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SWEETENERS AS SUGAR SUBSTITUTES IN FOOD INDUSTRY – CONDITIONS OF USE AND CONSUMER SAFETY®

Substancje słodzące jako substytuty cukru w przemyśle spożywczym – warunki stosowania oraz bezpieczeństwo konsumenta®

Sweeteners, notably non-nutritive sweeteners (NNS) used in the production of food and flavoured beverages give sweet taste with low or no energy and have a much higher sweetening power compared to sugar. Each one of the different sweeteners has a unique physical and chemical properties and sweet taste. Reduction in the intake of sugar-sweetened beverages and foods is advised around the world as part of healthier dietary patterns to help reduce energy intakes, obesity risk and obesity-related disorders. Replacing added sugars with sweeteners is one approach to reduce added sugars. Due to the popularity of such product reformulation, the safety of increased dietary intake of sweeteners should be considered. This review describes types of sugar substitutes and sweeteners available and the European Union regulations applicable to sweeteners based on well-established risk-assessment procedures. Currently, eleven non-nutritive sweeteners (NNS) are permitted in foods and beverages in the European Union. Each sweetener has undergone a safety assessment and most have a numerical Acceptable Daily Intake (ADI). This is the amount of a substance that can be ingested daily over a lifetime with no appreciable health risk. It is important to monitor the use of NNS by the food industry as well as the dietary intake to ensure ADI is not exceeded. It is also key to identify potentially sensitive consumers of each sweetener. Further innovations in the food industry could arise from using naturally occurring sweetening compounds and/or improvements to the substances that are already permitted to be used in food.

Key words: sugar substitutes, non-nutritive sweeteners, low-calorie sweeteners, food additives, acceptable daily intake, ADI, safety evaluation.

Substancje słodzące, w szczególności intensywne nieodżywcze substancje słodzące, stosowane w produkcji żywności i aromatyzowanych napojów celem nadania słodkiego smaku, przy niewielkiej lub prawie zerowej wartości energetycznej, mają wyjątkowe właściwości fizyko-chemiczne oraz znacznie większą słodkość w porównaniu z cukrem. Na całym świecie zalecane jest ograniczanie spożycia napojów i produktów słodzonych cukrem (część prozdrowotnych wzorów żywieniowych), aby obniżać ryzyko wystąpienia otyłości i zaburzeń zdrowotnych. Zastąpienie cukru substancjami słodzącymi to jeden ze sposobów na obniżenie w produkcie zawartości cukrów dodanych. W niniejszym przeglądzie przedstawiono substancje słodzące będące substytutami cukru oraz regulacje prawne EU dotyczące stosowania substancji słodzących, a także procedurę ich dopuszczenia w ramach oceny ryzyka. Obecnie w UE dozwolonych jest jedenaście intensywnych substancji słodzących jako dodatki do żywności. Dla każdej substancji przeprowadzono ocenę bezpieczeństwa, większość z nich ma ustaloną wielkość dopuszczalnego dziennego spożycia (ADI). Jest to ilość substancji, którą można spożywać codziennie przez całe życie bez ryzyka dla zdrowia. W ocenie bezpieczeństwa jest ważne, aby stosowanie substancji przez przemysł, a także ich spożycie w diecie było monitorowane, w celu zapewnienia nieprzekraczania ADI. Kluczowe jest również zidentyfikowanie potencjalnie wrażliwych grup konsumentów. Innowacje w przemyśle spożywczym mogą wynikać ze stosowania naturalnie występujących substancji słodzących i/lub ulepszenia dotychczasowych, które są już dopuszczone do stosowania w żywności.

Słowa kluczowe: substytuty cukru, nieodżywcze substancje słodzące, niskokaloryczne substancje słodzące, substancje dodatkowe, dopuszczalne dzienne pobranie, ADI, ocena bezpieczeństwa.

