The Impacts of Sugar Intake on The Body and The Feasibility of Anti-Sugar Diet

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Abstract. In today's society, people are increasingly mindful of their daily dietary habits, with particular attention given to sugar consumption. While sugar provides a quick source of energy, excessive intake can lead to oxidative stress and have detrimental health effects. It has been linked to a number of illnesses, including obesity, type 2 diabetes, dental problems, and even cancer. Additionally, sugar can have lasting effects on skin health through a process known as antiglycation. Hence, the call to reduce or combat sugar intake is gaining traction. The anti-sugar movement advocates for a reduction or complete elimination of added sugars from diets, so emphasizing the importance of following proper guidelines is needed. This article aims to conduct a thorough examination of the mechanisms related to sugar consumption and explore the repercussions of adjusting sugar intake. It will also delve into the distinctions and similarities among three prevalent dietary patterns: high-sugar, low-carb, and ketogenic diets. Furthermore, it will explore the relevance of these dietary patterns in the context of anti-glycation efforts. By providing comprehensive insights into these dietary choices, this article seeks to empower individuals to make informed and objective decisions about sugar intake, rather than making hasty decisions that may adversely affect their health.

Keywords: Anti-sugar, low-carb diets, high-sugar diets, ketogenic diets.

1. Introduction

Carbohydrates (CHO) constitute a primary source of bioavailable substances in the human body and serve as a crucial energy source. Alongside fats and proteins, carbohydrates are fundamental components of the foods and beverages we consume daily. Chemically, carbohydrates have the formula (C-H2O) n, where n≥3. They provide food energy, with digestible CHO contributing 4kcal/g, while certain non-digestible CHO contribute 0-2kcal/g. Carbohydrates also play roles in sweetening, flavoring, and acting as water-binding humectants in food products. They can be categorized chemically as monosaccharides, disaccharides, oligosaccharides, and polysaccharides. From a dietary perspective, they are classified into simple sugar, starch, and dietary fiber. This article primarily focuses on added sugars.

Sugar, a simple carbohydrate widely prevalent in human diets, constitutes an inevitable component of daily intake. While sugar provides a rapid source of energy, excessive consumption can lead to adverse health effects. It has been linked to various conditions including obesity, type 2 diabetes, and can even have long-lasting effects on skin health. Hence, reducing or regulating sugar intake has become a prominent area of research in nutrition. A maximum of 50 grams of sugar per day is the amount that the WHO advises.

The anti-sugar movement advocates for reducing or completely eliminating sugar from the diet. However, many supporters may lack an objective understanding of sugar and may not be aware that low sugar intake can also pose health risks. This article aims to delve into research related to sugar intake, summarizing the impact of sugar consumption and strategies for adjustment. Low-carb and ketogenic diets, known for their reduced carbohydrate content, have gained considerable attention. This article will explore the viability of these dietary patterns as alternatives to high-sugar diets.

2. Sugar

Sugar, scientifically known as sucrose, is a naturally occurring compound found in various forms and variations, and it is essential for most life forms on Earth. It is estimated that about 75% of packaged foods contain some form of sugar. In addition to its natural presence, chemically refined and highly purified forms of sugar (such as sucrose and high fructose corn syrup) have become readily available in the modern world, although they do not exist in nature except in rare cases such as bees producing honey. The pure form of sugar is a relatively recent addition to the diet.

Numerous foods and beverages that are essential components of a satisfying diet are made tastier and more palatable by sugar. Some fruits and vegetables naturally contain significant quantities of sugar, providing them with their characteristic sweet flavors, in some species, it can reach 10% sucrose. Notably, sugar beet and sugar cane, the primary sources of commercial sugar production, have sucrose contents of about 16% and 14%, respectively. This underscores the diverse sources and forms of sugar in the diet, both from natural and refined sources.

