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Stevia: beyond the sweetener

1. Summary

More and more people use sweeteners as sugar substitutes, and among these, one can find products of both natural and artificial origin. One of the most popular ones among natural sweeteners is Stevia of plant origin, and the popularity of the use of dried Stevia leaves as tea has been increasing as well. There are approximately 150 to 300 species that belong to the genus Stevia. Of these, the best known is *Stevia rebaudiana Bertoni*, and the sweetening power of the product, containing a mixture of glycosides, that can be obtained from its leaves, can be as high as 350 times of that of sugar. Before its authorization for use as a food additive in 2011, several evaluations were carried out regarding the safety of steviol glycosides, and finally an ADI value of 4 mg per kilograms of body weight was determined by the EFSA in 2010. Nonetheless, the *Stevia rebaudiana Bertoni* plant itself and its dried leaves are currently classified in the European Union as not authorized novel foods. This is so, because steviol glycosides authorized as sweeteners contain 95% purified stevioside and/or rebaudioside A, while dried Stevia leaves contain a variety of other components. Research into the risks of these are still taking place.

2. Introduction

The eating habits of developed Western societies have changed significantly over the past century. Mainly, a dramatic increase in sugar consumption can be observed, which is primarily due to the spread of the use, in the food industry, of high fructose corn syrup. Growing sugar consumption have also been accompanied by an increase in the prevalence of a number of non-infectious diseases (cardiovascular diseases, type 2 diabetes) and their risk factors (obesity). In the primary and secondary prevention of these diseases, the use of sweeteners as sugar substitutes can play an important role.

In the wide variety of sweeteners, products of both natural and artificial origin can be found. Among sweeteners of natural origin, currently Stevia (also called in Hungarian “Sztívia” or “sztevia”) is one of the most popular ones. Not only the sweetener obtained from the leaves of the plant, but the use, as tea, of dried Stevia leaves are gaining popularity. Therefore, in our article, various forms of use of plant parts and their legal aspects are discussed.

3. Introducing the Stevia plant

Stevia rebaudiana Bertoni (also known as candyleaf, sweetleaf, or sugarleaf), belonging to the order Asterales, is a perennial plant native to South America, which is also called the sweet herb of Paraguay. There are approximately 150 to 300 species belonging to the genus Stevia. Of these, the best known is *Stevia rebaudiana Bertoni*, common in the southern United States, northeastern Paraguay and southeastern Brazil, as well as in Mexico, Central America, in the South American Andes and the Brazilian highlands.

Indigenous people living in Paraguay and Brazil already used the leaves of the plant [31] for sweetening and healing [28] before recorded history. However, the scientific discovery of Stevia is dated to the 1500s, when the plant was first studied by a Spanish scientist, Petrus Jacobus Stevus (Pedro Jaime Esteve). It became more widely known at the end of the 1800s, thanks to an Italian-born Swiss scientist, emigrating to Paraguay, who first wrote about the “new species” in 1887 in a botanical journal published in Asunción, and he later named it *Stevia rebaudiana Bertoni*, referring to the first discoverer, himself and his coworker, Rebaudi [11].

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The sweetener made from the *Stevia rebaudiana Bertoni* plant has been used in the food industry since the 1970s in Japan, which is still the largest user in the world [18], [22]. In North America and in Europe, the Stevia plant first appeared in the 1970s and 1980s in herbal stores and shops selling so-called “healthy foods” [3]. Today, it is grown in Paraguay, Mexico, Central America, Japan, China, Malaysia, South Korea, and within Europe in Spain, Belgium and the United Kingdom [28].

The leaves contain a complex mixture of sweet diterpene glycosides [28]. The glycoside consists of one or more sugar molecules (glycone) and a non-sugar type molecule (aglycone). The basic skeleton of steviol glycosides is steviol, and depending on what kinds of sugar compounds are connected to this or to its aglycone part, we can talk about, for example, stevioside, different types of rebaudiosides (A, B, C, D, E, F) and dulcoside. To date, at least 40 different steviol glycosides were identified in the leaves of *Stevia rebaudiana* [26]. The most important representatives of steviol glycosides are stevioside, containing three glucose molecules, and rebaudioside A (Reb-A), which contains one more glucopyranose and has a more pleasant taste (Reb-A) [11], [3].