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INTRODUCTION

Reduction in intake of sugar-sweetened beverages and foods is advised around the world as part of healthier dietary patterns to help reduce energy intakes, obesity risk and obesity-related disorders [4, 5, 26, 34, 38]. Replacing added sugars with non-nutritive sweeteners (NNS) is one approach to reduce added sugars [1, 2, 3, 23, 26, 28, 29, 31, 37].

The World Health Organisation (WHO) in 2015 issued sugar guidelines, recommending that adults and children should limit their added sugar intake to less than 10% of total energy intake per day [44]. In 2020, the WHO published an updated draft guideline confirming this recommendation and suggesting that there are additional benefits of a further reduction to below 5% [45]. Evidence from prospective and randomized controlled trials indicates that a large share of sugar is introduced in the diet as high-fructose sweetening syrups, used widely, but not exclusively, in sugar-sweetened beverages [26, 34, 36]. Added sugars, mainly consumed through the intake of sugary drinks, lead to a high dietary energy intake. Sugars, if taken in excess, are an important risk factor for the development of obesity, cardiometabolic diseases, including metabolic syndrome and type 2 diabetes [5, 27, 31, 44, 45]. In consideration of the importance of prevention, both at the individual level and at the level of public health concern, achieving a reduction of sugar intake requires implementation of a range of strategies [26, 36, 38]; utilising sweeteners is one of the strategies which can be used by the food industry [1, 2, 4, 15].

Sweeteners, especially intense sweeteners, that are added to foods to replace the sweetness provided by sugars, may be a useful tool for reducing sugar intake which can help in the reduction of total energy intake, with increased odds of achieving current dietary guidelines on sugars intake [1, 23, 26, 31, 37]. Due to the popularity of such product reformulation, the safety of increased dietary intake of NNS should be considered [2, 10, 15, 28, 30].

The objective of this review is to introduce on the EU legal framework on the use of sweeteners and the approval processes, to highlight the most important criteria of evaluation of the safety based on well-established risk-assessment procedures and emphasize future directions and technological challenges for food industry.

TYPES OF SUGAR SUBSTITUTES AND SWEETENERS AVAILABLE

This review follows a widely used classification of sweeteners into two groups: non-nutritive sweeteners NNS (also called non-calorie sweeteners, intense sweeteners, synthetic sweeteners) that provide no/negligible amounts of energy, and nutritive sweeteners (also called caloric sweeteners) [3, 15, 26, 32, 43]. NNS's, which are hundreds to thousands of times sweeter than sucrose, can be classified into chemically synthesized sweeteners, including e.g. aspartame, saccharin, and sucralose [15, 26]; and sweeteners extracted from natural plants, such as steviol glycosides (from leaves *Stevia rebaudiana* Bertoni) and thaumatin (from katemfe fruit, *Thaumatococcus daniellii* Benth) [29, 32, 39, 43].

The use of NNS in most of the cases is authorised in beverage or food categories for the production of energy-reduced food (with a reduction of at least 30% of energy) or food with no added sugars, which are used by the food industry in the production of "light" food and drinks [15, 18, 26, 43]. The nutritive sweeteners include polyols (sugar alcohols), which are used as bulking agents, are usually slightly less sweet than sucrose and are therefore used in similar volume to sugars for achieving a similar sweetness level and texture of the food [24, 25].

Sweeteners with a high sweetening power can be used to reduce the sugar and energy content of beverages and some foods whilst maintaining a similar sensory profile. Many sweeteners show a synergistic effect when used in mixtures; then the taste intensity of the mixture is higher than the sum of the intensities of the single components. This is of practical importance, since it offers several advantages [27]. The use of blends of intensive sweeteners helps in approaching the optimal sucrose taste, which can be mimicked by varying the components' concentrations in order to achieve the desired intensity profile of the mixture (e.g. saccharin and cyclamate; acesulfame K, aspartame and cyclamate; saccharin and neotame). Sweetener mixtures can also result in a lower daily consumption of the individual sweeteners with food [3, 16, 32, 43].

