



## ARTIFICIAL SWEETENERS – A REVIEW

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**ABSTRACT:** The study provides an overview of types of artificial sweeteners, sweeteners history, chemical structure, biological fate, physiological effects. At present the sugar free foods are very much popular because of their less calorie content. So the food industry uses various artificial sweeteners which are low in calorie instead of high calorie sugar. A sweet taste is innate and sweeteners can increase the preference and pleasure of eating.

Nutritive sweeteners contain carbohydrates and provide energy. They occur in natural food (or) maybe added in food processing (or) by consumers before consumptions. Non-nutritive sweeteners, substituted in nutritive sweeteners may help consumers limit energy and carbohydrate intake as a strategy to manage blood glucose (or) weight. Artificial sweeteners are intensity sweets so small amount are required to imitate sugar's sweet taste.

**Keywords:** sugar substitutes, diet beverages, sugar alcohol, saccharin, sucralose, low calories.

**Introduction:** Artificial sweeteners are synthetic sugar substitutes. But they may be derived from naturally occurring substances, such as herbs (or) sugar itself. Artificial sweeteners are also known as intense sweeteners because they are many times sweeter than sugar. Artificial sweeteners can have alternative to sugar because they add virtually no calories to our diet, when compared with the amount of sugar we generally use.

Artificial sweeteners and other sugar substitutes are found in a variety of food and beverages marketed as "sugar free" "diet". Artificial sweeteners are a type of intense sweeteners and also popular for home use, even can be used in cooking (or) baking, soft drinks and ice creams. Certain recipes may need ingredients modification because unlike sugar artificial sweeteners provides no bulk (or) volume. There one has to check the labels for appropriate quantity. These sweeteners are intended for health purpose as they are from 200 to 400 times sweeter than sugar.

Which means a very small amount is needed to add sweetness and they don't have calories (or) affect blood sugar levels. Many dieters use artificial sweeteners and artificially sweetened foods as a way to cut sugar without reducing all things. Artificial sweeteners are a type sugar substitutes which means any sweetness used instead of normal sugar. These are synthetic substitutes but can also be made from some natural herbs.

Aspartame, saccharin, sucralose, etc. are some of the examples of artificial sweeteners. Nowadays the lifestyle and eating habits led to change on increase in obesity with the world health organization reporting 12% of the adult population being obese (WHO, 2012). Recently, the reduced calorific value of high sugar food products have resulted in food manufacturers replace sugar with a range of products including natural sweeteners. It is significant that these products may offer sweetness greater than that of sugar but may not provide any of the technical functions of sugar and vice-versa. Artificial sweeteners are mainly used in processed foods including: canned foods, dairy products, puddings, baked goods, jams and jellies, candy, soft drinks, powdered drinks mixes and other beverages.

## Uses of sugar alcohols:

Generally sugar alcohols are not used when we use to prepare food at home. But they are in many processed foods and other products including chocolate, chewing gum and toothpaste candy, chicky etc. Sugar alcohols add bulk sweetness and texture to the food. Sugar alcohols are often mixed with artificial sweeteners to increase the sweetness. Food labels may use the general term "sugar alcohol" or list the specific name such as sorbitol.

Artificial sweeteners are mainly used for special situations like:

### I. Managed sugar level and diabetes:

unlike sugar artificial sweeteners generally don't raise blood sugar levels, because they are not carbohydrates. But it's important to always check with your doctor (or) dietician about using any sugar substitutes, if one has diabetes.

### II. Weight loss and obesity:

virtually artificial sweeteners have no calories which makes appealing to include in weight loss diets and also need only a fraction as compared to the regular sugar. But the types and quantity of sweetener to be used needs to be checked with a doctor or a dietitian.

### III. Avoiding tooth decay:

sweeteners do not contribute to tooth decay as they are not broken down to acid by bacteria in the mouth. FSSAI (Indian Regulatory body) approved the artificial sweeteners for use in India.

The 4 most common artificial sweeteners used in Food industry are:

Aspartame, Acesulfame K, saccharin and sucralose.

I. Aspartame: it is a more intense artificial non-nutritive sweetener which is being marketed under various brand names like Equal, Nutra sweet spoonful, Indulge, Equal-measure etc.

Aspartame found in variety of products like instant breakfasts, gelatins, desserts, tabletop sweeteners, cereals, laxatives, tea beverages, soft drinks, beverages, sugar free chewing gums etc.

