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RELATIONSHIP OF THE STRUCTURE, PROPERTIES AND MAIN FIELDS OF USE OF SUCRALOSE

The article analyzes the properties of sucralose and the main fields of application in industry. It is noted that sucralose is relatively easily excreted from the body. Basis on the analysis of the literature, it was established that the positive properties of sucralose include the following qualities, in particular, it doesn't penetrate the brain, doesn't increase blood sugar level (allows it to be used by people with diabetes), resistant to bacteria in the oral cavity (therefore does not cause caries). Sucralose is used in the food and pharmaceutical industry as a flavor sweetener, registered in Europe as a food additive E-995.

Prospective use is as a molecular marker for identification of pollution sources of natural water bodies. Scientists have established that such sugar substitutes as saccharin, aspartame and cyclamates decompose in the environment, and sucralose and its derivatives (salts and esters) were present in soil and wastewater, which is a sign of its accumulation in the environment. Bacterial strains performing the function of reductants will gradually decrease in the presence of sucralose, which will lead to a change in ecosystem. Given that bacterial colonies can convert sucralose into dichloraldehydes, which are toxic, it is necessary to investigate the impact on the life processes of organisms in the relevant water bodies. When processing library sources, it was found that sucralose suppresses the growth of roots, asexual reproduction of some river algae. This is what prompted us to analyze the literature on the properties of sucralose and the safety of its use in various industries.

Key words: sucralose, natural sugar substitutes, licorice root, steviol and its glycosides, tagatose, locust bean gum (E 410), low calorie sweetener.

Sucralose is an artificial sweetener that is more than 600 times sweeter than sugar. Sucralose was accidentally discovered in 1976 and after twenty years of testing was approved as a food additive. Currently, sucralose is the best sugar substitute and occupies a leading position in the United States of America. In Europe Sucralose is registered as a food additive E-995. This substance is often included in various sugar substitute mixtures. On the market the sweetener can be found under the names: Sucralose, Splenda, FitParad (2, 7, 9, 10, 11), Sladella, Milford Sucralose, Sunvision Sucralose, FillDay, Sladis Elit.

Sucralose (E 955) is dangerous when it is heated in dry form to temperatures above 125°C because harmful substances release. Long term use can cause a decrease in the body's immunity and diseases of the gastrointestinal tract. Therefore, determining the concentration of sucralose (E 995) in food products is important for determining the content of dissolved substances in the sample. In addition, the constant use of a sweetener causes problems with vision, memory and worsens the functioning of the brain. We justify this by the fact that the body does not have enough glucose.

The purpose of the article is to analyze the scientific literature on the structure, properties and safety of sucralose use in the food industry.

Task of the research is to justify ways of solving problems related to the presence of sucralose in beverages, as well as to its accumulation in the environment.

Methods and materials of research

Sucralose is one of the common and widely used synthetic sweetener [2–10]. This substance is a derivative of galactosucrose, in which three hydroxyl groups are replaced by chlorine atoms, according to the formula (Fig. 1).

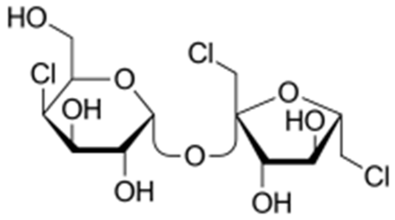
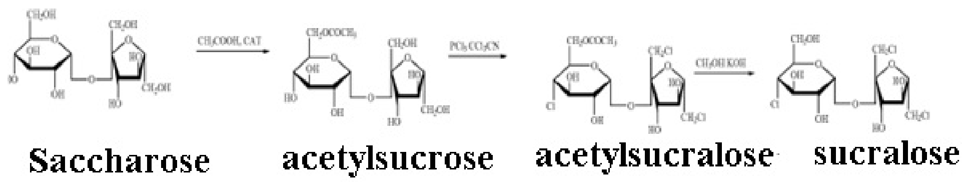


Fig. 1. Sucrose.

Discussion. According to its physical properties in the free state, sucralose is a shiny, white, odorless crystalline substance that is well soluble in water. It is believed the sucralose is sweeter than all known sugar substitutes, being twice as sweet as saccharin, three times as sweet as aspartame, and 600 to 1000 times sweeter than sugar.

Despite the fact that sucralose is a derivative of natural substances, it does not exist in nature, so it is obtained artificially. The starting material for the synthesis of sucralose is sucrose, and the production of sucralose takes place in several places:



At the same time toxic substances (diethylazodicacarboxylate (Fig. 2), phosphorys, pentachloride, acetonitrile, methanol) are used as reagents, catalysts and solvents in the synthesis process.