The potential for sugar reduction is more limited in foods than in beverages and depends on the options for reformulation and what is used to replace the bulk of sugar. The NNS can only to a certain extent be incorporated into candies, biscuits or cakes, chocolate, ice-cream and dessert, thus potentially limiting the opportunities for food reformulation. Non-nutritive sweeteners with improved taste performance are a partial solution, but a greater challenge is the replacement of the bulking, browning and other properties that sucrose provides in many solid food products [3, 16, 32, 43].

SWEETENERS IN THE LEGAL FRAMEWORK

EU defines "sweeteners" as food additive substances used to impart a sweet taste to foods or in table-top sweeteners [15, 26]. In the European Union (EU), sweeteners are regulated as food additives under a comprehensive set of regulations for foodstuffs which perform specific technological objectives but are not ingested as a food product itself. Under EU legislation, sweeteners are only permitted if used to replace sugars for the production of energy-reduced food (i.e. with 30% less energy) or food with no added sugars. All sweeteners are regulated substances which are subject to safety evaluation prior to market authorization (Table 1).

Regulation (EC) No. 1331/2008 [17] sets out a common authorisation procedure, while Regulation (EC) No. 1333/2008 [18] on food additives and Regulation (EC) No. 1129/2011 [21] include the principles for sweeteners. Annex II of the Regulation (EC) No. 1333/2008 [20] contains food categories and a positive list of sweeteners permitted in the EU including the maximum quantities and their conditions of use. Regulation (EU) No. 231/2012 lays down the specifications for food additives listed in Annex II, including origin, and describes the acceptable criteria of purity [22].

Table 1. Sweeteners regulations in the EU - a review of current provisions

Tabela 1. Regulacje prawne dotyczące substancji słodzących w UE – przegląd obowiązujących przepisów

Authorisation procedure	Regulation (EU) 1331/2008
List of approved sweeteners and their conditions of use in foods and permitted levels.	Regulation (EU) No. 1333/2008 and Regulation (EC) No. 1129/2011 amending Annex II to Regulation (EC) No. 1333/2008
Purity and specifications	Regulation (EU) No. 231/2012
Labelling	Regulation (EU) No. 1169/2012 and Regulation (EU) No. 1333/2008
Setting up a programme for the re-evaluation of approved food additives	Regulation (EU) No. 257/2010

Source: Own study based on: [17-22]

Źródło: Opracowanie własne na podstawie: [17-22]

APPROVAL PROCESSES

Prior to approval for use, all sweeteners undergo a comprehensive safety evaluation [7, 10, 17, 19, 30]; the responsibility for these evaluations lies with the regulator i.e. the European Food Safety Authority (EFSA). Figure 1 shows the main stages and actors of the approval process in the EU. The EFSA is responsible for the risk assessment and the EC is responsible for risk management through the committee procedure involving the representatives of the member states.

An application to authorise a new sweetener is sent to the European Commission (EC) which asks EFSA to carry out a risk assessment. The EC can also act on its own initiative, requesting a review of approved sweeteners. To modify the intended use and conditions of use of an approved additive or to remove it from the list of approved sweeteners, the same procedure is followed. At EFSA, the Panel on Food Additives and Flavourings (FAF), made up of scientists from expert organisations in the EU member states, evaluates the safety of the sweeteners or new proposed uses as a food additive.

EFSA sends its opinion to the EC and the member states and publishes the opinion to the public. The opinion includes the identity and characterisation of the sweetener, the assessment of the biological and toxicological data, a dietary exposure assessment for the European population taking into account other possible sources of dietary exposure and an overall risk assessment establishing an acceptable daily intake (ADI) value. A sweetener may be approved if there are no safety concerns at the proposed legal-use level, a technological need is considered justified, there are advantages and benefits for the consumer, and the consumer is not misled. In that case, the EC submits a draft regulation, taking account of EFSA's opinion, to the Standing Committee on Plants, Animals Food and Feed.

