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Palak Sardana
University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Punjab, India

Dr. Asma Fayaz Lone
University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Punjab, India

Munish Kaundal
University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Punjab, India

Corresponding Author:
Palak Sardana
University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Punjab, India

Stevia rebaudiana: Nature's zero calorie sustainable sweetener

Palak Sardana, Asma Fayaz Lone and Munish Kaundal

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Abstract
Stevia rebaudiana Bertoli also referred to as stevia or honey leaf, is a defenceless sweetener that has both nutritional and therapeutic use. Stevia is traditional both as a sweetener and a medicine in all parts of the globe, thus the plant comes in the Asteraceae family and is native to South America. The physicochemical traits of the plant make it sweet, as the compound, steviol glycosides, predominantly stevioside and rebaudioside A are sweeter than sucrose (200300 times) and it contains no calories, making them a sustainable substitute for conventional sugar. Currently, stevia is cultivated in more than 30 countries, with China being the largest producer.
Agronomically, stevia grows well in warm, semi-humid climates with loamy soil, and is primarily propagated vegetatively due to its poor seed germination. Cultivation practices, including efficient irrigation, proper harvesting, and controlled drying, play a vital role in maintaining glycoside content and quality. Modern extraction techniques such as enzyme-assisted, ultrasound-assisted, and microwave-assisted methods are increasingly being employed to obtain high-purity stevia extracts in an eco-friendly and sustainable manner

Keywords: *Stevia rebaudiana* Bertoni, natural sweetener, pharmacological properties, health benefits, diabetes

1. Introduction
Stevia, which is a natural sweetening plant, as it possesses medicinal and market significance throughout the entire world. It is a sweetener that has been in use in hundreds of years. "*Stevia rebaudiana* Bertoli is the botanical name of stevia plant that falls in the genus Asteraceae. It also contains 230 species yet only one of them species, is *Stevia rebaudiana* Bertoli that manufacture sweet steviol glycosides. [1]. The origin of Stevia is in Paraguay and Brazil. It is also known as honey leaf. It is a perennial sedub that reaches the height of 60-100cm and the size of the respondents, the 2cm to 10cm leaves are on the plant. Each plant contains 40-45 leaves. Stevia is a short-day plant that has to be grown in a loamy soil and it requires a warm climate. The suitable climate is a semi humid area with temperatures of 21 to 40 degrees Celsius.

Table 1.1: Taxonomic characteristics of stevia [Yadav AK, Singh S, Dhyani D, Ahuja PS. A review on the improvement of stevia, Canadian journal of plant science 2011;91: 1-27]"

"Botanical name	*Stevia rebaudiana*
Kingdom	Plantae
Division	Angiosperms
Class	Eudicots
Order	Asterales
Family	Asteraceae
Genus	Stevia
Species	S. rebaudiana

Stevia extract is better than sugar in many ways; it can become a great alternative for sugar; it is 200 to 300 times sweetener than sugar [2] Many studies show that Stevia leaves contain beneficial effects for human health, like for diabetic patients or high blood pressure problems.

The main compound that is responsible for the sweetness is steviol terpene glycosides, also called as stevioside and rebaudiosides, and they also used as a sweetener in the food industry. Long back, the herb seemed only to be used as medicine, but now all other countries are growing stevia, approximately 1000000 hectares worldwide of stevia are cultivating while China has the largest portion in the whole world. In 2008 United states of America recognised stevia as a natural sweetener.[3] The stevia leaf is extracted and used as alternative sweeteners for the table sugars [4]. The stevia is effective on the human health like digestive system and skin disorders. [5]

2. Biologically Active Compounds of Stevia:

Stevia has also over 30 steviol glycosides in its leaves. Stevioside as well as the Rebaudioside A is the key compound of interest because of the sweetness, they are present in greater quantity and derivative glucosides such as rebaudioside D, F, C, G, Rubusoside as well as steviolbioside are also present but in lesser amount.

