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BENEFITS AND HAZARDS OF SWEETENERS IN DIABETES MELLITUS DIET

©*Evseev A.*, ORCID: 0000-0001-9155-1518, SPIN-code: 7490-5556, Ph.D.,
Vladimir State University, Vladimir, Russia, andrej.yevsejev@rambler.ru

ПОЛЬЗА И ВРЕД ПОДСЛАСТИТЕЛЕЙ В ДИЕТИЧЕСКОМ ПИТАНИИ ПРИ САХАРНОМ ДИАБЕТЕ

©*Евсеев А. Б.*, ORCID: 0000-0001-9155-1518, SPIN-код: 7490-5556, канд. пед. наук,
Владимирский государственный университет им. А.Г. и Н.Г. Столетовых, г. Владимир,
Россия, andrej.yevsejev@rambler.ru

Abstract. According to the statistics submitted by the World Health Organization, sugar consumption has been constantly increasing worldwide. Craving for sugary foods is a fairly common form of addiction. Poor nutrition, caused by external and internal factors, provokes an increase in the incidence of obesity, arterial hypertension, and diabetes mellitus. This deadly triad annually takes hundreds of thousands of lives across the globe, since the pathologies listed above often go hand in hand, being interconnected. The article discusses the problem of using artificial and natural sweeteners in diet therapy for diabetes mellitus. Nutritionists around the world are concerned about how to preserve the usual sweet taste of dishes and drinks for patients with diabetes, on the one hand, yet avoiding additional harm to their health, and possibly improving the quality of diabetic life, on the other. The author summarized the materials on recent clinical studies on the subject discussed. The article analyses the four sweeteners most commonly used by diabetics: fructose, sorbitol, xylitol and honey stevia (*Stevia rebaudiana* Bertoni) leaf powder. Considerable attention is paid to the history of the appearance of each of the substances and medicinal raw materials studied. The author indicates their safe properties and possible disadvantages of use, as well as side effects.

Аннотация. По статистике Всемирной организации здравоохранения с каждым годом в мире растет потребление сахара. Тяга к употреблению сладкого является довольно распространенным видом зависимости. Нерациональное питание, обусловленное внешними и внутренними причинами, провоцирует рост заболеваемости ожирением, артериальной гипертензией, сахарным диабетом. Это смертоносная триада уносит сотни тысяч жизней ежегодно, поскольку перечисленные выше патологии часто идут «рука об руку» друг с другом, являясь взаимосвязанными. В данной статье рассматривается проблема применения искусственных и натуральных подсластителей в диетотерапии сахарного диабета. Нутрициологи всего мира озабочены тем, как сохранить привычный сладкий вкус блюд и напитков, которые потребляют пациенты с сахарным диабетом, с одной стороны, и не причинить дополнительного вреда их здоровью, а возможно и улучшить качество жизни последних, с другой. Обобщен материал по зарубежным клиническим исследованиям последних лет, посвященным исследуемому вопросу. Основное содержание статьи составляет анализ четырех наиболее часто применяемых диабетиками подсластителей: фруктозы, сорбита, ксилита и стевии медовой. Значительное внимание уделяется истории

появления каждого из исследуемых веществ и лекарственного сырья. Автор указывает на их безопасные свойства и возможные недостатки применения, а также побочные эффекты.

Keywords: sweetener, diabetes mellitus, diet, nutritionist, healthy lifestyle.

Ключевые слова: подсластитель, сахарный диабет, диета, нутрициолог, здоровый образ жизни.

Introduction

Sweeteners are becoming more and more popular in the world nowadays both among those who lead a healthy lifestyle and ordinary people. Any attempts to restrict or even give up using sugar in meals make human beings feel ill at ease. Hence, nutritionists worldwide are puzzled how, on the one hand, to preserve the customary taste in foods and drinks we consume, and, on the other hand, cause no harm to human health. As for diabetes mellitus (DM), how can one choose a sugar substitute that makes a full-fledged substitute for sugar and, at the same time, be safe? Are all sweeteners dangerous or is it another myth that requires debunking? Let us have a go at handling these issues.