Upon approval, the sweetener is entered into the list in Annex II of the food additive regulation and a unique identifier, the E number, is assigned for it. The list also specifies the name of the sweetener, the foods to which the additive may be added, the conditions under which the food additive may be used. If concerns about safety arise after long-term consumption, the sweetener may be re-evaluated by EFSA.

AUTHORISED SWEETENERS, LABELLING AND USE OF FOODSTUFFS

Like all food additives, sweeteners are subject to an authorisation procedure harmonised at the EU level. All sweeteners are regulated substances which are subject to safety evaluation prior to market authorization. Only the additives on this list can be added to foodstuffs. The authorised sweeteners in the EU and their major dietary sources are listed in Table 2.

At present, a total of 19 sweeteners are approved within the EU for use in accordance with the EU Regulation 1333/2008 on food additives [15, 18, 20, 26]. All sweeteners are included in the ingredient lists on product labels which must identify both the function of the food additive in the finished food, and the specific substance used either by referring to their full name and/or their specific identity number (E-number).

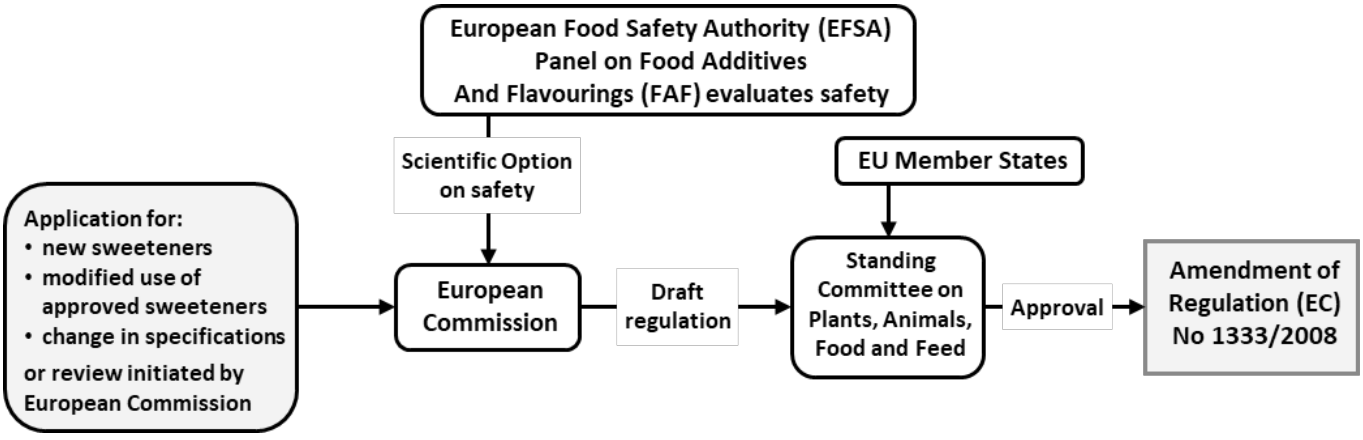

Fig. 1. The approval processes of sweeteners.

Rys. 1. Proces zatwierdzania substancji słodzących.

Source: Own study based on: [7, 10, 15, 17-22, 26]

Źródło: Opracowanie własne na podstawie [7, 10, 15, 17-22, 26]

Table 2. Sweeteners approved for use under Regulation (EC) No 1331/2008, including subsequent amendments, and their major sources

Tabela 2. Substancje słodzące zatwierdzone do stosowania zgodnie z Rozporządzeniem (WE) nr 1331/2008 z późniejszymi zmianami oraz ich główne źródła w żywności

