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DIRECTIONS ON THE USE OF STEVIA LEAVES (*STEVIA REBAUIDANA*) AS AN ADDITIVE IN FOOD PRODUCTS

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ABSTRACT

Due to the high intake of sugars, especially sucrose, global trends in food processing have encouraged producers to use sweeteners, particularly synthetic ones, to a wide extent. For several years, increasing attention has been paid in the literature to the stevia (*Stevia rebauidana*), containing glycosidic diterpenes, for which sweetening properties have been identified. Chemical composition, nutritional value and application of stevia leaves are briefly summarized and presented.

Key words: stevia, *Stevia rebaudiana*, health effect, stevioside, rebaudioside, sweetener

INTRODUCTION

In recent years, there has been a significant increase in the occurrence of diet-dependent diseases, such as obesity, diabetes, cancer, cardiovascular diseases, and also dental problems, which are a consequence of, among others, inappropriate diet and a lack of physical activity. Due to the high intake of sugars, especially sucrose, global trends in food processing have encouraged producers to use sweeteners, particularly synthetic ones, to a wide extent (Anton et al., 2010). For several years, increasing attention has been paid in the literature to the stevia (*Stevia rebauidana*), 'the sweet herb from Paraguay', a natural alternative to 'white sugar' (Soejarto, 2002; Chatsudthipong and Muanprasat, 2009; Samsheri Goyal and Goyal, 2010; Mishra et al., 2010; Thomas and Glade, 2010; Yadav et al., 2011).

Stevia rebaudiana (Bertoni) belongs to the *Asteraceae* family and originates from South America; to be precise, from the mountainous region of the Cordillera del Amambay in north-eastern Paraguay near the border with Brazil (Soejarto, 2002; Yadav et al., 2011; Lemus-Mondaca et al., 2012). For centuries, this plant has been locally known by native Guarani Indians as 'kaa he-he', which means 'sweet herb', and has been used in the local cuisine and in the treatment of various ailments (Soejarto et al., 1983; Jeppesen et al., 2002; 2003). The natural environment of *Stevia rebaudiana* are subtropical meadows at an altitude of about 200–500 meters above sea level, with temperatures ranging from –6°C to 43°C, average 23°C (Brandle and Rosa, 1992).

The annual rainfall ranges between 1500–1800 mm (Yadav et al., 2011). The plant reaches a height of 65 cm to even 120 cm, possesses ellipse-shaped leaves and blooms in white. Cultivation conditions for stevia are quite varied. Stevia grows both on dark, damp, sandy soils and on loamy, highly-permeable soils. In addition, it is to be found on the banks of swamps, on infertile, acidic sands or muck soils. The optimal

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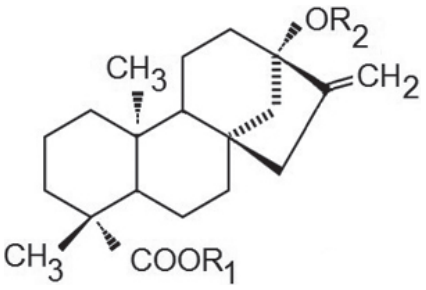
subsoil for the cultivation of *S. rebaudiana* is constantly moist, but not exposed to prolonged flooding (Mishra et al., 2010; Lemus-Mondaca et al., 2012). The first attempts to crop outside the natural environment were reported in the UK in 1943, then in 1968 in Japan (Lewis, 1992), and currently the main producers of stevia on a large scale are countries such as Brazil, Korea, Mexico, the U.S.A., Indonesia, Tanzania, Canada and India (Brandle and Rosa, 1992; Fors, 1995; Yadav et al., 2011).

S. rebaudiana Bertoni was botanically classified in 1899 by Moisés Santiago Bertoni. Originally called *rebaudianum Eupatorium*, in 1905 its name was changed to *S. rebaudiana* Bertoni (Bertoni, 1905). Undoubtedly, the major advantage of the plant is the presence of steviol glycosides (an overall amount of 4–20% of the dry weight) (Starrat et al., 2002; Ghanta et al., 2007), which provide a sensation of sweetness up to 450 times more intense than that of sucrose (Chatsudthipong and Muanprasat, 2009; Thomas and Glade, 2010). The amount of glycosides in different parts of the plant varies and is presented as follows (in descending order): leaves, flowers, stalk, seeds and roots. Dwivedi claimed that the roots are the only organs that do not contain stevioside; however, the sweetness of the leaves is two twice as high as that in the inflorescence (Dwivedi, 1999; Yadav et al., 2011).