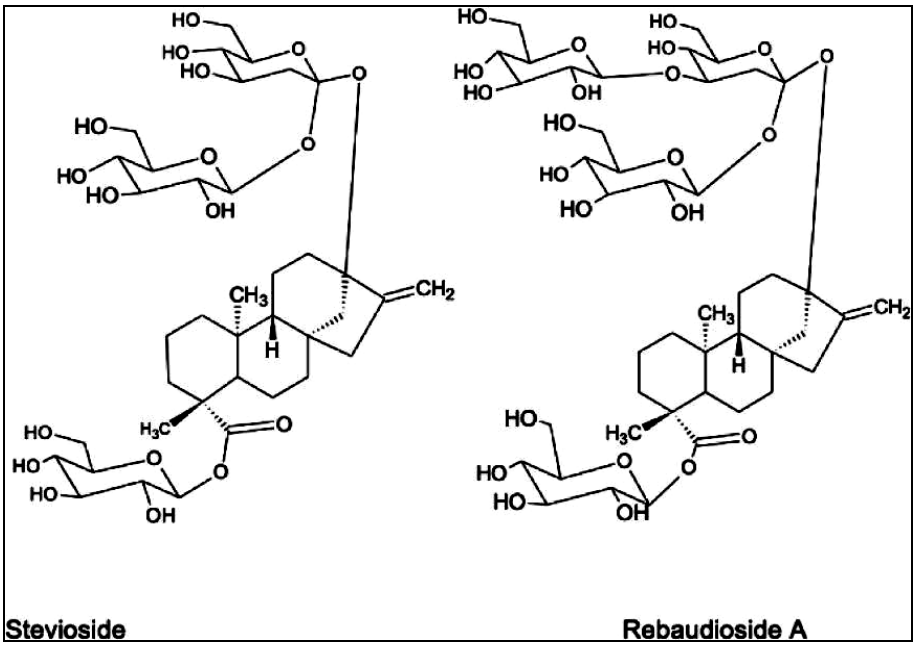
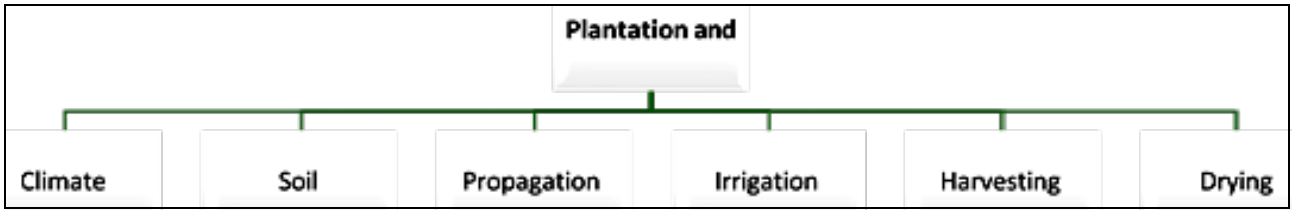


Fig 1: Chemical structure of two key compounds of the Stevia leaves that make it sweet. [Singh SD, Rao GP. Stevia: Herbal sugar of the 21 st century. Sugar Tech. 2005;7(1):17-24.]

3. Production technology



3.1 Nursery sowing; For a good germination we required only a dark brown or black seeds which can be used for nursery sowing. Seeds should have a best germination percentage, and it can only be grown in pots or plastic bags which filled with a mixed amount of sand, silt, clay and organic matter. The bags should be covered properly so that they conserve moisture. Light amount of irrigation is required with proper sunlight. When the seedling is ready then transplant into main field.