E-number	Non-nutritive sweeteners	E-number	Polyols
E 950	Acesulfame K	E 420	Sorbitols
E 951	Aspartame	E 421	Mannitol
E 952	Cyclamic acid and its Na and Ca salts	E 953	Isomalt
E 954	Saccharin and its Na, K and Ca salts	E 964	Polyglycitol syrup
E 955	Sucralose	E 965	Maltitols
E 957	Thaumatin	E 966	Lactitol
E 959	Neohesperidine dihydrochalcone	E 967	Xylitol
E 960	Steviol glycosides	E 968	Erythritol
E 961	Neotame		
E 962	Salt of aspartame-acesulfame		
E 969	Advantame		
Use in foodstuffs and major sources			
✧ Replacing sugar in a variety of processed foods and beverages, such as flavoured carbonated and non-carbonated drinks/soft drinks, confectionery, desserts, jams, chewing gums. ✧ Table-top sweeteners.		✧ Replacing sugar in a variety of processed foods, such as confectionery, cakes, biscuits, ice-cream, desserts, jams, chewing gum. ✧ Table-top sweeteners.	

Source: Own study based on: [6, 8, 9, 11, 15, 18, 20, 26]

Źródło: Opracowanie własne na podstawie: [6, 8, 9, 11, 15, 18, 20, 26]

To keep the intake of non-nutritive sweeteners at safe use level, regulations define in which foods their use is permitted and where appropriate also set maximum limits for their content. In the EU, the use of each individual sweetener is limited to defined food categories and the addition of sweeteners to unprocessed food, and, for example, unflavoured milk, natural mineral water, coffee and coffee extracts, unflavored leaf tea, is not permitted at all. Polyols, listed as group IV additives in the regulation, are authorised in food categories at *quantum satis*, meaning no maximum level is specified. These sweeteners which are mostly of natural origin, are to be used in accordance with good manufacturing practice, at a level not higher than necessary to achieve the intended purpose [18, 20].

Under EU legislation, food products containing a sweetener or sweeteners must include the statement 'with sweeteners' or 'with sugar(s) and sweetener(s)' on the label accompanying the name of the food product. If aspartame is listed in the ingredients by its E number, E 951 or E 962, then the label must also include the statement 'contains aspartame (a source of phenylalanine)'so that people who have the inherited disease phenylketonuria can avoid consuming these products. Foods containing more than 10% added polyols are required to state on the label that 'excessive consumption may produce laxative effects' [18, 20, 21].

Food industry operators are legally responsible for the safety of their products as well as applying the correct labelling. EU member states are responsible for maintaining systems to monitor and verify the fulfilment of the relevant requirements covering all stages of production, as well as monitoring the consumption and use of sweeteners. Official controls must use a risk-based approach [7, 10, 15, 19, 26, 30].

SAFETY EVALUATION OF SWEETENERS

The EFSA bases its approval of a sweetener on risk assessment in line with international good practice laid down by the FAO/WHO Joint Expert Committee on Food Additives (JEFCA) and requires a large amount of health outcomes to enable evaluation of the safety of a sweetener additive and to define the necessary risk-management measures. These information requirements are laid down in the regulations and in more detail in the EFSA guidance documents for applicants [7, 17] and include detailed descriptions of the identity and properties of the substance and the manufacturing process, proposed foods or food categories, expected use levels and exposure assessment, supported by documented studies and data. The safety evaluation is based on toxicological data and set minimum test requirements, complemented with more specific and elaborate testing depending on the properties of the substance. Where evidence was previously evaluated by other authorities, such as the JECFA and the US Food and Drug Administration [30, 41], that is also taken into account in the EFSA assessment.

As part of its safety evaluations of food sweeteners, when sufficient information is available, EFSA seeks to establish an Acceptable Daily Intake (ADI) for each substance. When re-evaluating previously authorised sweeteners, EFSA may either confirm or amend an existing ADI following a review of all available evidence (see Table 3). The ADI is typically specified following the application of large safety factors (often a factor of 100 times lower than the 'no observed adverse effect level' (NOAEL) to give a large margin of safety for even the most susceptible and sensitive individuals in the population. An ADI that is determined for NNS maintains a sufficient safety margin and indicates the amount of food additive that can be consumed daily, over a lifetime, without presenting an appreciable risk to health. ADIs are usually expressed in mg per kg of body weight per day (mg/kg bw/day) [7, 17, 19, 28, 30].