Eight glycosidic diterpenes, for which there are sweetening properties in the tissues of stevia leaves, have been identified (Tateo et al., 1999; Singh and Rao, 2005; Abou-Arab et al., 2010). The most desired glycosides are stevioside (5–10% d.w.) and rebaudioside A (2–4% d.w.) (Dacome et al., 2005; Yadav et al., 2011). *Stevia rebaudiana* steviosides and related compounds structures presents Figure 1. Stevioside, the main sweetener, which constitutes 60–70% of the total glycoside content present in the leaves and also in lesser amounts in the tissues of Stevia stalks, is 110–270 times sweeter than sucrose (Yadav et al., 2011). In the 1970s, stevioside, as well as stevia extracts, were formally accepted in Japan as a sweetener. At the same time, and as a result of detailed analyses of the glycosides occurring in stevia tissues, rebaudioside A, inter alia, was isolated and described (Barriocanal et al., 2008) as having a sweetening effect even higher than stevioside (250–450 times sweeter than sucrose) (Chatsudthipong and Muanprasat, 2009; Thomas and Glade, 2010). The compilation of stevia sweetness in comparison with other compounds presents Table 1.



Compound	R1	R2
Steviol	H	H
Steviolbioside	H	β-Glc-β-Glc(2→1)
Stevioside	β-Glc	β-Glc-β-Glc(2→1)
Rebaudioside A	β-Glc	β-Glc-β-Glc(2→1) I β-Glc(3→1)
Rebaudioside B	H	β-Glc-β-Glc(2→1) I β-Glc(3→1)
Rebaudioside C (Dulcoside B)	β-Glc	β-Glc-α- Rha(2→1) I β-Glc(3→1)
Rebaudioside D	β-Glc-β-Glc(2→1)	β-Glc-β-Glc(2→1) I β-Glc(3→1)
Rebaudioside E	β-Glc-β-Glc(2→1)	β-Glc-β-Glc(2→1)
Rebaudioside F	β-Glc	β-Glc-β-Xyl(2→1) I β-Glc(3→1)
Dulcoside A	β-Glc	β-Glc-α- Rha(2→1)

Glc – glucose, Xyl – xylose, Rha – rhamnose, sugar moieties (De et al., 2013; Geuns, 2003).

Fig. 1. *Stevia rebaudiana* steviosides and related compounds structures

Rebaudioside A levels range between 30–40% of the total content of sweeteners in stevia. Rebaudioside A,

Table 1. *Stevia rebaudiana* leafs and other compounds sweetness level in reference to sucrose

Sweetener		Sweeteness factor (x sucrose)
Aspartame		350–400
Acesulfame K		150–200
Xylitol		0.8–1.1
Lactitol		0.3–0.5
Taumatin (*Thaumatococcus danieli*)		2000–3000
Stevia rebaudiana leafs		15–45
Steviol glycosides		
	Stevioside	200–450
	Steviolbioside	100–125
	Rebaudioside A	150–450
	Rebaudioside B	30–350
	Rebaudioside C	50–450
	Rebaudioside D	150–450
	Rebaudioside E	150–300
	Rebaudioside F	30–120
	Dulcoside A	50–125
	Rubusoside	114

Compilation of references: Kinghorn and Compadre (2001), Chatsudthipong and Muanprasat (2009), Geuns (2003), Das et al. (2007), Gwak et al. (2012), Świąder et al. (2011), Bugaj et al. (2013), Goudable (2011).

in comparison to stevioside, is characterized by a better flavor profile due to the lack of flavor in the mouth, often described as 'liquorice, pungent'. Therefore, the authors of many scientific reports on steviol glycosides pay special attention to the ratio of rebaudioside A to stevioside; namely, the higher its value, the higher the quality of sweetening, while the equalized ratio of the above-mentioned glycosides eliminates any undesirable flavor profile, and the effect of sweetening is similar to sucrose (Yadav et al., 2011).

On March 10, 2010 ANS (The Panel on food additives and nutrient sources added to food) issued a decision on the safety of steviol glycosides, prepared on the basis of a proposal from the European Commission (EFSA, 2010). The document cites the results of conducted studies, in which it has been found that substances derived from stevia are not carcinogenic or associated with any other negative effects. Furthermore, an acceptable daily intake (ADI – Acceptable Daily Intake) was established at 4 mg per kilogram of body weight. Then, on November 11, 2011, the European Commission passed a regulation allowing the use of steviol glycosides in 31 different food categories, including beverages, desserts, sweets and sweeteners. Previously in Poland, products made of stevia had been sold as a cosmetic for external use. Currently, stevia or products made of stevia are approved for use as a food additive, sweetener (Singh and Rao, 2005; Yadav et al., 2011; Commission Regulation, 2012; Lemus-Mondaca et al., 2012; Elkins, 1997).

CHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF STEVIA LEAVES

Stevia (*Stevia rebaudiana* Bertoni) is a low-calorie plant, because it provides the body with only 2.7 kcal/g. This means that, due to its sweetening capabilities (steviol glycosides are up to 450 times sweeter than sucrose) and also the calculated energy supply, stevia can compete with currently known and commonly used sweeteners such as acesulfame K (zero calories), aspartame (4 kcal/g), saccharin (zero calories) and sucralose (zero calories) (Savita et al., 2004). This situation results from the fact that stevia decomposes only marginally in the gastrointestinal tract.

