Analysis of Unique Properties of Sorbitol

Overview

Sorbitol (also known as Sorbitol, D-Glucitol, CAS: 50-70-4) is a hexahydric alcohol functional sweetener prepared by catalytic hydrogenation reduction of glucose. Its chemical name is (2S,3R,4R,5R)-hexane-1,2,3,4,5,6-hexaol. It naturally exists in apples, pears, peaches and various other plant fruits. Since the mid-20th century, it has obtained regulatory recognition from global authoritative institutions including China, the European Union, JECFA and FDA. It is a multi-functional sugar alcohol raw material featured with **low calorie, low glycemic index, high moisturizing property and anti-caries effect**. With core advantages such as low calorie, low GI, excellent thermal, acid and alkali stability, strong moisturizing performance, anti-caries capacity and mild intestinal regulation, it has become a mainstream multi-functional sugar alcohol additive widely applied in sugar-free & reduced-sugar food, food moisturizing, oral care, pharmaceutical and daily chemical industries.

I. Physical and Chemical Characteristics

1. Basic Chemical Information

- **Chinese Name：** 山梨醇（山梨糖醇、D - 葡萄糖醇）
- **English Name：** Sorbitol (D-Glucitol)
- **Molecular Formula：** $C_6H_{14}O_6$
- **Molecular Weight：** 182.17
- **Structure：** Straight-chain hexahydric alcohol containing 6 hydroxyl groups with no reducing aldehyde group
- **Source：** Industrially produced mainly from starch-hydrolyzed glucose through catalytic hydrogenation, refining, concentration, crystallization and blending. It is divided into two major forms: crystalline type (α/β/γ/δ crystal forms) and liquid type (70%/80% aqueous solution)

2. Sensory and Physical Properties

- **Appearance：** Crystalline form is white odorless crystalline powder or granules; liquid form is colorless, transparent and viscous liquid with no odor
- **Sweetness：** 60%–70% relative to 100% sucrose, presenting a fresh and cool taste without bitter aftertaste or metallic odor
- **Sweetness Quality：** Refreshing with mild cooling sensation, pure flavor close to sucrose and strong compound adaptability
- **Cooling Sensation：** Significant endothermic dissolution with obvious oral cooling effect, superior to lactitol and maltitol
- **Solubility：** Easily soluble in water (solubility ≈235g/100mL at 20℃), soluble in glycerin and propylene glycol, slightly soluble in ethanol, insoluble in organic solvents such as ether and acetone
- **Melting Point：** 88℃–102℃ for crystalline type (approximately 110℃ for anhydrous form)
- **Calorie Value：** ≈2.6kcal/g (≈16.7kJ/g), accounting for 65% of sucrose (4kcal/g)
- **Density：** Relative density of approximately 1.49 (20℃)

3. Stability

- **Thermal Stability:** Extreme heat resistance (stable below 200℃), suitable for high-temperature baking, spray drying, UHT sterilization and sugar boiling processes
- **pH Stability:** Broad-spectrum stability at pH 2.0–9.0 with acid and alkali resistance, adaptable to acidic beverages, alkaline food and fermentation systems
- **Maillard Reaction:** Free of free reducing aldehyde groups, no Maillard browning reaction, maintaining the original bright color of food during processing
- **Caramelization:** No caramelization reaction under high temperature with extremely weak coloring, ideal for transparent beverages, light-colored baked goods and white candies
- **Hygroscopicity:** Low hygroscopicity for crystalline type (slow moisture absorption only when humidity > 80%); liquid type possesses strong moisturizing capacity (substitute for glycerin), with dual properties of anti-caking and water retention
- **Crystallinity:** Crystalline type features good fluidity and high compressibility, applicable to tablet candies and pharmaceutical excipients; controllable crystallization of aqueous solution with no easy sanding
- **Antioxidation:** Resistant to air oxidation and light stable, effectively extending the shelf life of food

II. Functional Characteristics

1. Metabolic Properties: Low-Calorie & Low-Glycemic, Insulin-Independent, Slow Intestinal Fermentation

- **GI Value≈9:** Extremely low glycemic response, far lower than sucrose (GI=65), leading to minimal postprandial blood sugar fluctuation
- **Absorption Mechanism:** Only 10%–15% is slowly absorbed in the small intestine, while 85%–90% directly enters the large intestine for microbial fermentation and utilization
- **Insulin Independence:** Metabolism does not stimulate insulin secretion or affect blood sugar regulation, suitable for diabetic patients
- **Non-Cariogenic:** Unable to be fermented and utilized by oral Streptococcus mutans, producing no acid and avoiding enamel corrosion with prominent anti-caries effects

2. Physiological Functions

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

- **Low glycemic, low-calorie and low insulin response**, ensuring stable postprandial blood sugar without sharp peaks
- **Applicable Crowds:** Substitute for sucrose for type 1/type 2 diabetes, impaired glucose tolerance, obesity and weight management populations
- **Auxiliary Metabolic Regulation:** Long-term intake reduces calorie intake and helps maintain stable body weight and blood lipid levels

(2) Intestinal Health Regulation (Mild Laxation + Microecological Regulation)

