

CULTIVATION AND USES OF STEVIA (*Stevia rebaudiana* Bertoni): A REVIEW**Hossain MF^{1*}, Islam MT¹, Islam MA² and S Akhtar³****Farid Hossain**

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ABSTRACT

Stevia [*Stevia rebaudiana* Bertoni; Family Asteraceae] is a natural sweetener plant that is grown commercially in many parts of Brazil, Paraguay, Central America, Thailand, Korea, China and India. The leaves of stevia are the source of sweet glycosides. It is mainly used as a sweetener and flavor enhancer in the food and beverage industry. The chemical compound obtained from stevia is considered to be the best alternative source of sugar especially for diabetes patients. Climatic factors and agronomical practices affect the quality and quantity of yield. The concentration of stevioside in the leaves is higher when the stevia plants are grown under long days and when these plants are harvested just prior to flowering. Time of harvesting depends on land type, type of stevia and growing season. The first harvest can be done four months after planting and subsequent harvest once after every 3 months. Such medicinal plants are becoming fairly popular for the treatment of different diseases all over the world. It could be suitable for diabetic and obese persons. It also showed antibacterial, antiseptic, anti-inflammatory, anti-fertility, hypotensive, diuretic and cardiogenic properties. Stevia is a small perennial shrub that has been used for centuries as a bio-sweetener and for other medicinal purposes. In addition, alternative sweeteners offer another benefit in maintaining good dental health. *S. rebaudiana* sweeteners are used sparingly and there seems to be no threat to public health. Stevia has been introduced to the Kenyan market as one of the cash crops for agro-based industry. The changes in leaf yield and accumulation of stevioside in response to different environmental conditions and nutritional variations might provide some leads to develop strategies for increasing the productivity of the stevia. Quality of the stevia product depends on drying temperature; high temperatures negatively affect quality, diminishing medicinal and commercial value. Multiple global regulatory organizations have determined that consumption of high quality stevia products within recommended doses is safe for all.

Key words: Stevia, Cultivation, Medicinal uses, Diabetes, Natural sweetener, Flavor enhancer, Glycosides



INTRODUCTION

Stevia (*Stevia Rebaudiana* Bertoni) is native to the valley of the Rio Monday in the highlands of North-eastern Paraguay in South America [1]. It is commonly and variously known as sweet leaf, honey leaf, candy leaf, sweet weed or sweet herbs. Stevia is gaining significant popularity in different parts of the world and is expected to be a major source of high potency sweetener [2]. The leaves of this popular plant are sweet and ideal for people who are conscious of sugar and carbohydrate intake. With zero calories, the plant is being recognized as a great replacement for sugar and other sweeteners [3]. Worldwide, 32,000 hectares have been under stevia cultivation and China has a major chunk of 75%. It is a natural sweetener plant and is grown commercially in many parts of Brazil, Paraguay, Central America, Thailand, Korea and China [4]. Japan is currently using large amounts of stevia [5]. This natural sweetener can provide Kenyan farmers with an opportunity to be part of a rapidly growing supply chain that includes several other countries from around the world [3]. Several countries have now started its commercial cultivation [6].



Figure 1: Stevia Herb

Stevia is a plant with carbohydrate-based compounds that are 200-300 times sweeter than sugar. It is reported that steviosides have insulinotropic effects in pancreatic beta cells because it increases insulin secretion and thereby decreases blood glucose level. It can be extracted and used as alternative sweeteners for sugars [7]. In Bangladesh, about 5 million