Dried stevia leaves are characterized by a sufficiently significant protein content which ranges from 10 to 20.4 g/100 g of the product. Mohammad et al. (2007) have identified nine amino acids in the leaves of stevia; namely, glutamic acid, aspartic acid, lysine, serine, L-isoleucine, alanine, proline, tyrosine and methionine. Then, Abou-Arab et al. (2010) determined a total of seventeen amino acids, and of exogenous amino acids the occurrence of all except for tryptophan was reported, which makes the protein of stevia leaves very valuable from a nutritional point of view. Stevia is characterized by low lipid content in the dry mass, ranging from 1.9 to 5.6 g/100 g of the product. On the other hand, the determined ash content deserves special attention (6.3 to 13.1 g/100 g of the

product). Stevia contains significant quantities of important minerals that are essential to protect an organism, and for the regulation and maintenance of various metabolic processes. Elements such as potassium, calcium, magnesium, sodium, zinc and iron have been determined in stevia leaves. In addition, the results obtained by Kim et al. (2011) on stevia show that 'sweet herb' also constitutes a good source of some vitamins. First of all, stevia is characterized by a high content of folic acid (52.18 mg/100 g of aqueous extract of stevia) and vitamin C (14.98 mg/100 g of aqueous extract of stevia).

ANTIOXIDANT PROPERTIES AND THE TOTAL POLYPHENOL CONTENT

In recent years, in the literature authors pay increasing attention to antioxidant compounds, due to their ability to neutralize free radicals (Devasagayam et al., 2004; Gramza-Michałowska and Korczak, 2013; Kuźma et al., 2014; Sarić et al., 2013; Bajčan et al., 2013). It has been found that antioxidants may interfere with oxidation reactions with free radicals, exhibit properties to chelate catalytic metals, as well as scavenge oxygen (Buyukokuroglu et al., 2001). Antioxidant compounds present in edible plants are currently promoted as food additives, as they exhibit few or no toxic side effects (Seong et al., 2004).

There are a lot of reports devoted to the phenolic compounds occurring both in the edible and non-edible parts of plants, which are at the same time characterized by a high antioxidant activity. These compounds are important components of plants, necessary for their proper growth and development, and protect them from pests and damage (Jeszka et al., 2010; Kobus et al., 2009; Kucner et al., 2014). Polyphenols play an important role in the prevention of many diet-dependent diseases, among others heart diseases, atherosclerosis or cancer (Sidor and Gramza-Michałowska, 2014). Widely known natural antioxidants are α-tocopherol and L-ascorbic acid, which exhibit a beneficial effect on the human organism and are reported to be safe. More powerful antioxidants are the synthetic compounds butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) however, they also exhibit possible negative effects on the human organism by activating promoters of carcinogenesis (Seong et al., 2004; Anagnostopoulou et al., 2006; Tadhani et al., 2007; Shukla et al., 2009). Hence, one can observe a growing demand for new, natural antioxidants.

Extracts from the leaves of stevia contain flavonoids, alkaloids, water-soluble chlorophylls and xanthophylls, hydroxycinnamic acids (such as caffeic, chlorogenic), oligosaccharides, free sugars, amino acids, lipids, oils and minerals (Komissarenko et al., 1994). Tadhani et al. (2007) evaluated the *in vitro* antioxidant activity of HCl-methanol leaves and stalks of stevia extracts (*Stevia rebaudiana*). The total polyphenol content in stevia extracts was estimated at 25.18 and 35.86 mg/g of stevia leaves and callus per gallic acid, respectively. The flavonoid content was 21.73 mg/g in the stevia leaves and 31.99 in the callus (per gallic acid). Moreover, the ferric reducing ability of plasma (FRAP) and radical, 2,2-Diphenyl-1-picrylhydrazyl (DPPH) tests were also performed to estimate the antioxidant activity. From the conducted studies, one can conclude that extracts from stevia leaves exhibit high antioxidant activity and constitute a good source of antioxidants. Research of Shukla et al. (2009) clearly indicated that stevia plant possess significant potential to be used as promising natural antioxidant.

STEVIA LEAVES IN THE PREVENTION OF CIVILIZATION DISEASES

Reduction of the risk and/or prevention against the development of diet-dependent diseases can be achieved through a change in lifestyle and eating habits, and the introduction of a well-balanced diet into the nutrition of a population. The reported properties of stevia (*Stevia rebaudiana*) have resulted in significantly increased interest in the therapeutic potential of stevia in food production targeted at the human organism.

