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THE EFFECTS OF ERYTHRITOL INTAKE ON CARDIOVASCULAR HEALTH: A REVIEW

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Abstract

A popular low-calorie sweetener is erythritol, a naturally occurring sugar alcohol that can be found in fruits and fermented foods. Due to its lower calorie content, it has become a popular replacement for sugar, particularly for those who have diabetes. Although erythritol is believed to be safe for the majority of individuals, current research indicates that it may be linked to cardiovascular diseases, including a higher risk of blood clots formation, heart attack, and stroke. This paper discusses the erythritol's natural occurrence, production, and metabolism while raising concerns about its potential effects on human health.

Keywords: *Sugar alcohol, Erythritol, Cardiovascular disease, Sweetener.*

INTRODUCTION

Sugar alcohols, which are also referred to as polyols, serve as sweeteners and additives with the purpose of increasing bulk. This substance is naturally present in various food sources, particularly derived from plant-based products like fruits and berries (Gultekin et al., 2020). As a sugar alternative, sugar alcohol offers reduced calories content (approximately half to one-third fewer calories than standard sugar). This happens due to slower conversion of glucose, minimal to no insulin requirement for metabolism, and the ability to prevent sudden increase in blood sugar levels. That is why sugar alcohol is well known among diabetic people. There are several types of sugar alcohol such as mannitol, sorbitol, xylitol, erythritol and many more. Among the various sugar alcohols, erythritol is the one with zero calories (Msomi et al., 2021; Sollid, 2019).

Erythritol can be found naturally in several types of fruits, vegetables and fermented food and beverages (Mazi & Stanhope, 2023). The sweetness of erythritol is not the same as regular sugar, it has a sweetness of approximately 60-80% from regular sugar. Erythritol is mainly used as sweeteners in the production of baked goods, beverages, confectionery products, and individual sweetener packets (Regnat et al., 2017). In addition, it is highly recommended for someone dealing with obesity, diabetes and metabolic syndrome to regulate calorie consumption and sugar level to consume sugar free products containing erythritol (Ruan., 2023).

Besides its benefits, erythritol can have adverse effects on health. It can increase the risk of cardiovascular disease (Fernández-Ruíz, 2023). So, individuals that consume erythritol will show no spike in the blood sugar level, but show an increase in platelet aggregation, and thrombus or thrombosis formation. Cardiovascular disease involves the heart and blood vessels most of the time affecting other organs as time passes (WHO, 2021). The four classifications of cardiovascular diseases are coronary heart disease, stroke, peripheral arterial disease, and aortic disease (Cardiovascular Disease, n.d.). The intake of

erythritol can lead to blood clot formation. Consequently, this could increase the risk of heart attack or stroke.

The purpose of this paper is to examine the effect of erythritol consumption on cardiovascular health, including the potential effect on heart function. Moreover, to understand the metabolism of erythritol in the body and the production of erythritol**.**

RESEARCH METHODS

In this review article, a systematic method was used to analyze literature thoroughly. The goal was to offer a comprehensive and unbiased analysis of the topic matter by evaluating and gathering relevant journals. Essential data sources included academic databases like Elsevier, ScienceDirect, and Google Scholar. Specific keywords and controlled vocabulary related to "sugar alcohol," "erythritol," "cardiovascular disease," and "sweetener" were utilized in the search strategy. Filtering the most relevant journals was based on predetermined selection criteria. Data gathering involved sorting and summarizing information from various sources. Content analysis was employed to establish the relationship between the topic and the content found in the collected literature.

RESULTS AND DISCUSSION

Erythritol-Naturally Occurring and Endogenously Produced

A naturally occuring sugar alcohol, erythritol can be found in fruits and fermented foods. Pears, watermelons, grapes, and mushrooms are examples of foods that contain erythritol naturally. These natural erythritol sources contribute to the sweetness of foods (Anderson & Zagorski, 2023). Both in humans and animals, erythritol can be found in plasma and urine (Mazi & Stanhope, 2023). In healthy human erythrocytes, erythritol is produced endogenously from glucose through the pentose phosphate pathway (PPP), a section of the glucose metabolism that also results in the synthesis of nucleic acid, Deoxyribonucleic Acid (DNA), and Nicotinamide Adenine Dinucleotide Phosphate Hydrogen (NADPH). It is extensively expressed in the liver and kidney and is also generated by human lung cancer cells. This endogenous production contributes a negligible amount of erythritol to the bloodstream (Yoriko Heianza et al., 2023).