3.2 Land preparation: the field should be ploughed properly which has a smooth planting surface. The soil should be well drained which is properly mixed with organic matter and nutrients

3.3 Nursery transplantation: After 15 days of sowing of seed we can directly sown the seedling into the main field or the pots. The optimum temperature should be around Nursery sowing- For a good germination we required only a dark brown or black seeds which can be used for nursery sowing. Seeds should have a best germination percentage, and it can only be grown in pots or plastic bags which filled with a mixed amount of sand, silt, clay and organic matter. The bags should be covered properly so that they conserve moisture. Light amount of irrigation is required with proper sunlight. When the seedling is ready then transplant into main field. The temperature should be around 22 °C to 24 °C [6] and the day light should be less than 16 hours because summer days support plant growth and short day can trigger the growth of the plant. The soil is well drained, fertile loamy soil, which should be rich in organic matter. The pH range should be from 6-7 for the better growth and development. But they don't grow in a waterlogged area. In a study it revealed that at a dry matter accumulation, stevia plant consists of 1.4% N, 0.3% P and 2.4% of K. The nutrition dosage is dependent on the climatic condition. [7]

3.4 Propagation: The best way for the stevia plant to grow is vegetative propagation which is used for seed multiplication due to their low seed germination capacity. [8] We can propagate

stevia by stem cutting, micropropagation and rood division but the seed is not reliable for the large-scale production and the best way for seed multiplication is Vegetative propagation because of its germination capacity.

3.5 Fertilizer and Irrigation scheduling: It required a proper dosage of the nutrients whhich are two bags of Urea (50 kg per bag), one bag of DAP and one bag of ammonium suphate should be given to the crops for better yield. The irrigation should be given 1-2 times in a day. Stevia needs well irrigation because it can't grow in a dry condition. The best method of irrigation is sprinkler irrigation; we need to irrigate the plant on 3 to 5 days. Excessive amounts of water can increase the chances of the fungal disease.

Disease and insect - Stevia is generally attacked by the termites or sucking pests like aphids and thrips. But it cannot severely effect on the plant.

3.6 Harvesting- The time of harvesting depends on their maturity, variety and land type. The harvest is started after 3 to 4 months of planting. The best month for harvesting is mid-September to late September when plants height reaches 50-70cm in height. Stevia leaves may be used in so, any ways like in tea or can be combined with mint also.

3.7 Yield- 18-22 mounds dry leaves per acre

3.8 Drying- In this process the leaves moisture is eliminated which affects the texture, colour and aroma and shape of the leaves. The high temperature effects the final quality of the product.[9] It can be dried in a normal method like in drying racks inside the polyhouse, the drying of stem and leaf material is immediately after harvesting but in a large scale it generally takes 24 to 48 hours to dry at 40 to 50 degrees of temperature. For a large-scale production artificial drying is also used.

4. Different forms of Stevia

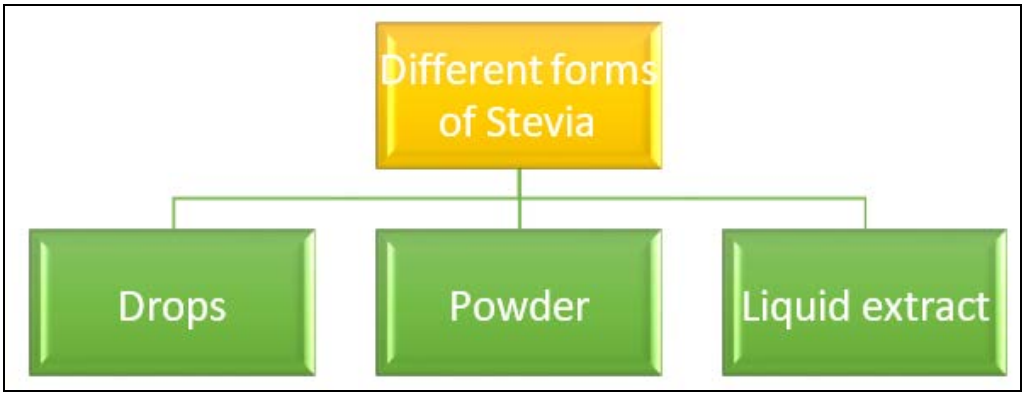


Fig 1.2: Stevia Drops **Fig 1.3:** Stevia powder **Fig 1.4:** Stevia leaf extract

4.1 Green stevia drops: This is refined starch converted to liquid form. This amounts to about 1-Tablespoon which is a one cup amount of sugar. It also possesses a lingering flavor that is higher as compared to the finer powder with a sweeter flavor. They are normally packaged in handy packets that are easy to use work-in beverages.