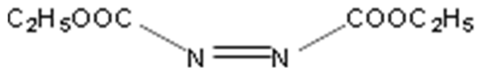


Fig. 2. Diethylazodicacarboxylate.

According to its chemical properties, sucralose resembles chlorohydrins – products of halogenation of polyatomic alcohols. Sucralose is used in the food industry to give a sweet taste to drinks, confectionery products, in the production of non-alcoholic and alcoholic drinks, dairy desserts, canned and frozen fruits and vegetables, jams, bakery products, sauces, mayonnaise, marinades, breakfast cereals, dry mixtures (for cupcakes), chewing gums, etc. [1–2]. The use of this substance, which is a sugar substitute, three times sweeter than aspartame, twice as sweet as saccharin and a thousand times sweeter than sugar, helps to reduce the production cost of these goods due to their low cost (compared to sugar and the most common sugar substitutes).

In terms of sweetness, sucralose is inferior to the synthetic sugar substitutes neotame and lugdun, as well as the natural sugar substitute periraltin, used only in Japan. The permissible daily dose of consumption is up to 15 mg/kg of body weight [11–12]. Sucralose is recommended as a low-calorie dietary product for certain categories of patients (diabetes, obesity), as well as for fitness nutrition. In addition to this sucralose is used as a flavor sweetener in the food industry and an additional agent (taste corrector) in the production of medicine in the pharmaceutical industry.

At the same time, the wide use of sucralose, its fairly high stability, minimal biodegradation in the drainage system and treatment facilities, led researchers to think about the possibility of using this compound as a reliable molecular marker to identify the pollution sources of natural water reservoirs.

Moreover, due to its stability, sucralose and its derivatives can be used as components of anti-corrosion composites, both independently and as an additive to polymer, carbon and silicone materials. At the same time, the independent use of sucralose quaternary salts is possible for non-aqueous environments and fat soluble sucralose derivatives can perform a protective function in aqueous environments as well.

Although sucralose is considered by experts to be one of the safest sugar substitutes, which is allowed to use even by pregnant women and children, and sugar substitutes are one of the most carefully tested food additives, still multi-level studies are currently being conducted to assess their safety. Studies of these substances effects, and sucralose in particular, on the living organism are conducted regularly and are aimed at obtaining a sufficient amount of scientific data for confidence in the safety of these substances [13–15].

As a result of a number of studies, it was established that the use of low calorie sweeteners in diet carbonated drinks can contribute to metabolic deregulation, change the level of glucose, insulin and contribute to the possibility of obesity, metabolic syndrome and 2 type diabete. Consequently, additional research is needed to clarify the possible mechanisms of this effect. Along with it has been shown that sucralose passes from mother to child through breast milk.

Modern studies [16] showed the presence of new sucralose metabolites in both urine and feces of rats that were administered sucralose at a dose of 80 mg/kg of weight for 40 days. Both water soluble (quaternary salts) and fat soluble (esters) metabolites formed, and they were found in urine, feces and adipose tissue. The complete elimination of metabolites occurred only on the 54th day after the start of the experiment. The same study described the inhibition of the beneficial bacteria growth in the intestines, which stopped with the end of sucralose use. At the same time, the restoration of the previous rates of microflora growth occurred gradually.

In addition to certain biological effects of sucralose, which indicate that organochlorine sweeteners are metabolically active and can disrupt metabolism through a negative effect on the metabolism of thyroid hormones, the presence of its certain metabolites, the safety profile of which is not yet known, has been established. Besides this, testing using several different methods showed the presence of mutagenic properties of sucralose hydrolysis products, as well as the possibility of formation of potentially toxic compounds – dioxins and tetrachlorodibenzofurans under the influence of high temperatures. This factor manifests itself more intensively when using sucralose and its derivatives as components of anti-corrosion agents. Sucralose is widely used in human nutrition, including special diabetic sports due to its low calorie content and slow, cumulative participation in human metabolism. However, if sucralose is relatively safe for the human body, it can be dangerous for other participants of the trophic chains – soil and water organisms.