II. Acesulfame potassium: It is a calorie-free sugar substitute (artificial sweetener) also known as Acesulfame K. Acesulfame K is 200 times sweeter than sucrose (table sugar) as sweet as aspartame about 2/3 as sweet as saccharin and 1/3 as sweet as sucralose. In carbonated drinks it is almost always used in conjunction with another sweetener such aspartame (or) sucralose.

III. Saccharin: saccharin and its salts have been used in variety of beverages, foods, cosmetics and pharmaceuticals. Its primary function is to provide sweetness without adding calories.

IV. Sucralose: sucralose is an artificial sweetener which is used in baking (or) in products that require a longer shelf life. Sucralose is used as a replacement for (or) in combination with other artificial (or) natural sweeteners such as aspartame, acesulfame potassium (or) high fructose corn-syrup.

## FSSAI Approved Artificial Sweeteners Which Can be Used In Our Products:

### Artificial sweeteners

1. Saccharin sodium
2. Aspartame
3. Acesulfame potassium
4. Sucralose
5. Neotame

**Table 1:** FSSAI Approved Artificial Sweeteners: FDA has approved the use of five artificial sweeteners: one is for sweeter than regular sugar, they include:

Artificial Sweeteners	Brand Name
1. Acesulfame-K	Sunnett-Sweet
2. Aspartame	Nutra sweet Equal
3. Neotame	No Brand names
4. Saccharin	Sweet'N'low, Necta Sweet
5. Sucralose	Splenda

**Table 2:** FDA approved artificial sweeteners:

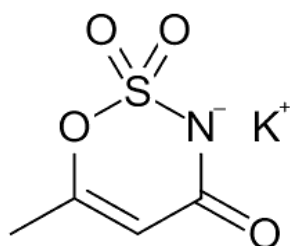
A variety of foods on the market that contain sugar substitutes:

Some food companies advertise this but you may need to look closely at the ingredient list to find out if a food is sweetened by a sugar substitutes. These sugar substitutes including artificial sweeteners, Stevia and sugar alcohols.

### i) Acesulfame-K

**Chemical formula:**  $C_4H_4KNO_4S$

**Structure:**



**Calorie value:** 0cal/g Ref [1]

**FDA Approved:** 1988- table top, 1993- beverages, 2003- general uses but not meat (or) poultry.

**Acesulfame-k:** Acesulfame-k (fig1) has been developed as sweetener by Hoechst (Clauss and Jensen 1970) it is a white crystalline powder approximately 120 times sweeter than sucrose and has high water solubility (Rynon Lipinski 1991).[2] Acesulfame-K is heat stable and can be used in cooking and baking (Nabors 2002)

**Metabolism and Health Aspects:** Acesulfame-K is not metabolized in the human body thus it provides no calories and it is not influence potassium intake despite its potassium content (ADA2004) in 1988 US FDA approved. The use of acesulfame in a variety of dry food products and in alcoholic beverages. In 2003 the agency of US FDA approved its use as a general purpose sweetener.

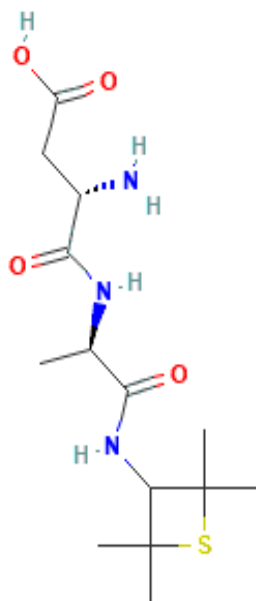
**Commercial uses:** Baked goods, frozen desserts, candies, beverages, cough drops, breath mints.

Number of times sweeter than Sucrose:- 200

ii) **Alitame:** It is an intense sweetener with sweetness potency 200 times greater than that of sucrose.

**Chemical formula:**  $C_{14}H_{25}N_3O_4S$

**Structure:**



**Calorific value:** 1.4 cal/g

**FDA approved:** Pending

**Metabolism and Health Aspects:** Alitame is readily absorbed in the GI tract and then immediately metabolized and excreted. The two main components are aspartic acid and alanine amide. The aspartic acid component is metabolized normally and the alanine amide passes through the body with minimal metabolic changes. In humans, the glucuronic derivatives of D-alanine tetramethyl-thietane amide is the major urinary metabolite. JEFCA reviewed safety data on alitame in 2002.