The leaves of *stevia rebaudiana* contain low-calorie sweeteners (steviol glycosides), the consumption of which may have a beneficial effect on human health (Gardana et al., 2010). Stevia glycosides possess valuable biological properties. It has been proved that regular consumption of these compounds reduces glucose and cholesterol concentrations (Atteh et al., 2008), enhances the regeneration of cells and blood clotting, inhibits tumor cell growth and strengthens blood vessels (Jeppesen et al., 2003; Barriocanal et al., 2008; Maki et al., 2008). Moreover, it has been noted that the substances

of Paraguay sweet leaves exhibit cholagogic (Kochikyan et al., 2006), anti-inflammatory (Jayaraman et al., 2008; Sehar et al., 2008) diuretic activity, prevent gastrointestinal ulcers (Kochikyan et al., 2006), exhibit antihypertensive (Chan et al., 2000; Lee et al., 2001; Jeppesen et al., 2002), antihiperglycemic (Suanarunsawat and Chaiyabutr, 1997; Jeppesen et al., 2000, 2002; Chen et al., 2006), antirotaviral activity (Suanarunsawat and Chaiyabutr, 1997; Takahashi et al., 2001), exhibit a beneficial effect on glucose (Shivanna et al., 2013; Suanarunsawat and Chaiyabutr, 1997; Toskulkao et al., 1995) and kidney (Jutabha et al., 2000) metabolisms.

STEVIOL GLYCOSIDES APPLICATION IN FOOD

An increasing intake of sucrose has caused several nutritional and medical problems, including obesity (Anton et al., 2010; Puri et al., 2012). Indeed, there is an alarming increase in the frequency of the incidence of obesity, diabetes type 2 and metabolic syndrome in children and adults worldwide. This is somewhat related to the increasing availability of high-calorie food, including beverages. Therefore, for more than two decades, there has been a very strong increase in interest in sweeteners, which do not introduce additional energy into the organism (Brahmachari et al., 2011; Boudová Pečivová et al., 2013; Reguła and Kowalewska, 2010). On the other hand, consumers increasingly pay attention to the character of the consumed food, whether it fits with the motto of 'natural, healthy food'. Stevia (*Stevia reaudiana* Bertoni) as the 'miraculous Paraguay herb', providing a sensation of sweetness up to 300 times more intense than sucrose (steviol glycosides), is an ideal natural sugar substitute (Anton et al., 2010; Puri et al., 2012).

In the natural environment, tribes of Indians (Guarani) used 'honey leaves' both in their cuisine, among others for sweetening their yerba mate (Soejarto et al., 1983), as well as in medicine, in the treatment of many skin and mouth diseases etc. (Brandle and Telmer, 2007; Lemus-Mondaca et al., 2012).

In Japan, food manufacturers have been using stevia in the processing of many food stuffs for over 40 years (Chatsudthipong and Muanprasat, 2009; Thomas and Glade 2010). The main group of foods, in which stevia and its products have been used is quite surprising, namely salty products / food / snacks. It has been reported that the combination of stevioside with sodium chloride gives a dish softness, and therefore its wide use in the production of pickled vegetables, dried seafood, soy sauces and miso products (Tadhani and Subhash, 2006; Goyal et al., 2010). Furthermore, sweet Stevia leaves are also utilized in beverages of reduced energy content, candies, chewing gums, baked goods, yogurts, ice creams, teas, and finally constitute a component of numerous toothpastes and mouthwashes. Of course, stevia is also used directly as a sweetener in the form of liquid, powder and tablets (Yadav et al., 2011; Lemus-Mondaca et al., 2012).

The Japanese are also pioneers in the purification of stevia extracts obtaining well-defined steviol glycosides characterized by an intensive sweet taste. Particularly noteworthy is rebaudioside A, because it has a more refined sweet taste without the characteristic bitter flavor symptomatic for other glycosides. Many methods for the extraction of stevia glycosides and innovative solutions in the application of sweetener mixtures, e.g. stevia with other natural and synthetic sweeteners, have been patented in Japan (Brahmachari et al., 2011; Yadav et al., 2011).

An important advantage of stevia is its stability during heat treatment, which facilitates its introduction into the recipes for many food products. Stevioside is stable at 95°C, and therefore it is suggested that the sweetener under investigation is suitable as a cooked food additive. At elevated temperatures and over one hour, the sweetener demonstrated good stability at a temperature up to 120°C, while at temperatures exceeding 140°C it underwent degradation, and its complete degradation occurs when exposed to 200°C (Kroyer, 2010). In addition, Kroyer found that aqueous solutions of steviol glycosides were degraded only at 5% at pH 2–10 (exposure for 2 hours, at 80°C). It has also been noted that stevia extracts are not fermented, and do not contribute to the browning reaction of cooked or baked products (Crammer and Ikan, 1986; Abou-Arab et al., 2010). Another advantage of stevia is that it does not form a precipitate in acid solution, which allows its use for the sweetening of carbonated beverages.

Currently, in the European Union since December 2011, steviol glycosides with the E 960 symbol have been approved for use in 31 food categories (Commission Regulation, 2011).

CONCLUSION

Every year we observe increased interest in the application of stevia in food production. Stevia is a perfect answer to the needs of consumers, combining the qualities of a sweetener, but also constituting a source of many substances with a nutritional effect on the human organism. New types of food products enriched with stevia bring many benefits.

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REFERENCES

Abou-Arab, A., Abou-Arab, A., Abu-Salem, M. F. (2010). Physico-chemical assessment of natural sweeteners steviosides produced from *Stevia rebaudiana* Bertoni plant. Afric. J. Food Sci., 4, 269–281.