4.2 Stevia powder: We can dry the stevia leaves to increase the shelf life of the stevia plant. To make the stevia powder we sun dried the stevia leaves for approximately 12 hours. After that we can grind the dries leaves by the help of mortar and pastel. When prepared this way it has whitish colour. In healthy stores the stevia powder is made through many ways.

4.3 Stevia liquid extract: Another form of stevia which are commonly found in the market is the stevia liquid extract". This liquid extract contains some amount of alcohol; however, there are also non-alcoholic liquid too. There are many brands which has their own stevia liquid some are transparent with no flavours while some has many flavours such as vanilla, raspberry, chocolate.

1. **5. Various extraction process of stevia:** Researchers are focusing on a way to extract active ingredients from stevia leaves in a safer way so they cannot harm environment and maintain sustainability more environmentally friendly and safer way to avoid and lower the use of organic solvents (e.g., ethanol, methanol, acetone, chloroform, and petroleum.

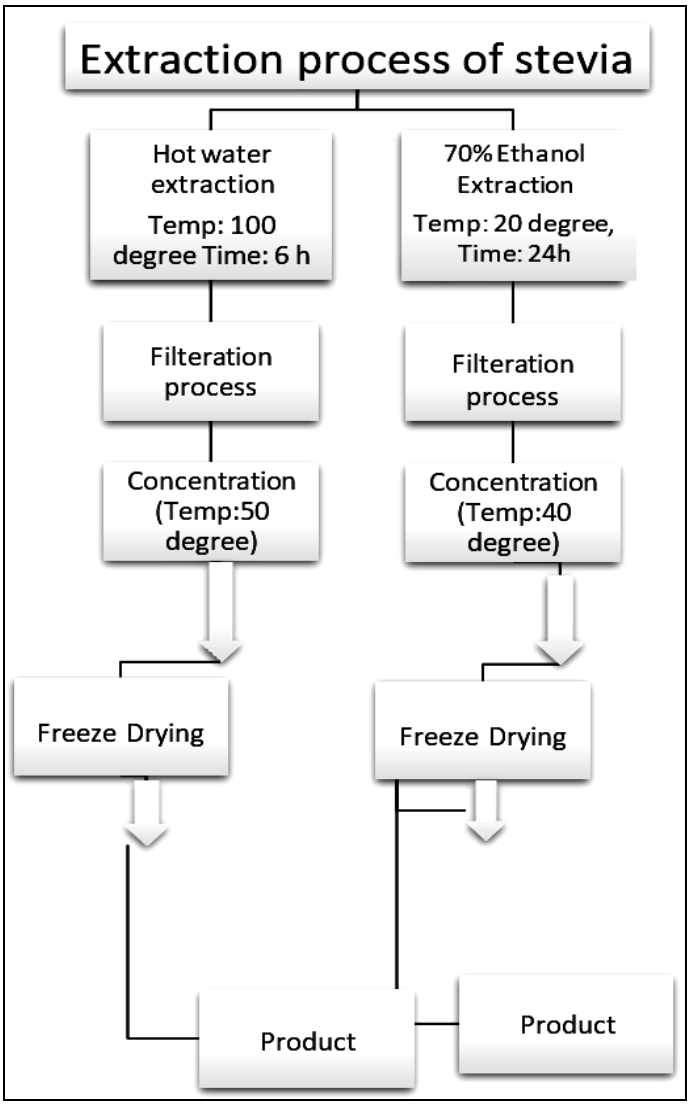
5.1 Conventional approach: This method is done by using hot water to extract sweet compounds (Steviol glycosides) from the dried leaves. The dried leaves are steeped into the hot or cold water to dissolve steviol glycosides. The extract is purified further using filtration and resin columns.

