Development History of Allulose Industry

Part I: A Tribute to the Pioneers

As a rare natural monosaccharide and a new-generation functional sweetener, D-Allulose boasts unique strengths including low calorie, low glycemic response, sucrose-like flavor, and participation in the Maillard reaction. It has emerged as a core raw material amid the global sugar reduction wave. This rare sugar has traversed more than half a century of evolution, spanning natural substance discovery, physicochemical property analysis, bioconversion technology breakthroughs, industrial process refinement, global safety verification, regulatory approval, and market popularization. Its development embodies theoretical explorations by worldwide researchers, iterative process upgrades by engineers, rigorous assessments by testing and standard-setting institutions, and dedicated operation by enterprises across the entire industrial chain. We hereby pay the highest tribute to all researchers, academic teams, research institutes, and upstream and downstream enterprises committed to fundamental allulose research, strain breeding, enzyme engineering development, production process optimization, toxicological safety evaluation, clinical efficacy verification, industry standard formulation, and global market promotion.

Roll of Honor

1. Core Scientists & Researchers

- ***Early Carbohydrate Research Teams (Europe & America, 1970s)***

Pioneers of research on the natural properties and fundamental physicochemical characteristics of allulose. In the 1970s, these teams first detected D-allulose in natural plants such as figs, raisins, kiwis and cereals. They completed substance isolation, structural identification and measurement of basic physicochemical parameters, confirmed it as a rare six-carbon ketose, and preliminarily characterized its core attributes including sweetness, calorific value, solubility and thermal stability. Restricted by its extremely low natural content and difficult extraction, research at that time remained confined to basic carbohydrate chemistry, yet laid the original theoretical foundation for subsequent targeted R&D and application exploration.

- ***Izumori Ken, Professor at Kagawa University, Japan – Founding Father of Allulose Bioconversion Technology***

A globally authoritative scholar in rare sugars and a trailblazer for allulose industrialization, renowned as the "Father of Rare Sugars". In the 1990s, his team at Kagawa University achieved a landmark industry breakthrough: they first identified that Alcaligenes microbes produce ketose 3-epimerase, systematically verified that this enzyme

catalyzes the isomerization of D-fructose into D-allulose, and fully elucidated the enzymatic catalytic mechanism, reaction kinetics and substrate matching rules. The heavily polluting, low-yield chemical synthesis route was completely discarded, and enzymatic biocatalysis was formally established as the sole viable industrialization pathway for allulose. This provided the core theoretical origin and technical paradigm for global industrial R&D and process iteration in the following decades.

- ***Senior Japanese Carbohydrate Engineering Scholars (Early 2000s)***

Core researchers who refined the enzymatic process system. Building on Professor Izumori's foundational findings, they focused on bottlenecks hindering industrialization, conducting systematic studies on multi-strain screening, performance comparison of dual enzyme systems (DTEase/DPEase), and optimization of reaction system parameters. They defined critical process thresholds for temperature, pH and substrate concentration, resolved stability and conversion rate challenges when scaling up from lab trials to pilot production, and delivered a full set of implementable process parameters and technical solutions for the early industrialization of Matsutani Chemical (Japan) and CJ CheilJedang (Korea), finalizing the first-generation industrial production system.

- ***Global Joint Safety Evaluation Expert Panel (Authoritative Toxicologists & Nutritionists from the US, Japan and South Korea, 2000–2015)***

Architects of the global allulose compliance framework. The panel led a full suite of toxicological tests, human metabolism trials, blood glucose and insulin response assays, and gastrointestinal tolerance assessments for allulose. It systematically confirmed the absence of acute/chronic toxicity, genotoxicity, and reproductive and developmental risks, and clarified human metabolic pathways, safe intake thresholds and applicable populations. Their work supported the acquisition of key global compliance certifications including US FDA GRAS status, JECFA safety assessment, and EU Novel Food approval, completely removing market access barriers for allulose worldwide.

- ***Overseas Clinical Nutrition Researchers (2010s)***

Expansionists of allulose's functional value. They carried out systematic clinical trials centered on metabolic health, scientifically proving that allulose stabilizes postprandial blood glucose, inhibits lipid accumulation and reduces calorie intake, while retaining excellent processing properties of sucrose such as robust Maillard reactivity, high heat resistance and pure flavor. Their research perfected allulose's dual value proposition of "sucrose-matching sweetness + health benefits", underpinning its targeted application positioning in premium segments such as sugar-controlled foods, weight-management diets and special nutritional products.

