following are some of the commonly used artificial sweeteners (Table 2).

- **Saccharin** is the oldest known artificial sweeteners and about 300 times more sweet than table sugar. It is available as "calcium saccharin", "sodium saccharin" and "acid saccharin." Common brand under which it is sold are "Sweet 'N Low", "Sweet Twin" and "Necta Sweet". One-gram of any brand include dextrose, 3.6% sodium saccharin and calcium silicate (an anti-caking agent). It is used in beverages and

tabletop products. It should be avoided during pregnancy or breastfeeding. It is now banned in major part of the world as sodium saccharin is found to be carcinogenic.

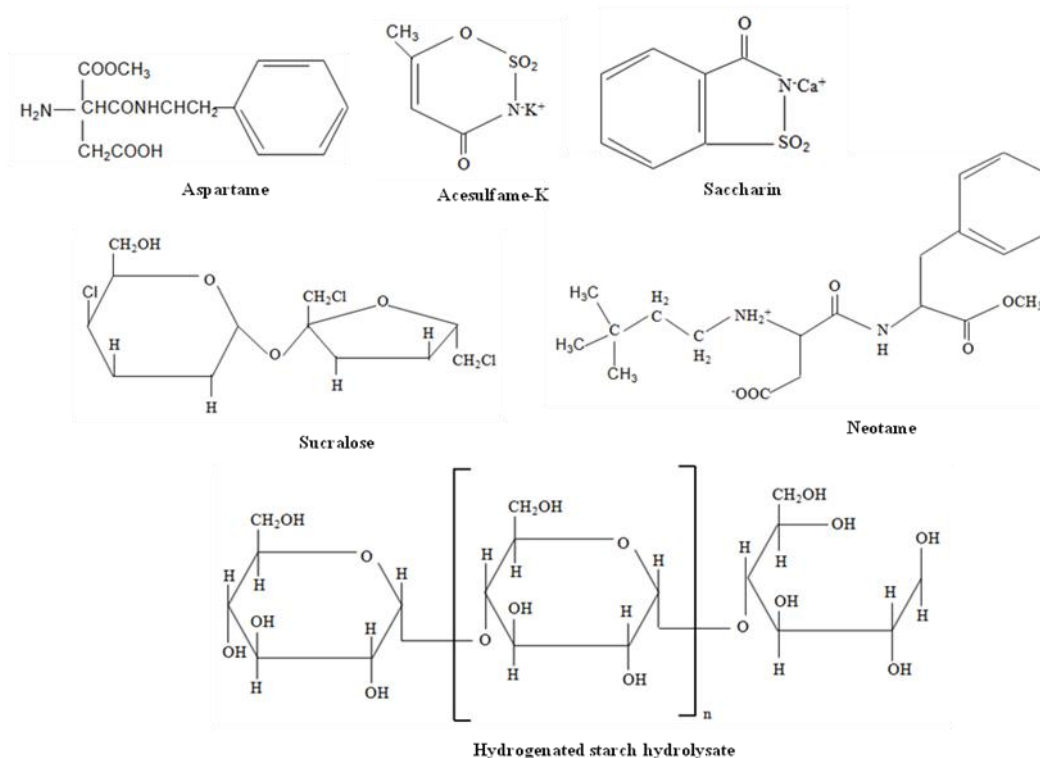


Fig 4: Commonly used artificial sweeteners

- **Aspartame** is now most common in use and available under brands NutraSweet, Equal and Sugar Twin. It is broken down by the body into two amino acids – aspartic acid and phenylalanine – and methanol. Since it is unstable at higher temperature and loses its sweetness, its use is limited in baked goods and some dry dessert mixes. It is not advisable for use by patients of “phenylketonuria”, a rare genetic disorder due to the presence of phenylalanine (Magnuson et al., 2007).
- **Acesulfame Potassium or acesulfame-K** is sold as Sweet One, Swiss Sweet, and Sunett. Because of its stability at temperature up to 400°F, it can be used in both cold and hot foods including baking. It is about 200 times sweeter than sugar but has no calories because it is not metabolized by the body. Acesulfame K is commonly blended with other nutritive and artificial sweeteners (Haber *et al.*, 2006).
- **Sucralose** is marketed under the brand name “Splenda”. It is made from sucrose by a multi-step manufacturing process that selectively replaces three hydroxyl groups with chlorine atoms (Daniel et al., 2000). This modification makes sucralose 600 times sweeter than sugar. It is preferred by food manufacturers because of its heat stability and can be used in hot and cold foods (Grotz and Munro, 2009).

- **Neotame** is one of the newer artificial sweeteners approved for use in 2002, manufactured by “NutraSweet”. Neotame is about 8,000 times more sweet than sucrose, and is used as a sweetener as well as a "flavor enhancer”.

