Ecofarming (e-Magazine)

Agriculture

Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

The Sugar Shift

Unlocking the Role of Artificial Sweeteners

Nisha Rani, Keerti Dhanda, Reena Chauhan, Sushil Ahlawat, S.G. Sarowar[1]
Department of Chemistry, CCS HAU, Hisar
[1]ICAR-Indian Agricultural Research Institute, New Delhi

Received: April, 2025; Accepted: May, 2025; Published: July, 2025

Carbohydrates or carbs is a complex macronutrient vital for a living body as it provide us energy commonly present in whole grains, fruits, potatoes including sugar. Sugar is a broad term encompassing various types of simple carbohydrates, with sucrose commonly known as white table sugar being the most prevalent. Consuming too much of table sugar has no nutritional benefits instead it may cause many health problems *viz.*, raise in blood sugar level, insulin resistance, metabolic syndrome, tooth decay or cavities, increased triglycerides, obesity.

All over the world overweight/obesity is a major issue, which may cause heart diseases, diabetes (II), problem in body movements etc. As per reports people are now conscious about their health and fitness, for this, they are making efforts by involving in different types physical activities like exercises or yoga. But alone exercise/yoga is not sufficient to control the problem of overweight therefore a good diet plan becomes compulsory for those who wants to lose their weight and stay healthy. A good diet should contain nutrients in sufficient amount for the proper functioning of body organs but at the same time they shouldn't be cause overweight. Those who are fond of eating sweets, wants replacement of sugar that's taste sweet but don't contain sugar which low in calories of may be calories free. In this article we are going to discuss about artificial sweeteners. Artificial sweeteners or non-nutritional sweeteners (NNSs), have varied chemical structures and they are the compounds of heterogeneous class. Being low in calories there is an exponential increase in their use over the time as a substitute of sugar in foods and beverages.

Types of artificial sweeteners

The first artificial sweetener i.e. saccharin was discovered by scientist Constantin Fahlberg in year 1879. Sweeteners are categorized as caloric (nutritional) and non-caloric (non-nutritional) sweeteners. Sugar and sugar alcohol come under nutritional sweeteners *per se* sorbitol, erythritol, xylitol, maltitol, reducing starch syrup *etc.*, having calorific value of sucrose above 2% per equivalent unit of sweetening capacity. Non-nutritional sweeteners (NNS) have below 2% of the calorific value of sucrose per equivalent unit of sweetening capacity. NNS are much popularized as an alternate source of sugars with low caloric content and high sweetness. They are further categorized as artificial sweeteners and natural sweeteners. Artificial sweeteners are synthesized in the laboratory namely sucralose, neotame, acesulfame-k, saccharin *etc* whereas natural sweeteners are extracted directly from the plant's *viz*., stevia, hoodia, agaves, and Luo Han Guo Monk fruit extracts. Some of the important artificial sweeteners are enlisted in Table1.

Table 1. Artificial sweeteners and their properties

Sweetener	Molecular formula	Solubility (in water)	Effect of temperature	Acceptable levels intake by an individual per day in mg/kg of body weight	Class
Acesulfame—k (Ace-k)	$C_4H_4KNO_4S$	Highly soluble	Thermally stable	15	Non nutritional
Sucralose	$C_{12}H_{19}Cl_3O_8$	Highly soluble	Thermally stable	5	Non-nutritional
Saccharin	$C_7H_5NO_3S$	Sparingly soluble	Thermally stable	5	Non-nutritional
Neotame	$C_{20}H_{30}N_2O_5$	Slightly soluble	Thermally stable	0.3	Non-nutritional
Cyclamate	$C_6H_{12}NNaO_3S$	Highly soluble	Thermally stable	11	Non-nutritional
Aspartame	$C_{14}H_{18}N_2O_5$	Slightly soluble	Thermally unstable	50	Non-nutritional
Advantame	$C_{24}H_{30}N_2O_7$	Slightly soluble	Thermally stable	32.8	Non-nutritional
Xylitol	$C_5H_{12}O_5$	Highly soluble	Thermally stable	-	Nutritional
D-allose	$C_6H_{12}O_6$	Readily soluble	Thermally stable	-	Nutritional
Erythritol	$C_4H_{10}O_4$	freely soluble	Thermally stable	-	Nutritional

