Sugar Substitutes and Artificial Sweeteners

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Table sugar (sucrose) is prepared by fermentation of the sugarcane juice and each teaspoon gives 4 grams of sugar and 16 calories. It can raise the blood sugar varying by 10 to 20mg depending on the body weight and requires 0.5 units of insulin to be metabolized. The average daily intake of sugar by an individual is about 30 grams coming to a total sugar consumption of about 750 kg throughout life. Sugar has bad effects on general health with a potential role in obesity, diabetes, heart disease and possibly cancer¹. As per WHO, the daily consumption of sugars should amount to 5% of the total daily intake for proper health.

With diabetes reigning as the commonest metabolic and lifestyle disease, patients reluctantly avoid table sugar/sugar rich foods. But the lure for sweetness makes patients to ask for sugar substitutes. More over obese and overweight individuals may come up with queries regarding sugar substitutes. Sugar substitutes or artificial sweeteners are used to sweeten foods and beverages instead of table sugar and contain either no or relatively less energy (either zero calorie or low calories). Different types of sugar substitutes are available². Some sugar substitutes are natural and some are synthetic. Those that are not natural are, in general, referred to as artificial sweeteners².

Chemically sugars are simple monosaccharide (glucose, fructose and galactose) and complex disaccharide (sucrose,

maltose, lactose). Fructose is a natural sugar substance which is different from glucose in that it causes only a modest rise in blood glucose levels, does not require insulin for metabolism. However the problem of ingesting large quantity of fructose is a rise in cholesterol and triglycerides. Table sugar contains sucrose which is a combination of glucose and fructose. Lactose is naturally occurring sugar found in milk. Some substances may have sugary taste (glycerol and sugar alcohols) but are not included in group sugars.

A **sugar substitute**/artificial sweetener may be derived through manufacturing of plant extracts (sorbitol, xylitol and lactitol) or processed by chemical synthesis³. As it is not commercially feasible to extract these products from fruits and vegetables they are produced from catalytic hydrogenation of corresponding sugar (xylose to xylitol, lactose to lactitol glucose to sorbitol, isomaltose to maltitol) to form sugar alcohols. These are less sweet than sucrose and are commonly used as sweeteners and bulking agents. Their absorption is limited and as such do not raise blood sugar level if used in moderation⁴. To enhance their sweetness these alcohols are mixed with artificial sweetener

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and are used in products labeled as sugar free (chewing gum, ice creams, candy, cough lozenges).

Six safe sugar substitutes produced chemically have been approved for human consumption - aspartame, acesulfame, sucralose, neotame, saccharin and advantame. Moreover 2 plant based sweeteners from Stevia leaves (contain steviol glycosides) and from monk fruit extract are also approved.

Aspartame, a low calorie sweetener, contains two major amino acids, aspartic acid and phenylalanine, is 200 times sweeter than sucrose. It is not heat stable, once cooked or stored at high temperatures it breaks down into its constituent amino acids and hence cannot be used in baking and cooking. It finds its use in a range of foods including tabletop sweeteners, carbonated soft drinks, yoghurt and confectionery. The current weight of evidence is that aspartame is safe at current levels of consumption as a nonnutritive sweetener^{5,6,7}.

Acesulfame potassium is a non-caloric sweetener with a clean, quickly perceptible sweet taste. It is an odorless white powder, stable under high temperatures and has good solubility, allowing it to be used as a food additive in baking or in products that require a long shelf life. It is 200 times as sweet as sugar and is used as a tabletop sweetener, in frozen desserts, beverages, chewing gum, protein shakes and pharmaceutical products, especially chewable and liquid medications, where it can make the active ingredients more palatable.

Sucralose (commonly used) is the only non-caloric sweetener made from sugar and considered zero-calorie sugar substitute. It is a chlorinated sugar that is about 600 times as sweet as sugar. It is produced from sucrose when three chlorine atoms replace three hydroxyl groups. Its unique combination of sugar-like taste and excellent stability allow sucralose to be used as a replacement for sugar in virtually every type of food (about 4,000 food products) and beverages, frozen desserts, chewing gum, baked goods, and other foods. Unlike other artificial sweeteners, it is stable when heated and can therefore be used in baked and fried goods. Sucralose is minimally absorbed by the body and most of it passes out of the body

unchanged⁸.

Neotame is a no-calorie sweetener, which is a derivative of the dipeptide composed of the amino acids, aspartic acid and phenylalanine. Neotame is about 8,000 times sweeter than table sugar and 40 times sweeter than aspartame. Neotame is chemically related to aspartame, but it is more stable, enabling the new sweetener to be used in baked foods. It is used mostly in low-calorie foods, but may also be used as a flavoring agent in other foods, but is still rarely used.

Saccharin, rebianado not raise the blood glucose levels and are heat stable, can be used for baking and cooking purposes. Saccharin has been used as a non-caloric sweetener in foods and beverages for more than 100 years. Saccharin and acesulfame have a slight bitter after taste at high concentration hence blended with other sweeteners sweetener such as aspartame or sucralose. Stevia is derived from Stevia rebaudiana, a South American plant, and it has been used for centuries to sweeten beverages and make tea in Paraguay⁹. Stevia has no calories.

Sweetness intensity of an artificial sweetener compared to table sugar is called as multiplier of sweetness intensity (MSI) while as acceptable daily intake (ADI) is the amount that can be safely taken each day (measured in mg per kg of body weight per day). The commercially available artificial sweeteners are along with their MSI and ADI are represented in Table 1.

Artificial sweeteners have been in use for more than 2 decades and it has been scientifically established that they can be used as a safe alternative to sugar if used in moderation (within ADI). They have not been shown to increase risk of other diseases and their carcinogenic potential has not been documented in humans. So it can be safely said as of today these products are neither unsafe or have any improved health. But theoretically proper use of non-nutritive sweeteners could help reduce added sugars in diet, therefore lowering the number of calories and thus help attain and maintain a healthy body weight, thereby lower risk of heart disease and diabetes¹⁰.

Table 1. Artificial Sugar Substitutes

Sugar	Trade name	MSI*	ADI (mg/kg)**	Calories/gram
Acesulfame	Sweet one, Sunett	200	15	0
Advantame		20,000	32	0
Aspartame	Equal, Nutra sweet Sugar free Gold	160-200	50	3.6
Neotame		7000-13000	18	0
Saccharin	Sweet'n low, Sugar twin	200-700	5	0
Sucralose	Splenda Sugar free Natura	600	5	3.3
Stevia	Truvia, Purevia Sugar free Green	200-300	3.5	0
Sugar Alcohols (Xylitol)	Xylosweet	0.4	4	2.4

* Multiplier of sweetness intensity

** Acceptable daily intake

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