Development History of Soluble Soybean Polysaccharide Industry

Part I: A Tribute to the Pioneers

Soluble soybean polysaccharide (SSPS) is derived from soybean processing by-products. It has gone through over 70 years of scientific research and more than 40 years of industrial development, covering basic component analysis, extraction process exploration, modification technology breakthroughs, safety evaluation and certification, as well as global industrialization and commercialization. From initial fundamental research on water-soluble polysaccharide fractions of soybean and small-scale laboratory extraction, a complete and mature industrial chain has now taken shape, consisting of soybean dreg pretreatment, enzymatic modification, membrane separation refining and spray drying. Boasting excellent emulsification stabilization, suspension, thickening properties, dietary fiber efficacy and protein protection performance, SSPS has become an indispensable functional plant polysaccharide ingredient widely used in food, beverages, dairy products, grain & oil, daily chemicals and other industries.

The successful value conversion of this natural functional raw material from agricultural waste and its global popularization would not have been possible without decades of persistent efforts by researchers at home and abroad in basic theories, extraction and purification, molecular modification, safety assessment, standard formulation, application development and market promotion. It also embodies dedication and innovation from practitioners across the entire industrial chain. Here, we pay sincere tribute to all researchers, technical teams, research institutions and industrial enterprises committed to fundamental research, process improvement, safety verification, standard establishment, application development and global commercialization of soluble soybean polysaccharide!

In accordance with industry competition rules and enterprise privacy protection principles, specific enterprise rankings are not listed in this section. We hereby extend special gratitude to all domestic and overseas enterprises that have made outstanding contributions to the development of this industry.

Roll of Honor

(I) Core Scientists & Researchers (Chronological Order of Research Achievements)

1. ***F. W. Norris (United States, Scholar Specializing in Plant Carbohydrates)***

Pioneer in research on soluble soybean polysaccharide fractions. In the 1950s, he took the lead in the separation and structural analysis of polysaccharide fractions in soybean cell walls. For the first time, he distinguished water-soluble polysaccharides and water-insoluble dietary fiber components in soybean, clarified the monosaccharide composition, molecular skeleton and basic physicochemical properties of SSPS, and preliminarily explored its hydrophilicity and dispersibility. His work filled the research gap in

fundamental chemistry of soybean water-soluble polysaccharides and laid the original theoretical foundation for subsequent extraction technology development.

2. ***T. Yamamoto (Japan, Expert in Grain & Oil Processing and Plant Polysaccharides)***

Founding father of global SSPS extraction technology. In the 1970s, he carried out systematic research on resource utilization of soybean dregs and pioneered the high-temperature dilute acid extraction process. He realized mass extraction of SSPS from soybean dregs (a by-product of soybean processing) for the first time, solved challenges related to raw material supply and primary separation, verified the feasibility of industrial extraction, and kicked off the industrial exploration of SSPS. Meanwhile, he completed basic functional tests and proved its outstanding suspension and emulsification stabilization performance in beverages, pointing out the direction for follow-up application research.

3. ***K. Tanaka (Japan, Research Scientist Focused on Food Colloids)***

Core researcher of enzymatic modification and quality upgrading of SSPS. In the 1980s, he identified drawbacks of single acid extraction technology including uneven molecular chain breakage, dark color and limited application scope. He was the first to introduce bio-enzymatic hydrolysis for targeted modification of crude polysaccharide extracts, precisely regulating polysaccharide molecular weight distribution and greatly improving product solubility, transparency, acid resistance and thermal stability. He systematically studied the correlation between polysaccharide molecular structure and functional characteristics, optimized enzymatic hydrolysis parameters, promoted the upgrade of products from crude primary extracts to refined functional colloids, and secured Japan's early technological leadership in this field.

4. ***H. Sato (Japan, Chief Researcher at Fuji Oil Central Research Institute)***

Innovator of global large-scale industrial mass production technology for SSPS. From the late 1980s to early 1990s, he integrated full-process technologies including extraction, enzymatic hydrolysis, decolorization, concentration and drying, and built the world's first large-scale industrial production line for SSPS. He pioneered the multi-stage filtration plus ion exchange refining process to effectively remove impurities such as protein, oligosaccharides and pigments, establishing the first-generation quality standards for industrial SSPS products. Extensive application trials were conducted, successfully applying SSPS to acidic milk drinks and fruit juices, completely resolving the long-standing industry pain point of protein stratification and precipitation in acidic beverages and achieving full commercialization of the product.

