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Erythritol's Impact on Body Weight and Overall Health

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Abstract

Erythritol, a sugar alcohol derived from carbohydrate hydrolysis, is gaining attention for its unique properties and potential health benefits. While it occurs naturally in small quantities in certain foods, industrial production methods have made it a popular sugar substitute in various consumer products.

Erythritol's sweetness coupled with its low or negligible calorie content, positions it as an attractive option for individuals seeking to manage weight or diabetes. Unlike some polyol sweeteners, erythritol's absorption in the small intestine does not lead to gastrointestinal distress, making it widely used in foods and beverages.

Research indicates that erythritol's ingestion does not significantly impact serum glucose or insulin levels, making it suitable for individuals with diabetes or those managing carbohydrate intake.

Moreover, erythritol shows promise in improving endothelial function and protecting against vascular complications associated with diabetes. Individuals with carbohydrate disorders or those who are overweight represent only a segment of the population that may benefit from erythritol. This sweetener also offers a spectrum of advantageous effects on oral and gastrointestinal health.

However, while erythritol offers numerous potential benefits, further studies are needed to fully understand its long-term effects on the human body.

This review compiles current data on erythritol's metabolism and underscores erythritol's multifaceted and beneficial potential role in health.

Keywords: “erythritol”; “sweetener”; “health”; “polyol”, ”diabetes”

Background

Erythritol belongs to the family of sugar alcohols (polyols), which are formed due to the processes of hydrolysation of the ketone or aldehyde group in carbohydrates. Polyols are naturally present in minor amounts in some fruits, vegetables, mushrooms as well as in fermented foods. [1]

However, extracting natural erythritol from plants is not very efficient, so on an industrial scale it is produced for example from glucose by an osmophilic yeast via fermentation of corn using biotechnological techniques [2]. Also, evidence suggests that erythritol can be endogenously produced by human metabolism from glucose via the pentose-phosphate pathway (PPP) [3].

The most important features of this sugar alcohol are its sweetness which is approximately 60-80% of sucrose and low or no calorie content [4, 5]. [1] The majority of erythritol is rapidly absorbed in the small intestine by passive diffusion and then is excreted unmodified into the urine, meaning that - unlike other popular polyol sweeteners such as xylitol - erythritol does not cause diarrhea. [1, 6] The remaining small part enters the colon, but studies showed that human gut microbiota does not ferment erythritol and that erythritol leads to lower osmotic pressures and to rarely any gas production in comparison to other polyols in comparable amounts. [6] Therefore it is widely used in as a sugar replacement such us tabletop sweetener, in beverages, chewing gum, chocolate or other sweets. [1]

Erythritol's Weight Management Potential

It is estimated that in 2016 about 124 million children and 650 million adults worldwide were obese. [7] The primary driver of obesity is the accumulation of fat resulting from a persistent imbalance between calorie intake and expenditure. [8]

Erythritol, a sugar alcohol, boasts an energy value estimated at a maximum of 0.4 kcal/g, rendering it virtually non-nutritive to the body. This unique characteristic distinguishes erythritol from other commonly used polyols, making it a perfect sweetener in specialized foods tailored for individuals with diabetes or those striving to manage excessive body weight. [1, 4]

Despite its promising low-energy profile, erythritol does not yield immediate weight-loss benefits. A week-long study involving a small group of participants demonstrated no significant changes in body weight following regular oral consumption of erythritol. [9] However, given the limited scientific data available, it remains uncertain whether erythritol's

low energy content could potentially facilitate excessive weight loss by reducing the energy density of foods. Consequently, further clinical trials are warranted to explore the long-term effects of erythritol consumption on body weight and its implications for weight management strategies.

The Role of Erythritol in Carbohydrate Management

Research conducted in human subjects has unequivocally illustrated that varying doses of erythritol do not trigger an increase in serum glucose levels [4, 10, 11, 12, 13] or insulin concentrations [4, 10, 11, 12, 13, 14].