Table 2: Artificial sweeteners and their properties

Artificial sugars	Trade names	Source	Sweetness (compared to sucrose)	Side effects	Cost (US \$ per Kg)
Aspartame	Equal, NutraSweet, Sugar Twin	Drinks, Dry dessert mixes, gum, yogurt, cough drops, beverages	180 times	Headaches, anxiety, memory loss, nausea, depression, heart palpitations, IBR, neurological disorders, Obesity	1-2
Acesulfame-K	Sunett, Sweet One, Swiss Sweet	Soft drinks, gelatins, chewing gum, frozen desserts, candies, Pharmaceutical products	200 times	Nausea, headaches, impairment of liver; kidneys, eyesight problems and possibly cancer, hypoglycemia	5-10
Sucralose	Splenda	Fruit drinks, canned fruit, syrups, baked products	600 times	Head and muscle aches, stomach cramps, diarrhea, skin irritation, dizziness, inflammation.	23-35
Saccharin	Sweet 'N Low, Sweet Twin, Necta Sweet	Canned foods, Candies, beverages	300 times	sulfa allergies, nausea, diarrhea, skin problems, allergy-related symptoms	6-7
Neotame	NutraSweet	Drinks, canned goods, low carb breads, tea mixes, stored juices, candies	8000 times	Similar to aspartame, Headaches, anxiety, memory loss, depression, heart palpitations, IBR, neurological disorders, Obesity	80-85

6.0. Too much sugar is NOT sweet for health

It is important to be aware of the amount of sugar consumed because our bodies do not need extra sugars. Added sugars lack any nutrient but contains many extra calories that can lead to extra pounds or even obesity. Major foods containing added sugars includes soft drinks,

candies, cakes, cookies, pies and fruit drinks (fruitades and fruit punch) dairy products (ice cream, sweetened yogurt and sweetened milk) and other grains like cinnamon toast and honey-nut waffles (Lindsay and Andrew, 2012).

6.1. How to spot extra sugar on food labels?

Although Nutrition Facts panel of any product mentions about sugars as total grams/or percentage per serving but lacks a separate list of amount of added and naturally occurring sugar. Our body does not distinguish between natural or added sugars. Food makers can also use sweeteners that are not technically sugar (table sugar, or sucrose) but are forms of added sugar (Marcason, 2004). Sugar usually has names ending in “ose,” such as maltose or sucrose but other names include corn sweetener, corn syrup, cane sugar, molasses, raw sugar, fruit juice concentrates or honey. Usually sugar contains four calories per gram, so if a product has 15 grams of sugar per serving that has 60 calories from the sugar alone, not counting the other ingredients. The presence of sugar in the sweetened products can be identified by the following ways.

- **No sugar** means the product does not contain natural sugar but may contain sugar alcohols or artificial sweeteners.
- **No added sugar** means that extra sugar has not been added during processing but the food source might have sugar. Also it may contain artificial sweeteners or sugar alcohols.
- **Sugar free** means that the product contains no sugars. However, it may contain sugar alcohols or artificial sweeteners.
- **Dietetic** means that the product has low calories content.
- **All natural** means that the product does not contain any artificial ingredient but may have natural sugars and/or sugar alcohol.

7.0. Glycemic index and its significance

Glycemic index (GI) is a tool to decide which carbohydrate food should be included in diet. It ranks carbohydrates by amount and speed at which they raise blood sugar levels. It measures glycemic response per gram of carbohydrate contained in a food, not per gram of the food. GI is about the *quality* of carbohydrates, not the *quantity*. Reference foods are evaluated against glucose (Sometimes with white bread) by comparing the rate and extent to which 50 grams of test food was absorbed and converted to glucose with the rate for 50 grams of pure glucose (Brouns et al., 2005). Lower the GI, slower the

absorption, which means a more gradual and healthier infusion of sugars into bloodstream (Teff, 2005). High GI causes blood-glucose levels to increase quickly and stimulates pancreas to release insulin to keep blood-sugar at a safe level. This inhibits the release of growth promoting hormones, which subsequently suppresses the immune system. Secreted insulin also promotes the storage of fat causing obesity and cardiovascular diseases (Itam et al., 2012).

GI of food also depends on the size of starch and cooking method employed. Smaller the particle size, greater is the glycemic effect (Jenkins *et al.*, 1981). Foods cooked by dry and short-time methods like roasting have a lower GI, as compared to the foods cooked by long cooking processes. Complex carbohydrates such as fruits and vegetables are absorbed more slowly and have less impact on blood-sugar levels (Jenkins, *et al.*, 1981). GI is of special significance to diabetic people. Studies show that honey has a lower GI than table sugar and is a steadier source of energy. It is free from fat and cholesterol and is a probiotic, anti-inflammatory and antibacterial agent. Raw honey is kept at room temperature to retain the nutritional value. Refined honey is excessively filtered which destroys some of the valuable nutrients. High fibre containing foods have a lower to medium GI. Eating low GI foods help to control blood sugar and cholesterol levels, lower the risk of heart disease and type 2 diabetes (Ludwig, 2002). Most healthcare organizations use a "high (> 70)," medium (60-70)" and "low (< 50)" rating system for GI.