- **Mild Laxation:** Forms a hyperosmotic environment in the intestine to soften feces, stimulate intestinal peristalsis and relieve functional constipation (osmotic laxation)
- **Intestinal Microecology:** Produces short-chain fatty acids via fermentation, selectively promotes the

proliferation of beneficial bacteria and optimizes intestinal flora structure

- **Tolerance:** Good tolerance for adults with daily intake ≤15g; slight abdominal distension and diarrhea may occur when intake exceeds 20g

(3) Oral Health (Powerful Anti-Caries Performance)

- **Anti-Caries Effect:** Inhibits Streptococcus mutans, reduces dental plaque formation and blocks acid production to lower the incidence of dental caries
- **Application Scenarios:** Core sweetening and moisturizing raw material for sugar-free chewing gum, hard candies, children's food, toothpaste and mouthwash

(4) Moisturizing and Tissue Protection (Core Advantages of Polyols)

- **Strong Moisturizing Capacity:** Six hydroxyl groups provide powerful water locking effect to prevent food drying, paste cracking and starch aging
- **Anti-Crystallization:** Inhibits precipitation of sugar and salt crystals to maintain uniform and delicate food texture
- **Freezing Protection:** Lowers freezing point and inhibits protein denaturation caused by freezing, suitable for frozen food and aquatic product processing

(5) Metabolic Safety

- No Accumulation: No accumulation in the human body; unabsorbed parts are excreted after fermentation without metabolic residues
- Liver and Kidney Friendly: Metabolism causes no extra burden on liver and kidneys, suitable for long-term consumption by people with normal liver and kidney functions
- Toxicological Safety: Oral LD_{50} > 10g/kg bw in rats, practically non-toxic; no carcinogenic, teratogenic or mutagenic risks

III. Unique Performances

1. Taste: Cool and Fresh Sweetness, Medium-Low Sweetness, Universal Compounding Performance

- Moderate Sweetness (60%–70% of sucrose): Meets reduced-sugar demands and can be used alone or in compound formulas
- Cool Flavor: Endothermic dissolution delivers a refreshing cooling sensation to optimize oral experience, better than most sugar alcohols
- No Undesirable Flavors: Pure taste without bitter aftertaste, metallic odor or irritation, achieving high consumer acceptance
- Synergistic Compounding Effect: Combined with erythritol, stevia and sucralose to complement flavors, mask aftertaste and optimize overall taste

2. Processing Performance: Ultra-High Temperature Resistance, Moisturizing & Anti-Caking, Full-Scenario Adaptability

- **Extreme Stability:** Stable at temperature ≤200℃ and pH 2.0–9.0, compatible with all food processing technologies including baking, sugar boiling, sterilization and spray drying
- **Dual-State Moisturizing:** Crystalline type realizes anti-caking performance while liquid type provides strong

water retention, meeting dual demands of dry and wet food

- **Anti-Browning and Discoloration Resistance:** Free of Maillard and caramelization reactions, keeping products bright in color and pure in appearance
- **Process Adaptability:** Crystalline type supports tableting and sugar boiling; liquid type features easy dissolution and blending, covering food, beverage, baking, daily chemical and pharmaceutical industries
- **High Compatibility:** No incompatibility with acids, alkalis, salts, flavors, pigments, colloids and proteins, ensuring high formula flexibility

3. Health Value: Low-Calorie & Sugar Control, Anti-Caries & Moisturizing, Mild Intestinal Care

- **Low Calorie (2.6kcal/g):** 65% of sucrose in calories, friendly for sugar and weight control to reduce calorie intake
- **Low-GI Safety:** Safe sucrose substitute for diabetic patients with stable blood sugar changes
- **Triple Health Benefits:** Integrated anti-caries, moisturizing and mild laxation functions, covering oral health, intestinal care and food quality maintenance
- **Diversified Applications:** Widely used in food, pharmaceutical, daily chemical and tobacco industries, serving as the only mainstream sugar alcohol with combined sweetening, moisturizing and anti-caries functions

4. Regulation and Safety

- **China:** Approved by GB 2760-2024, CNS 19.006 (solid) & 19.023 (liquid), INS 420(i)/(ii), usable in appropriate amounts as required by production
- **European Union**: Approved as E420 by EFSA with confirmed safety, allowed in food and beverages with authorized health claims
- JECFA: ADI value specified as "Not Limited", the highest safety level with no daily intake restriction
- **United States**: FDA GRAS certified (GRN 238), permitted for use in food, beverages, pharmaceuticals and daily chemical products
- **Global Recognition:** Approved in more than 100 countries and regions with over 60 years of application history, sufficient toxicological data and proven long-term safety

IV. Summary

Sorbitol is an all-round multi-functional sugar alcohol with natural sources, hexahydric alcohol structure, cool moderate sweetness, low calorie and low GI, ultra-high temperature stability, strong moisturizing property, excellent anti-caries capacity and mild intestinal regulation. Combining the advantages of low-calorie sugar control, extreme processing stability, dual-state moisturizing and anti-caking, anti-caries and laxation effects, as well as full-industry adaptability, it acts as a core sweetening and functional solution for sugar-free candies, baked goods, functional beverages, frozen aquatic products, diabetic food, children's food, toothpaste, cosmetics and pharmaceutical excipients. It integrates multiple functions including sweetener, moisturizer, stabilizer, anti-caking agent and anti-caries agent. Among all sugar alcohol products, it boasts the widest application scenarios, highest industrial value and largest market scale, serving as an indispensable basic multi-functional raw material for the global food and daily chemical industry.