Analysis of the Unique Properties of Xylo-oligosaccharides

Overview

Xylo-oligosaccharides (XOS), also known as xylo-oligosaccharides, are functional oligosaccharide mixtures formed by the precise linkage of 2 to 9 xylose molecules via β-1,4 glycosidic bonds, with a degree of polymerization of 2 to 9 and a molecular weight ranging from 282.28 to 942.93. As water-soluble dietary fibers and highly efficient prebiotics refined enzymatically from agricultural and forestry wastes such as corn cobs and straws, they possess four core advantages: ultra-strong prebiotic activity, exceptional acid and heat resistance, extremely low effective dosage, and broad-spectrum processing adaptability. They serve as golden functional ingredients in the food, health product, and pet food industries, providing efficient solutions for the development of intestinal health, sugar control and reduction, and clean-label products.

I. Core Physicochemical Properties

1. Basic Traits and Solubility Characteristics

- **Appearance and morphology:** White to pale yellow powder/granules, odorless, refined-grade purity ≥95%, with a refreshing taste and pure sweetness without after-bitter notes.
- **Sweetness and calories:** Sweetness is 40%–50% that of sucrose; energy coefficient is only 1.2–1.8 kcal/g, equivalent to 30%–45% of sucrose (4 kcal/g), showing remarkable low-calorie properties.
- **Solubility:** Solubility ≥60% at 25℃, forming colorless and transparent solutions; solubility increases further with rising temperature, making it suitable for high-solids and transparent formulations.
- **pH and thermal stability:** Structurally stable at pH 2.5–8.0 and temperature ≤**150℃**, with a retention rate ≥98% after heating at 100℃ for 2 hours; acid-resistant, heat-resistant, alkali-resistant, and non-coloring, adapting to food processing scenarios across the full pH range.

2. Rheological and Texture Properties

- **Viscosity regulation:** Viscosity is slightly higher than that of sucrose at the same concentration and decreases with increasing temperature. It can act as a thickener and stabilizer to optimize product texture and improve the reconstitution property of solid beverages.
- **Moisture retention and anti-aging:** Containing a large number of hydroxyl groups in the molecule, its moisture retention is superior to sucrose and can regulate the water activity of food; it inhibits starch retrogradation, delays the staling of baked goods, rice and flour products, and extends shelf life.
- **Anti-crystallization:** Amorphous structure with low crystallization tendency; when compounded with sucrose and sugar alcohols, it inhibits crystal precipitation and improves the taste stability of candies and frozen foods.

3. Metabolic Characteristics

- **Indigestibility:** Human α-amylase and sucrase cannot hydrolyze its β-1,4 glycosidic bonds; it is not absorbed in the small intestine but reaches the colon intact, without raising blood glucose or causing dental caries.
- **Blood glucose-friendly:** Glycemic Index (GI) ≈7 (extremely low glycemic response), with a very low relative blood glucose response, suitable for diabetic populations, sugar-controlled foods, and foods for special medical purposes.

II. Core Functional Properties

1. Intestinal Health and Prebiotic Function (Core Advantage)

- **Highly efficient proliferation of Bifidobacteria:** Known as the "King of Bifidobacteria Proliferation", it reaches the colon and is selectively fermented by Bifidobacteria and Lactobacilli. Daily intake of 0.7–1.4 g can increase Bifidobacteria count by 10–20 times in 2 weeks, inhibit harmful bacteria such as Escherichia coli and Salmonella (reducing them by 40%–60%), and optimize intestinal flora structure.
- **Improvement of intestinal peristalsis and constipation:** Fermentation produces short-chain fatty acids (SCFAs), increasing fecal volume and softening stool. Daily intake of 3–5 g can increase defecation frequency by 1.5 times in patients with chronic constipation in 4 weeks, shorten intestinal transit time, and reduce the risk of intestinal diseases.
- **Adsorption of harmful substances:** Its molecular structure can adsorb bile acids, cholesterol, and intestinal carcinogens, reducing human absorption, assisting in blood lipid regulation, and protecting the intestinal mucosa.

2. Metabolic Regulation and Weight Management

- **Enhancement of satiety:** Forms a viscous barrier in the small intestine to delay gastric emptying. Daily intake of 3 g can activate satiety signals, reduce excessive food intake, and support weight control.
- **Stabilization of postprandial blood glucose:** Delays the absorption of glucose and carbohydrates, lowering postprandial blood glucose peaks and fluctuations, suitable for low-GI foods and sugar-controlled formulations.

3. Nutrient Absorption and Bone Health

- **Promotion of mineral absorption:** SCFAs produced by fermentation acidify the intestinal environment, increasing the absorption rate of calcium, iron, and magnesium by approximately 30%–40%, supporting bone health and nutrient supplementation, suitable for products targeting middle-aged and elderly people, children, and pregnant women.