people are suffering from diabetes [8]. Non-caloric, natural sweeteners, which can save people from diabetes, may possibly receive greater focus in future. There is immediate focus on this plant now as a natural alternative to artificial sweeteners. Recent research has shown that, consuming stevia in its raw form, fresh or dried, helps to solve several health problems such as diabetes, allergies, digestive problems, anxiety, and high blood pressure [9]. Besides these benefits, stevia also contains vitamin C, calcium, beta-carotene, niacin, iron, magnesium, potassium, proteins and fiber. Therefore, it is important to find alternatives to drying the plant's leaves in order to minimize the negative effects of heat and to retain the regular medicinal properties [9]. Changes in leaf yield and accumulation patterns of stevioside have been observed in response to different environmental conditions. Nutritional variations provide leads for developing strategies to increase stevia productivity under different agro-climatic conditions [10]. Stevia is a good crop to promote resilience from pest infestation and a short-term crop to strengthen climate change adaptation in order to mitigate its adverse impacts in agriculture [11]. This article presents a literature review on stevia, the cultivation practices and uses.

History of Stevia

In 1887, a South American Scientist Dr Moies Santiago Bertoni, Director of the College of Agriculture in Asuncion, first described the biological properties of Stevia. In 1900, Ovidio Rebaudi first isolated the active ingredients, glycosides, responsible for sweetness of stevia leaf extract. The characterization of different glycosides of stevia was completed in 1931. Cultivation of stevia started in 1961. United States of America recognized stevia as a valid natural sweetener in 2008, while stevia has been approved by Canada for use in foods and beverages [12].

Distribution

The first report on commercial cultivation in Paraguay was in 1964 [13]. Since then it has been introduced as a crop in a number of countries including Brazil, Korea, Mexico, United States, Indonesia, Tanzania and Canada since 1990 [14]. Currently, its major production is centered in China and the major market is in Japan [15]. The no-calorie sweetener heaped with great health benefits is now being grown in more counties of Kenya including Kericho, Nandi, Nakuru, Laikipia, Uasin Gishu, Narok, Meru and Bungoma. Stevia, a natural sweetener, is creating opportunities for more farmers in Kenya and opening export markets in China, Malaysia, Paraguay and Brazil [16]. In Kenya, the commercial cultivation of the crop began in 2008 when the Malaysia-based firm set up a local subsidiary to take advantage of market opening in the United States (US). Kenya earned USD 50 million from stevia in 2011. Stevia is a sweetening plant and its introduction into the Kenyan market as one of the cash crops for agro-based industry may spell doom for the sugar industry [17]. It is used as a sweetener in place of sugar, especially in the cases of patients suffering from acute diabetes [17]. Nowadays, it is also being cultivated in Bangladesh. The climatic requirements of this plant indicate that it can be introduced in the hilly areas of Sylhet and Chittagong districts of Bangladesh [18].



Cultivation Technology

Climate

Stevia is a perennial herbaceous plant native to between 22° to 24° south and 53° to 56° west in Paraguay and Brazil [19, 20]. Plants grown at higher latitudes actually have a higher percentage of sweet glycosides [2]. Nutrition and climatic conditions play important roles on the growth and secondary metabolites of stevia plant [10]. Vegetative growth is reduced when temperatures are below 20°C and when day length is less than 12 hours. Increasing day length to 16 hours and increasing light intensity can increase vegetative growth and stevioside levels [21, 22]. However, some varieties appear to be photoperiod insensitive. Early flowering lines tend to have higher stevioside content but lower total yield [23]. The concentration of stevioside in the leaves increases when the plants are grown under long day conditions where the vegetative period is longer and steviol glycoside yields are higher [24, 25]. Planting density and transplanting date are the most important agronomical factors that may affect the quality and quantity of the yield [4]. The concentration of stevioside in the leaves increases when the stevia plants are grown under long days [25]. The natural habitat of stevia is semi-humid subtropical climate on the Tropic of Capricorn (22-23°S latitude), 200-400 meters above sea level, with 1,500-1,800 mm of rain and temperature extremes of -6°C to +43°C [26]. It is a semi-humid subtropical plant that shows higher leaf production under high light intensity and warm temperature. However, day length is more critical than light intensity. Long spring and summer days favor leaf growth. Short days trigger blossoming. Stevia prefers partial shade during considerable summer sunshine [24]. The overall cultivation studies suggest that stevia seedlings may be planted from 15th February to 30th April for better yield of leaves in Bangladesh [2].