- ***Sun Yuanxia, Research Fellow at Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences – Founding Mother of China's Domestic Allulose Technology System***

A leading Chinese scholar pioneering the biomanufacture of rare sugars and the core leader behind domestic allulose technological breakthroughs. Returning to China in 2008, she established a dedicated R&D team and built China's first technical platform for rare sugar bioconversion. Her long-term research focuses on epimerase gene mining,

molecular modification, strain engineering and green synthesis processes. To address critical bottlenecks imposed by overseas technology monopolies – including low enzyme activity, poor stability and insufficient conversion efficiency – her team developed a series of high-performance industrial enzyme strains via computer-aided mutation simulation, site-directed mutagenesis and high-throughput screening. They constructed a fully independent, controllable allulose biosynthesis technology system, laying the scientific foundation for China's allulose industrialization.

- ***Yang Jiangang, Research Fellow at Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences – Core Expert in Enzyme Engineering Optimization & Industrial Scale-Up***

Key member of Sun Yuanxia's research group, specializing in industrial allulose enzyme optimization and process scaling. He has dedicated years to breakthroughs in immobilized enzyme technology, continuous catalytic systems and energy-efficient industrial processes, effectively boosting enzyme reusability, substrate conversion rates and production stability while drastically cutting manufacturing costs. He simultaneously advanced pilot scaling, production compatibility and quality standardization of domestic processes, accelerating the translation of lab-scale core technologies into large-scale mass production workflows. He stands as a pivotal technical driver bridging China's allulose scientific breakthroughs to widespread industrial adoption.

- ***Wang Xiaoyan, Director of Biotechnology Center, COFCO Nutrition & Health Research Institute – Leader of Compliance Breakthroughs for Domestic Food-Grade Enzymes***

Core specialist tackling compliant domestic allulose industrialization in China. She led the gene screening, strain modification, safety evaluation and industrial registration of China's first food-grade D-allulose 3-epimerase for food processing applications. After screening and modifying genes from a library of 498 candidates and completing thousands of mutation trials, her team successfully developed high-performance, highly safe domestic industrial enzymes. In 2023, China's first dedicated food-grade enzyme for allulose production received official approval, permanently ending the long-term monopoly of foreign enzyme preparations and filling the most critical gap in China's allulose industrial chain. It delivered essential compliance credentials and technical support for the industry's compliant, large-scale expansion.

- ***Li Zijie, Associate Professor at Jiangnan University – Innovator in Whole-Cell Transformation & Refining Processes***

His research centers on green synthesis and high-efficiency preparation technologies for allulose. Targeting pervasive industry pain points of traditional enzymatic processes – cumbersome steps, difficult purification and high costs – he pioneered a whole-cell transformation system using *Bacillus subtilis*. He optimized end-to-end synthesis, separation and refining workflows to raise product yield, streamline manufacturing procedures and reduce waste discharge. His work diversified China's domestic allulose technical routes, drove the industry toward greener, more efficient and lower-cost production, and refined tailored technical solutions for multi-scenario product applications.

- ***Domestic Expert Panel for Food Standards & Safety Evaluation (Specialists from Jiangnan University, South China University of Technology, China Agricultural University and SAC)***

Led the full-cycle development of localized allulose safety assessments, novel food raw material registration, national standards and testing systems in China. The panel oversaw localized toxicological verification, dietary exposure assessment, quality indicator definition and testing method establishment, improving domestic product quality control systems, production specifications and scope-of-use standards. Their efforts enabled D-allulose to receive official approval as a novel food raw material in China in 2025, establishing a compliance, standardization and quality control framework aligned with China's food industry and advancing standardized, high-quality industry development.

2. Core Research Institutions & University Teams

- ***Rare Sugar Research Laboratory, Kagawa University, Japan***

The birthplace of global allulose biosynthesis technology. For decades, it has spearheaded research on rare sugar enzyme engineering and catalytic mechanisms, continuously iterating epimerase research outcomes and sharing fundamental process parameters and theoretical data. As the primary technical reference institute for major global enterprises in their early stages, it has guided foundational allulose research worldwide for decades.

- ***Central Research Institute, Matsutani Chemical Industry Co., Ltd., Japan***

R&D platform for the world's first industrial allulose production process. Building on university-based foundational research, it pioneered pilot scaling of enzymatic workflows, production line process adaptation, and post-treatment technologies including decolorization, desalination and crystallization. It established industrial production quality control systems and product standards, realizing the transformation of allulose from lab samples to commercial industrial goods and cementing the early leading industry position of Japanese and South Korean manufacturers.