Saccharin history as food additive

The first sugar substitute was accidentally invented by the Russian chemist Konstantin Falberg. He paid attention to the sweet taste of bread he was eating during lunch. It appeared that it was not flour that was sweet in taste but the chemist's fingers. Thus, sulphobenzoic acid was discovered. A little later, Falberg synthesized saccharin (E954) from it which he successfully patented in 1884. Saccharin is eliminated from the body in its original form with urine.

A few studies held in 1960s in the US proved saccharin was a carcinogen causing urinary bladder cancer in rats. The latter were fed with high dosages of saccharin which exceeded their weight. In 1977 the US Food and Drug Administration (FDA), Canada and the USSR banned saccharin in the food industry. However, later it was established and confirmed that the permissible daily dosage of 5 mg per 1 kg of human weight is completely harmless. In 1991 FDA re-established saccharin as safe sweetener. Still the product packaging inscriptions with warnings of possible health consequences of saccharin were maintained in 1981–2000. Nowadays the use of saccharin is authorized in more than 90 countries, including Russia.

Saccharin is used in the food industry as a sweetener and flavoring. It is zero-calorie, from 300 to 500 times sweeter than sugar. In the production of beverages, it is used as one of the components of sweeteners, because when used alone, foods acquire an unpleasant metallic taste. But now its use in the food industry is significantly reduced.

The most popular sugar substitutes among diabetics are fructose, sorbitol, xylitol and stevia.

Fructose impact on glycemic control

Fructose is the sweetest of all-natural sugars. It is present in all sweet fruits, honey, some vegetables, while it is less calorie than sugar and not so harmful to the teeth. Unlike other carbohydrates, fructose is involved in intracellular metabolism without insulin. It is removed from the blood in a short period of time, as a result, blood sugar rises less than after glucose. The daily

allowed intake of fructose is about 35 grams. Fructose is allowed in the diabetic diet. Due to its high sweetness, it helps to reduce the consumption of sugar. Its nutritional value is 368 kcal per 100 grams of dry powder.

Cozma's et al. (2012) meta-analysis inquired into the effect of fructose on glycemic control in DM. The research proved that isocaloric exchange of fructose for other carbohydrate improves long-term glycemic control, as assessed by glycated blood proteins, without affecting insulin in people with diabetes. DM changes the macronutrients metabolism. Hence, the role of diabetic diet and the quality of carbohydrates consumed are of considerable interest [1].

Gomez-Samano et al. (2018) investigated the complications which may be caused by fructose intake. Their research was dedicated to possible links between albuminuria and fructose consumption in people with T2DM. As many as 136 volunteers participated in a single centre cross-sectional study and were assessed. The research proved a significant positive link between fructose intake and albuminuria in people with T2DM. The scientists reported gender differences in albuminuria progress. Despite the fact that fructose intake equalled in male and female participants, albuminuria was higher in males than in females. In addition, a high fructose intake (>25 g a day) was reported to aggravate oxidative stress and increase uric acid, triglycerides, hence, leading to kidney damage (diabetic nephropathy) [2].

Sorbitol use: pros and cons

Sorbitol (E420) is one of the most popular sugar substitutes on the Russian domestic consumer market. The import of sorbitol (mostly from France) totalled 32m USD in 2018 [3]. Sorbitol is widely used in the food industry as a natural sweetener and an ingredient with a wide range of technological and functional properties. Sorbitol is a colorless sweet crystals, soluble in water and alcohol. It is also used in pharmaceuticals, cosmetics and some other areas. Sorbitol's nutritional value is 3.5 kcal/g only. The sweetness of the sugar substitute is 40 per cent lower than sugar. At the same time, when consumed, it almost does not lead to a hike of glucose in blood because of its poor absorption. Sorbitol glycemic index is equal to 4. As much as 98 per cent of sorbitol consumed is absorbed by the human body. It is non-toxic and harmless for human health.