4. Processing Adaptability and Texture Optimization

- **Sugar reduction substitution:** Replaces 20%–50% of sucrose, retaining pure sweetness while reducing calories, suitable for beverages, baked goods, candies, dairy products, etc., achieving "sugar reduction without taste loss".
- **Texture improvement:** Enhances the moisture retention and softness of foods, improves the freeze-thaw resistance of frozen foods, and optimizes the reconstitution and dispersibility of solid beverages.
- **Clean-label compatibility:** Aligns with the global clean-label trend, can be labeled as "dietary fiber" and "prebiotic", meeting consumers' health demands and increasing product premium.

III. Unique Performance

1. Structural Uniqueness: Linear Short Chains + Precise β Bonds for Extreme Prebiotic Activity

- **Linear short-chain oligosaccharide structure for precise targeted proliferation.**

Different from fructo-oligosaccharides (β-2,1 glycosidic bonds), polydextrose (randomly cross-linked highly branched), inulin (long-chain fructans), and resistant dextrin (branched glucose polymers), XOS features a linear short-chain oligosaccharide structure, with β-1,4 glycosidic bonds targeting Bifidobacteria precisely, and its prebiotic specificity and activity far exceed most dietary fibers.

- **Controllable degree of polymerization (2–9) for stable functionality.**

Unaffected by raw material sources, it is suitable for large-scale industrial production.

2. Prebiotic Specificity: Exclusive "Food" for Bifidobacteria with Precise Functionality

- **Significantly higher proliferation efficiency and selectivity for Bifidobacteria** than fructo-oligosaccharides, polydextrose, and resistant dextrin; recognized as one of the top prebiotics, with clear intestinal microecological regulation effects and sufficient clinical data.
- **Mild fermentation gas production and excellent gastrointestinal tolerance:** Superior to inulin, daily intake of 10 g (Chinese Dietary Reference Intake) rarely causes bloating or flatulence discomfort.
- **Extremely low effective dosage:** Only 0.7–1.4 g per day is required to exert significant prebiotic effects, which is 1/4 to 1/2 of that of fructo-oligosaccharides (3–6 g), highlighting outstanding cost advantages.

3. Processing Adaptability: All-Scenario Versatility and Excellent Compounding Compatibility

- **Stable across full pH and temperature ranges:** Stable at pH 2.5–8.0 and temperature ≤150°C, compatible with mainstream food processing technologies such as baking, extrusion, high-temperature sterilization, spray drying, and freezing without degradation or denaturation.
- **Excellent compatibility** with proteins, starches, oils, sweeteners, probiotics, etc., with no incompatibility issues, simplifying the formulation development process.

4. Broad-Spectrum Applicability: Full-Coverage Fields and Boundless Scenarios

- **Food sector:** Dairy products (yogurt, milk powder, cheese), baked goods (bread, biscuits, pastries), beverages (functional drinks, solid reconstituted drinks, carbonated drinks), frozen foods (ice cream, desserts), candies, meat products, grain foods, etc., to increase fiber content, optimize taste, and reduce calories.
- **Health product sector:** Dietary fiber supplements, probiotic synergistic products, sugar/weight control formulations, and intestinal health health products to strengthen health claims.
- **Pet food/feed sector:** Pet snacks and staple foods to improve pet intestinal health, reduce intestinal diseases, and enhance nutrient absorption rate.
- **Pharmaceutical sector:** Pharmaceutical excipients (improving tolerance of intestinal drug delivery) and raw materials for intestinal health medicines.

5. Natural Attributes and Safety: Green Sources + Authoritative Certifications for High Market Trust

- **Green raw materials:** Produced from agricultural and forestry wastes such as corn cobs, corn straws, and wheat straws via enzymatic conversion and refining, with no chemical residues, realizing resource recycling.
- **Authoritative certifications:** Safety certified by China GB 2760, GB/T 23528.3-2025, US FDA GRAS (GRN No.458, GRN No.816), EU EFSA, JECFA, and other authoritative bodies.
- **Storage and transportation:** Solid form with a shelf life of 24 months, low storage and transportation costs, outstanding cost performance, suitable for the mass market and large-scale applications.

IV. Summary of Commercial Value

With its unique structure of linear short-chain β-1,4 glycosidic bonds, highly specific Bifidobacteria proliferation activity, extremely low effective dosage, all-scenario processing adaptability, and green and safe properties, xylo-oligosaccharides have become core ingredients for sugar reduction and upgrading in the food industry and the development of intestinal health products. Its six core values—high-efficiency prebiotic activity, blood glucose friendliness, promotion of mineral absorption, texture optimization, clean-label compatibility, and cost advantages—precisely meet consumers' demands for intestinal health, sugar control, and natural nutrition, while helping enterprises reduce costs, improve efficiency, and enhance product competitiveness. As a golden prebiotic ingredient in functional foods, health products, pet foods, and pharmaceuticals, it boasts broad market prospects.