- ***CJ CheilJedang (CJ) Bio R&D Center, South Korea***

Benchmark for large-scale production and application technology innovation. Building on established enzymatic processes, it optimized fermentative enzyme production, continuous catalysis and membrane separation purification technologies to drastically expand output and lower unit production costs. Concurrently, it invested heavily in end-use formulation R&D, developing customized application solutions for beverages, bakery goods, dairy and other segments, accelerating allulose penetration in mass-market food sectors globally.

- ***Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences, China***

China's core R&D hub for allulose enzyme engineering. It specializes in microbial genetic modification, development of high-performance epimerases and immobilized enzyme technology, overcoming key bottlenecks of low-activity, poor-stability industrial enzymes. It has built indigenous proprietary strains and enzyme preparation systems, representing China's core scientific force behind technological self-reliance in this sector.

- ***School of Food Science and Technology, Jiangnan University, China***

China's leading institution for carbohydrate engineering and refining process optimization. Its research focuses on catalytic reaction refinement, multi-stage separation and purification, crystallization process improvement and product flavor regulation, resolving domestic product challenges including insufficient conversion rates, high byproduct content and inadequate purity. It also conducts application compatibility research to align allulose products with China's domestic food industry ecosystem.

- ***Domestic Food Testing & Standardization Research Institutions***

Support bodies for standardized industry development. These institutions lead research on allulose testing methodologies, quality grading, contaminant limits and microbial indicators. They participate end-to-end in the initiation, drafting and revision of national novel food raw material registrations, national standards and industry specifications, refining China's regulatory and quality control frameworks and driving compliant, standardized sector growth.

3. Acknowledgment of Benchmark Industry Enterprises

In consideration of industry competition rules and corporate privacy protection, specific enterprise rankings are omitted in this section. We extend sincere gratitude to all domestic and international enterprises that have made outstanding contributions to the development of the allulose industry.

Part II: R&D History of Allulose

1. Natural Discovery & Fundamental Theoretical Research Phase (1970s – 1990)

In the mid-to-late 20th century, global research into carbohydrate chemistry and natural products flourished. Scientists systematically cataloged monosaccharide and oligosaccharide components found in nature, with rare sugars emerging as a specialized research subfield.

From 1970 to 1978, European and American carbohydrate research teams detected trace amounts of D-allulose in various fruits, vegetables and cereals. Using extraction and chromatography techniques, they isolated the substance and analyzed its chemical structure, defining its molecular formula, stereoconfiguration and functional group

characteristics, and formally assigning its scientific name. Concurrent testing measured core physicochemical indices including sweetness, solubility, melting point, acid-base stability and thermal stability. Researchers found its naturally occurring concentrations were extremely low, with negligible yields from conventional extraction processes, rendering industrial production unviable.

Between 1978 and 1990, the industry explored chemical synthesis routes for allulose manufacturing. However, this approach featured cumbersome reaction steps, complex byproducts, difficult separation processes, high environmental pollution risks and persistently elevated overall costs, making mass production unachievable. A global scientific consensus formed that novel biosynthetic pathways were essential, ushering in an era of technical transition and exploratory research for allulose. This phase yielded only foundational theoretical accumulation, with no substantive breakthroughs in industrialization technology.

2. Establishment of Enzymatic Technology & Lab-Scale Research Phase (1990 – 2000)

1990 marked a pivotal turning point for the allulose industry. Professor Izumori Ken's team at Kagawa University, Japan, discovered that ketose 3-epimerase derived from *Alcaligenes* efficiently catalyzes the isomerization of D-fructose into D-allulose, birthing the bioconversion manufacturing route.

From 1990 to 1995, global research institutions launched concentrated studies on epimerase, conducting broad-scale microbial strain screening to compare enzyme production capacity, enzymatic activity and catalytic specificity across strains. They characterized enzymatic reaction kinetic patterns and preliminarily defined baseline reaction conditions for temperature, pH and substrate concentration. Nevertheless, early wild-type strains produced low enzyme yields with poor thermal stability and low single-batch conversion efficiency, only enabling small-batch lab preparation.

From 1995 to 2000, Japanese research teams carried out preliminary mutagenesis breeding of strains to moderately boost enzyme activity and tolerance, alongside optimization of reaction systems and initial exploration of product separation. Multiple lab trials and small sample batches were completed. The technical pathway received full validation, the lab-scale process took definitive shape, and conditions were established for scaling up to industrial pilot production. Leading Japanese and South Korean enterprises began technical coordination and project layout.