- **Acesulfame—k:** This sweetener was developed by Hoechst in the year 1967 accidentally. Acesulfame is the potassium salt of 6-methyl-1,2,3-axathiazine-4 (3H)-one 2,2-dioxide, molecular weight 201.24 g/mol and molecular formula $C_4H_4KNO_4S$. It is 120 times sweeter in compared to sucrose, greater solubility in water, crystalline in nature, white in colour and heat resistant or stable at high temperature, therefore used in baking and cooking. To enhance the sweetness of some of the sweeteners like sucralose or aspartame, Ace-k is sometimes mixed with them.
- **Sucralose:** Sucralose was developed by Shashikant Phadnis in 1976. It was an accidental discovery during research on sucrose. Sucralose tastes sweet and is around 450-650 times sweeter than sucrose. Its quality is also similar to that of sucrose. It shows a moderate synergistic effect with other sweeteners. It has high solubility in water and it can withstand a broad range of pH and temperatures. At high temperature it liberates HCl and shows some kind of discoloration.
- **Saccharin:** Remson and Fahlberg discovered Saccharin as a sweetener in 1878 at the Johns Hopkings University, Baltimore. It is a sweetener of 1,2-benzoisothiazol-3-(2H) on 1,1 dioxides which falls under non-nutritional class. The flavour of saccharin is displeasing; it's metallic or bitter. The sweetener is often employed as the calcium or sodium salt because the parent ingredient is only weakly soluble in water but both salts dissolve well in water. Compared to sucrose, it is roughly 300 times sweeter.
- **Cyclamate:** Cyclamate was discovered by Michael Sveda in 1937. It was used as a low-calorie sweetener in the United States

in 1950s and 1960s. It is a salt of cyclohexyl sulfamic acid. Sodium cyclamate is used as non- nutritive sweetener and the analogous calcium salt used specially in low sodium diets. Cyclamate is 30 times sweeter than sucrose. It tastes somewhat bitter but works as a good synergist with saccharin so as to provide sweetness. It dissolves in water and can be made more soluble by making a calcium or sodium salt (Bopp et al. 1986).

- **Neotame:** Neotame is derived from a dipeptide molecule that contains the amino acids phenylalanine and aspartic acid. Neotame, which is produced by N-alkylating aspartame, is a sweetener with a high degree of sweetness. Level of sweetness is basically determined by combination of neotame with another sweetener. It is around 30 to 60 times sweeter than aspartame and 7000 to 13,000 times sweeter than sugar. Neotame is a white to grey-white powder that has a high sweetness and no smell. It dissolves easily in alcohols and just negligibly in water. Neotame's 0.5% aqueous solution has a pH of 5.8, which is somewhat acidic.
- **Xylitol:** Xylitol is a sugar that occurs naturally. It is a sugar alcohol with five carbons, which can be produced artificially or naturally. It is mostly made chemically from plant materials or by using yeast or bacterial strains to ferment the hemicelluloses found in agricultural biomass. This polyol is used as a dental caries preventive because it has a strong antiplaque action on the surface of teeth and can lessen gingival irritation. Xylitol has the ability to bond with calcium ions, which remineralizes tooth enamel and prevents osteoporosis.
- **D-allose:** A cis-aldohexose with high antioxidant qualities, D-allose is a non-caloric sweetener and bulking agent. D-allose is an uncommon monosaccharide that is hardly ever found in nature with an 80% sweetness level compared to table sugar, D-allose is a perfect substitute for table sugar in food products because it is extremely low in calories and non-toxic. In a variety of domains, such as food systems, clinical therapy, and the medical profession, it exhibits distinct physiological functions and health benefits. Additionally, D-allose is employed as a possible inhibitor of other glycosides.
- **Erythritol:** Erythritol, often known as polyol, is a sugar alcohol with four carbons. About 60–80% of its sweetness comes from sucrose. Low-digestible carbohydrates called polyols are not well absorbed from the small intestine because unabsorbed polyol raises the gut lumen's osmotic potential and has other gastrointestinal effects, excessive intake produces a laxative effect. Erythritol is thought to be non-toxic. Human studies have demonstrated that erythritol taken in food is absorbed from the small intestine and eliminated in the urine.