Furthermore, its administration demonstrates no impact on glucagon concentrations [11] while concurrently exhibiting a reduction in hemoglobin A1c levels. Erythritol boasts an exceptionally low glycemic index, estimated at 0, which significantly contrasts with the much higher glycemic indices of sucrose or glucose [29].

This collective body of evidence underscores the unique metabolic profile of erythritol and its promising potential for individuals with type II diabetes and other carbohydrate management disorders.

Erythritol and Lipid Metabolism

Erythritol does not induce any significant effects on serum levels of total cholesterol, triacylglycerol [10, 11] or free fatty acids [10, 12].

Erythritol's Protective Effects on Endothelial Health

Dysfunction of the endothelium, marked by an imbalance between vasodilators and vasoconstrictors, compromises its crucial role in vascular function. Nitric oxide (NO) emerges as pivotal in maintaining vascular relaxation and impeding the progression of atherosclerosis, highlighting its significance in evaluating endothelial health. This dysfunction, often linked with cardiovascular risk factors such as diabetes, precedes the onset of atherosclerosis and exacerbates various vascular complications. [15]

An encouraging pilot study involving 24 patients with type II diabetes revealed promising outcomes: those consuming 26 grams per day of erythritol for 4 weeks exhibited reduced arterial stiffness and improved endothelial function [16].

Furthermore, under hyperglycemic conditions, erythritol attenuates glucose-induced cell death, resulting in a remarkable protective effect on the endothelium under stress conditions, such as increased nitric oxide release or high peroxynitrite levels, both of which often accompany diabetic patients. This is extremely important for these patients, as endothelial cell dysfunction is the beginning for vascular complications leading to blindness, renal failure, nerve damage and to further consequences of atherosclerosis such as stroke or limb amputations [17]. [16, 18, 19, 20] Also, erythritol, thanks to its antioxidant activity, may help protect against hyperglycemia-induced vascular damage through its membrane-protective properties [18]. However, it appears that in non-diabetic subjects, erythritol has only minimal effect on endothelium. [18, 19, 20]

Extensive research in this area is warranted; however, it can now be concluded that erythritol presents itself as an attractive potential sweetener substitute for people diagnosed with diabetes.

The implications of erythritol on kidney and water-electrolyte balance

While erythritol is primarily eliminated through urine, its consumption does not notably alter plasma osmolarity, water intake, or urine production. [9, 13] Additionally, it does not cause significant changes in serum levels of sodium, potassium, chloride [9, 10] and phosphate [9] or plasma and urine electrolyte balance. [13] The only exception is calcium, where its excretion slightly increases with repeated erythritol ingestion at daily doses of 1 g/kg body weight. [9, 30]

Erythritol's Influence on Gastric Emptying and Fullness Sensation

The immediate consumption of erythritol triggers the release of gut hormones like glucagon-like peptide-1 (GLP-1) and cholecystokinin (CCK), known for their roles in inducing satiety, delaying gastric emptying, and regulating glucose levels. [11, 14] Erythritol induces a delay in gastric emptying, which contributes to the sensation of fullness and ultimately prompts meal termination [14].

Despite the release of these hormones, research has not identified any discernible impact of erythritol treatment on sensations related to appetite [11].

Erythritol and Gastrointestinal Health: Absorption, Tolerance, and Hormonal Effects

It is estimated that up to 90% of ingested erythritol is instantly absorbed in the small intestine. Then it is poorly reabsorbed by the kidneys, and it is quantitatively excreted in the urine [4]. A much smaller fraction, approximately less than 10%, enters the colon. That raises the question whether erythritol may be susceptible to fermentation in a human intestine.
Data on this subject is quite limited, but single studies have been able to find out, that although erythritol seems to be readily absorbed, it undergoes no further metabolism as well as that fractions missed in an absorption are not metabolized by the faecal flora. [6, 21]

Moreover, erythritol is completely resistant to the attack by the colonic microbiota during the fermentation lasting 24 hours. [6]

In another trial medium doses of erythritol ingested in a liquid caused no side effects, while large doses (50 grams) caused only a significant increase in borborygmi and nausea whereas medium and large doses of xylitol (35-50g) were associated with significant intestinal symptom scores and watery faeces.

