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THE HIDDEN IMPACT OF ARTIFICIAL SWEETENERS AND FOOD DYES ON HUMAN HEALTH

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Abstract
Food additives, including artificial sweeteners and colors, are widely used in the food industry. However, their safety has become a major concern due to the potential health risks associated with their consumption. Artificial sweeteners, such as saccharin, aspartame, and cyclamate, have been linked to various health problems, including cancer, cardiovascular disease, and obesity. However, the evidence is not conclusive, and more research is needed to fully understand their impact on human health. Synthetic food colors, such as tartrazine and rhodamine B, have also been linked to potential health risks, including hyperactivity and cancer. However, regulatory agencies have set acceptable daily intake limits for these colors, and more research is needed to fully understand their impact on human health. Natural food additives, on the other hand, may have health benefits and could be used as substitutes for unhealthy food additives.
However, more research is needed to fully understand their impact on human health. In conclusion, while food additives may have potential health risks, more research is needed to fully understand their impact on human health. Regulatory agencies should continue to monitor the safety of food additives and set acceptable daily intake limits to protect public health. Artificial sweeteners are widely used as a low-calorie alternative to sugar. However, their impact on human health is still a topic of debate. Some studies have suggested that artificial sweeteners may be linked to an increased risk of cancer.
Keywords: Artificial sweeteners, Sugars. Obesity, Cancer. Diabetes, Food Colorants.

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Introduction

In recent trends, it has been observed that increase in the incidence of diabetes mellitus and cardiovascular diseases. Intake of added sugars is directly related to higher energy consumption and is thought important contributor to the rise in obesity worldwide.[1] In 2016, the number of overweight adults exceeded 1.9 billion while over 650 million were classified as obese, reflecting a global prevalence of 13% [2]. It is inherent nature of humans to like sweet food. Previously published studies have reported the inclination of new-borns towards sweet-tasting nutrition. Therefore, sweetening agents has always been popular in man-made food preparations.[3] In view of customer satisfaction, the pressure to meet dietary requirements with caloric restrictions and competition between factors like taste and appearance, the food industries are continuously in search of low calorie and intense artificial sweeteners. A number of marketed low calorie products are now available as healthier food choices. Artificial sweeteners also classified as food additives for man indispensable part of modern food industry. In the European Union, the following artificial sweeteners are allowed to be used: acesulfame-K, aspartame, cyclamates, saccharins, sucralose, neohesperidine DC, neotame and salt of aspartame-acesulfame.

Artificial Sweetener and toxicological effects

Artificial sweeteners are non-sugar alternatives used as substitutes for sugar. They are widely used in the food industry and classified as nutritive and non-nutritive sweeteners.[12] Non-nutritive sweeteners, also known as high-intensity sweeteners, are 30 to 13,000 times sweeter than natural sugar sucrose. However, more research is needed to fully understand the potential health effects of artificial sweeteners [4]

- **Saccharin:** Saccharin is the oldest artificial sweetener, with a lowest acceptable daily intake (ADI) among four sweeteners according to the World Health Organization (WHO). It is used in various products, including beverages, dairy products, and table top sweeteners.[5] Saccharin is formed through electrochemical oxidation of otoluenesulfonamide or diazotization of methyl anthranilate. Saccharin has been used as a sweetener for over a century. Its use

has been widespread, particularly in the food and beverage industry. However, concerns have been raised about the potential health effects of saccharin. Some studies have suggested a link between saccharin consumption and cancer. [6] Saccharin has been used in various applications, including food, beverages, and pharmaceuticals. Its use has been widespread due to its low cost and high sweetness intensity. However, concerns have been raised about the potential environmental impact of saccharin. Some studies have suggested that saccharin may persist in the environment and have toxic effects on aquatic organisms [7]

- **Sucralose:** Sucralose is a non-nutritive sweetener made from sucrose by substituting three hydroxyl groups with three chloride atoms. It is 600 times as sweet as sugar with no calories and is marketed under the trademark Splenda. However, high doses of sucralose may trigger a decrease in food intake, reducing food conversion efficiency and body weight gain. Sucralose is widely used in the food industry due to its stability and sweetness intensity. The resulting sucrose crystals are then refined to produce white sugar. For example, sugar is often used as an offering in Hindu and Buddhist rituals. The consumption of sucrose has been linked to an increased risk of dental caries. This is because the bacteria in the mouth feed on sucrose and produce acid, which can damage tooth enamel. Sucrose is also used in the production of biodegradable plastics. The fermentation of sucrose produces lactic acid, which can be used to produce polylactic acid (PLA). The price of sucrose can fluctuate significantly depending on global supply and demand. This can have a major impact on the profitability of sugarcane farmers and sugar producers [8].
- **Aspartame:** Aspartame, a non-sugar sweetener, was first approved in 1974 and is 200 times sweeter than sucrose. It produces 4 calories per gram.

IARC categorized aspartame as probably carcinogenic to humans, citing limited evidence. JECFA confirmed the tolerable daily dose of 40 mg/kg body weight. Aspartame is widely used in low-calorie foods and beverages. It is commonly used as a tabletop sweetener. However, some studies have raised concerns about the potential health effects of aspartame. Aspartame is metabolized in the body to produce phenylalanine, aspartic acid, and methanol. It is commonly used in combination with other sweeteners, such as sucralose and acesulfame potassium [9].