The committee concluded that there was no proof that alitame is carcinogenic. An ADI of 0-1 mg/kg body weight was allocated on the basis of the NOAEL of 100mg/kg body weight/day to an 18 month. [3]

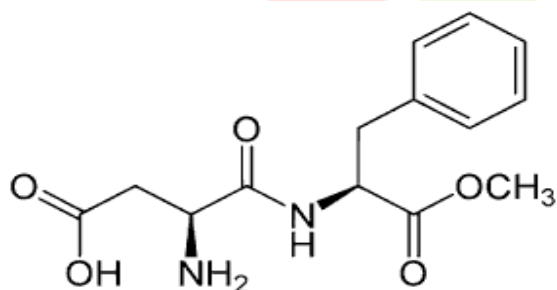
**Commercial uses:** Baked goods, hot and cold beverages, milk products, frozen desserts and mixes, fruit preparations, chewing gum, and candies, tabletop sweeteners, toiletries, pharmaceuticals

Number of times sweeter than Sucrose:- 2,000

**iii) Aspartame:** In 1965, aspartame was discovered by James Schattler, a chemist (Mazur et al - 1970) [4]. Aspartame is an artificial non-saccharide sweetener. [5]

**Metabolism and Health Aspect [6]:** Aspartame is a low-calorie sweetener used to sweeten a variety of low and reduced-calorie foods and beverages, including low-calorie table-top sweetener as well as for use in gum, breakfast cereals, and other dry products. Aspartame provides energy of 4 calories per gram. Aspartame is unstable if subjected to prolonged heating and therefore cannot be used in baking or cooking. [7]

**Structure:**



**Chemical formula:**  $C_{14}H_{18}N_2O_5$

**Calorific value:** 4 cal/g

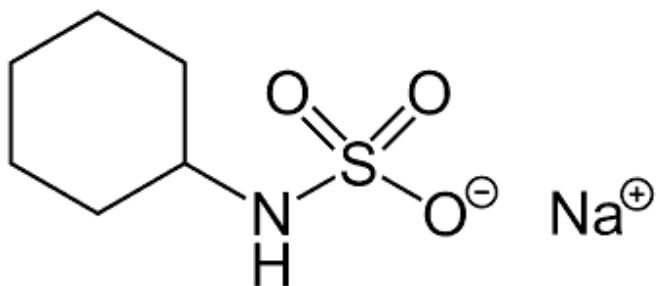
**FDA approved:** 1981 - tabletop 1996 - general purpose.

**Commercial uses:** General - purpose foods

Number of times sweeter than Sucrose:- 200

#### iv) Cyclamate:

**Structure:**



**Chemical Formula:**  $C_6H_{12}NNaO_3S$

**Calorie value:** 0 CAL/g

**FDA approved:** GRAS until banned in 1970

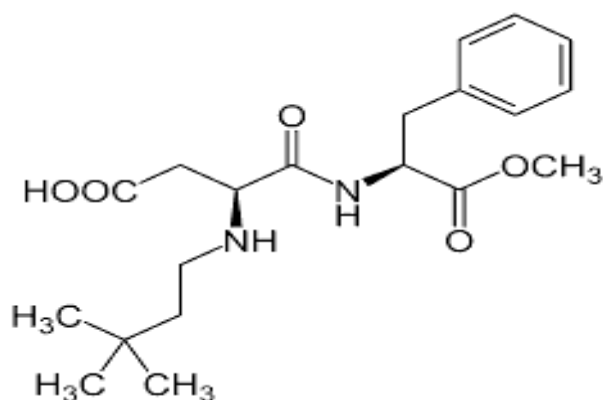
**Cyclamate:** Cyclamate was discovered in 1937. Cyclamate used as a low calorie sweetener in the united states in 1950s and 1960s. Cyclamate is 30 times sweeter than sucrose. It is soluble in water and its solubility can be increased by preparing the sodium or calcium salt (Boop et al 1986).**[8]**

**Metabolism and Health Aspects:** Cyclamate itself shows very low toxicity but is metabolized by the gut bacteria to cyclohexylamine which shows greater toxicity (Bopp et al 1986).**[9]** Because of the nature of cyclamate metabolism. It would be inappropriate to assume that the total daily intake of cyclamate is metabolized to cyclohexylamine. The acceptable daily intake (ADI) for cyclamate was calculated by both the scientific committee of food (SCF) and the Joint expert Committee on food additives (JECFA) Based on the no observed adverse effect level (NOAEL).