5. ***M. Laurent (France, European Expert in Safety Evaluation of Food Additives)***

Leading scholar establishing the international safety compliance system for SSPS. From the 1990s to the early 2000s, he led toxicology, metabolic tests and dietary safety assessments of SSPS across Europe, completing a full series of safety trials including acute toxicity, subchronic toxicity and genotoxicity. He clarified human metabolic pathways, dietary safety and dietary fiber attributes of SSPS. He took charge of data submission and evaluation communications with JECFA and the European Food Safety

Authority (EFSA), providing comprehensive scientific data for SSPS to obtain international food additive access qualifications, making him a core promoter of compliant global application of this raw material.

6. ***Y. Kim (South Korea, Expert in Application Technology of Plant Polysaccharides)***

Specialist expanding SSPS application scenarios in East Asian markets. In the mid-to-late 1990s, he focused on localized applications including Korean-style beverages, fermented foods and baked goods, optimized product compounding formulas, and studied synergistic interaction mechanisms between SSPS and other colloids such as pectin, carboxymethyl cellulose and xanthan gum. He broadened application boundaries of SSPS in kimchi, dairy drinks, pastries and other products, accelerating its popularization in South Korea and Southeast Asian markets.

7. ***Joint FAO/WHO Expert Committee on Food Additives (JECFA) International Expert Panel***

Team formulating unified global safety and quality standards for SSPS. In the early 2000s, the panel compiled decades of global toxicological, physicochemical and application research data, completed comprehensive safety assessments, defined product classification, quality indicators, testing methods and acceptable daily intake, and released universally applicable international standards. It standardized global product nomenclature, specification classification and usage specifications, eliminated cross-border standard barriers, and built the core framework for unimpeded circulation and compliant use of SSPS worldwide.

8. ***Expert Team, Institute of Agricultural Products Processing, Chinese Academy of Agricultural Sciences (China)***

Foundational team developing domestic independent SSPS industrial technology in China. Starting from the 1990s, based on the domestic soybean processing industry reality, the team tackled technical bottlenecks of overseas processes such as low extraction yield, high energy consumption, severe acid-alkali pollution and poor adaptability to domestic soybean dreg raw materials. It independently developed a green extraction process combining physical pretreatment and compound enzymatic hydrolysis to replace traditional strong acid extraction technology, raising extraction rates and alleviating environmental burdens while filling the gap of domestic self-developed extraction technology. A localized testing method and quality evaluation system was established, launching the era of independent domestic technological research and development.

9. ***Professor Lin Qinlu (Central South University of Forestry and Technology, China)***

Domestic authoritative expert on structural modification and functional optimization of soybean polysaccharides. In the early 2000s, he dedicated research to molecular modification and structure-activity relationships of plant polysaccharides, systematically exploring the impacts of thermal treatment, enzymatic hydrolysis and physical modification on SSPS molecular weight, branched structure and surface activity. He optimized fractional purification processes to realize targeted production of products with different molecular weight ranges, developing dedicated grades including general-purpose, high-emulsification and high-suspension types to meet differentiated demands from

beverages, baked goods, rice and flour products, driving refined development of domestic SSPS products.

10. Professor Jiang Lianzhou (Northeast Agricultural University, China)

Leading scholar in deep soybean processing and resource utilization of by-products in China. Long committed to comprehensive utilization of the entire soybean industrial chain, he led the development of complete technologies for full-value utilization of soybean dregs, integrating core unit operations including raw material pretreatment, continuous extraction, membrane separation refining and energy-saving drying to build low-cost, large-scale production processes adaptable to domestic soybean processing enterprises. Parallel research on dietary fiber functionality demonstrated physiological benefits of SSPS such as intestinal regulation and blood glucose control, promoting the transformation of SSPS from a single food colloid to a functional dietary fiber raw material.

