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Stevia Plant Stevia rebaudiana: A Natural Alternative to Aspartame.

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Abstract
The main purpose of this article is to introduce the stevia plant, *Stevia* rebaudiana, as a natural alternative to the popular artificial sweetener aspartame; to explain how to used it correctly; to discuss the benefits of the stevia plant as a healthy food alternative; to examine the potential side effects of using stevia products; to explore the best ways to propagate the plant and assess its economic importance; and to review the stevia products available on the markets, which will be examined in this research. The findings of this study, in line with those of the majority of previous studies, support the general scientific principle that artificial sweeteners are harmful and may increase appetite and lead to geater weight gain than stevia or even table sugar. Conversely, natural sweeteners were found to lower blood sugar levels with not causing weight gain. It is well-established that consuming sugar-sweetened and aspartame-sweetened beverages is a major contributor to metabolic disorders, such as cravings for sweet foods, obesity, and diabetes, making the use of low-calorie stevia sweeteners an effective and desirable strategy for weight management.

Keywords: Stevia Plant; Stevia rebaudania; Natural Alternative; Aspartame .

Introduction

Stevia rebaudiana is a perennial herbaceous plant in the dicotyledonous family Asteraceae. The Stevia genus includes 280 species. It grows in tropical and subtropical regions and can live for up to seven years. Stevia requires at least 12 hours of light daily, and its growth slows during months with shorter daylight hours, when it flowers. It prefers sunny locations with long periods of daylight, as high temperatures and sunlight promote photosynthesis and growth. Stevia cannot tolerate salinity levels exceeding 1200 parts per million (ppm) and requires a consistently humid environment. Stevia has an exceptionally high sweetening power, being more than 300 times sweeter than sucrose extracted from sugarcane or sugar beets. Its leaves are also low in calories, making it a safe and ideal sweetener for people with diabetes and those on low-calorie diets. Global demand for stevia increased in the late 1990s due to its therapeutic and nutritional benefits, as well as its antibacterial and antifungal properties. It is also used to treat cardiovascular diseases, thereby lowering blood pressure and blood sugar levels and inhibiting fat accumulation in the body [1].

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Stevia attracted the attention of scientists only in the late 19th century. In 1887, the Swiss botanist Moisés Santiago Bertoni, whose photograph is shown in Figure 1, discovered stevia in Paraguay, where he met with local people and learned about their use of it. He then conducted extensive research to document its sweetness and unique properties. Throughout the 20th century, researchers focused on the chemical composition of the stevia plant, particularly its steviol glycosides. It was confirmed that these glycosides are hundreds of times sweeter than sucrose (table sugar) and contain no calories, making stevia a healthy alternative sweetener [2].

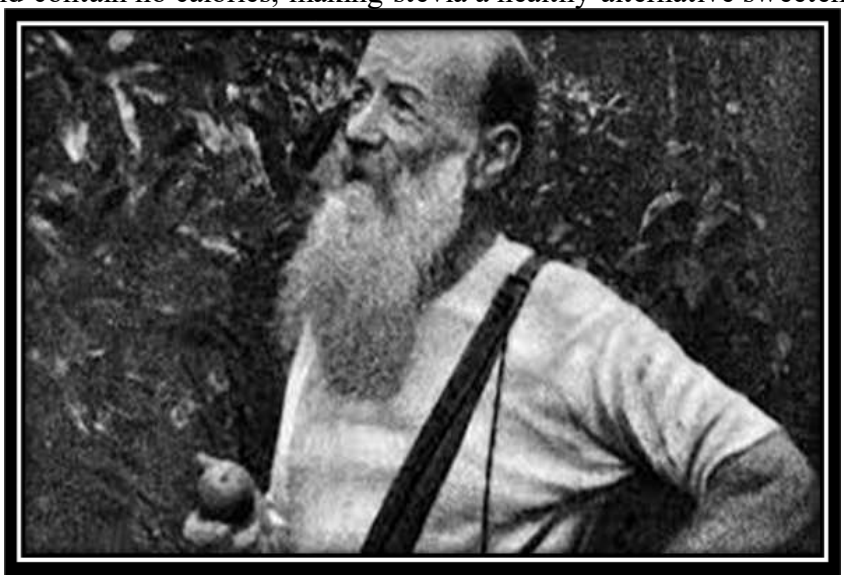


Figure 1: The Swiss Botanist Bertoni (1875-1929).