A group of scientists from North Carolina State University [17] showed that while other sugar substitutes such as saccharin, aspartame and cyclamates decompose in the environment, sucralose and its derivatives (salts and esters) were present in soil and wastewater, which is a sign of its accumulation in the environment. Concentration dependent inhibition of the growth of some bacterial strains performing the reductant function in the presence of sucralose was also shown. When the growth of bacterial strains is restrained and their population gradually decreases, it will lead to changes in trophic chains and, accordingly, in the entire ecosystem. Furthermore, bacterial colonies can convert sucralose into dichloraldehydes, which are toxic.

Another study showed that sucralose caused some biochemical and behavioral changes in Daphnia magna crustaceans (they are also used as aquarium fish food) related to a change in the activity of the enzyme acetylcholinesterase, an acceleration of fat peroxidation and an improvement in the absorption of free oxygen radicals. Also modern studies have shown the negative effects of sucralose on some river algae – suppression of root growth, asexual reproduction.

In view of the above, as well as the fact that the anticorrosive effect of sucralose and its derivatives, and the composite materials, a part of which they are, will also depend on the concentration of the sugar substitute, further research into the methods of identifying sucralose and its transformation products is promising, and the development of methods quick and high quality analysis are important and relevant [17–22].

The main and most important way to solve the problem of the presence of sucralose and other sugar substitutes in drinks is to replace them with natural ones. The most common are: licorice root, steviol and its glycosides, tagatose, locust bean gum (E 410) – carob, perilartin.

1. Licorice root contains sweet-tasting substances – glycerizin and liquiritin. In addition, it contains salts of trace elements – calcium, potassium and magnesium (Fig. 3, 4).

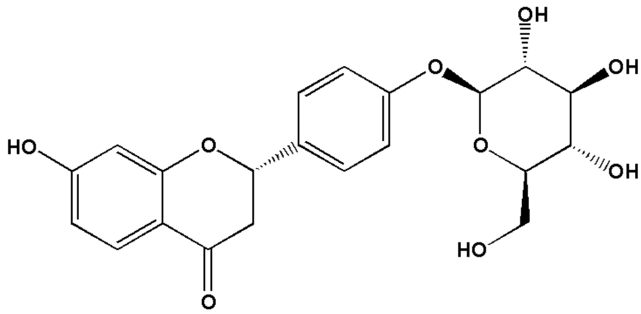


Fig. 3. Liquiritin.

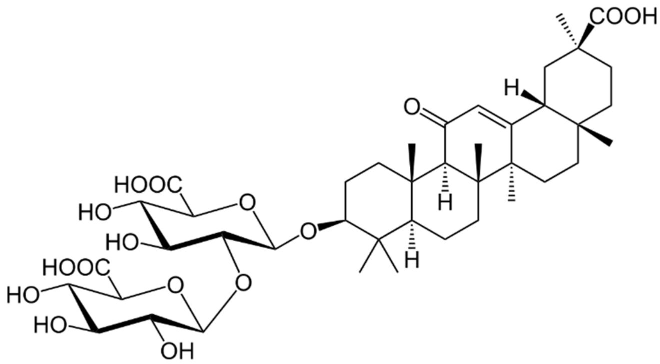


Fig. 4. Glycerizin.

Glycerizin is similar in composition to the steviol glycosides mentioned below.

2. Steviol and its glycosides are substances contained in the extract of the stevia plant. It is believed that the extract is 195 times sweetener than sugar (Fig. 5).

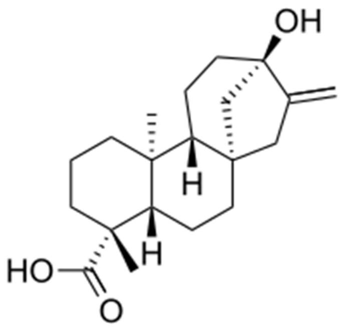


Fig. 5. Steviol.

Both substances can be actively used in the production in both beverages and confectionary products and in special nutrition.

3. Tagatose. The natural carbohydrate is isomeric to fructose and galactose. It is synthesized from them in the presence of calcium hydroxide. It is limited presence in fruits, cocoa and dairy products (Fig. 6).

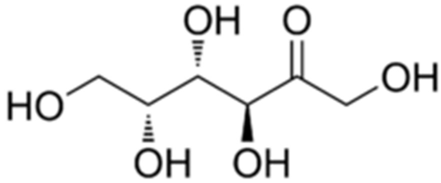


Рис. 6. Tagatose.

It is believed that its sweetness corresponds to 0.8 of the sucrose sweetness and since its metabolism differs from the metabolism of isomeric glucose and does not affect insulin secretion. The glycemic index of tagatose is three, which is lower than the values for glucose, fructose and galactose.