Soil

The nutritional dosage is strongly governed by the soil properties and climatic conditions of the growing region [10]. Stevia grows in well-drained fertile sandy loam or loamy soil, rich in organic matter. It prefers acidic to neutral (pH 6-7) soil for better growth and requires a consistent supply of moisture, but not waterlogged fields [24]. It naturally grows in low lying areas on poor sandy acidic soils adjacent to swamps, and so is adapted to and requires constantly wet feet or shallow water tables [26, 27]. Urea fertilizer should be applied in three splits viz. once at basal and remaining two applications after first and second cutting of leaves [24]. Stevia plants prefer low nitrogen, but high level of phosphorus and potassium. Slow releases of nitrogen (N) sources are better due to requirement of low level of N in addition to steady release of N from the source. Sometimes stevia shows the symptoms of boron deficiency, which leads to leaf spot that can be rectified by spraying Borax 6% [24]. Since the feeder roots tend to be quite near the surface, addition of compost for extra nutrients is beneficial. A previous study revealed that at the point of maximum dry matter accumulation, stevia plants consist of 1.4 % N, 0.3% P and 2.4 % K [24].



Propagation

Vegetative propagation is the best way for seed multiplication of stevia due to low seed germination capacity [28]. *In vitro* propagation can become an important alternative to conventional propagation and breeding procedures for a wide range of plant species [18]. Stevia is grown in the following season in the same field after uprooting the mother plant [3].

Irrigation

Stevia cannot grow in dry conditions. Sprinkler irrigation is found to be advantageous since the herb is highly sensitive to water stress and requires frequent light irrigation. During summer, watering at an interval of 3-5 days gives best results. In order to reduce the impact of drought and high temperature, addition of mulches around the plant is recommended [24].

Harvesting

Time of harvesting depends on land type, variety and growing season. The first harvest of the crop can be done four months after planting and subsequent harvest once after every 3 months. The best harvesting time is mid-September to late September when plants are 50-70 cm in height. Short days induce flowering. It is harvested just prior to flowering to get maximum steviol glycoside content in the leaves [29]. The easiest harvesting technique is by cutting the branches off with pruning shears before stripping the leaves. The tips of the stems can be clipped off and added to harvest as they contain as much stevioside as the leaves. On average, three commercial harvests can be obtained in a year. It is better to cut the plants leaving about 10 cm stem portion from the ground. This will facilitate new flushes to emerge, which can be harvested as the next crop. For domestic use, leaves may be used fresh for tea or may be combined with mint leaves [24].



Figure 2: Leaf of stevia



Drying

Drying process is to eliminate moisture and leads to a reduction of the visual, organoleptic and functional characteristics of the stevia plants, which negatively affects its final quality parameters like color, texture, aroma, essential oil content and shape. High temperature negatively affects the final quality of the product, diminishing their medicinal properties and their commercial value [9]. Immediately after harvest the herb is dried. This can be accomplished on a glass sheet or net. The freshly harvested plants can be hung upside down and dried in a shade. It can also be dried using simple drying racks inside transparent poly house or transparent glass roofing or by passing dry air just above room temperature. Drying of the stem and soft green leaf material is completed immediately after harvesting using a drying wagon, a kiln or done naturally in case of large-scale production. Depending on weather conditions and density of loading, it generally takes 24 to 48 hours to dry stevia at 40 to 50°C. The drying process does not require excessive heat; more important is good air circulation. On a moderately warm fall day, stevia can be quickly dried in the full sun in about 12 hrs. Longer drying time will lower the stevioside content of the final product. A home dehydrator can also be used although sun drying is the preferred method. After adequate drying, the leaves are stripped of the stems / twigs, packed and stored in a cool and dry place. For large-scale commercial production, artificial drying and threshing of the dry herbs to separate leaves may be employed [24].