Stevia extracts began to be used in dietary supplements and healthy foods in the 1990s and were approved as healthier food alternatives, particularly in Japan and Paraguay. However, in the United States and Europe, safety concerns delayed approval by organizations such as the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA). It took decades of research and industry effort to gain approval for use as a certified sweetener. In 2008, the FDA granted steviol glycosides "generally recognized as safe" (GRAS) status, allowing their use as food additives sugar substitutes. Steviol glycosides were subsequently approved for use in the European Union in 2011. This approval has contributed to the widespread use of stevia extracts in the food and beverage industry, providing consumers with a natural, calorie-free sweetener option. As a result, stevia has been included as an ingredient in soft drinks, flavored water, yogurt, chewing gum, and other products. Furthermore, its anti-inflammatory and antioxidant properties have been studied; however, moderate consumption is still recommended [3].

Plants are usually cultivated for several reasons; for example, prickly pear is cultivated for its fruits, while the rest of its parts are used as animal feed [4]. Stevia has become a household staple in many countries and a dietary staple for individuals seeking to reduce their sugar intake and maintain their weight. The global stevia market has grown markedly, driven by its use in products such as table sweeteners, baking mixes, and sugar-free sweets. Stevia's impact extends far beyond the food and beverage industry, as its cultivation provides economic opportunities for farmers in countries such as Paraguay, China, and Kenya, as well as in other tropical and subtropical countries, where it is grown on a large commercial scale. Moreover, its growing popularity aligns with consumer demand for healthier and more sustainable food options [5].

This study aims to examine the stevia plant as an alternative to common sugar, investigate the potential side effects of using stevia, explore methods of plant propagation and its economic importance, and identify stevia products available on the market.

Morphological Discerption & Classification:

Stevia is a perennial plant native to South America and is now cultivated in almost all regions except the warmer regions of the United States. It is also known as "sweet leaf," "sugar leaf," or "sugar bush." The leaf is the active part of the plant, containing sweet-tasting glycosides that give it its sugary flavor. Ground leaves and raw leaf extracts are used as natural sweeteners. Stevia is a slender herb that grows to a height of 30.5–80 cm (1–2.5 ft). Its oblong, aromatic leaves, about 2.5 cm (1 in) long and characterized by a prominent midrib, are arranged oppositely along the stems. The small, tubular flowers have five white petals and grow in terminal clusters. The flowers are usually removed to improve the flavor of the leaves. Stevia seeds are difficult to germinate because the plant requires rich, well-drained soil and thrives in warm, humid climates [6].

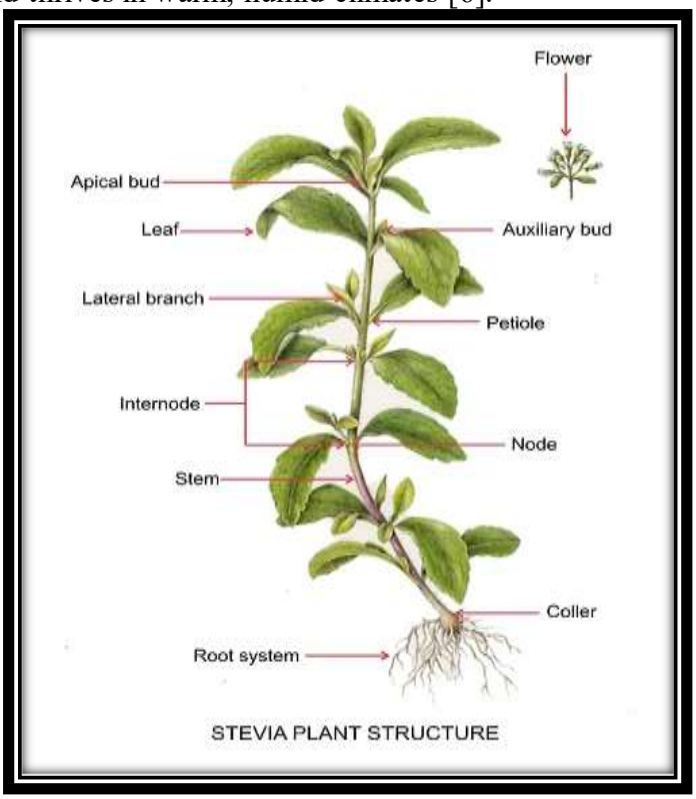


Figure 2: Morphological Structure of Stevia rebaudiana.