Anagnostopoulou, M. A., Kefalas, P., Papageorgiou, V. P., Assimepoulou, A. N., Boskou, D. (2006). Radical scavenging activity of various extracts and fractions of sweet orange peel (*Citrus sinensis*). Food Chem., 94, 19–25.

Anton, S. D., Martin, C. K., Han, H., Coulon, S., Cefalu, W. T., Geiselman, P., Williamson, D. A. (2010). Effects of stevia, aspartame, and sucrose on food intake, satiety, and postprandial glucose and insulin levels. Appetite, 55, 37–43.

Atteh, J., Onagbesan, O., Tona, K., Decuypere, E., Geuns, J., Buyse, J. (2008). Evaluation of supplementary Stevia (*Stevia rebaudiana* Bertoni) leaves and stevioside in broiler diets: Effects on feed intake, nutrient metabolism, blood parameters and growth performance. J. Anim. Phys. Anim. Nutr., 92, 640–649.

Bajčan, D., Tomáš, J., Uhlířová, G., Árvay, J., Trebichalský, P., Stanovič, R., Šimanský, V. (2013). Antioxidant potential of spinach, peas and sweet corn in relation to freezing period. Czech J. Food Sci., 31, 613–618.

Barriocanal, L., Palacios, M., Benitez, G., Benitez, S., Jimenez, J., Jimenez, N. (2008). Apparent lack of pharmacological effect of steviol glycosides used as sweeteners in humans, a pilot study of repeated exposures in some normatensive and hypotensive individuals and in type 1 and type 2 diabetics. Regul. Toxicol. Pharm., 51, 37–41.

Bertoni, M. (1905). Le Kaa' He-e' Sa nature et ses proprieties. Anales Cientificos Paraguayos 5, 1–14.

Boudová Pečivová, P., Kubáň, V., Mlček, J., Rop, O. (2013). Textural and sensory properties of the sweet Czech Christmas bread with sugar solutions. Acta Sci. Pol., Technol. Aliment., 12(2), 223–229.

Brahmachari, G., Mandal, L. C., Roy, R., Mondal, S., Brahmachari, A. K. (2011). Stevioside and related compounds – molecules of pharmaceutical promise: A critical overview. Arch. Pharm. Chem. Life Sci., 1, 5–19.

Brandle, J. E., Rosa, N. (1992). Heritability for yield, leaf: stem ratio and stevioside content estimated from landrace cultivar of *Stevia rebaudiana*. Can. J. Plant Sci. 72, 1263–1266.

Brandle, J., Telmer, P. (2007). Steviol glycoside biosynthesis. Phytochemistry 68, 1855–1863.

Bugaj, B., Leszczyńska, T., Pysz, M., Kopeć, A., Pacholarz, J., Pysz-Izdebska, K. (2013). Charakterystyka i prozdrowotne właściwości *Stevia rebaudiana* Bertoni [Profile and pro-health properties of *Stevia rebaudiana* Bertoni]. Żywn. Nauka Technol. Jakość, 3(88), 27–38 [in Polish].

Buyukokuroglu, M. E., Gulcin, I., Oktay, M., Kufrevioglu, O. I. (2001). In vitro antioxidant properties of dantrolene sodium. Pharmacol Res., 44, 491–494.

Chan, P., Linson, B., Chen, Y., Liu, J., Hsieh, M., Cheng, J. (2000). A double blind placebo-controlled study of the effectiveness and tolerability of oral stevioside in human hypertension. Brit. J. Clin. Pharm., 50, 215–220.

Chatsudthipong, V., Muanprasat, C. (2009). Stevioside and related compounds: Therapeutic benefits beyond sweetness. Pharmacol. Therapeut., 121, 41–54.

Chen, J., Jeppesen, P., Abudula, R., Dyrskog, S., Colombo, M., Hermansen, K. (2006). Stevioside does not cause increased basal insulin secretion or b-cell desensitization as does the sulphonylurea, glibenclamide: Studies in vitro. Life Sci., 78, 1748–1753.

Commission Regulation (EU) No 1131/2011 of 11 November 2011amending Annex II to Regulation (EC) No 1333/2008 of the European Parliament and of the Council with regard to steviol glycosides.

Commission Regulation (EU) No 231/2012 of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council.

Crammer, B., Ikan, R. (1986). Sweet glycosides from the stevia plant. Chem. Brit., 22, 915–916.

Dacome, A. S., da Silva, C. C., da Costa, C. E. M., Fontana, J. D., Adelmann, J., da Costa, S. C. (2005). Sweet diterpenic glycosides balance of a new cultivar of *Stevia rebaudiana* (Bert) Bertoni: isolation and quantitative distribution by chromatographic, spectroscopic and electrophoretic methods. Process Biochem. 44, 3587–3594.