7.1. Difference between glycemic index and glycemic load

Major drawback of GI is that it does not take serving size into account. Glycemic load (GL) is one of the most important extensions of GI and a similar concept as the GI except it takes serving sizes into consideration. GL of a particular food is the product of its glycemic index and the amount (in grams) of carbohydrate present in a serving of the food divided by 100. A diet with a low glycemic load has been linked to a lower risk of heart disease. If a food has a low GL, it almost surely has a low glycemic index. Table 3 includes the Glycemic index and Glycemic loads of some common food items (Kaye et al., 2002). Widely accepted rating system for GL is as follows: "high GI (> 20)," medium GI (11-19)" and "low GI (< 10)" (Fiona et al., 2008).

Table 3: Glycemic index (GI) and Glycemic load (GL) of common foods.

Food	GI	Serving Size	GL
Glucose	100	50g	50
Cereals and Legumes			
Brown rice	55	200g	23
White rice	64	186g	33
Barley	48	150g	16
Oatmeal	55	250g	13
Maize chapatti	59	30g	8
Soya beans	16	150g	1
Mung bean	40	150g	7
Chickpeas	10	150g	3
Kidney beans	30	150g	7
Lentils	30	150g	5
Bean sprouts	25	100g	1
Black gram	43	150g	8
Fruits and Vegetables			
Orange	48	131g, 1 Large	6
Banana	50	120g, 1 Large	11
Papaya	58	120	5
Pineapple	70	120g	6
Grapefruit	25	166g	3
Watermelon	72	120g	4
Apple	40	120g	6
Grapes	43	120g	7
Mango (ripe)	62	120g	9
Peach	28	120g	4
Pear	33	120g	4
Plum	24	120g	3
Pea, green	54	80g	4
Pumpkin	65	80g	12
Carrots, raw	35	80g	2
1 Boiled potato	78	150g	20
Sweet potato	77	150g	16
Carrots	47	1 large (72g)	2
Tomato	38	125g	1.5

Food	GI	Serving Size	GL
Glucose	100	50g	50
Fast foods			
Spaghetti	42	140g, 1cup	16
Potato chips	54	114g, 4 oz	30
Snickers Bar	55	113g, 1bar	35
Macaroni with cheese	64	166g	30
Soft drinks	53	250ml	16
Hamburger	66	95g	17
Pizza	40	100g	9
Pasta	54	180g	24
Dark Chocolate	25	50g	6
Potato crisps	51	50g	12
Popcorn	55	20g	6
Milk and milk products			
Milk (Full Fat)	41	250ml	5
Milk (Skim)	32	250ml	4
Yoghurt	36	200g	3
Ice-cream	57	50g	6
Nuts			
Peanuts	7	50g	0
Apricots	31	60g	7
Raisins	65	60g	28
Cashew-nuts	25	50g	3
Dates (dried)	42	60g	18
Miscellaneous			
Honey	55	21g, 1tbs	9
Sugar (sucrose)	68	12g, 1tbs	8
White bread	70	30g, 1slice	10
Coarse-oat kernel bread	65	30g	12
Special K Kellogg's	69	30g	14
Cornflakes	86	30g	22
Wheat Bread	70	28g, 1slice	8
Sweet-corn (boiled)	48	150g	14
Millet porridge	62	150g	22
Muesli	66	30g	16

7.2. Tips to reduce sugar in diet

- Cut back on the amount of added sugar in food or drink regularly or consider using an artificial sweetener.
- Prefer fresh fruits and avoid fruit canned in syrup.
- Fresh fruit (bananas, cherries or strawberries) or dried fruit (raisins, cranberries or apricots) should be added to breakfast cereals in place of sugar.

- While baking cookies, brownies or cakes, cut the sugar mentioned in the recipe by one-third to one-half. Often it causes no remarkable difference in taste.
- Extracts such as vanilla, orange or lemon can be used in place of sugar in recipes.
- Enhance the taste of foods with spices like ginger, cinnamon etc instead of sugar.
- Substitute unsweetened apple sauce in equal amounts for sugar in recipes.
- Non-nutritive sugar substitutes like aspartame, sucralose or saccharin can be used which may be a way to satisfy the sweet tooth without adding more calories to diet.

8.0 Conclusion

Sugars are one of the major components of our diet but if taken in an inappropriate amount may lead to wide variety of disorders including diabetes, cardiovascular disorders, weight gain. Natural and added sugars are high in calories and may cause rise in blood sugar levels. Artificial sweeteners are no calorie synthetic sugars and are considered as boon to diabetes patients but have a numbers of side effects. Glycemic index, which explains how much a given food affects blood-glucose levels, is a useful tool to choose the type of food in diet. Glycemic load is a similar concept which also takes serving sizes into consideration. Eating foods with a low glycemic index and glycemic load may help to control blood sugar levels, blood cholesterol levels, heart disease and type 2 diabetes.

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