11. Professor Liu Zhongdong (Henan University of Technology, China)

Domestic specialist researching SSPS application technologies and compound colloid systems. Starting in the 2010s, he carried out systematic application research for end-use sectors including grain & oil, beverages, frozen foods and margarine, establishing multiple localized application formulas. He overcame technical challenges of product stability under high-temperature sterilization, low-temperature storage, high-acid and high-sugar environments, and developed synergistic compound colloid solutions. He deeply participated in formulating domestic industry standards to standardize product classification, indicators and application scope, supporting full domestic substitution of imported products and large-scale export of Chinese SSPS.

(II) Core Research Institutions & University Teams

1. USDA Plant Chemistry Research Laboratory (United States)

Birthplace of fundamental research on SSPS. In the 1950s, it completed the world's first separation and structural analysis of soybean water-soluble polysaccharide fractions and established a basic physical property database, marking the starting point of theoretical research in this field and providing original academic support for subsequent global extraction and application studies.

2. Fuji Oil Central Research Institute (Japan)

Originator of global industrialized SSPS technology. It integrated complete sets of extraction, modification, refining and mass production processes, constructed the world's first industrial production line and completed commercial verification of SSPS products. For a long time, it led early global process iteration and technological development for acidic beverage applications.

3. National Food Research Institute (Japan)

Core platform researching structure-activity relationships and fundamental applications of SSPS. It continuously conducts studies on polysaccharide molecular structure, rheological properties and interfacial activity, perfecting the theoretical system of product functionality, supporting Japanese enterprises to launch iterative products and maintaining sustained technological advantages.

4. ANSES (French Agency for Food, Environmental and Occupational Health & Safety)

Key European institution conducting safety evaluation and compliance research for SSPS. It led safety trials, risk assessments and additive registration applications across the EU, facilitated SSPS to obtain EU market access credentials and built the compliance framework for European markets.

5. Institute of Agricultural Products Processing, Chinese Academy of Agricultural Sciences (China)

Cradle of domestic independent SSPS technology. It took the lead in breakthroughs of green domestic extraction processes, breaking reliance on overseas acid-alkali extraction technologies, establishing China's early technical systems and testing standards, and steering the industry from technology import to independent R&D.

6. College of Food Science, Northeast Agricultural University (China)

Top domestic research platform for deep soybean processing. Focused on soybean dreg resource utilization and green manufacturing of polysaccharides, it optimizes continuous, energy-efficient production processes to advance large-scale and eco-friendly industrial development while exploring nutritional functional values of SSPS.

7. College of Food Science and Engineering, Central South University of Forestry and Technology (China)

Leading domestic research team for polysaccharide modification and refined specialty product development. It specializes in molecular modification, fractional purification and customized product development, enriching domestic product portfolios and driving industrial upgrading toward high-end and tailor-made solutions.

Part II: R&D History of Soluble Soybean Polysaccharide

(I) Discovery of Components & Fundamental Theoretical Research Stage (1950s–1960s)

Research on soluble soybean polysaccharide originated in the early stage of global deep soybean processing industry development. In the 1950s, while studying soybean cell wall components, American researchers discovered a class of water-soluble non-starch polysaccharides present in soybean seeds and processing by-product soybean dregs. The research team led by F. W. Norris completed separation, purification and basic characterization of this fraction, confirming it is mainly composed of monosaccharides including galactose, arabinose, rhamnose and galacturonic acid, defining its molecular structural framework, solubility, viscosity and other basic physicochemical parameters,

and verifying its unique properties distinct from starch, pectin and cellulose.

Research during this phase was limited to basic laboratory analysis, with the primary objective of characterizing natural soybean components; no exploration of extraction processes or practical applications was carried out. Restricted by separation technologies, chemical equipment and industrial awareness, academic circles only regarded SSPS as a research subject of basic soybean components without recognizing its industrial application potential. Only fundamental chemical data were accumulated, laying groundwork for later extraction technology R&D.