5.2 Enzyme-Assisted Extraction-This method involves specific enzymes that are used to break down the cell walls of the stevia plant. This method is used to maintain the quality and natural taste of the extract. The enzymes that are used in this process are

- **Cellulases:** which helps in breaking down the cellulose which is a major component of cell wall.
- **Pectinases:** which target the pectin which is another component of cell wall which are found in fruits and vegetables.
- **Hemicelluloses:** which helps in breaking down of hemicellulose which is a complex compound found in cell wall.

5.3 Ultrasound -Assisted Extraction (UAE): This process involves ultrasonic waves to enhance extraction of stevia; these waves create cavitation and improve solvent penetration. In this process leaves are suspended in water or ethanol, the ultrasonic waves are from range (20- 40 KZ) and then extract is filtered and purified.

5.4 Microwave-Assisted Extraction (MAE): This method includes heat internal moisture and rupture cells to release compounds. In this method the crush leaves are mixed with water or ethanol and then microwave energy is applied to them and at last the extract is filtered and purified properly.



6. Industrial and commercial application of stevia-

Our old folks are more health conscious and we are more concerned about food. They typically used several herbs as supplements to maintain health in themselves as well as to create different remedies and tonics used by themselves [10]. Consequently, individuals became healthier, and resistant to some diseases. Sweeteners are the most noteworthy components in the food market. The use of Stevia is mainly known in the food and beverage sector as a food sweetener and taste enhancer. Sweeteners are the most important ingredients in the field of food. Stevia is used because this is natural and healthy which helps in improving human health of the humans. According to the international federation India has estimated 77 million people is living with diabetes as of 2024 making it the diabetic capital of the world. Traditionally, the extract obtained from stevia leaves proved its effectiveness in treatment of diabetes.

6.1 Dairy products: Dairy products such as milk and milk based products form the indispensable elements of human health. The dairy processors are repackaging on how they sweeten their products without providing additional artificial sugar since people are now being health conscious. which take them away from sweetened dairy-based products. Stevi a is the only alternative to the sugar that exists since we know that they are 250 times sweeter than artificial sugar and they are also naturally occurring and do not require any chemicals to stabilize their condition when dairy products heat. The most popular ice creams are the frozen dairy products. The most consumed ice

cream sweetener is sucrose because of its cheapness and ability to be accepted by the market. Nevertheless, stevia and other non-nutritive sweeteners are increasingly becoming popular because of the potential harm of the alternative that is associated with the use of sucrose. Another popular food supplement in probiotics is yogurt. Sensory exploration of strawberry-flavoured yoghurt containing stevia showed, yoghurt containing a stevia-sucrose solution was better in terms of sensory characteristics [11] latter. The stevia worked in synergy when combined with other sweeteners to provide a yoghurt with a strawberry flavour. The amount of nutrients contained in plain milk is the same amount of ingredients distributed in the flavoured milk. Both adults and children prefer flavoured milk.

