Erythritol: Safety Assessment, Product Applications and Recommended Dosage

I. Basic Information

(I) Product Definition

Erythritol (CAS: 149-32-6) is a four-carbon sugar alcohol naturally widespread in grapes, pears, mushrooms, fermented foods and human body fluids. It is a classic zero-calorie bulk sweetener.

With sweetness equivalent to 60%~70% of sucrose and an energy coefficient of 0 kJ/g, it is barely metabolized by the human body. It is mainly rapidly absorbed in the small intestine and excreted through the kidneys via urine, does not participate in blood glucose metabolism or affect insulin levels, and delivers a clean, cool taste.

(II) Production Process

1. **Microbial Fermentation Method**: Using glucose and starch sugar as raw materials, fermented and converted by strains such as *Candida lipolytica* and *Moniliella pollens*, followed by filtration, decolorization, ion exchange, concentration, crystallization and drying (the mainstream and mature industrial process).
2. **Chemical Synthesis Method**: Synthesized by hydrogenation using butenediol and other raw materials; only applied industrially on a small scale due to cost and purity issues.

II. Safety Assessment

(I) Toxicological Assessment

1. **Acute Toxicity**: Oral LD_{50} in rats > 20 g/kg·bw, classified as practically non-toxic.
2. **Genetic Toxicity**: Negative results in Ames test, in vitro mammalian cell chromosome aberration test and mouse bone marrow micronucleus test; no potential mutagenic or teratogenic risks.
3. **Subchronic Toxicity (90 days)**: NOAEL = 9000 mg/kg·bw/day by oral gavage in rats; no organic organ damage or abnormal biochemical indicators observed.
4. **Chronic Toxicity and Carcinogenicity**: No carcinogenicity or target organ toxicity found in long-term animal feeding studies; body weight, food intake and hematological parameters remained normal.
5. **Reproductive and Developmental Toxicity**: No parental reproductive impairment, offspring developmental abnormalities or teratogenic effects at tested doses; wide safety margin for reproductive toxicity.
6. **Human Tolerance**: Good tolerance at single intake ≤ 0.8 g/kg·bw; excessive intake (> 1.0 g/kg·bw) may cause transient gastrointestinal reactions such as abdominal distension, borborygmus and mild diarrhea in some individuals, which resolve rapidly after cessation of intake.

(II) Global Safety Approvals by Authoritative Bodies

1. China (NHC / GB 2760-2014)

- Approved as a sweetener for use in all types of food at appropriate levels according to production needs, with no daily intake limit.
- No specific contraindicated populations; safe for infants, pregnant women and lactating women to consume in fortified foods under normal intake.
- Food safety indicators comply with national limits for heavy metals, microorganisms, methanol and reducing sugars.

2. United States (FDA)

- Granted GRAS status in 1997 (GRN 000017), permitted for use in full-category foods including beverages, baked goods and confectionery.

3. Europe (EFSA)

- Established an ADI of 'not specified' in 1999; safety reconfirmed in a 2015 re-evaluation.

4. Others

- Approved for widespread use as a food sweetener in Australia & New Zealand, Japan, South Korea, Canada and other regions; listed in the food additive standards by the Codex Alimentarius Commission (CAC).

(III) Safety Conclusion

Erythritol features complete and sufficient toxicological data, a long history of global application and excellent human tolerance, with no safety risks at normal dietary doses. Only excessive intake may cause mild gastrointestinal discomfort. It has no cumulative toxicity or metabolic burden, and no strict dietary restrictions for special populations, making it a widely recognized high-safety sugar substitute.

III. Product Application Properties and Applications

(I) Application Properties

1. **Clean Sweetness**: Similar to sucrose in taste, with a cool mouthfeel, no bitter, metallic or unpleasant aftertaste, and moderate sweetness release.
2. **Zero Calorie & Zero GI**: Zero energy value; does not raise blood glucose or stimulate insulin secretion, suitable for sugar-controlled, weight-management and diabetic populations.
3. **High Stability**: Heat-resistant (stable at 180℃ in baking), acid-alkali resistant (stable at pH 2~10), does not participate in Maillard reaction and is resistant to browning.
4. **Low Hygroscopicity**: Extremely low hygroscopicity in crystalline form, resistant to caking and moisture absorption, ideal for compressed candies, solid beverages and other products.

5. **High Solubility**: Good solubility in water with fast dissolution rate, suitable for industrial beverage production.
6. **Anti-cariogenicity**: Not fermented to produce acid by oral pathogenic bacteria, does not erode tooth enamel, and significantly reduces caries incidence.
7. **Excellent Compatibility**: Blending with steviol glycosides, mogrosides, allulose, sucralose and others corrects taste, improves sweetness realism and achieves synergistic effects.