- **Advantages:** Advantage is a recently approved artificial sweetener by the FDA in 2014. It is authorized for use as a broad-purpose sweetener and flavor enhancer, except in meat and poultry products. Advantame is composed of chemical components Aspartame and vanillin. It provides a heat-stable environment and produces lower levels of phenylalanine, making it safer for individuals with phenylketonuria. This makes it a more suitable option for certain individuals, particularly those with phenylketonuria [30].
- **Rare sugars**: Rare sugars, such as L-glucose, D-aloes, D-Picos, and D-tagatose, are scarcely present in nature but have gained attention due to recent progress in their largescale biosynthesis. These sugars have been valued for their ability to sweeten with few calories and are considered a favourable option for diabetic patients. Rare sugars, such as D-Pisces (PSI) and D-Tagatose (TAG), have been granted Generally Recognized as Safe (GRAS) status and have been shown to decrease the rise in blood glucose levels in individuals with hyperglycaemia [10].
- **Cyclamate**: Cyclamate is a non-nutritive sweetener used as a sodium or calcium salt. Cyclamate is metabolized in the body by gut bacteria to form cyclohexylamine, which exhibits higher toxicity. Recent studies have provided novel information about the conversion of cyclamate to cyclohexylamine during long-term intake. Recent studies have provided novel information about the conversion of cyclamate to cyclohexylamine during long-term intake. These studies have shown that the metabolism of cyclamate to cyclohexylamine can occur in the gut, and that this process may be influenced by factors [11].

Artificial sweetener	FDA approval	FDA Status*	Safe level ADI (mg/kg/day)	Clinical symptoms of toxicity in humans		Sweetness (compared to sucrose)
				Acute	Chronic	
Acesulfame -K	1988	NNS, REG	15	Headache, nausea, impairment of liver, eye sight problem, hypoglycaemia	Clastogenic, genotoxic at high doses	200 time
Aspartame	1974	NUTRS, REG, GMP	50	Dry mouth, dizziness, mood changes, reduced seizure threshold, thrombocytopenia	Lymphomas	180-200 times
Advantame	2014	-	32.8	Gastrointestinal disturbances	-	20000 times
Neotame	2002	NNS, REG, GMP	2	Headache, hepatotoxic at high doses	Lower birth rate, weight loss	8000 times
Saccharin	1977	NNS, REG	5	Nausea, vomiting, diarrhea, sulfa allergy	Low birth weight, bladder cancer, hepatotoxicity	300 times
Sucralose	1998	NNS, REG, GMP	5	Diarrhea, headache, muscle cramp, stomach cramp, skin irritation, dizziness.	Thymus shrinkage (animal studies)	600 times

3. Toxicological effects

The major physiological impacts of artificial sweeteners include which affects blood glucose levels, obesity, gut microbiome, cardiovascular health, and cancer.

- **Blood Glucose Concentration and Diabetes Mellitus:** Consuming artificial sweeteners has been linked to a rise in blood glucose levels, although the increase is less compared to consuming glucose. The relationship between artificial sweetener consumption and glucose homeostasis is complex and not fully understood. Some studies have suggested that artificial sweeteners can alter gut microbiota, leading to changes in glucose metabolism. However, other studies have found no significant impact of

artificial sweeteners on glucose homeostasis. The effects of artificial sweeteners on glucose homeostasis may vary depending on the specific sweetener and the individual's health status. For example, some studies have suggested that saccharin may be more likely to induce glucose intolerance compared to other artificial sweeteners [12].

- **Obesity:** Artificial sweeteners can impact energy balance and body weight differently than natural sugar through physiological processes. A meta-analysis of six prospective cohort studies found that the risk of obesity increased by 21% for every 250 mL/day rise in artificial sweetener-containing soft drink consumption. The absence of satiety signals may lead to increased food consumption, and consuming foods lower in energy may lead to an increase in overall food consumption. Artificial sweeteners have been widely used as a low-calorie alternative to natural sugar [13]. However, more research is needed to fully understand the relationship between artificial sweetener intake and obesity. The mechanisms by which artificial sweeteners may contribute to obesity are complex and multifaceted. However, research has suggested that artificial sweeteners may alter the gut microbiome, leading to changes in glucose metabolism and insulin sensitivity. Additionally, artificial sweeteners may also contribute to an increased risk of obesity by promoting weight gain and fat [14].
- **Cardiovascular Disease:** The consumption of added sugars has been extensively linked to various health problems, including cardiometabolic disorders. Artificial sweetener consumption has also been associated with a greater risk of cardiovascular system dysfunction. Certain artificial sweeteners, such as ACEK and sucralose, have been linked to an increased risk of coronary artery disease. [15] The Nutriment-Sante population-based cohort study found that use of artificial sweeteners, notably aspartame and ACE K, correlates with a higher cancer risk. However, this study had several limitations, including its observational design and reliance on self-reported data. While some studies have suggested a link between artificial sweeteners and cancer, others have found no such association. Further research is needed to fully understand the potential health risks associated with artificial sweeteners [16].