Erythritol tolerance was also successfully tested among 185 healthy young children aged four to six years. This trial showed that the limiting dose at which there are no side effects in children is 15 grams per single dose. No nausea, vomiting, borborygmi, excess flatus and abdominal pain occurred at any of the tested doses. Ingestion of larger doses of erythritol (15-25 grams) lowered stool consistency only on the first day of the study but beyond that did not cause any serious side effects. [22] Also, another trial examining tolerance of daily oral doses of erythritol indicated that after regular ingestion no signs of gastrointestinal intolerance were seen, and that stool frequency and appearance were not different between erythritol and sucrose trials. [9] Therefore, erythritol has been recognized as a sweetener with no or minimal laxative properties. [23]

Erythritol not only has the advantage of not causing many side effects, but also has the added benefit of inducing the secretion of gut hormones: glucagon-like peptide-1 (GLP-1) and cholecystokinin (CCK), which are responsible for satiation feeling, decelerating effect on gastric emptying and modulating glucose homeostasis. [14, 31, 32]

Erythritol's Impact on Oral Microbiota and Dental Health

The non-cariogenic nature of erythritol was initially investigated and substantiated in rat studies during the 1990s [24], subsequently corroborated in human trials. Ongoing research

has progressively unveiled the myriad favorable impacts of erythritol on oral health, including its inhibitory effects on the development of periodontopathic biofilms [25].

Furthermore, the use of erythritol was associated with an inhibition on the presence of caries-inducing bacteria such as the Streptococcus mutans - a key contributor to caries development - coupled with significant reduction in the mass of plaque [26]. [5]

In a separate three-year investigation, the daily consumption of modest erythritol doses (approximately 7.5 g) emerged as a preventative measure against caries in 485 children via the reduction in plaque growth, decreased levels of plaque acetic acid and propionic acid, and lowered oral counts of mutans streptococci.

Remarkably, this effect was achieved without altering salivary Lactobacillus levels, and in comparison to sorbitol and xylitol consumption, no significant changes were observed [27].

Another extensive study involving erythritol showcased its correlation with the lowest incidence of Streptococcus mutans and caries prevalence [28].

Beyond its protective influence against caries susceptibility, erythritol's impact extends to enhancing oral sensations and mitigating unpleasant aftertastes, such as astringency. Notably, its high negative heat of solution contributes to a strong cooling effect. [1]

Summary

Erythritol, a sugar alcohol synthesized from glucose fermentation and occurring naturally in trace amounts in various foods, serves as a popular sugar substitute due to its unique properties. Despite its sucrose-like sweetness, erythritol boasts minimal calorie content, making it suitable for diabetic and weight management diets. Additionally, it exhibits a low glycemic index and has no cariogenic effects, contributing to its potential in managing diabetes and oral health.

Furthermore, erythritol's remarkable digestive tolerance and antioxidant properties, along with its potential as an endothelium-protective agent, make it a promising addition to dietary regimens. Its ability to regulate satiety and mitigate endothelial dysfunction underscores its role in weight management and vascular health. However, comprehensive clinical trials are needed to assess its long-term effects on metabolic diseases and cardiometabolic outcomes.

In summary, erythritol offers a range of benefits, including its non-caloric nature, low glycemic index, and potential to inhibit caries-inducing bacteria. Its antioxidative properties and potential to protect endothelial cells add to its appeal as a sugar substitute.

Nevertheless, further research is essential to fully understand erythritol's impact on metabolic diseases and to address its potential role in managing cardiovascular health.