However, for polyols that are present in the body or are regular components of the diet or that did not indicate adverse effects in animal studies, there is no need to set an ADI, instead, it should be technologically efficacious and should be used at the lowest level necessary to achieve its effect [7, 10, 15, 30]. It should be noted that, in the future, the benchmark dose will be the preferred approach for establishing a reference point [25].

For each substance, a safety assessment is performed in four steps: hazard identification, hazard characterization, exposure assessment, and risk characterization, in accordance with the risk assessment guideline. In an assessment, estimated daily intake is compared with ADIs to investigate the likelihood of potentially hazardous effects in humans. Overall, the Panel needs to conclude that, using data provided by the food industry and a member state, the reported uses and use levels of a substance would not be of safety concern at the estimated exposure [7, 10, 15, 17, 19]. The reports (opinions) of EFSA from recent years are available on the internet, similarly to the earlier work of the EU Scientific Committee on Food (SCF) [30].

The EFSA's expert Panel on Food Additives and Flavourings assesses the safety of sweeteners and also re-evaluates all sweeteners permitted for use in the EU before 20 January 2009 [19]. The order of priorities is set in the Regulation EU 257/2010 re-evaluation programme, which shall be completed by the end of 2020. As part of the exercise, a technical report was published which presents the outcome of the public consultation on a draft protocol for assessing exposure to sweeteners as part of their safety assessment under the food additives re-evaluation programme [13]. The works on the re-evaluation programme have not yet been completed [14].

FUTURE DIRECTIONS AND TECHNOLOGICAL CHALLENGES

The reduction of sugar and energy values in the diet has been a long-standing challenge for the food industry, not only to support consumers seeking to limit their sugar intake but also as a response to public health policy initiatives, such as sugar taxes for the food industry and government reformulation programmes [4, 23, 26, 36]. Future sweetener use will be driven by the needs of an increasingly overweight society. There is currently great interest in reducing the sugar content of foods to control dietary intake [1, 4, 26, 31, 37].

NNS with improved taste performance are a partial solution, but a greater challenge is the replacement of the bulking, browning and other properties that sucrose provides in many solid food products. Reformulation of beverages, where sugar is simply substituted by NNS, is relatively straightforward when compared to reformulation of products where sugars are present in the food matrix [5, 16, 32, 43].

In recent years, responding to this challenge has become more difficult for food manufacturers, as consumers are increasingly seeking products formulated using a limited range of natural, clean – label ingredients. Naturally occurring sugar substitutes have recently emerged as an alternative category of sweeteners. Therefore, the food/beverage industry has focused on the use of natural sweeteners, which may be a better alternative to sugar than synthetic sweeteners [2, 5, 29, 39, 40].

Polyols are gaining popularity as a sugar replacer and are used in a wide range of sugar-free diets. Theyare saccharide derivatives which occur naturally in fruit, vegetables and some fermented foods, and can be chemically manufactured by hydrogenation of mono- or disaccharides. Compared with sugars, polyols (e.g., sorbitol, xylitol) are poorly absorbed and provide fewer calories and lower glycaemic responses. These sweeteners are often used in combination with NNS, but polyols have a relatively lower sweetness index, which enables them to be used in larger quantities as a bulk sweetener. Due to their poor gastrointestinal tolerance, they have laxative effect when consumed in higher doses [15, 24, 26, 35].

Hhigh – potency sweeteners that are currently most popular and are widely distributed throughout the world are steviol glycosides, extracted from the leaves of the *Stevia rebaudiana* Bertoni. Stevioside and rebaudioside A are the main glycosides found in the *Stevia rebaudiana* plant and are each approximately 250-300 times sweeter than sucrose. Stevioside, in its pure form, has a prolonged aftertaste with some bitterness [27, 33, 39]. EFSA authorised the use of steviol glycosides as a sweetener in food with the number 'E 960' [6].