Das, K., Dang, R., Shivananda, T. N., Sekeroglu, N. (2007). Influence of bio-fertilizers on the biomass yield and

nutrient content in *Stevia rebaudiana* Bert. grown in Indian subtropics. J. Med. Plants Res., 1(1), 005–008.

De, S., Mondal, S., Banerjee, S. (2013). Introduction to stevioside. In Stevioside technology, applications and health. John Wiley, 1–27.

Devasagayam, T. P. A., Tilak, J. C., Boloor, K. K., Sane, K. S., Ghaskadbi, S., Lele, R. D. (2004). Free radicals and antioxidants in human health: current status and future prospects. J. Assoc. Physicians India, 794–804.

Dwivedi, R. S. (1999). Unuttered and untapped super sweet nonsaccharifierous plant species in India. Current Sci. (Bangalore) 76, 1454–1461.

EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS). European Food Safety Authority (EFSA), Parma, Italy (2010). Scientific Opinion on the safety of steviol glycosides for the proposed uses as a food additive. EFSA J., 8 (4), 1537.

Elkins, R. (1997). Nature's sweetener. Orem: Woodland Publishing.

Fors, A. (1995). A new character in the sweetener scenario. Sugar J., 58, 30.

Gardana, C., Scaglianti, M., Simonetti, P. (2010). Evaluation of steviol and its glycosides in *Stevia rebaudiana* leaves and commercial sweetener by ultra-highperformance liquid chromatography – mass spectrometry. J. Chromatogr. A, 1217, 1463–1470.

Geuns, J. M. C. (2003). Molecules of interest stevioside. Phytochemistry, 64, 913–921.

Ghanta, S., Banerjee, A., Poddar, A., Chattopadhyay, S. (2007). Oxidative DNA damage preventive activity and antioxidant potential of *Stevia rebaudiana* (Bertoni) Bertoni, a natural sweetener. J. Agric. Food Chem., 55, 10962–10967.

Goudable, J. (2011). Les édulcorants intenses: utiles pour lutter contre l'obésité? Are the artificial intense sweeteners useful in obesity? Obésité, 6, 212–217. DOI 10.1007/s11690-012-0304-2.

Goyal, S., Samsheri Goyal, R. (2010). Stevia (*Stevia rebaudiana*) a bio-sweetener: A review. Int. J. Food Sci. Nutr., 61, 1–10.

Gramza-Michałowska, A., Korczak, J. (2013). Oxygen radical absorbance capacity of selected food products. Acta Sci. Pol., Techn. Aliment., 12(2), 175–180.

Gwak, M. J., Chung, S. J., Kim, Y. J., Lim, C. S. (2012). Relative sweetness and sensory characteristics of bulk and intense sweeteners. Food Sci. Biotechn., 21(3), 889–894.

Jayaraman, S., Manoharan, M., Illanchezian, S. (2008). In-vitro antimicrobial and antitumor activities of *Stevia rebaudiana* (Asteraceae) leaf extracts. Trop. J. Pharm. Res., 7, 1143–1149.

Jeppesen, P. B., Gregersen, S., Alstrup, K. K., Hermansen, K. (2002). Stevioside induces antihyperglycaemic, insulinotropic and glucagonostatic effects in vivo: studies in the diabetic Goto-Kakizaki (GK) rats. Phytomedicine, 9, 9–14.

Jeppesen, P. B., Gregersen, S., Rolfsen, S. E. D., Jepsen, M., Colombo, M., Agger, A., Xiao, J., Kruhøffer, M., Orntoft, T., Hermansen, K. (2003). Antihyperglycemic and blood pressure-reducing effects of stevioside in the diabetic gotokakizaki rat. Metabolism, 52, 372–378.

Jeppesen, P., Gregersen, S., Poulsen, C., Hermansen, K. (2000). Stevioside acts directly on pancreatic a cells to secrete insulin: Actions independent of cyclic adenosine monophosphate and adenosine triphosphate-sensitive K+ channel activity. Metabolism, 49, 208–214.

Jeszka, M., Flaczyk, E., Kobus-Cisowska, J., Dziedzic, K. (2010). Związki fenolowe – charakterystyka i znaczenie w technologii żywności [Phenolics – characteristic and significance in food technology]. Nauka Przyr. Technol., 4, 2, #19 [in Polish].

Jutabha, P., Toskulkao, C., Chatsudthipong, V. (2000). Effect of stevioside on PAH transport by isolated perfused rabbit renal proximal tubule. Can. J. Phys. Pharm., 78, 737–744.

Kaushik, R., Pradeep, N., Vamshi, V., Geetha, M., Usha, A. (2010). Nutrient composition of cultivated Stevia leaves and the influence of polyphenols and plant pigments on sensory and antioxidant properties of leaf extracts. J. Food Sci. Tech., 47, 27–33.

Kennelly, E. (2002). Sweet and non-sweet constituents of *Stevia rebaudiana* (Bertoni) Bertoni. In A. Kinghorn (Ed.), Stevia, the Genus Stevia. Medicinal and aromatic plants – industrial profiles. London, NY: Taylor and Francis, 19, 68–85.