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References

[1] Regnat K, Mach RL, Mach-Aigner AR. Erythritol as sweetener-wherefrom and whereto?. Appl Microbiol Biotechnol. 2018;102(2):587-595. doi:10.1007/s00253-017-8654-1

[2] Park YC, Oh EJ, Jo JH, Jin YS, Seo JH. Recent advances in biological production of sugar alcohols. Curr Opin Biotechnol. 2016;37:105-113. doi:10.1016/j.copbio.2015.11.006

[3] Hootman KC, Trezzi JP, Kraemer L, et al. Erythritol is a pentose-phosphate pathway metabolite and associated with adiposity gain in young adults. Proc Natl Acad Sci U S A. 2017;114(21):E4233-E4240. doi:10.1073/pnas.1620079114

[4] Bornet FR, Blayo A, Dauchy F, Slama G. Plasma and urine kinetics of erythritol after oral ingestion by healthy humans. Regul Toxicol Pharmacol. 1996;24(2 Pt 2):S280-S285. doi:10.1006/rtph.1996.0109

[5] Mäkinen KK. Sugar alcohol sweeteners as alternatives to sugar with special consideration of xylitol. Med Princ Pract. 2011;20(4):303-320. doi:10.1159/000324534

[6] Arrigoni E, Brouns F, Amadò R. Human gut microbiota does not ferment erythritol. Br J Nutr. 2005;94(5):643-646. doi:10.1079/bjn20051546

[7] Cuciureanu M, Caratașu CC, Gabrielian L, et al. 360-Degree Perspectives on Obesity. Medicina (Kaunas). 2023;59(6):1119. Published 2023 Jun 9. doi:10.3390/medicina59061119

[8] Yoo S. Dynamic Energy Balance and Obesity Prevention. J Obes Metab Syndr. 2018;27(4):203-212. doi:10.7570/jomes.2018.27.4.203

[9] Tetzloff W, Dauchy F, Medimagh S, Carr D, Bär A. Tolerance to subchronic, high-dose ingestion of erythritol in human volunteers. Regul Toxicol Pharmacol. 1996;24(2 Pt 2):S286-S295. doi:10.1006/rtph.1996.0110

[10] Noda K, Nakayama K, Oku T. Serum glucose and insulin levels and erythritol balance after oral administration of erythritol in healthy subjects. Eur J Clin Nutr. 1994;48(4):286-292.

[11] Wölnerhanssen BK, Drewe J, Verbeure W, et al. Gastric emptying of solutions containing the natural sweetener erythritol and effects on gut hormone secretion in humans: A pilot dose-ranging study. Diabetes Obes Metab. 2021;23(6):1311-1321. doi:10.1111/dom.14342

[12] Ishikawa M, Miyashita M, Kawashima Y, Nakamura T, Saitou N, Modderman J. Effects of oral administration of erythritol on patients with diabetes. Regul Toxicol Pharmacol. 1996;24(2 Pt 2):S303-S308. doi:10.1006/rtph.1996.0112

[13] Bornet FR, Blayo A, Dauchy F, Slama G. Gastrointestinal response and plasma and urine determinations in human subjects given erythritol. Regul Toxicol Pharmacol. 1996;24(2 Pt 2):S296-S302. doi:10.1006/rtph.1996.0111

[14] Wölnerhanssen BK, Cajacob L, Keller N, et al. Gut hormone secretion, gastric emptying, and glycemic responses to erythritol and xylitol in lean and obese subjects. Am J Physiol Endocrinol Metab. 2016;310(11):E1053-E1061. doi:10.1152/ajpendo.00037.2016

[15] Flammer AJ, Anderson T, Celermajer DS, et al. The assessment of endothelial function: from research into clinical practice. Circulation. 2012;126(6):753-767. doi:10.1161/CIRCULATIONAHA.112.093245

[16] Flint N, Hamburg NM, Holbrook M, et al. Effects of erythritol on endothelial function in patients with type 2 diabetes mellitus: a pilot study. Acta Diabetol. 2014;51(3):513-516. doi:10.1007/s00592-013-0534-2