(II) Product Applications

1. Core Value

With **zero calories, non-glycemic response, high stability and low hygroscopicity** as core advantages, it fully replaces sucrose and high-calorie sweeteners to meet the development needs of sugar-free and reduced-sugar foods. Featuring excellent processing adaptability and taste coordination, it is widely used in food, health products, oral care and other fields, aligning with market trends of healthy consumption, sugar-controlled diets and anti-caries benefits.

2. Mechanism of Action

- **Sweetness Mechanism**: Molecular structure activates oral sweet receptors, producing a sucrose-like sweet perception with mild sweetness and cooling sensation, no bitter aftertaste.
- **Zero-Calorie Mechanism**: The human body lacks key enzymes for erythritol metabolism; over 90% is absorbed in the small intestine and excreted directly via urine without participating in glycolysis or energy synthesis, providing zero energy.
- **Glycemic Control Mechanism**: Does not enter the glucose metabolic cycle, does not affect blood glucose concentration or insulin sensitivity, safe for diabetic consumption.
- **Processing Stability Mechanism**: Stable molecular structure; does not decompose or brown under high temperature, acidic or alkaline conditions, does not undergo Maillard reaction with proteins or amino acids, maintaining stable product color.
- **Anti-cariogenicity Mechanism**: Cannot be utilized by *Streptococcus mutans* to produce acid, does not lower oral pH or cause enamel demineralization, providing natural anti-caries effects.
- **Low Hygroscopicity Mechanism**: Dense distribution of molecular hydroxyl groups with weak water-binding capacity, making products resistant to moisture softening and improving shelf-life stability.

3. Recommended Dosage Forms and Typical Products

Application Category	Recommended Dosage Form	Typical Products
Beverages	Powder, crystalline granules	Sugar-free soda, zero-calorie tea drinks, sugar-free coffee, sugar-controlled juice, sports drinks, protein beverages
Baked Foods	Crystalline granules, powder	Sugar-free biscuits, bread, cakes, cookies, low-sugar pastries, mooncakes, walnut cakes
Dairy & Frozen Foods	Crystalline granules	Sugar-free yogurt, ice cream, sorbets, smoothies, low-fat cheese, flavored milk
Confectionery & Preserves	Crystalline granules, powder	Sugar-free hard candies, compressed candies, chewing gum, chocolate, throat lozenges, low-sugar preserved fruits
Condiments & Sauces	Powder, syrup	Sugar-free jam, salad dressing, tomato sauce, seasoning sauce, barbecue sauce, compound sauces
Functional Foods	Powder, granules	Meal replacement powder, protein bars, dietary fiber foods, diabetic-specific foods
Non-Food Fields	Powder	Toothpaste, mouthwash, chewing gum, oral care products, pet food, pharmaceutical excipients

4. Application Schemes

4.1 Beverage Application Scheme

- Single use: Dosage 4%~10%, direct replacement of sucrose, simple dissolution, clean taste, suitable for water-based drinks and tea beverages.
- Blended use: Blending with steviol glycosides / mogrosides to compensate for insufficient sweetness and enhance sweetness fullness, suitable for carbonated drinks and functional beverages.
- Processing note: Fully dissolves at room temperature; stable during high-temperature sterilization (121℃) without decomposition, discoloration or off-flavors.

4.2 Baked Food Application Scheme

- Single use: Dosage 5%~12%, replacement of sucrose, resistant to browning, crisp texture, suitable for biscuits and cookies.
- Blended use: Blending with allulose and maltitol to improve color and aroma, suitable for cakes and bread.
- Processing note: As no Maillard reaction occurs, adjust baking time appropriately or add a small amount of sugar source to improve color.

4.3 Dairy & Frozen Food Application Scheme

- Yogurt / fermented milk: Dosage 3%~7%, can be added before or after fermentation without affecting probiotic activity, balancing acidity.
- Ice cream / sorbets: Dosage 5%~10%, lowers freezing point, inhibits large ice crystal formation, delivering a smooth, non-crunchy texture.

4.4 Confectionery & Preserve Application Scheme

- Compressed candies / hard candies: Dosage 80%~95%, low hygroscopicity, good formability, non-sticky, long shelf life.
- Preserved fruits: Dosage 3%~6%, reduces total sugar content, improves water retention, reduces cloying sweetness.

4.5 Functional Food & Non-Food Application Scheme

- Meal replacements / protein bars: Dosage 4%~10%, improves taste, masks raw material off-flavors, supports sugar and calorie control.
- Oral care products: Dosage 1%~5% in toothpaste and mouthwash, assisting anti-caries and breath-freshening effects.
- Pet food: Dosage 2%~5%, improves palatability, protects pet teeth, prevents obesity.

