Analysis of Unique Properties of Stevia

Overview

Stevia (also known as steviol glycosides, CAS: 57817-89-7) is a natural high-potency sweetener extracted and purified from the leaves of *Stevia rebaudiana Bertoni* of the Asteraceae family. Its core components are a mixture of more than ten steviol glycosides, including **Stevioside (Stv)**, **Rebaudioside A (Reb A)**, and **Rebaudioside M (Reb M)**. Since the 1970s, it has obtained regulatory recognition from global authoritative institutions such as China, the United States, the European Union, and JECFA, and is a clean-label zero-calorie sweet raw material. It features core advantages including ultra-high sweetness, zero calorie, zero GI, excellent acid-base and thermal stability, non-fermentability, strong anti-caries effect and auxiliary metabolic regulation. Currently, it is one of the mainstream sugar substitutes widely applied in the market that meets the demands for sugar reduction, health and natural cleanliness.

I. Physicochemical Characteristics

1. Basic Chemical Information

- Chinese Name: Steviol Glycosides (Stevia)
- English Name: Steviol Glycosides (Stevia)
- Molecular Formula: $C_{38}H_{60}O_{18}$ (Taking stevioside as an example)
- Molecular Weight: 804.88 (Stevioside)
- Structure: Tetracyclic diterpenoid glycoside, the molecule contains multiple glucosyl groups and a steviol skeleton
- Source: Industrially, dried leaves of artificially cultivated stevia are the mainstream raw materials, prepared through water extraction, flocculation, resin adsorption, decolorization, crystallization and drying.

2. Sensory and Physical Properties

- Appearance: White to off-white crystalline powder, odorless and highly hygroscopic
- Sweetness: 200%–450% (relative to 100% of sucrose); high-purity Reb M can reach more than 350 times
- Sweetness Quality: Pure and fresh sweet taste; slight bitter aftertaste/liquorice taste at high concentration (>0.1%); Reb M has the taste closest to sucrose with no obvious peculiar smell
- Cool Sensation: Mild heat absorption upon dissolution, weak cool taste in the mouth without pungent cold feeling
- Solubility: Easily soluble in water (solubility at 25℃≈40g/100mL) and ethanol; insoluble in organic solvents such as benzene, ether and chloroform
- Melting Point: 198℃–202℃ (Stevioside)
- Calorie Value: ≈0 kcal/g (non-metabolizable by human body, negligible), accounting for 0% of sucrose (4 kcal/g)

3. Stability

- Thermal Stability: Good heat resistance (stable at ≤95℃), suitable for pasteurization, UHT sterilization and low-temperature baking; slight decomposition occurs upon long-time heating above 100℃
- pH Stability: Broad-spectrum stable at pH 2.5–7.0, compatible with acidic beverages, fermented foods and neutral systems; easy to degrade under long-time heating at pH < 2 or pH > 9
- Maillard Reaction: Free of free reducing sugars, no Maillard browning reaction, maintaining the original bright color of food during processing
- Caramelization: No caramelization reaction at high temperature with extremely weak coloring capacity, suitable for light-colored beverages, candies and baked products
- Hygroscopicity: Powder is prone to moisture absorption and caking; aqueous solution has moderate moisturizing property, superior to high-potency synthetic sweeteners
- Crystallinity: Good crystallinity; white needle-shaped crystals can be precipitated from high-concentration aqueous solution, applicable to the production of compressed candies and granules

II. Functional Characteristics

1. Metabolic Traits: Zero-Calorie & Zero-Sugar, Blood Sugar Stabilizing, Insulin-Independent

- GI Value = 0: No blood sugar-raising effect, far lower than sucrose (GI=65), causing no fluctuation in postprandial blood sugar
- Absorption Mechanism: Indigestible and non-absorbable by human body; only a small amount is decomposed into steviol by intestinal microorganisms and finally excreted through urine with no energy intake
- Insulin Independence: Metabolism does not stimulate insulin secretion or affect insulin sensitivity, suitable for diabetic patients
- Non-Cariogenic: Oral Streptococcus mutans cannot ferment and utilize it, producing no acid and causing no enamel corrosion

2. Physiological Functions

(1) Blood Sugar and Metabolic Regulation (Sugar Control & Weight Loss Friendly)

- Zero blood sugar elevation and zero insulin response, no postprandial blood sugar peak with stable blood sugar level throughout the whole process
- Applicable Groups: Complete substitute for sucrose for type 1/type 2 diabetes, impaired glucose tolerance, obese and weight-control populations
- Auxiliary Lipid Regulation: Long-term replacement of sucrose can slightly reduce triglycerides and improve blood lipid profile

(2) Intestinal Tolerance (High Safety)