Cyclohexylamine in rats assuming that 18.9% of the daily intake of cyclamate is metabolized to cyclohexylamine each day (scf2000). The plasma concentrations of cyclohexylamine following cyclamate intake will depend on both the extent of metabolism by the intestinal flora and the extent of elimination of cyclohexylamine from the circulation.**[10]**

**Commercial uses:** tabletop sweetness beverages.

Number of times sweeter than Sucrose: - 30

**v)Neotame:****Structure:**

**Chemical formula:**  $C_{20}H_{30}N_2O_5$

**Calorie value:** 0 CAL/g [11]

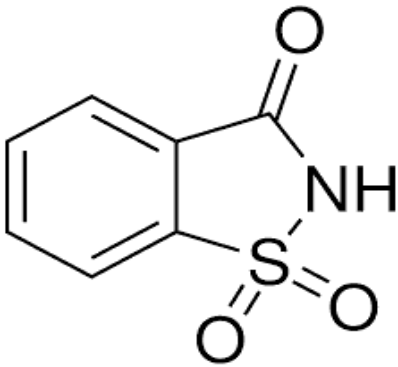
**FDA approved:** 2002

**Neotame:** Neotame has been developed as a sweetener with high degree of sweetness. Which can be changed according to the kind of food and blend composition? It is 7000 to 13000 times and about 30 to 60 times sweeter than sugar. Aspartame respectively (prakas etal 2002) [12]

**Metabolism and Health Aspect:** Neotame is quickly metabolized totally eliminated and do not accumulate in the body. The major metabolic pathway of neotame is hydrolysis of the methyl-ester by esterase which present throughout the body. This yields de esterified neotame. The Major metabolite and a significant amount a meth-enol. Due to the presence of the 3-3-d: methyl-butyl group.[13] peptidase which would typically break the peptide bond between the aspartic acid and phenylalanine moieties are essentially blocked. Thus reducing the availability of phenylalamine, the amount of methanol derived from neotame is exceeding small. (Neotame 200). Neotame was approved by the USFDA as a general purpose sweetener in July 2002 (USFDA 20022). It also has been favorably evaluated by JECFA (JFECFA 2004) which established on ADI of 2mg/kg body weight/day. The ADI for neotame in the US is 18 mg/peronday (USFDA 2002).[14]

**Commercial uses:** Baked goods soft drinks chewing gum, frosting, frozen desserts, Jams, Jellies, Gelatins, Puddings, Processed fruit and fruit juices, tappings syrup.

Number of times sweeter than Sucrose: - 7,000 - 13,000

**vi) Saccharin:  $C_7H_5NO_3S$** **Structure:****Molecular formula:  $C_7H_5NO_3S$** **Calorific value:** 0 cal/g [15]**FDA Approved:** GRAS

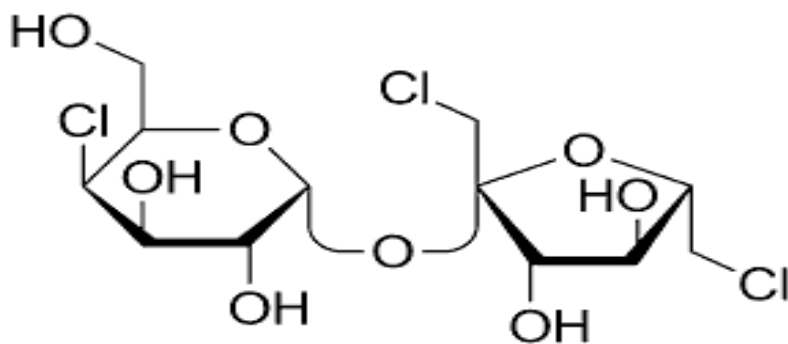
**Saccharin:** Saccharin was discovered by Remson and Fahlberg in 1878 at the Johns Hopkins university, Baltimore. Saccharin is a non-nutritive sweetener. It is an unpleasant bitter or metallic off taste. It is about 300 times sweeter than sucrose.