2.1. Sources and Classification of Sugar

The history of sugar is a fascinating journey through time and across continents. It's believed that sugar cane was first cultivated by the indigenous people of New Guinea around 8,000 BCE. Over the centuries, knowledge of sugar cane cultivation spread through sea trade routes, reaching Southeast Asia, China, and India between 8,000 BCE and 600 CE. By the period of 0 to 600 CE, crystallized sugar had found its way into the medical practices of ancient Rome and Greece, where it was employed in treating indigestion and stomach ailments. China, inspired by Indian techniques, developed its own methods for sugarcane cultivation. This knowledge then made its way to Persia, where sugarcane became widely cultivated between 640 and 900 CE. Then, Crusaders returning from the Holy Land in the late 11th century brought back sugar, which was referred to as "sweet salt". Fast forward to 1747, Andreas Marggraf made a significant discovery by extracting sugar from beetroot. Another milestone occurred in 1813 when Edward Charles Howard devised an efficient method for refining sugar using a closed kettle system. The mechanization of sugarcane harvesting marked a major leap in 1938.

When think of sugar today, people often envision the small white granules found in sugar canisters and packaged goods. Chemically, sugar is a combination of glucose and fructose molecules. These two simple sugars form a disaccharide, which are the building blocks of complex carbohydrates. Glucose, fructose (also known as fruit sugar), and galactose (found in milk) are the three primary monosaccharides that make up all forms of complex carbohydrates. These monosaccharides don't require a digestive process, they're swiftly absorbed into the bloodstream. They can also combine in various ways to form disaccharides, which are essential for human nutrition. Furthermore, the starches and fibers in food are comprised of multiple linked monosaccharides. This intricate structure lies at the heart of understanding of sugars and carbohydrates.

2.2. Types of Sugar

Carbohydrates come in many forms, not just sucrose (Fig. 1). Monosaccharides are the simplest form of carbohydrates, consisting of single polyhydroxy aldehyde or ketone units that cannot be further broken down [1]. All monosaccharides are considered reducing sugars because they contain a functional group (either an aldehyde or ketone) that can undergo reduction reactions, such as the Maillard reaction. The most common monosaccharides are those with six carbon atoms, such as glucose and fructose. These sugars are stereoisomers, meaning they have the same chemical formula but differ in spatial arrangement due to asymmetric chiral carbons.

Glucose and galactose are structural isomers of fructose, indicating they have the same chemical formula but different atom connectivity. Glucose is a fast-releasing sugar, as it can be rapidly digested into two glucose molecules, providing quick energy. Fructose, on the other hand, is sweeter and more soluble than glucose due to its structural differences. In their molecular structures, monosaccharides

can also adopt cyclic formations, either in five or six-membered rings, which are more stable in common foods. Interestingly, the ring structure of fructose resembles a compound called furanose, a five-membered ring structure. In addition to the commonly mentioned monosaccharides, there are deoxy sugars like rhamnose and deoxyribose, which lack one or more hydroxyl (OH) groups.

When two monosaccharides are linked together by a glycosidic bond, they form a disaccharide. One of the most common disaccharides is sucrose, which can be hydrolyzed into glucose and fructose. Maltose and lactose are two other important disaccharides. Unlike monosaccharides, disaccharides contain two types of sugars: non-reducing sugars (lacking a free aldehyde or ketone group) and reducing sugars.

Lactose is hydrolyzed into galactose and glucose by the enzyme lactase. Lactase is sometimes added to lactose-free milk for lactose-intolerant individuals. Maltose, derived from starch by amylase, and intestinal maltase enzyme, is a substrate commonly used in fermentation processes for beer and bread production. Sucrose, broken down into glucose and fructose by the enzymes sucrase and invertase, is crucial in syrup-making processes.

Polysaccharides consist of more than ten monosaccharides linked together. They serve as a major source of energy and deliver beneficial phytochemicals. Polysaccharides have two primary functions: energy storage (e.g., glucan, starch, and glycogen) and providing structural support (e.g., cellulose and pectin). They can adopt linear or branched conformations and can be classified into digestible (starch in plants, glycogen in animals) and indigestible (dietary fiber) polysaccharides from a nutritional standpoint. Starch, a major storage polysaccharide in plants, consists of two main structures: amylose and amylopectin. The proportion of these structures affects properties like gel formation and thickening power.