Siraitia grosvenorii Swingle (commonly known as Luo Han Guo or monk fruit) contains varying levels of mogrosides – triterpene glycosides which are sweetening constituents of the fruit primarily responsible for the characteristic. The sweetening power depends on the mogroside content which is reported to be 250-560 times sweeter than sucrose. However, its sweetness profile is characterized by a lower peak sweetness, additional off-tastes, and longer lasting sweetness when compared to sucrose. Further work exploring different blends of monk fruit and natural sweeteners with fewer side tastes is in progress [27, 39]. Unfortunately, the use of mogrosides is still limited due to their lack of authorization for use in food products in the EU [12] despite being recognized as safe (GRAS) in the US [41].

A number of natural sweeteners are becoming popular food ingredients for consumers, e.g. carob molasses, maple syrup, agave nectar, coconut syrup and sugar, and although they contribute to dietary energy intake, these sweeteners tend to have lower glycaemic potency than refined sugars. Despite

Table 3. Available ADI values and characteristics of certain sweeteners approved in the EU

Tabela 3. Wartości ADI oraz charakterystyka substancji słodzących zatwierdzonych w UE

Sweeteners		ADI*	Comments
E 950	Acesulfame K	0 – 9	Can be used for cooking and baking, Bitter taste, 130-200 times sweeter than sucrose, Safety evaluation by SCF in 2000
E 951	Aspartame	0 – 40	Suitable for table use, It is not heat-stable and loses its sweetness when heated, so usually it is not used in baked goods, Source of phenylalanine, 200 times sweeter than sucrose, Safety re-evaluation by EFSA in 2013 (due to the publication of new scientific data)
E 952	Cyclamate	0 – 7	To improve palatability cyclamate is often blended with saccharin, 30-50 times sweeter than sucrose, Safety evaluation by SCF in 2000
E 954	Saccharin	0 – 5	Suitable for cooking or table use, 300-500 times sweeter than sucrose, Safety evaluation by SCF in 1995
E 955	Sucralose	0 – 15	Heat-stable, 600-650 times sweeter than sucrose, Safety evaluation by SCF in 2000
E 957	Thaumatin	ADI not specified	Used according to GMP, flavour enhancer, 2000-3000 times sweeter than sucrose, Safety evaluation by EFSA in 2015
E 959	Neohesperidine DC	0 – 5	Bitter taste, flavour enhancer, 1500-1800 times sweeter than sucrose, Safety evaluation by SCF in 1988
E 960	Steviol glycosides	0 – 4	Can be used for cooking and baking, 200-300 times sweeter than sucrose, Safety evaluation by EFSA in 2010
E 961	Neotame	0 – 2	Heat-stable, flavour enhancer, 800 times sweeter than sucrose, Safety evaluation by EFSA in 2007
E 962	Salt of aspartame-acesulfame	As for aspartame and Ace-K	350 times sweeter than sugar, Produced by mixing 64% aspartame and 36% acesulfame, Safety evaluation by SCF in 2000
E 969	Advantame	0 – 5	Heat-stable, flavour enhancer, 20000-37000 times sweeter than sucrose, Safety evaluation by EFSA in 2013

*ADI: Acceptable Daily Intake (mg/kg body weight/day)

Source: Own study based on: [6, 8, 9, 11, 15, 26]

Źródło: Opracowanie własne na podstawie: [6, 8, 9, 11, 15, 26]

their many valuable nutritional and health-promoting properties, these substitutes are still sugars added to products and should be used in limited quantities as a substitute for sucrose [2, 5, 29, 31, 39, 40].

More recently, the potential use of rare sugars as low-calorie sweeteners in the food industry was also highlighted [29, 42]. Naturally occurring mono- and disaccharides have emerged as an alternative category of sweeteners. A number of beneficial properties have been attributed to this saccharides, including antioxidative effects. Especially allulose has a wide range of health effects [42]. It is noteworthy that compared to intense sweeteners and polyols, the metabolic effects of rare sugars have not been as extensively studied [27].