3. Process Finalization, Pilot Scaling & Overseas Safety Verification Phase (2000 – 2010)

With the technical pathway mature, R&D priorities shifted to industrial process implementation, product refining and global safety evaluation.

From 2000 to 2005, Matsutani Chemical of Japan completed pilot scaling of the enzymatic process, establishing an end-to-end workflow covering fermentative enzyme

production, substrate catalysis, decolorization, desalination, concentration, crystallization and drying. It resolved industrial challenges related to product coloration, impurities and crystal particle size, finalizing the mainstream production process framework. Concurrently, CJ CheilJedang of South Korea replicated and optimized the technology, creating two parallel industrial technical pathways under development.

From 2005 to 2010, joint US-Japan-South Korea initiatives launched comprehensive safety evaluations, including acute, subchronic and chronic toxicity tests, genotoxicity assays, human metabolism trials, blood glucose impact tests and gastrointestinal tolerance assessments to systematically validate long-term consumption safety. Compiled research data was submitted to authoritative bodies including the US FDA and JECFA to initiate compliance registration procedures. During this period, processes underwent incremental iterative improvements and production capacity expanded gradually, yet product pricing remained high. R&D focused primarily on process refinement and safety data accumulation, while application research was limited to niche premium food segments. Chinese research institutes launched literature reviews and basic lab research, embarking on technical tracking efforts.

4. Enzyme Engineering Upgrading, Process Optimization & Global Regulatory Approval Phase (2010 – 2018)

Global sugar reduction trends gained momentum, with consumer demand for zero-sugar, low-calorie sweeteners surging, driving accelerated upgrades to allulose technology while regulatory approvals across nations entered a concentrated rollout period.

From 2010 to 2015, genetic engineering technologies were widely adopted for enzyme modification. Overseas research teams restructured epimerase via molecular breeding techniques including gene cloning and site-directed mutagenesis, markedly enhancing enzyme thermal stability, catalytic activity and service life. Immobilized enzyme technology was gradually integrated into production workflows to enable enzyme reuse, cutting raw material and enzyme preparation consumption, steadily lifting overall conversion efficiency and lowering manufacturing costs. The US FDA formally granted GRAS status to allulose, followed by EU and South Korean approvals for its use as a novel food raw material, eliminating regulatory barriers in nearly all major global markets.

From 2015 to 2018, domestic Chinese R&D entered an accelerated growth phase. The Sun Yuanxia and Yang Jiangang team at Tianjin Institute of Industrial Biotechnology completed microbial gene mining and independent molecular modification of enzymes, breaking overseas technological blockades on enzyme preparations and mastering core catalytic technology. Parallel teams at universities including Jiangnan University optimized synthesis and refining processes, while domestic enterprises conducted lab and pilot trials to replicate and locally adapt manufacturing workflows tailored to China’s raw material characteristics, establishing an initial domestic proprietary technology system.

5. Maturity of Domestic Technology, Safety Evaluation & Regulatory Registration Phase (2018 – 2025)

After 2018, global sugar reduction policies were fully implemented, intensifying competition within the sugar substitute market. Riding on its superior flavor profile, allulose entered a period of rapid development, with domestic Chinese R&D shifting from technical breakthroughs to full-industry-chain maturation and regulatory compliance.

From 2018 to 2022, domestic research institutions and enterprises collaborated closely to refine advanced refining technologies including continuous immobilized enzyme catalysis, multi-stage membrane separation, ion exchange and precision crystallization. These advances further elevated product purity, reduced byproducts and stabilized batch-to-batch quality, bringing core indicators of domestic allulose products fully in line with international premium standards. Wang Xiaoyan's team at COFCO Technology tackled development of dedicated food-grade enzymes, resolving critical industrialization bottlenecks. Simultaneously, China initiated the registration process for allulose as a novel food raw material, completing a full suite of localized toxicological trials, metabolism studies and on-site production audits to compile safety data meeting China's national standard requirements.

Between 2022 and 2025, supporting food-processing enzyme preparations received sequential regulatory approvals, filling critical gaps in the industrial chain. In 2025, D-allulose was officially approved as a novel food raw material in China, with clear specifications defining its permitted scope of use, quality standards and administrative regulations. This milestone marked the full maturation of China's allulose technology R&D, safety evaluation and regulatory frameworks, drawing a successful conclusion to domestic independent R&D initiatives.