Kim, I., Yang, M., Lee, O., Kang, S. (2011). The antioxidant activity and the bioactive compound content of *Stevia rebaudiana* water extracts. LWT – Food Sci. Technol., 44, 1328–1332.

Kinghorn, A. D., Compadre, C. M. (2001). Less common high potency sweeteners. In L. O'Brien-Nabors (Ed.), Alternative sweeteners. Revised and Expanded, Marcel Dekker, 209–234.

Kobus, J., Flaczyk, E., Siger, A., Nogala-Kałucka, M., Korczak, J., Pegg, R. B. (2009). Phenolic compounds and antioxidant activity of extracts of Ginko leaves. Eur. J. Lipid Sci. Techn., 111, 1150–1160.

Kochikyan, V., Markosyan, A., Abelyan, L., Balayan, A., Abelyan, V. (2006). Combined enzymatic modification

of stevioside and rebaudioside A. Appl. Biochem. Microb., 42, 31–37.

Komissarenko, N. F., Derkach, A. I., Kovalyov, I. P., Bublik, N. P. (1994). Diterpene glycosides and phenylpropanoids of *Stevia rebaudiana* Bertoni: Rast. Research, 1 (2), 53–64.

Kroyer, G. (2010). Stevioside and Stevia-sweetener in food: application, stability and interaction with food ingriedients. J. Verbr. Lebensm., 5, 225–229.

Kucner, A., Papiewska, A., Klewicki, R., Sójka, M., Klewicka, E. 2014. Influence of thermal treatment on the stability of phenolic compounds and the microbiological quality of sucrose solution following osmotic dehydration of highbush blueberry fruits. Acta Sci. Pol., Technol. Aliment., 13(1), 79–88.

Kuźma, P., Drużyńska, B., Obiedziński, M. (2014). Optimization of extraction conditions of some polyphenolic compounds from parsley leaves (*Petroselinum crispum*). Acta Sci. Pol., Technol. Aliment., 13(2), 145–154.

Lee, C. N., Wong, K., Liu, J., Chen, Y., Chan, P. (2001). Inhibitory effect of stevioside on calcium influx to produce antihypertension. Planta Med., 67, 796–799.

Lemus-Mondaca, R., Vega-Galvez, A., Zura-Bravo, L., Ah-Hen, K. (2012). *Stevia rebaudiana* Bertoni, source of a high-potency natural sweetener: A comprehensive review on the biochemical, nutritional and functional aspects. Food Chem., 132, 1121–1132.

Lewis, W. H. (1992). Early uses of *Stevia rebaudiana* (Asteraceae) leaves as a sweetener in Paraguay. Econ. Bot., 46, 336–337.

Maki, K., Curry, L., Reeves, M., Toth, P., Mckenney, J., Farmer, M. (2008). Chronic consumption of rebaudioside A, a steviol glycoside, in men and women with type 2 diabetes mellitus. Food Chem. Toxicol., 46, 47–53.

Mishra, P., Singh, R., Kumar, U., Prakash, V. (2010). *Stevia rebaudiana* – A magical sweetener. Global J. Biotechn. Biochem., 5, 62–74.

Mohammad, M., Mohammad, U., Sher, M., Habib, A., Iqbal, A. (2007). In vitro clonal propagation and biochemical analysis of field established *Stevia rebaudiana* Bertoni. Pakistan J. Bot., 39, 2467–2474.

Puri, M., Sharma, D., Barrow, C. J., Tiwary, A. K. (2012). Optimisation of novel method for the extraction of steviosides from *Stevia rebaudiana* leaves. Food Chem., 132, 1113–1120.

Reguła, J., Kowalewska, M. (2010). Zawartość aspartamu, acesulfamu K i sacharyny w produktach spożywanych przez osoby otyłe i chore na cukrzycę [Contents of aspartame, acesulphame K and saccharine in foods preferred by obese patients and diabetics]. Nauka Przyr. Technol., 4, 5, #67.

Sarić, G., Marković, K., Vukičević, D., Lež, E., Hruškar, M., Vahčić, N. (2013). Changes of antioxidant activity in honey after heat treatment. Czech J. Food Sci., 31, 601–606.

Savita, S., Sheela, K., Sunanda, S., Shankar, A., Ramakrishna, P. (2004). *Stevia rebaudiana* – A functional component for food industry. J. Hum. Ecol., 15, 261–264.

Sehar, I., Kaul, A., Bani, S., Pal, H., Saxena, A. (2008). Immune up regulatory response of a non-caloric natural sweetener, stevioside. Chemio-Biol. Interact., 173, 115–121.

Seong, S. H., Seog, C. L., Yong, W. C., Jin, H. K., Seung, H. B. (2004). Antioxidant activity of crude extract and pure compounds of acer ginnala max. Bull. Kor. Chem. Soc., 25(3), 389–391.

Serio, L. (2010). La *Stevia rebaudiana*, une alternative au sucre. Phytothérapie, 8, 26–32.