Kingdom: Plantae (Plants)
Division: Magnoliophyta
Class: Magnoliopsida
Sub-Class: Asteridae
Order: Asterales
Family: Asteraceae/Compositae
Genus: *Stevia*
Species: *rebaudiana* [7], [8]

The Chemical Composition of Stevia:

Many studies have examined the chemical composition of stevia and isolated its active compounds, with a particular focus on the leaves. These studies show that

the dry leaf extract contains glycosides responsible for the sweet taste, the most important of which are steviol and rebaudioside A, as well as chlorophylls, xanthophylls, alkaloids, flavonoids, tannins, caffeic acid, chlorogenic acid, amino acids, and essential oils. The leaves also contain several minerals, including potassium, phosphorus, calcium, magnesium, sulfur, and sodium, as well as trace amounts of iron, copper, cobalt, manganese, zinc, selenium, and molybdenum. It can be argued that the bioactive compounds found in stevia justify its wide range of practical applications in the food and pharmaceutical industries [9].

According to one study, several bioactive compounds were found in the leaves of Renggak (*Amomum dealbatum Roxb*), a medicinal plant in the Zingiberaceae family, according to a study [10]. This finding highlights the potential uses of natural plant extracts in a variety of fields. In addition, fermented stevia extracts have been shown to inhibit several pathogenic bacteria, such as E. coli and other foodborne pathogens, included *Salmonella*. Stevia was used in the past to treat wounds, ulcers, and gum diseases[11].

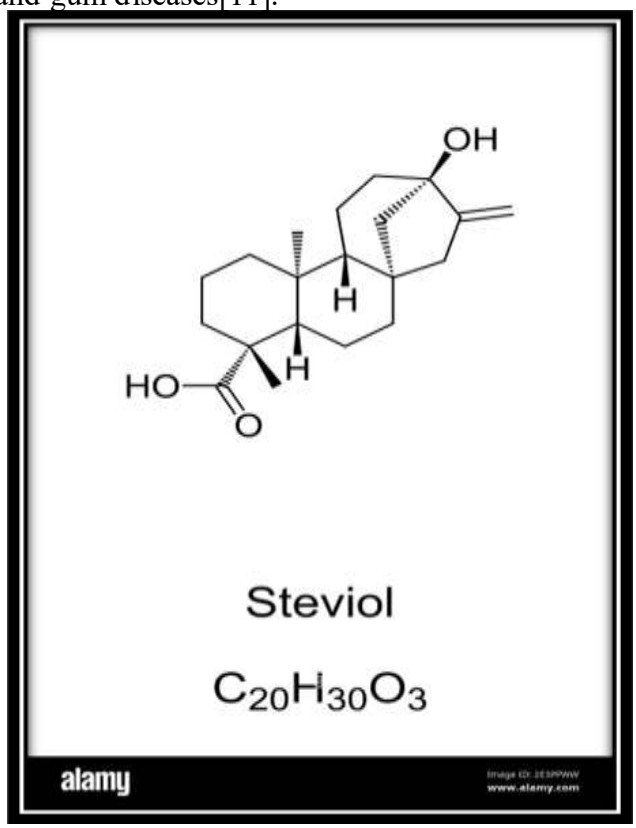


Figure 3: Steviol Glycoside

Benefits of Stevia:

• **Lowering Blood Sugar Levels in Diabetic Patients**: Studies have yielded mixed results on the effect of stevia on blood sugar levels. One study published in the journal Metabolism in 2004 indicated that consuming 1000 mg/day of stevia leaf extract containing 91% stevioside may reduce post-meal blood sugar levels by 18% in individuals with type 2 diabetes. However, another study published in the Journal of Regulatory Toxicology and Pharmacology in 2008 showed that consuming 250 mg of stevioside three times daily for three months did not reduce HbA1c levels in diabetic patients. Therefore, it is recommended to monitor blood sugar levels after consuming stevia or other stevia-containing sweeteners [12].

• **Lowering Blood Pressure**: Studies on the effect of stevia consumption on blood pressure are conflicting. Some studies indicate that consuming 750-1500 mg/day

of stevioside may reduce systolic blood pressure by 10 to 14 mmHg and diastolic blood pressure by 6 to 14 mmHg. However, other research suggests that stevioside consumption does not lower blood pressure. Therefore, individuals at risk of low blood pressure are advised to consult their doctor before consuming stevia or stevia-containing sweeteners [13].

• **Weight Loss**: Stevia sugar, unlike other artificial sweeteners, can contribute to weight loss when used as a substitute for high-calorie foods and drinks. Some studies have shown a significant decrease in body weight in mice that consumed stevia compared with those that did not [5].

• **Medicinal Value**: Stevia leaf extract is a powerful antioxidant, has anti-cavity properties, boosts the immune system, has anti-inflammatory effects, and may stimulate fertility [1]. Much like stevia, honey is a natural product that may be beneficial to health due to its antibacterial and anti-inflammatory properties [14].