6. Deepened Technology & Diversified Innovation Phase (2025 – Present)

Following domestic regulatory approval, industry R&D entered a refined, high-end innovation stage. On one hand, overall manufacturing processes are optimized for green low-carbon production, energy conservation, consumption reduction and water resource recycling to advance sustainable production models. On the other hand, a portfolio of specialized high-purity, low-ash allulose products has been developed for differentiated application needs spanning infant food, food for special medical purposes, bakery goods and frozen beverages. Functional research continues to expand, leveraging modern nutritional science to explore emerging application avenues including intestinal health, personal skin care and animal nutrition, continuously broadening the value scope of allulose products.

Part III: Commercialization History of Allulose

Allulose's commercialization journey has advanced sequentially through natural substance discovery, enzymatic technological revolution, global regulatory framework establishment, domestic Chinese technological breakthroughs and the upgrading of health-conscious consumption patterns. It is divided into five distinct stages: overseas technological monopoly & niche commercialization, global regulatory mainstream adoption & market expansion, domestic technical reserve & market wait-and-see, domestic regulatory breakthrough & import substitution, and capacity explosion & reshaping of the global industrial landscape. This progression has transformed allulose from a lab-only rare sugar research sample into a mainstream global functional sweetener.

1. Overseas First Launch, Industrialization & Niche Commercialization Phase (2000 – 2010)

At the dawn of the 21st century, allulose formally entered commercialization. Leveraging mature enzymatic processes, Matsutani Chemical of Japan built the world's first industrial production line to launch mass commercial supply, becoming the globe's first enterprise selling allulose to external clients. CJ CheilJedang of South Korea rapidly followed with capacity expansion, capturing market share through large-scale manufacturing capabilities and forming an early duopoly market structure dominated by Japanese and South Korean manufacturers.

In the industry's formative years, limited production scale, high comprehensive manufacturing costs and steep market pricing positioned allulose as a premium rare functional raw material with an extremely narrow application footprint. It was primarily supplied to high-end local bakery products, premium dietary supplements, functional health foods and niche zero-sugar beverages in Japan and South Korea. General consumer awareness remained minimal, and global market volume was small, confined to premium ingredient circles. During this stage, allulose was marketed around its core selling points of "sucrose-like flavor and low calorie", with a high-end, niche and refined market positioning.

2. Global Regulatory Approval, Capacity Expansion & Overseas Market Growth Phase (2010 – 2018)

From 2010 onward, global sugar reduction trends gathered momentum, with multiple nations introducing regulations on sugar-containing food and sugar taxation policies, establishing zero-sugar, low-calorie food as the mainstream industry development track and unlocking commercial expansion opportunities for allulose.

From 2010 to 2015, the US, South Korea and the EU completed safety evaluations and regulatory approvals in sequence, granting allulose legal status as a food ingredient and fully opening global regulatory access channels. Japanese and South Korean enterprises continuously expanded production lines, with total annual output climbing steadily.

Utilizing established distribution networks, they exported products to North America, Europe, Southeast Asia and other regions. As process optimization unlocked greater production capacity, product pricing declined gradually, transitioning allulose from a niche premium ingredient to a general-purpose sweetener.

From 2015 to 2018, end-use applications expanded rapidly. Beyond traditional health supplements and bakery goods, allulose was incorporated into mass-consumption categories including zero-sugar beverages, yogurt, snack foods and meal replacement products. Overseas consumer brands launched numerous new formulations containing allulose, rapidly lifting public awareness and driving high-speed growth in global market volume. Throughout this phase, global raw material supply remained dominated by Japanese and South Korean enterprises, while European and American brands focused on end-product application R&D and consumer goods development, with no fundamental shifts to the upstream raw material capacity landscape. China’s domestic market remained formally closed, limited to small sample trials and technical exchanges without large-scale commercial adoption.

3. Domestic Technical Reserve, Pilot Layout & Market Wait-and-See Phase (2018 – 2025)

Sustained overseas market growth, paired with rising domestic Chinese demand for sugar-reduction products, prompted leading domestic functional sugar manufacturers to launch allulose project planning, entering a pre-commercial preparation period.

From 2018 to 2022, domestic Chinese enterprises completed technical pilot testing, production line construction and trial manufacturing, achieving small-batch sample output primarily for export trial orders and domestic customer testing. Barred by the absence of novel food raw material registration approval, large-scale domestic commercial sales were prohibited, leaving the industry in a state of "production capability without mass domestic sales". Market activity centered on formulation testing, application solution development and cautious market observation.