**Metabolism and health aspects [16]:** FDA banned saccharin in 1977 because animal studies had shown that it caused cancer in rats. Many studies performed on saccharin. It does not show a clear casual relationship between saccharin consumption and health risk in human at normal doses. These studies have shown correlation between consumption and cancer incidence. (Wiehrauch and Diehl 2004) [17] Saccharin is currently permitted for use under an interim regulation specified the amount of saccharin permitted in beverages processed foods and sugar substitutes and requires that the product label must state saccharin in the ingredient declaration and specify the amount used (Kroger et al 2006)

**Commercial uses:** tabletop sweeteners, baked goods, soft drinks, jams, chewing gum.

Number of times sweeter than Sucrose:- 200-700



**vii) Sucralose:****Structure:**

**Chemical formula:**  $C_{12}H_{19}Cl_3O_8$

**Calorie value:** 0 cal/g

**Food approved [18] :** 1998- in 15 food categories 1999- general purpose sweetener

**Sucralose:** sucralose was discovered in 1976. This sucralose is non-nutritive sweetener. sucralose is 450-650 times sweeter than Sucrose, it has a pleasant sweet taste and its quality and time intensity profile is very close to that of sucrose.[19]

**Metabolic and Health Aspects:** Sucralose is made with sugar the human body does not recognize to it. But it acts as sugar and does not metabolize. And therefore it provides no calories. The bulk of sucralose ingested does not leave the gastrointestinal tract and is directly excreted in the feces. While 11-27% of its absorbed in knight 1993[20] and the amount of that is absorbed from the gastrointestinal tract is largely removed from the blood stream by the kidney and eliminated in the urine. As it is an organochloride and some of which are known to have significant toxicity (Patel Etal 2006) Food and Drug Administrative approve is based on the finding that sucralose is safe for human consumption. US Food and Drug Administration (USFDA)

**Commercial uses:** Tabletop sweeteners, beverages, chewing gums, frozen desserts, fruit juices, gelatins.

Number of times sweeter than Sucrose: - 600

**Toxic side effects of Artificial sweeteners:** Many varieties so called "sugar substitutes" on the grocery store shelf, most common sugar substitutes in grocery store are sucralose (Splenda), aspartame (Nutra sweet, equal, sugar twin) and saccharin (sweet N low). Consumers reach very promptly for these artificial sweeteners in order to satisfy their sugar craving while ingesting little to no added calories. However, many consumers do not know the possible side effects and health risks relating with the ingestion of chemically processed artificial sweeteners.

FDA has a list of artificial sweeteners which are termed high intense sweeteners approved for the use as food additives items. These include saccharin, aspartame and stevia. All of these are labeled GRAS (Generally recognized as safe by the FDA) only those with phenylketonuria (pku) should avoid aspartame consumption.

The American Dietetic Association states that children below 2 years of age, lactating women and pregnant women should not use artificial sweeteners even though they are deemed safe by the FDA. Food products contain artificial sweeteners: many processed products contain these artificial sweeteners including chewing gums, desserts, candies, beverages, dairy products, salad dressings, gelatin, breath mint preserves, toothpastes, mouthwashes, yogurts, vitamins, baked goods, pharmaceuticals, breakfast cereals, snack foods, soups and tabletop sweeteners. For the average frequently used consumers, these sweeteners are not easily identified on a food label. Most processed products will be labelled as "sugar free", but will contain an artificial sweetener. For those with grain sensitiver manufacturers will use corn as fillers to make these artificial sweeteners which creates an inflammatory response in body. All of these products processed contain an artificial sweeteners will continue to mislead consumers if labels are not read carefully. Artificial sweeteners risk related to health problems: Artificial sweeteners effects and the long-term health risks relating with the ingestion cyclamate (an early artificial sweeteners) was banned by the FDA in 1970 due to carcinogenic risks in experiment with animals. Consumers were left scared knowing there could be a cancer risk associated with ingestion of artificial sweeteners. Manufacturers replaced one toxic artificial sweetener with new equally toxic sweetener. Many consumers report headaches, dizziness, rashes, bloating, nausea, diarrhea and digestive problems after ingesting artificial sweeteners. These side effects can build severe and serious long term diseases with regular continuous consumption of these processed sugars. Currently the great debate is between the FDA and scientists. In a study determining the very side effects of saccharin, sucralose and aspartame. Consumption in both mice and humans. The ingestion of artificial sweeteners altered microbial metabolic pathways. Glucose intolerance was elevated due to changes in gut microbiota. Gut health has to be optimal. In order to maintain a healthy immune system and normal metabolic functions in our body. Such metabolic function include maintaining normal blood pressure, blood glucose and cholesterol levels. More studies were conducted, but scientists believe that there are having a relationship between sweeteners and certain chronic fatigue syndrome. Parkinson's disease, cancer, Alzheimer's disease, multiple sclerosis, systemic lupus and autism, weight loss with the ingestion of artificial sweeteners, there is not enough proof that consumption is beneficial in weight management, short term weight loss, but lack of any long-term weight loss resulting. However, consumers are still consuming artificial sweeteners in order to reduce their calorie intake with the intent of weight loss based on physician's recommendations. Artificial sweeteners can also develop addiction. These processed sugars are 200-13,000times sweeter than regular sugar. The regular consumption of these artificial sweeteners can alter taste buds and result in a constant craving for foods that are overly sweet. Most of the nutritious foods such as fruits and vegetables become less palatable, so less nutritious sugar free substitutes and carbohydrates are consumed. Consequently, risks for weight gain increase and deficiencies. Impact of artificial sweeteners on our health: artificial sweeteners are not food. They are completely synthetic. Any food-like substance (or) chemical that we put into our body that is not from nature increase the toxic load and carry side effects. The DNA of our cells gets all Kaleidoscoped and we continue to feed ourselves disease building processed foods. Artificial sweeteners in our regular routine include the food we eat take stress our activity levels. Our digestion and sleep-don't work in our favor to repair DNA to improve the integrity of our cell membranes and the efficiency of our own elimination pathways (poop, skin, liver, kidneys, lungs) that we are working towards building disease.