[17] Brownlee M. Biochemistry and molecular cell biology of diabetic complications. Nature. 2001;414(6865):813-820. doi:10.1038/414813a

[18] den Hartog GJ, Boots AW, Adam-Perrot A, et al. Erythritol is a sweet antioxidant. Nutrition. 2010;26(4):449-458. doi:10.1016/j.nut.2009.05.004

[19] Boesten DM, Berger A, de Cock P, et al. Multi-targeted mechanisms underlying the endothelial protective effects of the diabetic-safe sweetener erythritol. PLoS One. 2013;8(6):e65741. Published 2013 Jun 5. doi:10.1371/journal.pone.0065741

[20] Roberts AC, Porter KE. Cellular and molecular mechanisms of endothelial dysfunction in diabetes. Diab Vasc Dis Res. 2013;10(6):472-482. doi:10.1177/1479164113500680

[21] Hiele M, Ghoos Y, Rutgeerts P, Vantrappen G. Metabolism of erythritol in humans: comparison with glucose and lactitol. Br J Nutr. 1993;69(1):169-176. doi:10.1079/bjn19930019

[22] Jacqz-Aigrain E, Kassai B, Cornu C, et al. Gastrointestinal tolerance of erythritol-containing beverage in young children: a double-blind, randomised controlled trial. Eur J Clin Nutr. 2015;69(6):746-751. doi:10.1038/ejcn.2015.4

[23] Cvikl B, Lussi A. The Biocompatibility of a New Erythritol-and Xyltol-Containing Fluoride Toothpaste. Healthcare (Basel). 2021;9(8):935. Published 2021 Jul 25. doi:10.3390/healthcare9080935

[24] Kawanabe J, Hirasawa M, Takeuchi T, Oda T, Ikeda T. Noncariogenicity of erythritol as a substrate. Caries Res. 1992;26(5):358-362. doi:10.1159/000261468

[25] Hashino E, Kuboniwa M, Alghamdi SA, et al. Erythritol alters microstructure and metabolomic profiles of biofilm composed of Streptococcus gordonii and Porphyromonas gingivalis. Mol Oral Microbiol. 2013;28(6):435-451. doi:10.1111/omi.12037

[26] Mäkinen KK, Saag M, Isotupa KP, et al. Similarity of the effects of erythritol and xylitol on some risk factors of dental caries. Caries Res. 2005;39(3):207-215. doi:10.1159/000084800

[27] Runnel R, Mäkinen KK, Honkala S, et al. Effect of three-year consumption of erythritol, xylitol and sorbitol candies on various plaque and salivary caries-related variables. J Dent. 2013;41(12):1236-1244. doi:10.1016/j.jdent.2013.09.007

[28] Honkala S, Runnel R, Saag M, et al. Effect of erythritol and xylitol on dental caries prevention in children. Caries Res. 2014;48(5):482-490. doi:10.1159/000358399

[29] Livesey G. Health potential of polyols as sugar replacers, with emphasis on low glycaemic properties. Nutr Res Rev. 2003;16(2):163-191. doi:10.1079/NRR200371

[30] Munro IC, Berndt WO, Borzelleca JF, et al. Erythritol: an interpretive summary of biochemical, metabolic, toxicological and clinical data [published correction appears in Food Chem Toxicol 1999 Jun;37(6):I-II. Bernt WO [corrected to Berndt WO]]. Food Chem Toxicol. 1998;36(12):1139-1174. doi:10.1016/s0278-6915(98)00091-x

[31] Storey D, Lee A, Bornet F, Brouns F. Gastrointestinal tolerance of erythritol and xylitol ingested in a liquid. Eur J Clin Nutr. 2007;61(3):349-354. doi:10.1038/sj.ejcn.1602532

[32] Bonnema A, DeCock P, Eapen A, Bosscher D. The tolerance of erythritol and xylitol based on effective dose methodologies. Am J Physiol Endocrinol Metab. 2016;311(4):E761. doi:10.1152/ajpendo.00300.2016