Of the glycoside compounds present in the leaves, on a dry weight basis, the most abundant is stevioside (4-13%), while the amount of rebaudioside A is 2-4%, of rebaudioside C is 1-2%, of dulcoside is 0.4-0.7%, and there are traces of steviolbioside and rebaudioside B, D and E. The composition of the dry weight is approximately 6.2% protein, 5.6% lipids, 52.8% carbohydrates, 15% stevioside [12], [28], and approximately 42% of its weight consists of water-soluble substances [17], [28]. In addition, the following, non-sweet components were detected in the leaves: labdane diterpenes, triterpenes, sterols, flavonoids, volatile oil components, pigments and inorganic substances [17], [28].

4. Steviol glycosides as sweeteners

Stevia is primarily known as a sweetener. The sweetening power of the products, containing a mixture of glycosides that can be obtained from the leaves, can be as high as 350 times of that of sugar [26]. They have a slightly bitter aftertaste, although their taste depends on a number of factors (e.g., soil quality, climatic conditions, plant breeding orientations) [22].

„Stevia” is a generic term for the above-described components (glycosides, lipids, carbohydrates, pigments, etc.) found in various parts of the *Stevia rebaudiana Bertoni* plant. However, currently authorized and commercially available sweeteners which are extracted from the leaves of plants (e.g. extraction with boiling water) and cleaned up (e.g. using absorption resins) contain only 95% of steviol glycosides, which are stevioside and/or rebaudioside A.

The degree of purity is determined using a validated analytical method [24]. Thus, when we talk about the sweetener, the proper term is not „Stevia”, but „steviol glycosides”. In scientific opinions, when assessing dietary intake, steviol glycosides are expressed in steviol equivalents. The conversion is necessary, because the toxicity of the glycosides is related to the steviol content [11].

There was a long and bumpy road until the use of purified steviol glycosides, extracted from the leaves of the Stevia plant, as a sweetener was authorized. Numerous scientific assessments were made about whether it could be considered safe, before it was partially accepted in the European Union in 2011 [29], [34], [6]. The ADI (Acceptable Daily Intake) established by the European Food Safety Authority (EFSA) in steviol equivalent is 4 mg per kilogram of body weight per day. Commission Regulation (EU) No 1131/2011 was issued on November 11, 2011, „amending Annex II to Regulation (EC) No 1333/2008 of the European Parliament and of the Council with regard to steviol glycosides”, specifying the use of steviol glycosides (E960) as an additive in the food categories listed in the annex, one by one [7]. Specification of the steviol glycosides that can be marketed as sweeteners (E960) is defined by Commission Regulation (EU) No 231/2012.

5. Stevia as a novel food

Almost at the same time as the attempt was made to have it authorized as a sweetener, in 1998, they tried to authorize the plant *Stevia rebaudiana Bertoni* and its dried leaves, according to Regulation (EC) No 258/97 concerning novel foods and novel food ingredients [8].

The opinion of the Scientific Committee on Food (SCF) on the *Stevia rebaudiana Bertoni* plant and its leaves was published in 1999. According to the conclusions of the assessment, the information submitted was not sufficient to determine the specification, or to evaluate safety [28]. Almost all of the available toxicological data, both in the case of the raw and the purified stevioside, were causes for concern [29], [33]. As a result, in Commission Decision 2000/196/EC, issued on February 22, 2000 [9] placing on the EU market of *Stevia rebaudiana Bertoni* plants and dried leaves as a novel food or novel food ingredient was refused. According to paragraph (4) of the Decision, *Stevia rebaudiana Bertoni* plants and dried leaves are a novel food in the sense of Regulation (EC) No 258/97 [8]. However, they do not satisfy the requirements specified in paragraph (19) of Article 3, according to which “Foods and food ingredients falling within the scope of this Regulation must not: present a danger for the consumer, mislead the consumer, differ from foods or food ingredients which they are intended to replace to such an extent that their normal consumption would be nutritionally disadvantageous for the consumer”. Therefore, these products cannot be marketed in the Community [9], [8].