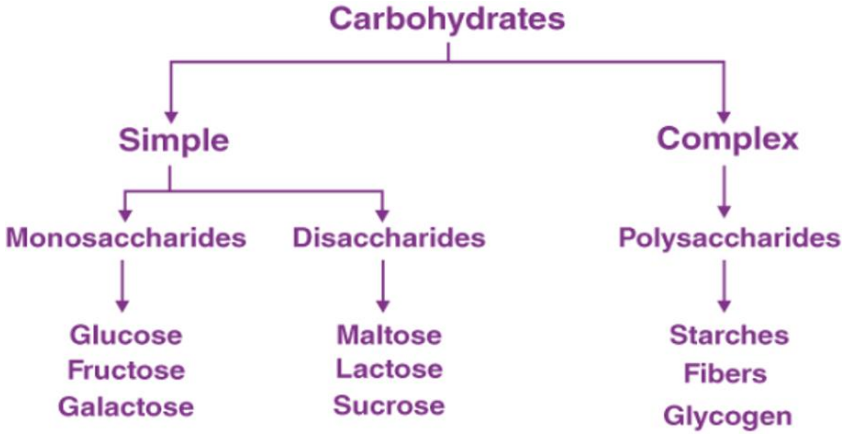

Figure 1. Types of Carbohydrates [1].

3. Effects of Sugar Intake on the Human Body

The impact of sugar intake on health is still be a controversial topic. Sugar has two principal rewarding aspects which are flavor or taste and nutrition. Sugar is both highly appetizing and beneficial, in terms of flavor and nutrient content, and is particularly common in everyday life. Sugar can also be a mental placebo when people are down. However, in addition to boosting the glycemic index, excessive sugar consumption can cause neuronal changes in the reward system that dissociate eating habits from calorie needs and result in compulsive overeating [2].

The dorsal striatum is the primary site of dopamine release for nutritional rewards from sugar, while the sweetness reward is centered in the ventral striatu. As a result of research, it has been shown that the mice that have had DRD2 signaling in the ventral striatal NAC's shell disrupted show enhanced milling sugar reinforcement and glucose-paired flavor reward learning as well as decreased learning flexibility [3]. In addition, these mice metabolize glucose presented in less efficiently. Hence, DRD2 is located in the NAC is critical of the aim is to regulate peripheral glucose levels and

reinforce/reward glucose consumption learning, where explains why bulimia could be caused by dysregulation of this system [3].

Depletion of added sugars has also been associated with cognitive impairment, particularly the function of hippocampal memory is deteriorating. Rats on a high sugar/low fat diet exhibit hippocampal-dependent memory deficits [4]. Especially in the high sugar / low fat diet, this condition will occur by increasing hippocampal inflammation.

Because fructose is derived from fruit, some consumers could mistakenly believe that it is healthy. The fructose component of sugar directly contributes to the disturbance of lipid and carbohydrate metabolism. The indirect promotion of a positive energy balance by sugar results in weight gain and fat gain, which also leads to dysregulation of lipid and carbohydrate metabolism. A fruit piece and a sweetened beverage contain quite different amounts of fructose, which is important to note. In comparison to HFCS, which is half as heavy as fructose, peaches contain around 1% of the fruit's weight in fructose [2]. The body's inflammation is also a result of fructose. AGEs are produced when fructose is excessively present in the intestinal lumen.