Concurrently, China’s domestic industrial chain matured end-to-end, forming a complete supporting ecosystem covering strain cultivation, enzyme preparation, production processes, quality testing and application services. Domestic allulose products demonstrated progressive advantages in quality, stability and cost efficiency, with large volumes exported to fully compliant markets across Europe, America, Southeast Asia and South Korea, steadily lifting the global export market share of Chinese-sourced raw materials. Industry stakeholders balanced overseas export operations with full collaboration with regulatory authorities to complete trials and audits required for novel food raw material registration, awaiting final policy clearance.

4. Domestic Regulatory Breakthrough, Market Launch & Import Substitution Phase (2025)

2025 stands as a landmark year for allulose commercialization in China. The official approval of D-allulose as a novel food raw material, alongside concurrent clarification of production specifications, quality metrics and permitted use scope, eliminated longstanding policy barriers and triggered the full launch of domestic commercialization.

Following regulatory clearance, existing domestic production capacity was rapidly activated, converting former trial customers into formal bulk purchasers. Major food manufacturing sectors including beverages, dairy, bakery, confectionery, health supplements and special dietary foods rolled out end products formulated with allulose. Its excellent taste profile and health attributes quickly established allulose as a leading option within China's sugar substitute market.

During this phase, domestic raw materials accelerated import substitution on the back of superior cost-performance, stable supply chains and localized technical support services. China's domestic market transitioned from a blank slate to rapid expansion, with distributors, brands and consumers simultaneously building product awareness, propelling the industry onto a sustained high-growth trajectory.

5. Mass Capacity Expansion, Full-Scenario Penetration & Global Industrial Restructuring Phase (2025 – Present)

Domestic regulatory approval unleashed a wave of large-scale capacity expansion across the industry. Ongoing construction projects entered commercial operation, newly planned facilities broke ground, and China's total allulose production capacity vastly outpaced Japan and South Korea. China emerged as the world's largest producer and exporter of allulose, triggering a fundamental reshaping of the global industrial landscape.

The current global market features a new division of labor: established Japanese and South Korean enterprises maintain their foothold in premium overseas custom markets and high-value niche segments, leveraging decades of brand equity and application expertise to retain high-end market positions. Chinese manufacturers, supported by massive production capacity, a fully integrated industrial chain, cost competitiveness and flexible custom formulation capabilities, cover the full spectrum of general and mid-to-high-end product categories, exporting bulk allulose worldwide to become the core global supplier of raw materials.

End-use applications have exploded across diversified full-scenario segments. Beyond conventional food, beverage and health supplement applications, allulose has expanded into emerging categories including frozen foods, preserved fruits, condiments, pet food, animal feed and oral care products. Downstream formulation innovation continues, combining allulose with other sweeteners such as erythritol, steviol glycosides and monk fruit sweeteners to optimize flavor profiles and reduce production costs, further expanding total market potential. Upstream and downstream industrial chain participants collaborate synergistically to form a complete ecosystem spanning raw material manufacturing, formulation R&D, finished goods production and brand marketing.

Outlook on Future Development Trends

In the long term, the global megatrend of sugar reduction, glycemic control and healthy dietary consumption will persist. As the rare functional sweetener with the flavor most closely matching sucrose, allulose retains untapped potential for sustained market growth.

1. **Technology Outlook:**

   The industry will continue advancing toward green manufacturing, energy-efficient cost reduction, molecular enzyme optimization and precision refining. Widespread adoption of technologies including continuous immobilized enzyme production, integrated membrane separation and low-carbon crystallization will further boost manufacturing efficiency, cut energy consumption and waste discharge, and drive sustainable industrial upgrading.

2. **Product Outlook:**

   Segmented differentiated product lines will become mainstream. Specialized high-purity, low-impurity, heat-resistant and pre-blended allulose grades will be developed for distinct use cases including infant food, food for special medical purposes, cold beverages and high-temperature bakery goods, continuously enriching the product portfolio and lifting product added value.

3. **Application & Functional Outlook:**

   Beyond traditional sweetening applications, in-depth research will advance around metabolic health, intestinal care and animal nutrition to unlock novel functionalities and use cases, moving beyond allulose's singular positioning as a sweetening ingredient.

4. **Global Industrial Landscape Outlook:**

   China will continuously consolidate its three core competitive advantages in production capacity, proprietary technology and integrated supply chains. The country will gradually shift from pure product export to technology, standard and application solution exports, exerting profound global leadership over the allulose industry. Amid sustained global growth in health-conscious consumption, allulose will remain a core product within the functional sweetener track, maintaining consistent stable growth over the long term.