Pros of Artificial Sweeteners

Artificial sweeteners (AS) have emerged as broadly beneficial agents in the realm of nutritional science, offering viable strategies for reducing caloric intake without sacrificing palatability and many more benefits as listed below:

- **Prevention of Tooth Decay:** Artificial sweeteners seem to be useful in preventing tooth decay as it shows antimicrobial activity on dental bacteria. Therefore, the use of artificial sweeteners in foods, beverages, and personal care products containing aspartame, saccharin, and sucralose in considered amount helps in protecting against the development of caries and tooth decay. Furthermore, toothpaste containing both fluoride and xylitol proved to be more efficient at preventing tooth decay in kids with permanent dentition than toothpaste containing just fluoride.

- **Weight Reduction and Obesity Management:** Non-nutritive sweeteners (NNSs) are primarily used to induce an energy deficit by replacing sugar without contributing calories from additional sources like snacks. Evidence from randomized controlled trials (RCTs) suggests that individuals consuming Stevia maintained stable body weight compared to those in the placebo group, who experienced significant weight gain. Moreover, a meta-analysis encompassing 20 studies reported that NNS consumption led to lower body weight relative to sucrose intake, though no significant difference was observed when compared to water or placebo. Interestingly, artificial sweeteners (AS) appear to be particularly effective in adolescents with the highest body mass index (BMI), indicating a potential targeted benefit in this subgroup.
- **Prevention of Reactive Hypoglycaemia in T2DM:** Sweet-tasting sugars, even before they are consumed, cause physiological reactions linked to the release of gastric inhibitory polypeptide (GIP), a gastrointestinal hormone produced by the small intestine that encourages the secretion of insulin. However, artificial sweeteners do not trigger these hormones and therefore are not able to prepare the digestive tract for digestion and utilization of nutrients the same way as sugars. Accordingly, research shown that AS consumption has no impact on insulin levels in people who are healthy, diabetic, overweight, or obese. Thus, NNSs consumption is not associated with after meal reactive hypoglycaemia**.**

Cons of Artificial Sweeteners

Artificial sweeteners, though widely adopted for their perceived health benefits, have also drawn attention for their potential adverse effects as given

- **NNS use and Cancer risk:** Various investigations have been carried out to evaluate the possible connection between AS and the risk of cancer. A link between AS and bladder cancer was shown in a 1977 study, which was one of the first to raise concerns about AS. Showed that in a case-control study, there was a 1.6 risk ratio for every user of AS to develop bladder cancer compared to individuals who had never used these sweeteners. In another observational study, only frequent consumption of artificially sweetened beverages in postmenopausal women (i.e., more than one drink per day) may be associated with a higher risk of kidney cancer.
- **NNS use and Gut Microbiota:** Consuming artificial sweeteners disrupts the gut microbiota, which can result in prediabetic disorders resulting, diabetic patients are now reconsidering their use of NNSs. There are so still unresolved problems raised by the debate over the advantages and disadvantages of NNSs for public health.
- **Issues related to Gastrointestinal Tract:** Gastrointestinal tract problems are another worry with the use of artificial sweeteners. As per study consuming more AS may cause bloating and irregular bowel movement, may decrease the beneficial microorganisms and leads to Non-alcoholic fatty liver disease (NAFLD).

Conclusion

The number of individuals affected by diabetes, obesity, hypertension, and cardiovascular disease continues to rise globally, highlighting the critical need for effective dietary strategies. Concerns over the health impacts of the rising sugar content in foods, candies, soft drinks, and other items have been raised. Therefore, artificial sweeteners are getting a lot more attention these days**.** Considering the widespread use of NNSs in modern nutrition, it is important for healthcare workers to learn about their benefits and give patients

personalized advice on the right sweetener choice based on its safety and expected benefits.

Non-nutritive sweeteners help with weight loss, diabetes control, flavour enhancement, and tooth decay prevention, among other positive outcomes. However, they can cause a number of negative health effects, including hepatotoxicity, NAFLD, metabolic diseases, and carcinogenicity**.** Despite these concerns, FDA's research has shown that the majority of artificial sweeteners do not provide a greater risk to human health, which has greatly boosted their use. Mostly are used for baking and cooking purposes, particularly those that can tolerate high temperatures. However, additional research is required to guarantee human safety as production and use rise.