Fructose, as a supplementary sugar, Diabetes mellitus, retinopathy, kidney disease, and inflammation are all associated with it, along with metabolic syndrome, hypertension, insulin resistance, adipogenesis, and insulin resistance [2]. Therefore, lowering fructose in the diets of people who at the risks can reduce these symptoms. In the diets of overweight children, liver fat, de novo lipogenesis, diastolic blood pressure, triglycerides, and LDL cholesterol reduced but insulin sensitivity increased when extra fructose was switched out for glucose [2]. De novo lipogenesis in the liver will be increased by high dietary fructose, similar to ethanol. This could also explain the increased incidence of NAFLD, and the insulin resistance associated with fructose intake [5]. A recent study found that high sugar intake and substance use disorders (SUDs) are heritable, the phenomenon occurs in individuals who have a history of alcoholism or drug addiction in their family, with genetic and environmental factors explaining the variability in the relationship [2]. A high intake of sugar is not only harmful to the human organs, but also affects the skin. Dipropionate intake of sugar can cause glycation of the skin, roughness and dullness accelerating aging.

Excessive sugar consumption will cause the occurrence of cardiovascular diseases (CVD) and type 2 diabetes mellitus (T2DM) directly or indirectly, may be have hyperglycemia and hypoglycemia. Some epidemiological studies have shown that sugar consumption is associated with weight gain; the casual consumption of diets high in sugar promotes weight gain compared to the casual consumption of diets low in sugar. The higher cancer risk was also related to the total sugar intakes, with studies shown, the breast cancer risks were increased [6]. High sugar consumption boosts the postprandial glucose response, encourages the creation of pro-oxidant compounds (like peroxin trite), and causes DNA damage, all of which raise the risk of cancer [7].

4. Effects of Sugar Intake in Different Diets on the Body

Based on WHO suggestion, human’s diets should follow the dietary patterns and dietary guidelines in their own countries. Let’s take the American dietary guidelines (Fig. 2). as example, where preserving a healthy weight and balancing your calorie intake with physical activity is critical, variety of protein foods, in addition to limiting foods and beverages that are high in added sugar, fat (including but not restricted to saturated fats, trans fats, cholesterol) and sodium [8]. Vitamins and minerals supplements can be taken if necessary.

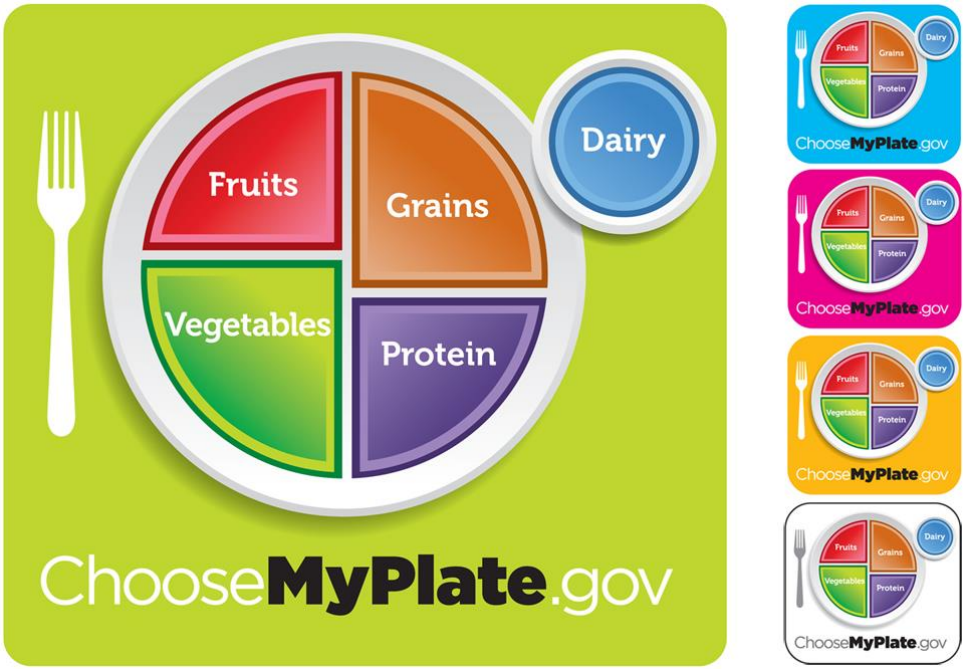

Figure 2. U.S. dietary guidelines [8].