Chemical Components

Stevia is a natural sweetener plant. The leaves of stevia are the source of glycosides. Even more, stevia contains a high percentage of phenols, flavonoids and antioxidant activity [30]. The two main glycosides are Stevioside (St), traditionally 5-10% of the dry weight of the leaves, and Rebaudioside A (R-A), being 2-4%; these are the sweetest compounds. There are also other related compounds including Rebaudioside C (1-2%) and Dulcoside A & C, as well as minor glycosides, including flavonoid glycosides, coumarins, cinnamic acids, phenylpropanoids and some essential oils [31]. Leaves of stevia contain around 10 sweetening glycosides of which stevioside (3-10%), rebaudioside-A (13%), and rebaudioside-B, C, D are important [32]. Eight phytochemical properties of stevia glucosides were discovered, viz. dulcosides A, rebaudiosides A-E, steviobioside and stevioside [33]. In addition, the triterpenes amyirin acetate and 3 esters of lupeol and the sterols like stigmasterol, sitosterol and campesterol can also be extracted from the leaves [34]. Non-caloric, natural sweeteners which are safe for diabetics might receive greater focus in future. There is greater interest in this plant now as a natural alternative to artificial sugar [5].

Uses

The leaves of stevia have a pleasantly sweet and refreshing taste that can linger in the mouth for hours. The material contains the sweet components surrounded by the bitter components in the veins [35]. The leaves are used to prepare sauces but are best in herbal teas and for direct consumption. Powdered or ground leaves are found in bulk form and in tea bags. The leaves are used as a color and flavor enhancer as well as sweetener in teas, salads, fruit, and



coffee, among others. Stevia is mainly used as a sweetener and flavor enhancer in the food and beverage industry. The health market is second in order of importance. The third most important market is by-products, which consists of the remainder of the plant after the best leaves have been harvested for tea or for extraction. The by-product market can be further developed by promoting use of these products as fertilizer and as an additive for animal food products [36]. The plant can be utilized for the production of a natural sweetener, as a source of chlorophyll (Oral-hygiene product, medicine) and as a source of phytosterols [24]. Fresh leaves have a mild licorice flavor. This is the simplest form of stevia in its most natural and unrefined state. The remaining parts of the plant, including stems, seeds, flowers and even leaves that were not selected for industrialization, are collected and processed into animal feed or fertilizers [36]. Stevia is a small perennial shrub that has been used for centuries as a bio-sweetener and for other medicinal uses such as lowering blood sugar. Its white crystalline compound (stevioside) is the natural herbal sweetener with no calories and is over 100-300 times sweeter than table sugar [37]. Japan is now the largest consumer of steviosides extracted from stevia leaves [7]. Stevia plant is widely grown for its sweet leaves and medical value. With its extracts having up to 300 times the sweetness of sugar, stevia has garnered attention with the rise in demand for low-carbohydrate and low-sugar food alternatives. Medical research has also shown possible benefits of stevia in treating obesity and high blood pressure. Because stevia has a negligible effect on blood glucose, it is attractive as a natural sweetener to people on carbohydrate-controlled diets [38]. The leaves are picked and separated from the stem mostly by hand and processed in special factories to extract rebaudioside A, a compound hundreds of times sweeter than sugar [39]. The leaves have been traditionally used for hundreds of years in Paraguay and Brazil to sweeten local teas, medicines and as a 'sweet treat'.