According to Rice et al. (2019), there are several factors affecting the generation of endogenous erythritol. Genetic factors can influence an individual's ability to manufacture erythritol. Certain individuals may have genetic differences that impact their body's ability to synthesize erythritol. Additionally, foods containing erythritol precursors, such as fruits and vegetables, can impact endogenous production. A diet high in these natural erythritol sources may promote endogenous production.

The collection of microbes that live in the digestive system, known as the gut microbiota, can also affect erythritol synthesis, impacting the gut's ability to produce erythritol (Di Rienzi & Britton, 2019; Ruiz-Ojeda et al., 2019). However, the liver is where erythritol is predominantly generated. The body's capacity to produce erythritol might be affected by the health and function of the liver. Endogenous erythritol synthesis may be impacted by conditions that alter liver function, such as liver disease or certain drugs (Rzechonek et al., 2017). Other factors affecting the generation of endogenous erythritol include metabolic pathways (hormonal regulation, enzyme activity, and the availability of precursor molecules), age and development, medication and supplements intake, and overall diet and nutrition (Hootman et al., 2017).

Commercial Production of Erythritol

Erythritol can be made by fermentation of yeast and fungi that resemble yeast, using substrates such as glucose, fructose, xylose, sucrose, cellulose, and glycerol (Rice et al., 2019; Rzechonek et al., 2017). The Food and Drug Administration (FDA) considers erythritol produced by microbes as a natural sweetener since it naturally occurs in nature (Mazi & Stanhope, 2023). This variety of sweetener is produced by going through a two step fermentation process. The first step is the growth of *Yarrowia lipolytica* on a medium with sucrose as the main source for carbon. *Yarrowia lipolytica* is a yeast used in a lot of biotechnological productions and is resistant to extreme environmental conditions (Celińska, 2022; Wang et al., 2020). The second step is the addition of pure or crude glycerol to initiate erythritol production. Glycerol is the major by-product of biodiesel production processes, thus has the role of an important renewable raw material (Mirończuk et al., 2014; Mirończuk et al., 2015).

Another research by Rzechonek et al. (2017) stated that typically, glucose is used as the main raw material in the synthesis of erythritol. Cornstarch is a popular option among the several sources that can provide this glucose. Enzymatic or acid hydrolysis mechanisms first convert the starch into glucose. The following phase is the fermentation of glucose into erythritol. For this, yeasts like *Moniliella pollinis* and *Trichosporonoides megachliensis* are often used (Shin et al., 2016). Through a metabolic process, these microbes have the capacity to particularly convert glucose into erythritol. Erythritol production is tightly managed by careful supervision of the fermentation process. In order to produce the perfect conditions for the yeast to convert glucose into erythritol, variables like temperature, pH, aeration, and nutrition levels are continuously monitored and adjusted (Rita, 2018).

After fermentation, erythritol and other byproducts and contaminants are present in the mixture. The erythritol is separated and purified using a variety of methods, some of which include chromatography, filtering, and crystallization. This process improves the quality of the erythritol by removing impurities (Bao et al., 2020). Typically, the refined erythritol retains the shape of a liquid. After drying, a fine, crystalline powder that may be easily mixed into a variety of products is produced. Processes like spray drying or crystallization are frequently utilized for this (Zhang et al., 2020). The application of quality control procedures guarantees that the finished erythritol product complies with the required standards. Testing for toxins, sweetness, and purity are all included in this (NALESSO-LEÃO et al., 2020). Erythritol is often packed in different ways, such as bags or bulk containers, depending on its intended purpose, once it has been made and has passed quality control (Drago et al., 2020).

Health Effect of Erythritol

However, although erythritol is considered a better or safer option than the other sugar alcohols because of its zero calories and does not increase blood sugar level, however, several research studies found significant correlations between the consumption of erythritol and cardiovascular diseases (Witkowski et al., 2023; Mazi & Stanhope, 2023). One of the observed effects is the increase of blood clot formation, affecting cardiovascular health, with risk of heart attack and stroke (Erythritol and Cardiovascular Events, 2023).