4.1. High-Carb Diets

A high-carb diets is a dietary pattern of eating large proportions of carbohydrates on a daily basis. Over 60% or more of total dietary energy is considered as high-carbohydrates diets. Increases in blood triglycerides and insulin resistance are caused by high-carbohydrate diets, which are particularly harmful for people with insulin-resistant conditions like T2DM or pregnancy. Diabetes type 2 and cardiovascular disease (CVD) are linked to high-carbohydrate diets. In North American countries, the background prevalence of obesity, insulin resistance, and type 2 diabetes mellitus is high due to the presence of high-glycemic carbohydrates as a result of food processing and soft drinks. But low-fat, high-carbohydrate diets have been shown to be effective in improving glucose metabolism [9]. This type diets tend to be had lower fat content when compared with ketogenic diets. The VLDL-rich triglyceride particles produced by it is thought to be less likely to cause atherosclerosis than those associated with insulin resistance syndromes.

4.2. Low-Carb Diets

A lot of people considered about low-carb diet to try to lose weight. This method could be safe, but the drawback of low-carb diet is hard to stay for long term, and it has limitation of amount of fiber takes each day. Prevalent dietary patterns such as the Atkin's diet, the ketogenic diet, and the paleo diet are often considered “low-carb” diets.

Low-carbohydrates diets is restricting the intake of carbohydrates, especially of sugars and starches, mainly focus on consumption of proteins and fats. This type of diets is suitable for short-term for people who in weight loss. Low-carbohydrate diets can be further broken down into very low and low CHO diets, which are respectively characterized as having a proportion of total calorie consumption between 10% and 26% and using protein and fat as a substitute for carbohydrates. This diet is believed to be helpful mostly because it induces ketone production physiologically. When nutritional ketosis is induced, glycogen is first depleted to prevent hypoglycemia, followed by the mobilization of adipose tissue fat to make fuel-producing ketones. Glycogen stores are nearly exhausted after 48 hours of carbohydrate restriction, and gluconeogenesis is in charge of maintaining glucose homeostasis and supplying glucose to the brain, red blood cells, and other organs. Fatty acids are released into the bloodstream and sent to the muscles and liver to produce energy [10].

For patients with diabetes or insulin resistance, the use of low-carb diets is permitted, which reduces the postprandial glycemic index. At the basic level of the fight against sugar, if blood sugar

levels are elevated then this can lead to glycosylation. AGEs, as mentioned above, are the products of the combination of sugars and proteins. And AGEs have been linked to various chronic diseases [11]. Some studies suggest that low-carb diets may reduce markers of inflammation and oxidative stress, which may be related to the process of glycosylation [12].

According to the survey, although there is a slight connection between low-carb diets and anti-sugar strategies, the focus of the two parties is different, with low-carb diets being more about dietary patterns and food combinations, whereas anti-sugar tends to minimize the intake of sugar in a broad and popular diet.

4.3. Ketogenic Diets

Recently, ketogenic diets are becoming much popular, especially in the group of weight-loss people. The ketogenic diet (KD) is a very low-carbohydrate diet with a focus on high-fat, low-carbohydrate foods with the goal of reducing body weight and controlling a variety of neurological and mental illnesses. This diet generates a state of ketosis in which the brain uses ketone bodies rather than glucose for energy. This state of ketosis is achieved by dramatically limiting carbohydrate intake while boosting fat and protein intake [2, 13]. The diet shows consistent clinical benefits in sick patients, potentially as a result of an increase in the anticonvulsant acetone in the brain [2]. The ketogenic diet's major objectives are to lower body fat and enhance metabolic health [13].

Recent research has indicated potential advantages in lowering the risk of several diseases, including type 2 diabetes, hyperlipidemia, heart disease, and cancer [12]. Parkinson's disease and Alzheimer's disease have both been treated with KD; regular usage of ketogenic substances results in cognitive improvement after 45–90 days. The effects of KD have also been investigated in the context of psychiatric conditions such ADHD, depression, and autism. However, there isn't enough data to say whether this diet is clinically effective [14]. There is also need to the further steps to identify how the benefits of ketogenic diet may have relationship with high sugar consumption.