• **Other Uses of Stevia**: Due to increased nutritional awareness and the rising prevalence of chronic diseases, consumers have become more inclined to choose products labeled "all-natural and low in sugar." Consequently, the food industry can boost its market share by using stevia as a natural sweetener in products such as biscuits, jams, chocolates, creams, baked goods, soft drinks, sodas, sweets, teas, coffees, and herbal teas, which are specifically targeted at people with diabetes and those interested in general health. All cooked and baked foods can be sweetened with very small amounts of stevia leaf powder. Just 50 g of stevia leaf powder can replace 1000 g of cane sugar (common sugar). Stevia is also characterized by its thermal stability and non-fermentability, which enhances quality and safety in use and provides a longer shelf life [15].

Harvesting and Storage:

Stevia is harvested in late summer, when the plants are mature and flowering begins, because the concentration of sweet compounds is highest under cooler temperatures and shorter days. However, the sugar content declines after flowering. Small plots are often harvested by hand to avoid damage, and a specially designed harvester may be used to harvest the crop at ground level. A bagged rotary mower can be adapted for larger plots that cannot be harvested by hand, and a separate unit should be used to prevent contamination or mixing with other crops.

Suitable Conditions for Growing Stevia and Propagation Methods:

Stevia is grown in sunny areas with relatively high temperatures, which helps improve vegetative growth. It is essential to provide the plant with adequate moisture, as it does not tolerate drought. A lack of irrigation water can have negative effects on the plant: Its cultivation methods include the following[16]:

• **Propagation by Seeds**: This method can be used, but it has many disadvantages, such as a low germination rate due to a loss of self-compatibility between plants. Also, the small size of the seeds is unsuitable for direct planting in the ground, which leads to damage, and there are several genetic differences between plants, as the shapes, concentration of active substances, and rate of sweet substances differ from one plant to another.

• **Propagation by Roots**: Plants produce root sections when they reach one year of age. Each root section can develop into a complete plant. The disadvantage of this method is the limited number of plants produced.

• **Propagation by Stem Cuttings**: It is preferable to propagate by stem cuttings in greenhouses, which provide high humidity and a warm environment suitable for plant growth. A rooting hormone can be used to stimulate root development before

planting the cuttings. This method is advantageous because it allows the plant to produce a large number of cuttings and yields a significant number of plants in a short period.

• **Propagation by Tissue Culture**: Stevia can be propagated by tissue culture, in which plant tissue is collected from mother plants with distinctive characteristics in productivity, either in vegetative growth or in the amount of natural sweet compounds produced.

Hydroponics is considered one of the best solutions for crop cultivation and achieving sustainable food security [17], particularly because stevia requires relatively small agricultural areas and demand for the plant is increasing.

Side Effects of Stevia:

The consumption of stevioside and rebaudioside A is generally considered safe when these compounds are used as food sweeteners. Rebaudioside A is on the list of compounds recognized as safe (GRAS). Stevioside has been used safely in studies at doses up to 1500 mg/day for two years. However, some people who use stevia may experience bloating, nausea, dizziness, muscle pain, or numbness. Regarding pregnant and breastfeeding women, there is insufficient reliable information on its safety; therefore its use is not recommended as a precautionary measure [18].

Stevia consumption may negatively affect people with certain health problems, such as allergies to plants belonging to the Asteraceae family, to which stevia belongs. Some research also indicates that stevia contains compounds that may lower blood sugar levels, thereby affecting blood sugar control in people with diabetes. Although other research does not support this finding, diabetics who use stevia should monitor their blood sugar levels regularly. Some inconclusive evidence suggests that certain chemicals in stevia may help lower blood pressure, especially in people with low blood pressure. Therefore, individuals with low blood pressure are advised to consult a doctor before consuming stevia or sweeteners containing it.

Consuming stevia or chemical compounds extracted from it may interfere with the effectiveness of certain drugs, such as lithium, antidiabetic drugs, and antihypertensive drugs, and may also cause other side effects and adverse effects. A study conducted on mice and published in the Journal of Medicinal Plants Research in 2013 indicated that stevioside compounds found in stevia may have diuretic properties, leading to a reduction in blood sodium levels and thus lowering blood pressure [19].

On the other hand, a 2013 study published in PLoS One indicated that consuming stevia may help maintain kidney health by reducing kidney cell damage and inhibiting the growth of kidney cysts. Conversely, a 2016 study published in Molecular and Cellular Endocrinology indicated that the steviol glycosides found in stevia are steroidal (androgenic) compounds and may affect the hormones of the endocrine system. Furthermore, the general negative effects of sweeteners may include persistent cravings for sweet foods.