Medicinal Uses

According to World Health Organization (WHO) findings, stevia regulates blood pressure, fights cavities, induces pancreas to produce more insulin, and acts as bactericidal agent [40]. No negative clinical reports have appeared in any of these countries where stevia is readily available [41]. Medicinal plants are becoming very popular for the treatment of different diseases all over the world [8]. Stevia is suited for diabetic and obese persons. It may later be advantageous in the prevention of type 2 diabetes. It also showed antibacterial, antiseptic, anti-inflammatory, anti-fertility, hypotensive, diuretic and cardiogenic property. It has shown good results in clearing up skin problems like dermatitis, eczema, wrinkles, skin blemishes, acne outbreaks, scarring, rashes and itchiness. Steviol regulates blood glucose level by enhancing not only insulin secretion but also insulin utilization in insulin deficient animals and is also used as a digestive tonic. It is expected to bring hope to diabetic people who have craving for sweets [23]. Its leaves contain approximately 10% of steviosides which are intensely sweet compounds with particular benefit to diabetics [7]. Stevia raw stuff works as a synthesizer of oral contraceptives, cholesterol suppressing medicine, antitumor activity against prostate tumors and activity against rheumatism. Its medicinal uses include regulating blood sugar, preventing hypertension, treatment of skin disorders, and prevention of tooth decay [42]. The compound obtained from stevia is considered to be the best



alternative sweetener source for diabetes patients. The added value for this new crop can go up to a considerable extent. Statistics indicate that in some countries up to 30 % of their needed sugar is replaced by stevioside-like sweetness products [42]. The leaves of stevia are the source of steviol glycosides, stevioside and rebaudioside, which are estimated to be 300 times sweeter than sugar but also have no effect on blood sugar, so it is helpful for hypo glycaemia and type-2 diabetes [43, 44]. It nourishes the pancreas and thereby helps to restore its normal function. Furthermore, stevia contains a high percentage of phenols and flavonoids, which cause stevia to have a high antioxidant activity [45, 46]. Phenols are the secondary metabolites that cause the cardiac and cancer diseases to decrease [47]. The plant may have cardio tonic actions, which normalize blood pressure and regulate the heartbeat [23]. The plant displays vasodilator actions in both normotensive and hypertensive animals. Stevia has also helped to reduce blood pressure cases and has increased diuretic and natriuretic effects in rats [23]. Dietary sucrose has been implicated to cause dental caries. It is believed that sugar substitutes can reduce the incidence of dental caries. Stevioside has been found to reduce dental caries. It may exert its action by three different ways: antibacterial effect, production of low acidic condition and anti-plaque activity [12]. In addition to their use in calorie control and for diabetics, alternative sweeteners offer another benefit in maintaining good dental health by reducing the intake of sucrose [48]. Stevia possesses anti-fungal and anti-bacterial properties in addition to its other versatile uses. It can safely be used in herbal medicines, tonics for diabetic patients and also in daily usage products such as mouthwashes and toothpastes. Mild stevia leaf tea also offers excellent relief for an upset stomach [37]. *Stevia rebaudiana* sweeteners are used sparingly and there seems to be no threat to public health, although caution should be exercised at higher daily intake levels [49]. Despite their widespread use in several different parts of the world, no evidence of adverse reactions due to the ingestion of *S. rebaudiana* extracts of stevioside by humans has appeared in the biomedical literature [50]. Food and Agriculture Organization of the United Nations, the World Health Organization and the Food & Drug Administration (FDA) have determined that high purity stevia extract is safe for consumption by the general population when consumed within the recommended levels [51].

CONCLUSION

Stevia (*Stevia rebaudiana* Bertoni) is gaining significant popularity in different parts of the world. Climatic factors and agronomical practices have impacts on quantitative and qualitative characteristics of stevia plants. Time of harvesting depends on land type, variety and growing season. Leaves of stevia gain optimum yield and quality stevioside just before flowering. Stevia is mainly used as a sweetener and flavor enhancer in the food and beverage industry. The compound obtained from stevia is considered to be the best alternative source of sweeteners for diabetes patients. Moreover, the unique selling points of stevia sweetener are very strong in Bangladesh due to the prevalence of diabetes and other metabolic diseases including obesity [18]. However, further studies are required to identify standard cultivation areas and technology to understand the relationships that are responsible for quality stevia production.



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