## **Artificial sweeteners impact/effects on our health:**

1.Dental care: Artificial sweeteners are used in conventional and natural toothpaste to make them taste better without causing damage to our teeth .One can make the argument that xylitol, a sugar alcohol often found in toothpaste. Artificial sweeteners are used in daily diet drinks and other low calories fat which may contain other ingredient, they damage our teeth such as citric (or) phosphoric acid. Dental health is not just about what comes directly in contact with our teeth (or) what we use to brush holistic. Dental care in about our entire diet practices and the way of life style that serve to oral health and protect our teeth. Artificial sweetened key lime pic yogurt just isn't a food that considered a significant part of the dental health picture.

2. The gut Microbiom: Many evidences point out the fact that artificial sweetener many change the gut microbiota and be the cause of some digestive distress symptoms. A fecal study of animal show that aspartame let to more consumption an increasing bacteria including the Enterobacteriaceae a family of bacteria that can include Salmonella and E.coli.

3. Blood Sugar + Diabetes: Artificial sweeteners claim that they are perfect for diabetics because they do not impact blood sugar levels. Just like weight loss claim, there is another "benefit" that has proven false. Artificial sweetener actually increases the risk of type 2 diabetes. In research examining 6,000 middle aged adults, scientists discovered that artificially sweetened soft drinks, boosted the risk of Metabolic syndrome, a collection of factor that include high blood sugar level, high blood pressure, obesity and high cholesterol. These findings are echoed in another study of close to 7,000 adults which relate a daily soft drink with a higher risk of type2 diabetes and metabolic syndrome.

4. Weight gain + Obesity: A recent meta-analysis of 37 studies that followed over 400,000 people concluded that artificial sweeteners are actually linked to an increase risk of weight gain, obesity, type2 diabetes, hypertension and metabolic syndrome.

5. Cancer and Tumors: The research is mainly conducted on animals that indicate artificial sweeteners are linked to tumor growth and cancer development.

Some of the research includes:

Researches of this study linked the rise in brain tumor rates to an increased consumption of artificial sweeteners.

Aspartame induced lung and liver in mice, particularly in the males.

Aspartame fed to rats caused on increased in tumors and lymphoma leukemia's. The animal model studies: May not mean that the exact same result will happen to human beings, but they point to a very real risk and is enough that some scientists and organizations have raised an alarm caution about the potential cancer risk in human.

6. Other health risks:

There is an extensive way that artificial sweeteners may impact our health.

Investigations show they can also cause:

Neurotoxicity and Neurological symptoms

Lead to Kidney decline

Trigger Migraines

Cause DNA damage

May accelerate aging

Damage the liver

Affect our ability to learn and emotional function

## Conclusions:

Artificial sweeteners are chemicals manufactured and used for two reasons. The first is that they are very sweet. Many times sweeter than sugar meaning they have much more effect on human sweet taste buds. Second, they are the chemicals that humans cannot digest and absorb.

The rise of obesity will cause more people to turn to artificial sweeteners to replace sugar in an effort to control their weight.

Artificial sweeteners alone will not cause weight loss. A restricted calorie plan and increased physical activity should be followed through to produce results.

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