4. Alternatives [or] substitutes of artificial sweeteners

The Dietary Guidelines Advisory Committee recommends reducing added sugars in the diet, but does not suggest replacing them with artificial sweeteners. The recommended daily limit for added sugar consumption is 100 calories for women and 150 calories for men. Rare sugars have been shown to improve glucose control and reduce body fat in human clinical trials and animal studies. The recommended daily limit for added sugar consumption is based on scientificevidence that excessive sugar consumption can lead to various health problems, including obesity and type 2 diabetes. Rare sugars, such as D-psychoses and D-tagatose, have been demonstrated to have potential health benefits, including improving glucose control and reducing body fat. These sugars have been shown to have a lower glycaemic index compared to sucrose, which can help regulate blood sugar levels. properties, which may provide additional health benefits. These sweeteners have been shown to have potential health benefits, including improving glucose control and reducing body fat.

- **Stevia:** Stevia is a natural sweetener that comes from the leaves of the Stevia rebaudiana plant, which is native to Paraguay and Brazil. This makes it a popular sugar substitute for people who are trying to reduce their calorie intake or manage their weight. Unlike sugar, which can contribute to obesity and other health issues when consumed in excess, stevia offers a healthier alternative without the added calories [17].
- **Monk fruit:** Monk fruit, also known as Sir aitia Grosvenor, is a small, green fruit native to southern China and northern Thailand. It has been used for centuries in traditional Chinese medicine for its purported health benefits, including its ability to treat sore throats and coughs. The fruit's sweetness comes from natural compounds called mogrosides, which are antioxidant-rich glycosides. Therefore, it's important to check labels to ensure that the monk fruit sweetener you're using is pure and free of unwanted additives [18].

5. Food Colour Additives & Adverse Effects

The Federal Food, Drug, and Cosmetic Act requires colour additives to receive FDA approval before use in food, drugs, cosmetics, or medical devices. The maximum allowable limit for permitted colour in any food product is 0.1 g per kg to ensure safety after consumption.

The FDA has established regulations for the use of colour additives in food and cosmetics. These regulations require manufacturers to demonstrate the safety of their colour additives before they can be approved for use. The FDA also sets limits on the concentration of colour additives that can be used in various products. In addition to FDA regulations, the Food Safety and Standards Authority of India (FSSAI) also establishes permissible levels of synthetic dyes for inclusion in food products [19].

6. Alternatives

- **Curcumin:** Curcumin is considered one of the natural colouring food additives, its safety is approved by the Food and Drug Administration (FDA) in the USA, the Joint FAO/ WHO Expert Committee on Food Additives

of the Food and Agriculture Organization/World Health Organization, and the Natural Health Products Directorate of Canada. It has the ability to scavenge the free radicals as antioxidant counteracting the oxidative stress that may cause by the artificial dietary colour dye such as tartrazine.

- **Gum arabic:** Gum Arabic is used as an emulsifier and flavor stabilizer in the food industries as a natural food additive. Gum Arabic is approved as a food additive by the Joint FAO/WHO Expert Committee wherein it has also a wide spectrum of health benefits such as antioxidant, anti-inflammatory, and antimicrobial effects. In addition, the Joint FAO/WHO Expert Committee suggested an acceptable daily intake of Arabic gum for human [20].
- **Nigella sativa:** Nigella Sativa and its oil have been found to have various health benefits, including anti-hypertensive, anti-diabetic, anti-inflammatory, and antioxidant properties. This shift can help reduce the environmental impact of food production and promote public health. In addition, more research is needed to explore the potential health benefits of natural food additives, such as Nigella Sativa and its oil. This research can help identify new and safer alternatives to synthetic food additives [21].

Conclusion

Food additives can be natural or synthetic and are classified into types such as preservatives, flavor enhancers, and sweeteners. However, the safety of many commonly used food additives is still debated. Some food additives, like monosodium glutamate and artificial sweeteners, have toxicological hazards, while others, like natural food additives, have health benefits. Azo dyes used as food Colores have been reviewed for toxicity and exposure risks. Regulatory agencies like EFSA and JECFA regularly assess their safety. Current acceptable daily intake (ADI) limits are generally consistent, but debates continue on using safer, plantbased food additives that promote human health and environmental safety. Artificial sweeteners have replaced natural sweeteners due to their low-calorie content. The FDA has approved 5 artificial sweeteners, which are non-nutritive and poorly absorbed. However, their consumption is controversial due to potential health risks. Studies suggest that artificial sweeteners are unhealthy and should be consumed in limited quantities, within acceptable daily intake levels. Further research is needed to evaluate their safety and metabolic effects. The increasing prevalence of chronic diseases has raised concerns about the health effects of dietary additives, including artificial sweeteners and food colorants. Therefore, reducing added sugars, exploring healthier alternatives, and advocating for stricter regulations on food colorants are recommended.

Author contributions

All authors are contributed equally.

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Declaration competing interest

The authors have no conflicts of interest to declare.

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