Shivanna, N., Naika, M., Khanum, F., Kaul, V. K. (2013). Antioxidant, anti-diabetic and renal protective properties of *Stevia rebaudiana*. J. Diabetes Complicat., 2, 103–113.

Shukla, S., Mehta, A., Bajpai, V. K., Shukla, S. (2009). In vitro antioxidant activity and total phenolic content of ethanolic leaf extract of *Stevia rebaudiana* Bert. Food Chem. Toxicol., 47, 2338–2343.

Sidor, A., Gramza-Michałowska, A. (2014). Advanced research on the antioxidant and health benefit of elderberry (*Sambucus nigra*) in food – a review. J. Funct. Foods. DOI: 10.1016/j.jff.2014.07.012.

Singh, S. D., Rao, G. P. (2005). Stevia: The herbal sugar of the 21st century. Sugar Technol., 7, 17–24.

Soejarto, D. (2002). Botany of Stevia and *Stevia rebaudiana*. In A. Kinghorn (Ed.), Stevia: The genus Stevia. London, New York: Taylor and Francis, 18–39.

Soejarto, D. D., Compadre, C. M., Medon, P. J., Kamath, S. K., Kinghorn, A. D. (1983). Potential sweetening agents of plant origin. II. Field search for sweet-tasting Stevia species. Econ. Bot., 37, 71–79.

Soejarto, D. D., Kinghorn, A. D., Farnsworth, N. R. (1982). Potential sweetening agents of plant origin. III. Organoleptic evaluation of Stevia leaf herbarium samples for sweetness. J. Nat. Prod., 45, 590–599.

Srimaroeng, C., Chatsudthipong, V., Aslamkhan, A. G., Pritchard, J. B. (2005). Transport of the natural sweetener, stevioside, and its aglycone, steviol, by hOAT1 (SLC22A6) and hOAT3 (SLC22A8). JPET Fast Forward. Laboratory of Pharmacology and Chemistry,

National Institute of Environmental Health Sciences, Research Triangle Park, NC., 10.1124, 104.080366.

Starrat, A. N., Kirby, C. W., Pocs, R., Brandle, J. E. (2002). Rebaudioside F a diterpene glycoside from *Stevia rebaudiana*. Phytochemistry, 59, 367–370.

Suanarunsawat, T., Chaiyabutr, N. (1997). The effect of steviosides on glucose metabolism in rat. Can. J. Phys. Pharm., 75, 976–982.

Świąder, K., Waszkiewicz-Robak, B., Świderski, F. (2011). Sweeteners – benefits and risks. Probl. Hig. Epidem., 92(3), 392–396.

Tadhani, M., Subhash, R. (2006). Preliminary studies on *Stevia rebaudiana* leaves: Proximal composition, mineral analysis and phytochemical screening. J. Med. Sci., 6, 321–326.

Tadhani, M. B., Patela, V. H., Subhasha, R. (2007). In vitro antioxidant activities of *Stevia rebaudiana* leaves and callus. J. Food Comp. Anal., 20, 323–329.

Takahashi, K., Matsuda, M., Oashi, K., Yaniguchi, K., Nakagomi, O., Abe, Y. (2001). Analysis of anti-rotavirus activity of extract from *Stevia rebaudiana*. Antivir. Res., 49, 15–24.

Tateo, F., Sanchez, M. L. E., Bononi, M., Lubian, E. (1999). Stevioside content of *Stevia rebaudiana* (Bertoni) Bertoni grown in East Paraguay. Ital. J. Food Sci., 3(11), 265–269.

Thomas, J. E., Glade, M. I. (2010). Stevia: It's not just about calories. Open Obes. J., 2, 101–109.

Toskulkao, C., Sutheerawatananon, M., Wanichanon, C., Saitongdee, P., Suttagit, M. (1995). Effect of stevioside and steviol on intestinal glucose absorption hamsters. J. Nutr. Sci. Vitaminol., 41, 105–113.

Yadav, A. K., Singh, S., Dhyani, D. Ahuja, P. S. (2011). A review on the improvement of stevia [*Stevia rebaudiana* (Bertoni)]. Can. J. Plant Sci., 91, 1–27.

KIERUNKI WYKORZYSTANIA LIŚCI STEWII (*STEVIA REBAUIDANA*) JAKO DODATKÓW DO ŻYWNOŚCI

STRESZCZENIE

Ogólnoświatowe trendy w technologii żywności legitymizują nadmierne wykorzystanie syntetycznych substancji słodzących w produktach spożywczych. Rozwój rynku żywności funkcjonalnej ukierunkowanej na wykorzystanie naturalnych dodatków pozwolił zwrócić uwagę na liście stewii (*Stevia rebauidana*), zawierające w składzie słodkie diterpeny glikozydowe. W pracy scharakteryzowano skład, wartość odżywczą oraz kierunki wykorzystania liści stewii.

Słowa kluczowe: stewia, *Stevia rebaudiana*, zdrowie, stewiozyd, rebaudiozyd, substancja słodząca

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