- Non-absorbable by human body, directly entering the large intestine with low fermentation rate; the risk of abdominal distension and diarrhea is far lower than sugar alcohols
- Tolerance Limit: No obvious discomfort for adults with daily intake ≤200mg (calculated as steviol), with

minimal individual differences

- Prebiotic Potential: Low concentration can promote the proliferation of beneficial intestinal bacteria and improve intestinal microecology

(3) Oral Health (Strong Anti-Caries)

- Powerful Anti-Caries Effect: Inhibits oral pathogenic bacteria (Streptococcus mutans), reduces dental plaque, blocks glucan production and lowers caries incidence
- Applicable Scenarios: The preferred natural sweetener for sugar-free chewing gum, hard candies, children's food, toothpaste and mouthwash

(4) Cardiovascular Health (Auxiliary Regulation)

- Mild Auxiliary Antihypertensive Effect: Exerts a mild hypotensive effect on pre-hypertensive and mild hypertensive populations
- Improve Vascular Endothelial Function: Reduces oxidative stress, protects vascular elasticity and lowers cardiovascular risks

(5) Metabolic Safety

- No Accumulation & Residue: Non-metabolizable and non-storable in the human body, completely excreted within 24 hours
- No Impact on Hepatic and Renal Functions: Metabolism does not increase the burden on liver and kidneys, suitable for patients with liver and kidney diseases

III. Unique Properties

1. Taste: Natural Fresh Sweetness, High Potency & High Efficiency, Compound Synergy

- Ultra-High Sweetness (200–450 times): A tiny dosage can achieve the sweetness of sucrose with low addition amount and cost
- Natural and Pure Flavor: Plant-derived and clean-label friendly; high-end components such as Reb M have no bitter aftertaste or metallic taste, with sucrose-like taste
- Remarkable Compound Synergy: Compound with erythritol, maltitol and sucrose to achieve synergistic sweetness improvement, completely cover bitter aftertaste and deliver mellow and full taste
- Long-Lasting Sweetness: Sweet taste lasts longer than sucrose with clean and residue-free aftertaste

2. Processing Performance: Acid and Heat Resistant, Non-Browning, Wide Compatibility

- Strong Acid and Heat Stability: Stable during processing at pH 2.5–7.0 and ≤95℃, suitable for carbonated beverages, fruit juices, yogurt and baked foods
- Non-Fermentability: Cannot be utilized by yeast and mold, causing no gas production or deterioration and extending food shelf life
- Colorless and Transparent with Color & Aroma Retention: Free of browning and coloring, retaining the original

color and aroma of beverages/foods and improving product appearance quality

- High Compatibility: No incompatibility with various food ingredients (acid, alkali, salt, essence, pigment), enabling flexible formula adjustment

3. Health Value: Zero-Calorie & Sugar Control, Anti-Caries & Antihypertensive, Natural and Safe

- Zero Calorie (0 kcal/g): No calorie intake at all, bringing no burden for weight control and weight loss and eliminating obesity risks
- Zero GI & Zero Blood Sugar Elevation: Safe sucrose substitute for diabetic patients with stable postprandial blood sugar and no blood sugar peak
- Dual Protection for Teeth and Cardiovascular System: Dual health benefits for oral cavity and cardiovascular system, optimal choice for children, middle-aged and elderly people and chronic disease patients
- Plant-Derived & Clean Label: Plant extraction without chemical synthesis, conforming to the consumption trend of "natural, healthy and sugar reduction"

4. Regulation and Safety

- China (1984): Approved by GB 2760 for application in beverages, candies, pastries, preserved fruits and other foods with appropriate dosage according to production needs
- United States (2008): FDA GRAS certified (high purity ≥95%), allowed for use in various foods, beverages and nutritional supplements
- JECFA (2010): ADI value of 0–4mg/kg bw (steviol equivalent), no strict intake restriction with high safety level
- EU EFSA (2011): Approved as E960 with confirmed safety, permitted in foods and beverages and eligible for health claim labeling
- Toxicology: LD_{50} > 5g/kg bw (oral administration in rats), practically non-toxic; more than 200 toxicological studies have verified the safety of long-term consumption with no risk of carcinogenicity, teratogenicity and mutagenicity

IV. Summary

Stevia is an all-round natural high-potency sugar substitute with natural plant source, ultra-high sweetness, zero calorie and zero sugar, zero GI, acid resistance, strong anti-caries effect and auxiliary metabolic regulation. With the combined advantages of natural clean label, zero-calorie sugar control, stable processing performance, anti-caries and antihypertensive effects and high safety, it has become the mainstream sweetener and health solution for sugar-free beverages, chocolates and candies, baked foods, yogurt and fermented milk, special diabetic foods and children's nutritional foods. Among natural high-potency sweeteners, it boasts the widest application scenarios, highest health value and greatest market potential in comprehensive performance.