Since the Commission Decision issued in 2000, the question of the status of *Stevia rebaudiana Bertoni* dried leaves as a novel food has been constantly on the agenda in the Union. According to certain member states (the Czech Republic, Germany, the Netherlands, the United Kingdom) dried leaves were on the market in tea blends before May 15, 1997, however, there is no sufficient data available to prove significant consumption. Italy does not consider Stevia a novel food in nutritional supplements. Belgium issued a negative list of novel foods and novel food ingredients in 2014, according to which the *Stevia rebaudiana Bertoni* plant and its dried leaves are included among unauthorized novel food ingredients [23].

In 2010, the non-profit body called World Stevia Organisation was established, performing research related to the Stevia plant in Germany and Austria [35]. In the opinion of the representative of the organization, the safety and novel food status of at least 20-25 Stevia species should be examined.

The hazards of *Stevia rebaudiana Bertoni* are studied by the EU-funded project Go4Stevia. The strategic objective of the program is to solve the existence problems of tobacco growers, with the new business opportunities provided by cultivating the Stevia plant. Within the framework of the project, a series of toxicology tests are performed, using the dried leaves of *Stevia rebaudiana Bertoni*, and the plan is to submit the application for authorization again in 2017, in light of the new findings [14].

6. Stevia in the eyes of consumers

There have been several studies showing that Stevia as a sweetener is generally known by consumers, and they have a favorable opinion of it [4], [25], [15], [16]. Among additives – it being of “natural” source – it is much more accepted than artificial sweeteners, such as aspartame [2]. It should be noted here that, even though there is no difference between the risk assessments of natural and artificial substances, consumers still make a distinction between the two categories, and treat materials of natural origin with less suspicion [10], [1]. A bigger problem is that it is hard for laypeople to understand the dose-toxicity relationship [19], [30]. Proper risk perception is helped by good communication, because the given risk is less likely to be either under- or overestimated, when in possession of the necessary knowledge (about dose-effect relationship or legal regulations) [2].

Even if “official” information gets through, incomplete and inaccurate information seen or heard in the media (e.g., on the internet) can make consumers unsure [1]. This is especially true regarding the Stevia plant, because several websites describe it as a miracle substance solving everything, they encourage home growing and consumption of the leaves – despite the fact that there is not yet an official position on the risk of consuming whole leaves, as was emphasized above. For example, the bacterial growth inhibiting effects of compounds found in the *Stevia rebaudiana Bertoni* plant have already been examined in several studies [32], [5], [13], which is also stressed by the above-mentioned websites. However, they fail to mention that these results can be achieved using the extract of the plant, or its fermented or purified forms, and not by the consumption of the entire leaf, with which potentially harmful components are also introduced, such as oxalic acid, which binds calcium and iron, and thus holds them back from our bodies [27], [21].

Test results regarding consumer awareness and perception about the Stevia plant as a novel food are barely available yet, since its marketing is only permitted as an additive.

7. Conclusions

In addition to steviol glycosides authorized in 2011 under the number E960, dried leaves of the Stevia plant are gaining popularity. There are approximately 150 to 300 species belonging to the genus Stevia and, of these, assessments have only been made regarding the *Stevia rebaudiana Bertoni* species so far. Based on these, marketing of the plant and its dried leaves as a food is not authorized in the European Union. Unfortunately, prepackaged dried Stevia leaves can be found in organic food stores and markets, as well as on the internet, with the only description on the label being “Stevia”. Since not one of the 150 to 300 species has been authorized as food in the European Union, and since the risks of even a single species tested cannot be determined, consumption of these leaves should be considered thoroughly. It is important to emphasize that steviol glycosides authorized for use as sweeteners contain purified stevioside and/or rebaudioside A in amounts of at least 95%, dried Stevia leaves contain a large number of other components. Research to test the safety of these are currently still under way.

8. References

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