Researchers at the Cleveland Clinic, led by Dr. Stanley Hazen, examined the association between erythritol and the risk of heart attacks and strokes. The scientists looked for blood molecules whose levels were predictive of future cardiac risks in a preliminary investigation involving more than 1,000 patients. This experiment had a three year long observation and they monitored severe unfavorable cardiovascular events, such as fatal heart attacks and nonfatal strokes (Releases, 2023).

Across all of these measurements, the observed association between erythritol levels and cardiovascular events was present. In particular, throughout the three-year follow-up, people with the highest erythritol levels were almost twice as likely to have cardiovascular events as people with the lowest levels. These findings raise the possibility of a connection between erythritol consumption, the formation of blood clots, and a higher risk of heart attacks and strokes.

Other than that, a research by Martău et al. (2020) claimed that other factors from erythritol can influence the cardiovascular system. Since erythritol is a sugar alcohol with zero calories, it is a popular choice for calorie restriction and weight control since it lowers the risk of obesity and weight gain, both of which are associated with cardiovascular diseases. Since stable blood sugar levels are essential for cardiovascular health, erythritol's low glycemic index is advantageous for individuals with diabetes or those who are at risk of developing the disease. Additionally, erythritol prevents tooth decay which indirectly boosts cardiovascular health.

Another research by Shin et al. (2016) stated that blood pressure does not seem to be significantly affected by erythritol. It does not cause the same rise in blood pressure that can come from eating too much food high in sugar and sodium. Even though erythritol is a sugar substitute that can be used to reduce sugar intake in a balanced diet, it is best to check with a healthcare professional or nutritionist to establish the best dietary options for specific health needs.

The Metabolism of Erythritol

Erythritol, a four-carbon sugar alcohol, distinguishes itself by its smaller molecular size and lighter weight when compared to commonly consumed counterparts such as xylitol and sorbitol. The absorption

of sugar alcohols in the small intestine occurs through passive diffusion, a process influenced by size regulation (Gromova et al., 2021). Consequently, erythritol demonstrates a swifter and more efficient absorption into the bloodstream than its larger counterparts.

Moreover, a significant fraction of erythritol remains undigested, being excreted unchanged in urine. Research by Hootman et al. (2017) suggests that 5-10% of erythritol in the human bloodstream may undergo oxidation, generating erythrose and subsequently erythronate. These findings introduce intriguing considerations about the metabolism of erythritol and its metabolites, particularly erythronate, and their potential implications for human health, notably in relation to conditions like obesity and diabetes, which are intricately linked to cardiovascular diseases (Bordier et al., 2022). The relatively tiny quantity of unabsorbed erythritol has often been considered to travel to the colon. As stated by Wölnerhanssen et al. (2020), in the early stages, neither the entirety of the absorbed erythritol nor the unabsorbed portion that transited to the large intestine underwent digestion by the gut flora.

However, findings from animal studies concerning erythritol do not consistently align with evidence gathered from human research. According to Kawano et al. (2021), approximately 1% of ingested erythritol is excreted as erythritol in feces, while 6 to 10% undergoes processing by colonic bacteria. In experiments involving mice fed a high-fat diet and provided with water containing 5% erythritol, elevated levels of short-chain fatty acids were observed in both their blood and feces, indicating a consistent pattern of intestinal flora fermentation of erythritol..

CONCLUSION

Erythritol is a typical artificial sweetener used to lower sugar and calorie intake. Erythritol is a common artificial sweetener. However, recent research has linked higher levels of erythritol in the blood to an increased risk of heart attack, stroke and other cardiovascular events. The paper suggests that erythritol can make platelets more active and form clots, which can lead to blood clots and cardiovascular problems. The relationship between erythritol and cardiovascular difficulties is unknown, but additional research is needed regarding the long-term effects of erythritol on cardiovascular health. In addition, it is important to note that although regulatory organizations generally believe that artificial sweeteners are safe, little is known about their long-term impacts on health. Therefore, it is best to consult a doctor or nutritionist before using artificial sweeteners, especially if you are prone to cardiovascular disease.

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