Stevia ice-cream

Stevia sweets

6.2 Beverages: The industry of beverages has been focused on reducing sugar in response to increased consumer awareness of their own health [12]. Stevia is used in beverages industry for so many years because it's a natural drink with zero calorie so it doesn't affect the human health and people with diabetic can also have this. They provide intense sweetness without adding calorie because it is 200-300 times sweetener than sugar. The common drink which includes stevia as a main ingredient are green cola and Zevia drink. In the 1970s stevia was introduces in Japan and they started searching their benefits and they saw a potential in using the stevia since then they are using it and then Japan become one of the major producing countries in the world [13]

Stevia cold drink

zevia energy drink

6.3 Jellified food

Jams and jellies the most favourite food items among children's but meanwhile they contain 70% of sugar in it so which mean they are not good for children health, So that the researcher introduced a jam which is made up of stevia which is best alternative for sugar by containing some ingredients like sucralose, stevia and agar- agar gelling. As a result, many authors do various change in formulation during the preparation of stevia, as partial replacement of the sucrose or input of other materials like hydrocolloids and acid regulators which enable the gelled item to be far more homogeneous to the original.[14]

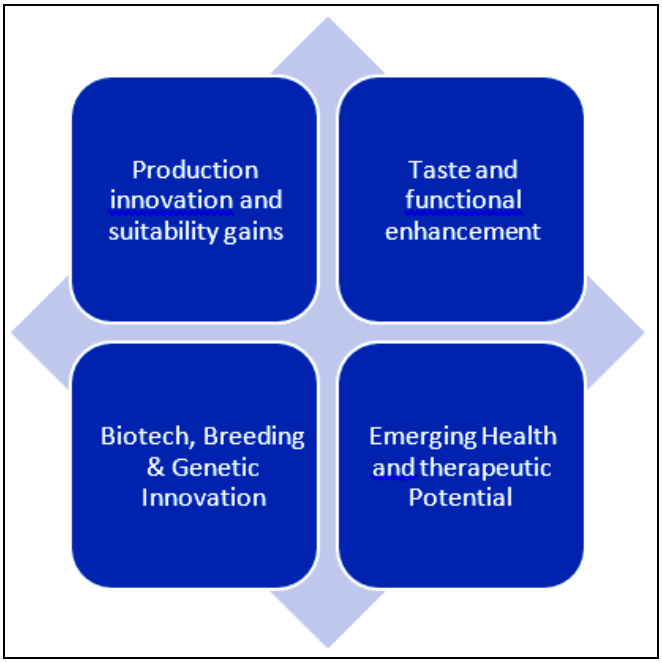
7. Pharmacological and Health Benefits

7.1 Anti-inflammatory properties of Stevia: In the recent studies they find out that it has a unique property they have a property of inflammatory and bactericidal properties, stevia can treat several diseases like edema. [15, 16]. Stevia can also help to treat the oral cavity [17]. *in vitro* studies have also shown that Stevia can also help to stops the growth of Streptococcus mutans, Lactobacillus acidophilus which associate the development of caries.[18]

7.2 Antidiabetic Effects - In several studies they have revealed that the compound which are found in stevia can reduce the plasma glucose level in the human body, Stevioside a compound that are found in stevia which decrease the level of the blood glucose through many mechanism, it increased the insulin secretion in the body and meanwhile decrease the glucagon level. About 90 % of population is diagonised with type 2 diabities all over the world 19] The study carried out by Lestari, *et al*. 2019 has also demonstrated that a 3.125 mg/kg BW dose, 6.25mg /kg BW dose, or the 12.5 mg/kg BW dose of water extract of the stevia leaf could lower the level of blood glucose.

International regulations: Different countries have their unique regulations, Stevia is used in many countries and approves by different organisation which can increase the cost in business of the global stevia market

