Analysis of Unique Properties of Mannitol

Overview

Mannitol (also known as Mannite, **D-Mannitol**, Xylitol; CAS: 87-78-5) is a six-carbon sugar alcohol functional sweetener prepared from mannose or glucose via catalytic hydrogenation, isomerization and refining. Its chemical structure is **(2R,3R,4R,5R)-hexane-1,2,3,4,5,6-hexaol**. It naturally exists widely in plants and algae such as kelp, brown algae, pumpkins, onions and dried persimmons. The core industrial source is deep-processed products of seaweed and starch sugar. Since the 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 with ultra-low calorie, **zero moisture absorption**, high stability, strong cooling sensation, anti-caries and high osmosis properties.

It possesses core advantages including extremely low calorie, zero glycemic response, excellent thermal, acid and alkali stability, non-hygroscopicity, strong cooling sensation, anti-caries effect and high osmotic dehydration. It is a dedicated high-performance sugar alcohol applied in sugar-free and low-sugar food, medical dehydration and diuresis, pharmaceutical tablet excipients, daily chemical moisturizing and oral care fields. It has irreplaceable value especially in solid preparations, sugar-free candies and dehydrated pharmaceuticals.

1. Physical and Chemical Characteristics

1.1 Basic Chemical Information

- Chinese Name: Mannitol (Mannite, D-Mannitol, Xylitol)
- English Name: Mannitol (D-Mannitol)
- Molecular Formula: $C_6H_{14}O_6$
- Molecular Weight: 182.17
- Structure: Six-carbon straight-chain sugar alcohol containing 6 hydroxyl groups without reducing aldehyde groups; it is an isomer of sorbitol (different orientation of C2 hydroxyl group)
- Source: Industrially mainly prepared from starch-hydrolyzed glucose/seaweed extract through hydrogenation isomerization, concentration crystallization, refining and drying; mostly crystalline form (α/β/δ crystal forms) with no commercial liquid dosage form

1.2 Sensory and Physical Properties

- Appearance: White acicular/crystalline powder or granules, odorless with excellent fluidity
- Sweetness: 57%–72% (relative to 100% of sucrose) with cool and pure sweet taste
- Sweetness Quality: Outstanding refreshing cooling sensation, no bitter aftertaste or metallic taste, strong oral comfort
- Cooling Sensation: High endothermic dissolution with remarkable cooling effect after ingestion, superior to sorbitol and xylitol
- Solubility: Easily soluble in water (solubility ≈216g/L at 25℃), soluble in glycerol and pyridine, slightly soluble in ethanol, insoluble in ether, acetone and chloroform
- Melting Point: 166℃–170℃ (anhydrous form, much higher than sorbitol)

- Calorie Value: ≈1.6kcal/g (≈6.7kJ/g), only 40% of sucrose (4kcal/g), the lowest calorific value among sugar alcohols
- Density: Relative density about 1.52 (20℃)
- Hygroscopicity: The only six-carbon sugar alcohol with non-hygroscopic property (no moisture absorption below 90% humidity) and excellent drying performance

1.3 Stability

- Thermal Stability: Ultra-high temperature stability (no decomposition ≤220℃), suitable for high-temperature sterilization, spray drying, baking and sugar boiling
- pH Stability: Broad-spectrum stable at pH 2.0–10.0, resistant to strong acid and alkali, compatible with various food and pharmaceutical systems
- Maillard Reaction: Free of reducing aldehyde groups, completely avoiding Maillard browning and maintaining pure white/transparent appearance
- Caramelization: No caramelization or coloration at high temperature, suitable for white candies, transparent beverages and tablet coating
- Hygroscopic Stability: Completely non-hygroscopic, anti-caking and anti-adhesion, keeping dry and loose during long-term storage
- Crystallinity: High crystal purity, good fluidity and excellent compressibility; an ideal excipient for pharmaceutical tableting with no easy sanding or caking
- Antioxidation: Not easily oxidized by air, light-resistant and anti-microbial fermentation with an extremely long shelf life

2. Functional Characteristics

2.1 Metabolic Properties:

Ultra-low Calorie, Zero Glycemic Response, Insulin-independent, Non-metabolizable in Vivo

- GI Value = 0: Zero glycemic effect without blood sugar fluctuation, an ideal sugar substitute for diabetic patients
- Absorption Mechanism: Only 5%–10% trace absorption via oral administration; 90%–95% unabsorbed in the small intestine, directly entering the large intestine or excreting out of the body
- Insulin Independence: Metabolism completely independent of insulin, no impact on blood sugar and insulin secretion
- In Vivo Metabolism: Hardly metabolized in the body; the absorbed part is excreted by the kidney in its original form without accumulation or liver and kidney burden
- Tolerance: Good tolerance for adults with daily intake ≤20g; excessive intake (> 20g) may cause slight abdominal distension and laxative effect

2.2 Oral Health: Strong Anti-caries, Non-cariogenic, Oral-friendly

- Strong Anti-caries Effect: Not fermented by oral streptococcus to produce acid, no enamel corrosion and inhibits dental plaque formation
- Non-cariogenic Property: Recognized as a non-cariogenic sweetener by FDA/EFSA, suitable for children's food

and oral care products

- Cooling Dental Care: Endothermic cooling sensation upon dissolution, serving as core raw material for chewing gum, throat lozenges, toothpaste and mouthwash