The Harmful Effects of Aspartame:

Some researchers suggest that calorie-free artificial sweeteners may increase cravings for sweet foods and could affect taste perception or nutrient absorption. Furthermore, their use may lead people to justify eating more high-calorie foods. A 2015 study in the Journal of the American Geriatrics Society linked consumption of soft drinks containing artificial sweeteners to higher rates of obesity. Another study in *Diabetes Care in 2009* reported that the risk of metabolic syndrome and

type 2 diabetes increases in people who consume soft drinks containing artificial sweeteners daily. A 2020 study in the *Journal of Family Medicine and Primary Care* found that individuals with type 2 diabetes who consume artificial sweeteners have higher rates of insulin resistance than those who do not. Although some studies have refuted this effect, further research is needed on the relationship between artificial sweetener consumption and insulin sensitivity [20].

A 2019 study in Advances in Nutrition showed that artificial sweeteners negatively affect beneficial gut bacteria and may disrupt the balance of these bacteria in the gut in some individuals, potentially increasing the risk of digestive disorders. A recent study by Alsaeh *et al*. [21], reported substantial increases in liver enzyme activity (AST, ALT, and ALP), higher levels of renal function makers (urea, creatinine, and uric acid), and electrolyte abnormalities (Na^+, K^+, and Ca^{2+}). The concentrations of the sex hormones FSH, LH, and testosterone were also lower than in the control groups. Histological examinations indicated distinct pathological alterations in liver, kidney, and testicular tissues, such as cell degradation, vascular congestion, inflammatory cell infiltration, and seminiferous tubule shrinkage. Taken together, these findings suggest that aspartame toxicity is dependent on dosage and duration of exposure.

A study showed that aspartame may cause structural changes in the kidneys following chronic exposure to 75 mg/kg body weight/day in female white mice, as a result of oxidative stress mechanisms. These changes include pathological renal histological changes, including glomerular atrophy, tubular epithelial degeneration, infiltration of inflammatory cells, and vascular congestion [22]. The same dose also causes marked changes in the myocardium, including disorganization of muscle fibers, severe vascular congestion, infiltration of inflammatory cells, hemorrhage, and focal necrosis [23].

Forms of Stevia Available on the Market:

Different forms of stevia have their own advantages and disadvantages. The best form of stevia depends on personal preferences and the intended use. These forms include [1]:

• **Liquid Stevia**: This is a concentrated form of stevia extracted from the leaves and mixed with water and alcohol. It's popular because it's easy to use and can be added to beverages and foods. It's also available in various flavors, making it a versatile sweetener. One benefit of liquid stevia is that it's low in calories and doesn't raise blood sugar levels.

• **Stevia Powder**: This is made by grinding stevia leaves into a fine powder. The powder is very popular among people who prefer using a natural sweetener for baking and cooking.

• **Stevia Extract**: This is a highly concentrated form of stevia, produced by extracting the sweet compounds from its leaves. It is one of the purest forms and tastes sweeter than other stevia forms. However, it is more expensive, and producing even small quantities requires several stages.

• **Stevia Blends**: These are mixtures of stevia with other sweeteners such as erythritol, xylitol, or aspartame. These blends are very popular because they have a taste and texture similar to sugar.

• **Whole Stevia Leaves**: These are the least processed form of stevia, marketed as dried and ground leaves in a green powder. Whole leaves are very popular among people who prefer a natural sweetener and avoid any form of processing. However, whole stevia leaves are less sweet than other forms of stevia.

Conclusion:

From the above, it is clear that there is general scientific agreement that the use of table sugar and artificial sweeteners poses numerous health risks. Researchers have examined the effects of stevia, aspartame, and sucrose (table sugar) on insulin and blood glucose levels and have found that stevia was superior in lowering these levels without increasing appetite after a meal. It was also noted that stevia provided a longer lasting feeling of satiety than sucrose and aspartame. The U.S. Food and Drug Administration (FDA) has given stevia glycosides a GRAS status, indicating that they are generally recognized as safe for human use. However the FDA has not approved whole stevia leaves or crude stevia extracts for use in foods and beverages due to a lack of information regarding their safety. The scientific community has also addressed one disadvantage of using stevia sweeteners: their slightly bitter taste, which results from certain chemical components,by developing precise and highly efficient extraction methods.

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Conflict of Interest

- Yes ☐
- **No** ☐

Data Availability

- **Yes** ☐
- No ☐

Authors' Contributions

No.	Author Name and Email	Study Conception / Idea	Data Collection or Contribution to Data Collection	Contribution to Previous Studies / Literature Review	Study Methodology	Conducting Analyses (Practical Aspect)	Data Analysis	Interpretation and Discussion of Results	Approval of Final Version
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3									