Rare sugars and their derivatives are found in nature in small quantities and are low on calories. This category includes e.g. D-allulose, D-tagatose and D-allose. The D-allulose is an epimer of D-fructose that has 70% of the sweetness of sucrose and because of its high solubility and antioxidant activity it is a good additive for food processing. On the other hand, D-Tagatose is also structurally similar to d-fructose and has good palatability and 92% of the sweetness of sucrose and good bulk properties. Furthermore, D-Allose is a sweetener that is mass produced from D-allulose that has 70% of the sweetness compared to sucrose. Long-term human trials are needed to determine the clinical benefits of using rare sugars to reduce added sugars [42].

SUMMARY

Sweeteners have changed since they were invented and widely used over the past years. Their role is becoming more and more important with the increase in obesity rates and new guidelines, policies and taxes are being introduced at government level to encourage the reduction of added sugars in the diet. Non-nutritive sweeteners undergo an extensive safety evaluation process by international and UE regulatory food safety authorities both before and after their approval for use in the market. Furthermore, there is an ongoing review process to ensure that any new information on safety is evaluated by the EFSA with the works are still ongoing. Non-nutritive sweeteners and polyols can be used to reduce the added sugars and/or replace total or partial content of sugar and energy content of beverages and some foods whilst maintaining a similar sensory profile, and can be used synergistically in blends to achieve the desired sensory profile

at lower levels of use in foodstuffs. For some consumers and food industry, naturally occurring sweetening compounds can serve as an alternative to synthetic sweeteners or refined sugars. Such compounds seem to be of great relevance to what constitutes a healthy diet, and further studies of their dietary properties are warranted. The use of sweeteners as well as low-energy product development and reformulation may help in achieving the current recommendations of restricting sugar consumption.

PODSUMOWANIE

Substancje słodzące od czasu ich powstania i stosowania zmieniły się w ostatnich latach. Znaczenie i ich rola w diecie staje się coraz ważniejsza w związku ze wzrostem wskaźników występowania otyłości. Nowe wytyczne i regulacje prawne, w tym podatkowe na szczeblu rządowym są wprowadzane aby zachęcić producentów i konsumentów do zmniejszenia zawartości cukrów w produktach oraz w całodziennej diecie. Substancje słodzące przechodzą szeroki proces oceny bezpieczeństwa przez międzynarodowe i unijne instytucje ds. bezpieczeństwa żywności, zarówno przed, jak i po ich dopuszczeniu do użytku na rynku. Obecnie trwa ponowny przegląd i ocena tych substancji przez EFSA, w celu, uwzględnienia wszelkich nowych badań dotyczących bezpieczeństwa stosowania substancji słodzących. Intensywne substancje słodzące oraz poliole mogą być stosowane w celu zmniejszenia ilości dodawanych cukrów i/ lub zastąpienia go całkowicie oraz zmniejszenia wartości energetycznej w napojach i niektórych produktach spożywczych, przy zachowaniu podobnego profilu sensorycznego. Mogą być one stosowane synergistycznie w mieszankach, aby osiągnąć pożądany profil smakowy przy niższych poziomach ich stosowania w produktach spożywczych. Dla konsumentów oraz przemysłu spożywczego, naturalnie występujące związki słodzące mogą służyć jako alternatywa dla syntetycznych słodzików. Wydaje się, że produkty zawierające takie substancje mają obecnie duże znaczenie i mogą stanowić jeden z elementów zbilansowanej diety. Dalsze badania dotyczące oceny ich właściwości żywieniowych są uzasadnione. Stosowanie substancji słodzących, a także zmiana składu i opracowywanie produktów niskoenergetycznych mogą być pomocne w osiągnięciu przez konsumenta obecnych zaleceń dotyczących ograniczenia spożycia cukru.

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