Ketogenic diets are similar to the low-carbohydrates diets; thus, they’re have some common goals like anti-sugar strategies. Particularly in blood sugar regulation, carbohydrates restriction and quantity of sugar intake. The ketogenic diet focuses on fat and protein intake, while carbohydrate intake is minimal, at about 5% - 10% carbohydrates [15]. The anti-sugar approach also focuses specifically on restrictions against added sugars or processed carbohydrates, which can lead to blood sugar rise rapidly.

5. Concept of Anti-Sugar and Dietary Advice

For many individuals pursuing fat loss, a fundamental prerequisite is the need to "combat sugar." Part of fat loss and weight loss people will use sweeteners as sugary substitute in their daily meals. Some individuals pick up non-caloric or low-calorie sweeteners to reduce sugar intake as well as keeping sweetness in foods. So, what exactly does "anti-sugar" entail? The concept of anti-sugar involves reducing or minimizing the intake of added sugars in one's diet. However, it does not necessitate the complete elimination of sugar from daily life. Sugar is, in fact, a crucial nutrient required by the human body. Depriving the body of sugar intake can lead to a reduction in the synthesis of enzyme-promoted glycoproteins, potentially resulting in issues such as hypoglycemia and anemia.

Therefore, it's important to clarify that anti-sugar does not equate to a total blockade of sugar intake. Instead, the principle of anti-sugar revolves around two key aspects. On one hand, it reflects the aspiration to enhance one's dietary choices by avoiding excessive consumption of sugar sources. On the other hand, it underscores the importance of mitigating the potential harm caused to the human body when glycation processes occur.

A large field of research focuses on the relationship between a high glycemic index and glycemic load and the risk of developing cancer. Furthermore, consuming too much sugar causes the body to produce endogenous late glycosylation end products, which are extremely reactive metabolites. These

may lead to an increase in cytokine release and the production of indicators for oxidative stress. Glycosylation is recognized as a primary molecular factor in several complications related to diabetes (Fig. 3). Maintaining controlled blood glucose levels is a potent and natural strategy to inhibit glycosylation in diabetes. However, inhibiting protein glycosylation is a complex process. There are multiple mechanisms that can be considered to address and prevent the formation of AGEs in the body. These include natural defense mechanisms, as well as antiglycating compounds, which can be either synthetic inhibitors or natural inhibitors. Furthermore, this protective process is supported by detoxifying liver enzymes, along with plasma amines and antioxidants.

Based on research, dietary patterns should be considered for anti-sugar supporter. Changing the habits of add sugar, avoid foods that contain concentrated sugar. Replacing sweets with diluted juices and eating fruit. Additionally, choose sugar substitute is a better choice to avoid consuming excessive sugar, for instance, xylitol, which is a plant-based sugar that has a low GI value and tastes like regular sugar, but it had very little effect on blood sugar levels. Carbohydrates that cannot be digested are called dietary fibre, eating a high-fibre diet containing these foods on a regular basis, a reduced risk of bowel cancer, diabetes and constipation will gain.

People should make sure getting enough food with the right kinds of carbohydrates. Eating whole foods and avoid overly processed food choices, preparing 5 types of vegetables daily, 3 types of fruit, no less than 4 and more servings of whole grains, avoid eating extra sugar in any form.

