Analysis of Unique Properties of Xylitol

Overview

Xylitol (1,2,3,4,5-pentanepentol, CAS: 87-99-0) is a naturally occurring five-carbon sugar alcohol (polyol) with a linear pentahydroxypentane structure. It has obtained regulatory recognition from global authoritative institutions including China, the United States, the European Union and JECFA since the 1960s, classified as a safe sweetening raw material. It possesses core advantages such as pure taste comparable to sucrose, low calorie, low GI, excellent processing stability, outstanding anti-caries property and moderate intestinal tolerance. Currently, it is one of the mainstream bulking sweeteners widely applied in the market, meeting both oral health and sugar control demands.

I. Physical and Chemical Properties

1. Basic Chemical Information

- Chinese Name: Xylitol
- English Name: Xylitol
- Molecular Formula: $C_5H_{12}O_5$
- Molecular Weight: 152.15
- Structure: Five-carbon sugar alcohol, containing 5 hydroxyl groups (-OH) in the molecule, linear saturated polyol
- Source: Naturally present in trace amounts in animals and plants such as strawberries, plums, cauliflowers, birch trees and corn cobs; Industrially, it is mainly produced by hydrolyzing corn cobs / sugarcane bagasse to obtain xylose, followed by catalytic hydrogenation reduction.

2. Sensory and Physical Properties

- Appearance: White crystalline powder or rhombic / monoclinic crystal, odorless
- Sweetness: 90%–100% (relative to 100% of sucrose), taste close to sucrose
- Sweetness Quality: Pure sweet taste, no obvious bitter or metallic aftertaste, refreshing finish
- Cooling Sensation: Endothermic upon dissolution (heat of solution ≈ -110 kJ/kg), delivering a distinct cooling sensation in the mouth
- Solubility: Highly soluble in water (solubility at 25℃ ≈ 160g/100mL), with clear and transparent aqueous solution
- Melting Point: 91℃–96℃
- Calorie Value: 2.4 kcal/g (10.05 kJ/g), approximately 60% of sucrose (4 kcal/g)

3. Stability (Processing Adaptability)

- Thermal Stability: Good heat resistance (stable at ≤200℃), tolerant to general baking, cooking and pasteurization
- pH Stability: Broad stability at pH 5–7, compatible with neutral to weakly acidic food systems
- Maillard Reaction: Free of aldehyde and ketone groups, free from Maillard browning, maintaining the original color of food during processing

- Caramelization: Hard to caramelize with extremely weak discoloration at high temperatures
- Hygroscopicity: Moderate hygroscopicity (prone to moisture absorption and caking under 60% humidity), helping baked goods maintain softness
- Crystallinity: Easy to crystallize, crystals can be precipitated from high-concentration solutions, suitable for the production of sugar-free hard candies and chewing gum

II. Functional Characteristics

1. Metabolic Traits: Low Burden and Stable Blood Sugar

- GI Value ≈7: Far lower than sucrose (GI=65), causing slight postprandial blood sugar fluctuation
- Absorption Mechanism: About 50%–70% absorbed in the small intestine, and the remaining part enters the large intestine for fermentation
- Insulin Independence: Metabolism does not rely on insulin, suitable for diabetic patients
- Non-Cariogenic: Cannot be fermented and utilized by oral Streptococcus mutans, producing no acid and causing no enamel corrosion

2. Physiological Functions

(1) Blood Sugar and Metabolic Regulation (Sugar-Control Friendly)

- Low glycemic response and low insulin response with low and rapidly declining postprandial blood sugar peak
- Applicable Crowds: Ideal sucrose substitute for type 2 diabetes patients, people with impaired glucose tolerance and weight management groups
- Partially converted into glycogen in the liver without significant blood sugar elevation

(2) Intestinal Tolerance (Moderate Level)

- 50%–70% absorbed by the small intestine, 30%–50% fermented in the large intestine
- Tolerance Dose: No obvious discomfort for adults with daily intake ≤30–50g, lower than erythritol
- Excessive Intake Risk: Osmotic abdominal distension and diarrhea with obvious individual differences

(3) Oral Health (Optimal Among Sugar Alcohols)

- Powerful Anti-Caries Effect: Inhibits oral pathogenic bacteria, reduces dental plaque and promotes saliva secretion to neutralize acid substances
- Recommended by WHO as a safe anti-caries sweetener, widely used in sugar-free chewing gum and toothpaste

(4) Liver Function Support

- Promotes hepatic glycogen synthesis, reduces consumption of fat and protein, and assists in improving liver function

III. Unique Performance Advantages

1. Taste: Sucrose-Level Sweetness, Fresh and Refreshing

- Sweetness close to sucrose with no peculiar odor; compounded with high-intensity sweeteners to improve bitter aftertaste

- Endothermic dissolution brings lasting cooling sensation, suitable for chewing gum, mints, cold drinks and other products
- Mild taste without the "cold residue" of erythritol, more applicable to baking and soft candies

2. Processing：Stable, Highly Compatible and Excellent Moisturizing Property

- Heat and acid resistance with anti-browning property: Preserves the original color of baked foods and beverages and avoids yellowing
- Moderate hygroscopicity: Delays staling of baked products and extends softness retention period and shelf life
- High solubility: Easy to prepare high-sugar sugar-free beverages, suitable for concentrated liquids and syrups
- Controllable crystallization：Delicate crystals, ideal for forming chewing gum, hard candies and tablet candies

3. Health：Low-Calorie & Sugar-Control, Teeth and Liver Protection

- Low calorie (2.4 kcal/g): Cuts 40% calories compared with sucrose, friendly for weight management
- Low GI and insulin-independent: Safe sucrose alternative for diabetic patients
- Top-tier oral protection: Remarkable anti-caries effect, the preferred sweetener for oral care products
- Natural source: Intermediate metabolite of human body with good biocompatibility

4. Regulation and Safety (Global Authoritative Recognition)

- China (1986): Included in GB 2760, allowed for use in appropriate amounts according to production requirements
- United States (1963): FDA GRAS certified, permitted for use in food and oral care products
- JECFA (1980): No ADI value specified with a high safety level
- EU EFSA (2011): Anti-caries efficacy confirmed with authorized health claims
- Toxicology：LD_{50} > 6.5g/kg bw (oral administration in rats), practically non-toxic grade

IV. Summary

Xylitol is a classic sugar alcohol sweetener with natural sources, sucrose-mimicking taste, low calorie, low GI, powerful anti-caries ability and stable processing performance. Featuring the combined strengths of pure sweetness, refreshing cooling taste, oral protection, sugar control and processing compatibility, it serves as a mainstream sweetening solution for sugar-free oral care products, baked foods, beverages and special diabetic foods. With highly balanced comprehensive properties among sugar alcohols, it boasts extensive application scenarios.