Sorbitol is widely used in the production of sugar-free confectionery since it adds mass and increases structural stability in foodstuffs. The sweetener regulates the moisture content, hence, increasing the foods shelf life. Sorbitol absorbs environmental moisture, thereby maintaining moisture and extending the shelf life of foodstuffs. For instance, candies, jelly, marshmallow and some other products dry out rapidly, their quality deteriorating. Therefore, for better preservation, from 5 to 10 per cent of sorbitol is added to them.

In cosmetics, sorbitol acts as a moisturizer, making human skin velvety and soft. Sorbitol is also used as an emulsifier, it gives a certain consistency to the products — it is used in the production of margarine, sauces, egg and fatty products. In addition, sorbitol is a free-flow agent, it tends to prevent the dry foods caking (e.g. in concentrates, jelly, puddings, and other powdered products). Sorbitol is also used in food production as a complex former and color stabilizer.

Sorbitol was first extracted from ash-berries in 1868. Its highest concentrations are found in ash-berries, blackthorn, cornel, apricots and haws. In subjects diagnosed for as T2DM it is absorbed better than glucose and does not require insulin. In addition, sorbitol has an antiketogenic effect which is important for patients with ketoacidosis episodes in medical history. Sorbitol affects the

activity of the gastrointestinal tract, stimulates the secretion of gastric juice, has a cholagogue effect and can be prescribed for hypotonic biliary dyskinesia. However, patients with T2DM are advised to make one-month intervals after each 3 months of continuous sorbitol consumption. Fermentation of sorbitol in the large intestine can create gastrointestinal discomfort including bloating, gas and diarrhea, dehydration, nausea and vomiting. But these effects are not the same for everyone. The FDA found sorbitol safe overall and approved its daily dosage of <50 g a day. Its use has not been studied well enough in pregnant women to determine whether it's safe for the fetus.

Medical use of xylitol

Xylitol (E967) was first synthesized in 1891 by Bertrand and Fisher by reducing D-, and L-xylose with sodium amalgam. Cotton husk, wood raw material (birch), sunflower husk, and other agricultural waste served as raw materials for the production of xylitol. The most important advantage was the cost-effectiveness of manufacturing these products, because the raw materials used for other purposes have almost never used before. Xylitol is absorbed more slowly than glucose: its absorption rate is 20 per cent lower than that of glucose. Thus, the sugar substitute can be recommended to patients with T2DM. In 2011, the European Food Safety Authority (EFSA) approved a marketing claim that foods or beverages containing xylitol or similar artificial sweeteners cause lower blood glucose and lower insulin responses compared to sugar-containing foods or drinks. Therefore, high dosages of xylitol may cause diarrhea due to its water retention effect through accumulation in the intestine. A 40-gramme daily intake of xylitol increases blood sugar by 1.1 mmol/l only. Xylitol is reported to enhance oxygen absorption and inhibits the formation of acetoacetic acid in liver. The sweetener is allowed for use in patients with DM, although it can be prescribed as cholekinetic which forces the gall bladder to contract without any side effects observed. Some reports say xylitol can be an allergen, so it should be taken with care by highly allergic individuals.

Stevia in T2DM

Stevia is a natural sweetener. Its main component, steviol glycosides, lacks calories and 300 times sweeter than sugar. Regular consumption of stevia in the permitted dosage (max. 2 mg/kg of body weight per day) is beneficial to the whole body.

FDA approved high-purity steviol glycosides as a safe food additive in the USA in 2008, although stevia leaf and crude stevia extracts are not considered safe and do not have FDA approval for use in food [4].

As to stevia consumption by T2DM patients, stevia lowers blood sugar levels, whereas it does not change normal sugar. Stevia also has the ability to stimulate insulin secretion in pancreas. That's why in some countries, medicines, which have stevia as an ingredient and tea with stevia, are included in the mandatory treatment programme for DM. Stevioside helps to restore the sensitivity of the body's cells to insulin and increase the penetration of glucose. Contra-indications to the use of stevia are idiosyncrasy, hypotension, allergy.

Conclusion

Thus, of the four sweeteners reviewed in the article, only stevia can be considered today as a safe alternative to sugar in DM, since it has a minimum of side effects and contraindications. It is less toxic than synthetic sugar additives, well-tolerated, has a good taste, and is affordable in price.

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