2.3 Physical Functions:

Non-hygroscopic, High Osmosis, Strong Moisturizing, Tissue Protection

- Non-hygroscopicity: Absolutely no moisture absorption, keeping products dry and preventing adhesion, caking and deterioration
- High Osmosis: High osmotic pressure characteristic with core medical effects of dehydration and diuresis, reducing intracranial pressure/intraocular pressure
- Strong Moisturizing Performance: 6 hydroxyl groups for water locking, applied in food water retention, daily chemical moisturizing, preventing starch aging and paste cracking
- Anti-crystallization: Inhibits precipitation of sugar/salt to maintain fine and uniform texture, suitable for frozen food and syrup
- Tablet Forming: Excellent compressibility and disintegration without moisture absorption, the preferred excipient for solid preparations

2.4 Safety Properties:

Non-toxic Grade, No Accumulation, Liver and Kidney Friendly, Non-teratogenic and Non-carcinogenic

- Toxicological Safety: LD_{50} > 17g/kg bw (oral administration in rats), practically non-toxic grade
- No Accumulation: Non-metabolizable and non-accumulative in vivo, excreted in original form without metabolic residue
- Liver and Kidney Safety: Metabolism does not increase liver and kidney burden; safe consumption for patients with kidney/liver diseases (non-edema period)
- Genetic Safety: No risk of carcinogenicity, teratogenicity or mutagenicity with extremely high long-term consumption safety

3. Unique Performance Advantages

3.1 Taste: Extreme Cooling Sensation, Medium-low Sweetness, Pure Flavor, Pleasant Oral Experience

- Top-tier Cooling Sensation: High endothermic dissolution brings prominent cooling effect after ingestion, superior to all mainstream sugar alcohols and enhancing flavor experience
- Moderate Sweetness: 57%–72% sucrose sweetness, suitable for sugar reduction and calorie control with fresh and non-greasy taste
- Pure Flavor: No unpleasant aftertaste (no bitterness, metallic taste or irritation) with extremely high consumer acceptance
- Compound Compatibility: Compatible with erythritol, stevia and mogroside to complement cooling sensation, optimize flavor and mask aftertaste

3.2 Processing Performance：

Ultra-stable and Temperature-resistant, Zero Moisture Absorption, Non-browning, Full Process Adaptability

- Extreme Stability：Stable at ≤220℃ and pH 2.0–10.0, compatible with all high-temperature/acid-base processing technologies
- Absolute Non-hygroscopicity：The only non-hygroscopic sugar alcohol, the first choice for dry food, tablets and powder products
- Zero Browning and Zero Coloration：No Maillard reaction or caramelization, permanently maintaining pure white/transparent appearance with optimal quality
- All-round Process Adaptability：Easy crystallization, tableting, mixing and dissolution, applicable to candies, tablets, baking, beverages and freeze-drying scenarios
- Formula Compatibility：No incompatibility with acid, alkali, salt, essence, pigment, protein and pharmaceuticals

3.3 Health Value:

Ultra-low Calorie, Zero Glycemic Response, Dental Care, High Osmosis, Dual Application Value

- Ultra-low Calorie：1.6kcal/g, only 40% of sucrose, the optimal choice for weight and calorie control
- Zero GI Safety：Completely safe for diabetic/sugar-controlled groups with zero blood sugar fluctuation
- Four-fold Health Benefits：Zero glycemic response + strong anti-caries + non-hygroscopicity + high osmotic dehydration, delivering dual value for food and pharmaceutical industries
- Exclusive Value：The only multi-functional sugar alcohol integrating **sweetness + zero moisture absorption + high osmosis + strong cooling sensation + anti-caries** properties

3.4 Regulation & Global Safety Recognition

- China：Approved by GB 2760-2024, CNS 19.009, INS 421, allowed for use according to production demand
- European Union：Approved as E421 by EFSA with confirmed safety; permitted in food, pharmaceutical and daily chemical industries with allowable anti-caries claim labeling
- JECFA：No specified ADI value, the highest safety level with no daily intake limit
- United States：FDA GRAS certified (21 CFR 180.25), allowed in various foods, pharmaceuticals and cosmetics
- Global Recognition：Approved in more than 100 countries with a century-long application history, sufficient toxicological data and undisputed safety

4. Summary

Mannitol is a high-performance multi-functional six-carbon sugar alcohol of natural origin, featuring extreme cooling sensation, ultra-low calorie, zero glycemic response, zero moisture absorption, ultra-high temperature stability, strong anti-caries effect and high osmotic dehydration.

With the combined advantages of **1.6kcal/g ultra-low calorie + GI=0 zero glycemic response + 220℃ ultra-high stability + absolute non-hygroscopicity + strong cooling sensation + zero browning + high osmosis + anti-caries**, it has become an irreplaceable core raw material in sugar-free candies, oral tablets, dehydrated pharmaceuticals, frozen food, children's food, oral care and daily chemical moisturizing fields.

It integrates multiple functions as a sweetener, anti-caking agent, excipient, dehydrating agent, moisturizer,

stabilizer and dental care agent. Among all sugar alcohols, it is the only one possessing dual core values of medical high osmosis and food zero moisture absorption. As a key basic raw material for the high-end, functional and stable development of global food, pharmaceutical and daily chemical industries, its industrial value and application barriers are significantly higher than ordinary sugar alcohols.