The future of the stevia market



8. Stevia Vs another Non- Caloric Sweetener

Both monk fruit and stevia are the most suitable alternatives of the artificial sugar since they are naturally growing vegetable plants, one Monk fruit otherwise called Swingle fruit, being a cup-shaped product of greenish brown colour and is found in the south of China. The cultivation of this fruit was an extended discipline that was used by the Buddhist monks hence giving it its name. The fruit is a part of de gourd family Cucurbitaceae, this fruit has been used over a number of years as a medicine in China to cure the few diseases such as the cold and the intestinal diseases. This fruit is now used as a juice which is much sweetener than the sucrose which is used as a drink because it is a no-calorie sugar. [25] It is extremely sweet than sugar because it contains a compound called Mogroside. It is too sweet that sometimes we mixed this fruit extract with the other products like inulin or erythritol to balance it. Monk fruit is approved for the use as a sweetener by the several countries and in 2010 the U.S food and drug administration has categorised as a safer alternative for sugar [26]. Stevia taste bitter after eating it this is because of the interaction between the minor steviol glycosides and taste receptors on the tounge,the sweet taste receptor detects the sweetness while the minor steviol glycosides simultaneously activate the bitter compound and sometimes the bitter taste is also due to poor manufacturing and packing or maybe because of the genetics because not every stevia has a bitter taste. Due to this we can choose other alternatives as a sugar.

Comparison between Stevia and Monk fruit

Table 2: Comparison between stevia and monk fruit

Aspects	Stevia	Monk fruit
Origin	Southern America	Southern China
Sweetening compound	Steviol glycoside	Mogrosides
Sweetness level	200-300 times sweetener than sugar	100-250 times more sweetener than sugar
Cost	Easily available and cost effective	Much expensive than stevia because of their complex extraction process
Availability	Available at all grocery shops	Less widely available but can be order online
Uses	Used in dairy products, jellies and beverages	Used in baked food
Safety	Generally recognised safe by FDA	Generally recognised safe by FDA

9. Safety Profile: In the stevia the two major compounds are present which are Rebaudioside and Stevioside which are used as a natural sweetener. In a study scientist stated that both compounds have a negative effect on the reproductive health of the male. In some other studies they stated that they have a lack of mutagenic and genotoxic and they are non- toxic and non-allergic to the people. People with diabetes can take this because they maintain their blood sugar level and the people who are suffering from losing weight can take this as a sweetener and studies revealed that if sucrose is replaced with stevia in a daily routine of the humans so there is a less chance of diabetes and obesity and other serious diseases.

9.1 Toxicity and side effects: According to food and drug administration the acceptable intake of stevia should be 4mg/Kg bodymass.[27]. There is one study on animal that shown the allergenic pottential of stevia. The stevia based sweeteneer contains more than 95% steviol glycosides because of the extracts have allergenic substances inherent in the Asteraceae family.[28]. There is one study which shows that stevia is mutagenic althogh the other studies denied this fact.[29]. However, these products are sold in a higher quality in all over the world. In Japan where it is used in daily life it shows that there is not any side efects on the human health.[30] In last most of the studies shows that the human body showed no effects on human health [31].

10. Conclusion

This study provides an updated information on *Stevia rebaudiana* which is a perennial shrub which is also known as

honey leaf which is 200 to 300 times more sweetener than sugar. It is a multipurpose crop which has several health benefits, sustainable agriculture, and the global food industry has a unique properties like high sweetness, has zero calorie and have many pharmacological benefits. In addition to food industry, they have many products that have stevia like diary product, jellified products and beverages. In this we have completely study about the cultivation and different extraction processes and their role in the food industry. Stevia plays important role in therapeutic. Stevia is natural alternative to sugar, which offers both nutritional and medicinal advantages to the humans. It is originated from South America, but this plant has been used for centuries in all over the. World. The active compound is Steviol glycosides such as stevioside and rebauside. Stevia does not only intensely sweet but also has zero calorie which makes stevia as an ideal sugar substitute for people who is diabetic, obesity and hypertension.

With increasing health concerns related to excessive sugar consumption, stevia has an ability to provide sweetness without any harmful effects on blood sugar or weight gain. In 2008 U.S FDA the stevia is recognised safe for all the people including children's too which has led to its widespread acceptance in the global market.

IIn last stevia represents a sustainable, health-friendly, and best alternative to traditional sweeteners. Its continued research, cultivation, and innovation promise a bright future in both health and industry sectors for the future generations. Therefore, we conclude stevia as an ideal zero calorie sweetener.

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