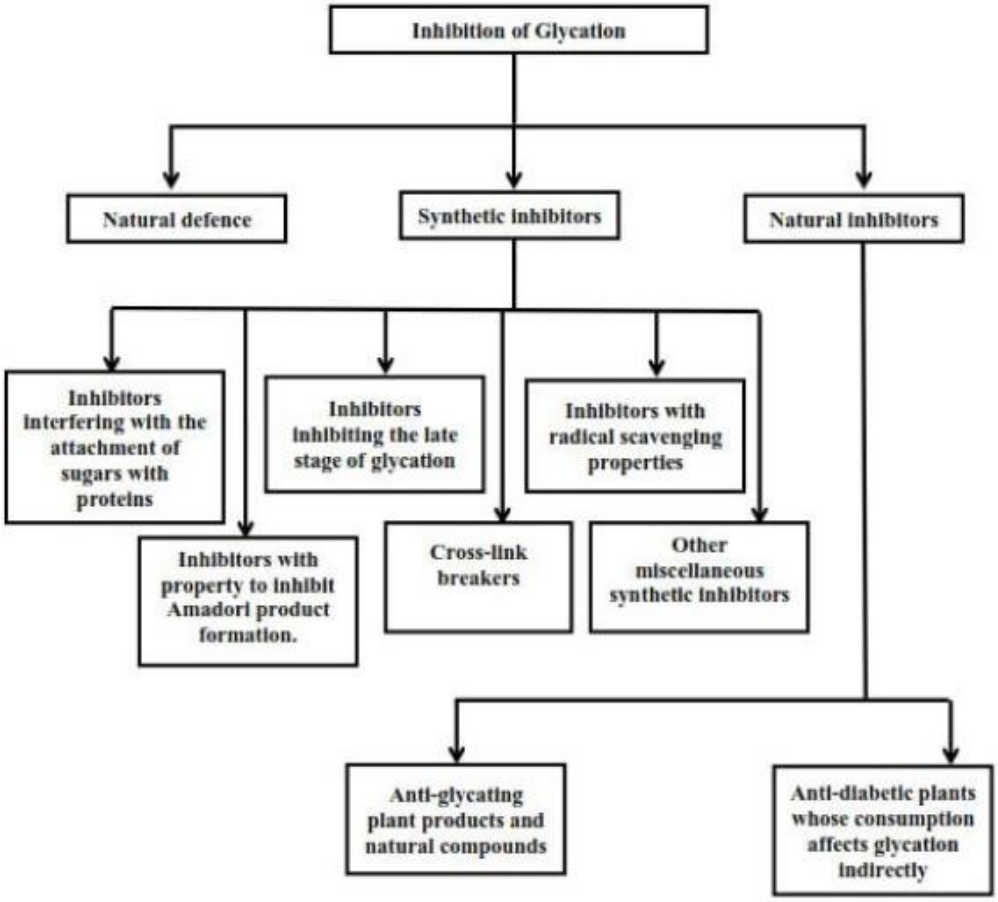

Figure 3. The possible strategies for inhibiting of glycation [16].

6. Conclusion

Sugar is the main source of energy to keep bodies functioning properly. Eating sweets also stimulates the brain to release endorphins, which help relieve low moods and make people feel happy. However, the paradox is that while sugar is made up of essential needs for bodies, excessive intake can lead to a range of health problems. Excessive use of added sugars has been related to obesity,

type 2 diabetes, an increase in cardiovascular disease, and a possible connection to cancer. Added sugars are frequently present in many processed foods and sugary drinks. Therefore, moderation and conscious control of sugar intake is imperative. Whichever dietary pattern one chooses, be it high carb, low carb or ketogenic, it must be complemented by regular physical activity. Exercise complements dietary choices by helping to regulate blood sugar levels, promote weight management and support overall health. The risk of sugar-related health issues can be decreased, and general health can be improved with a well-balanced diet that contains a variety of foods rich in nutrients and is modest in sugar intake.

Fear of high sugar levels has made anti-sugar a fad. It is important to note that dietary decisions should not be made impulsively or solely on the basis of fads. Everyone's nutritional needs are unique, and dietary choices should be tailored to individual goals and preferences. Instead of blindly following dietary trends, it is better to seek personalized advice from a relevant healthcare professional. Striking a balance between sugar intake, dietary choices, physical activity and a personalized nutrition plan is key to promoting overall health and minimizing the risk of sugar-related health problems.

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