Thus, tagatose is a true carbohydrate of natural origin and can be used as a sugar substitute.

4. Locust bean gum (E 410) – kerob. A natural heteropolysaccharide found in Mediterranean acacia. Apart from the actual carbohydrate fragments, it also contains quinone-hydroquinone compounds – tannins, other derivatives of gallic acid. Given its poor solubility in water, it is better to use it for sweetening cakes and chewing gums. In addition to its own sweetness, carob also exhibits the stimulating properties of caffeine, without showing its negative effects, which makes its possible to adequately replace it in the diet.

Perilartin is a natural sugar substitute based on Japanese perilla. This is an oxime of perillaldehyde (Fig. 7 on the left), the sweetness of which is twice more than in sucralose. It is widely used in both the food and pharmaceutical industries.

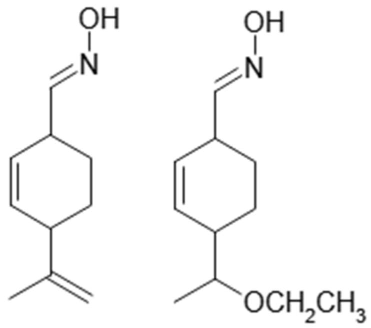


Fig. 7. Perilartin.

Perilartin's ether derivative is also used. Its sweetness is lower than that of sucralose and corresponds to aspartame. The disadvantage of perilartin is that Japanese perilla does not grow outside of Japan and accordingly, perilartin and its ether derivative are used only in Japan.

Results. The National Commission of Ukraine on the Codex Alimentarius and the Committee on Hygienic Regulation of the Ministry of Health of Ukraine hygienic standards for the content of the food additive sweetener E 995 (sucralose) and regulations for their use. (MDR) content of food additive sweetener E 995 in flavored non-alcoholic beverages based on water – 300.0 mg/kg; ice cream 320.0 - mg/kg; dairy desserts with reduced calorie content – 400.0 mg/kg; cocoa – 580.0 mg/kg; flavored alcoholic beverages – 700.0 mg.kg; candies of soft consistency – 1800 mg/kg; dietary supplements – 2400.0 mg/kg; chewing gum – 5000.0 mg/kg.

Conclusions

Therefore, the wide range of sucralose use in human nutrition makes the process of determining the concentration of this substance in various environments, as well as its extraction from wastewater and natural waters relevant. Further research will be directed at finding methods for determining sucralose.

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ВЗАЄМОЗВ'ЯЗОК БУДОВИ, ВЛАСТИВОСТЕЙ ТА ОСНОВНИХ ГАЛУЗЕЙ ВИКОРИСТАННЯ СУКРАЛОЗ

У статті проаналізовано властивості сукралози та основні галузі застосування в промисловості. Зазначено, що сукралоза відносно легко виводиться з організму. На основі аналізу літератури встановлено, що до позитивних властивостей сукралози науковці віднесли такі якості, зокрема: не проникає в мозок, не підвищує рівень цукру в крові (надає можливість вживати хворим на цукровий діабет), стійка до бактерій ротової порожнини (тому не викликає карієс). Сукралоза в харчовій та фармацевтичній промисловості в якості підсолоджувача смаку, зареєстрована в Європі – як харчова добавка Е-955. Перспективне використання – як молекулярний маркер для ідентифікації джерел забруднення природних водойм. Науковцями встановлено, що такі цукрозамінники як сахарин, аспартам та цикламати розкладаються в навколишньому середовищі, то сукралоза та її похідні (солі та естери) були присутніми в ґрунтових та стічних водах, що є знаком її накопичення в навколишньому середовищі. Бактеріальні штами, що виконують функцію редуцентів, у присутності сукралози поступово зменшуватимуться, що призведе до зміни у екосистемі. Враховуючи те, що бактеріальні колонії можуть перетворювати сукралозу на дихлоральдегіди, які є в свою чергу токсичними, потрібно дослідити вплив на процеси життєдіяльності організмів у відповідних водоймах. При опрацюванні літературних джерел встановлено, що сукралоза пригнічує ріст коренів, безстатеве розмноження деяких річкових водоростей.

Саме це спонукало нас проаналізувати літературу про властивості сукралози та безпечність її використання у різних галузях промисловості.

Ключові слова: сукралоза, натуральні цукрозамінннки, корінь солодки, стевіол та його глікозиди, тагатоза, камідь ріжкового дерева (Е410), низькокалорійний підсолоджувач.

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