IV. Field Applications and Recommended Dosage

(I) Beverages (based on finished product weight)

1. Carbonated Drinks / Juices / Tea Drinks

- Dosage: 4%–10%
- Function: Provides clean sweetness, zero calories, resists browning, maintains flavor stability.

2. Coffee / Functional Drinks / Plant Beverages

- Dosage: 3%–8%
- Function: Masks bitterness, improves palatability, does not interfere with active ingredients.

3. Protein Beverages / Milk Drinks

- Dosage: 3%–7%
- Function: Softens fishy notes, enhances smooth mouthfeel, prevents precipitation.

4. Solid Beverages / Instant Drinks

- Dosage: 5%–12%
- Function: Good flowability, low hygroscopicity, natural sweetness after reconstitution.

(II) Baked Foods (based on flour / total formula weight)

1. Biscuits / Cookies / Pastries

- Dosage: 5%–12%
- Function: Excellent crispness, low hygroscopicity, non-browning, significantly reduced calories.

2. Bread / Cakes / Western Pastries

- Dosage: 4%–10%
- Function: Improves texture, reduces cloying sweetness, delays staling, suitable for sugar-controlled products.

3. Mooncakes / Chinese Pastries

- Dosage: 5%–12%
- Function: Reduces sweetness, slows oil return, extends shelf life.

(III) Dairy & Frozen Foods (based on finished product weight)

1. Yogurt / Fermented Milk / Flavored Milk

- Dosage: 3%–7%
- Function: Adjusts acidity, smooth taste, does not affect fermentation.

2. Ice Cream / Sorbets / Frozen Desserts

- Dosage: 5%–10%
- Function: Inhibits ice crystals, smooth texture, no ice grit, strong freezing stability.

3. Cheese / Cream / Flavored Dairy Products

- Dosage: 2%–6%
- Function: Softens flavor, improves texture, supports sugar and calorie control.

(IV) Confectionery & Preserves (based on finished product weight)

1. Compressed Candies / Hard Candies / Chewing Gum

- Dosage: 80%–95%

- Function: Good formability, low hygroscopicity, anti-cariogenic, cool taste.

2. Chocolate / Filled Candies

- Dosage: 4%–10%
- Function: Enhances sweetness, does not affect fat crystallization, smooth mouthfeel.

3. Preserved Fruits / Jellies

- Dosage: 3%–6%
- Function: Reduces total sugar, retains moisture and color, lessens cloying sweetness.

(V) Condiments & Sauces (based on finished product weight)

1. Jam / Salad Dressing / Tomato Sauce

- Dosage: 2%–7%
- Function: Balances sweet-sour taste, inhibits browning, improves stability.

2. Oyster Sauce / Barbecue Sauce / Seasoning Sauce

- Dosage: 1%–5%
- Function: Boosts sweetness and umami, improves texture, resists moisture-induced deterioration.

(VI) Other Food Fields

1. Tabletop Sweetener: Added as needed

- Application: Direct replacement of sucrose for coffee, tea and table use, zero calories for healthier consumption.

Meal Replacement Bars / Protein Powder / Health Foods

- Dosage: 3%–10%
- Function: Supports sugar and calorie control, improves taste, masks off-flavors.

(VII) Pet Food / Animal Feed

- Dosage: 2%–5%
- Function: Improves palatability, protects teeth, prevents obesity and abnormal blood glucose.

(VIII) Non-Food Applications

1. Oral Care Products (Toothpaste / Mouthwash)

- Dosage: 1%–5%
- Function: Anti-cariogenic, breath-freshening, assists oral cleaning.

2. Pharmaceutical Excipients / Cosmetics

- Dosage: 1%–4%
- Used as a flavor corrector and humectant to improve product palatability and skin feel.

V. Usage Specifications and Precautions

1. Intake Recommendation

Single dose for adults ≤ 0.8 g/kg·bw; excessive intake may cause gastrointestinal reactions such as abdominal distension and diarrhea.

2. Population Applicability

No strictly contraindicated populations; safe for normal consumption by infants, pregnant women, lactating women and diabetics.

3. Blending Recommendation

Blending with allulose, steviol glycosides and mogrosides optimizes the sweetness profile and improves baking color.

4. Processing Tips

As no Maillard reaction occurs, add a small amount of allulose or food coloring if golden color is required for baked products; sealed storage is still recommended in high-humidity environments.

5. Storage Conditions

Store sealed in a cool, dry place, protected from moisture and sunlight to avoid caking.