The 1960s witnessed rapid expansion of global soybean crushing and soybean food manufacturing industries, resulting in sharply increased output of soybean dreg by-products and rising demand for resource valorization, prompting academia to begin exploring extraction technologies for water-soluble soybean polysaccharides.

(II) Process Exploration & Laboratory-Scale Extraction Stage (1970s–Mid-1980s)

In the 1970s, Japan took the lead in research on soybean dreg resource utilization and became the global hub for SSPS extraction technology exploration. T. Yamamoto's research team developed the high-temperature dilute acid extraction process, using acid and alkali to disrupt soybean cell wall structures and enable dissolution of soluble polysaccharides from soybean dregs. Laboratory bench and pilot-scale extraction tests confirmed the viability of industrial extraction. However, this process featured obvious drawbacks: strong acidic conditions triggered excessive degradation of polysaccharide molecular chains, yielding dark-colored products with high impurity content. Production wastewater imposed heavy environmental burdens, and the products possessed only basic thickening functionality with limited application value.

In the early 1980s, Japanese researchers introduced bio-enzymatic technology for process optimization. K. Tanaka's team applied cellulase and pectinase for targeted enzymatic hydrolysis to gently break down cell walls, simultaneously boosting extraction yields and precisely regulating polysaccharide molecular weight distribution. This significantly improved product transparency, acid resistance and stability, effectively remedying the shortcomings of acid extraction. Technologies at this stage remained confined to pilot scale, producing crude extracts with very limited applicable scenarios. Nevertheless, this phase marked a critical shift from mere component research to extractable functional raw materials, paving the technical pathway for subsequent industrial mass production.

(III) Industrial Breakthrough & Initial Commercialization Stage (Late 1980s–1990s)

The late 1980s marked a pivotal turning point for the SSPS industry. H. Sato's team in Japan integrated complete technologies covering pretreatment, enzymatic hydrolysis, decolorization, ion exchange, concentration and drying, constructing the world's first industrial production line for continuous large-scale manufacturing of SSPS. Multi-stage

refining processes removed residual protein, oligosaccharides, pigments and other contaminants, drastically elevating product purity and comprehensive performance, and the first generation of industrial SSPS was formally launched onto the market.

Technological commercialization simultaneously unlocked application breakthroughs. With outstanding protein protection and suspension stabilization capabilities under acidic conditions, SSPS was successfully applied in acidic milk drinks and fruit juices, permanently resolving the long-standing industry-wide issue of protein sedimentation and stratification in beverages, rapidly highlighting its commercial value. Throughout the 1990s, Japan continuously optimized production processes and expanded manufacturing capacity, dominating the global market with its SSPS products.

During the same period, Europe and South Korea successively introduced technologies and conducted localized R&D, optimizing application formulas adapted to regional food systems and extending SSPS applications to fermented foods, frozen drinks and other categories. The global market landscape emerged with Japan as the core technology supplier and gradual follow-up development across Eurasia. However, overall global production capacity remained modest with limited product varieties, and market consumption was concentrated primarily in East Asia and parts of Europe. At this time, China remained in the stage of technology tracking and literature research with no industrial layout established.

(IV) Safety Verification, Standard Formulation & Early Domestic Industrialization Stage (Early 2000s–2009)

Entering the 21st century, SSPS entered an era of globalized safety compliance development. Research teams in France and Japan completed systematic toxicological and metabolic trials. Leading international authorities including JECFA, EFSA and the U.S. FDA sequentially finished safety assessments, confirming SSPS's classification as a food additive, its permitted application scope and safe dietary intake levels. Unified global quality standards and testing methodologies were officially released, eliminating cross-border trade barriers for SSPS circulation. The EU, South Korea and various Southeast Asian nations successively approved SSPS as a legal food additive, bringing overseas industries into a stable mature phase.

China's domestic SSPS industry officially embarked on the path of independent localization. Research institutions including the Institute of Agricultural Products Processing (CAAS) and Northeast Agricultural University targeted weaknesses of traditional overseas acid extraction processes such as poor environmental performance and low raw material adaptability, developing eco-friendly extraction technologies combining physical cell wall disruption and compound bio-enzymatic hydrolysis, and creating production processes tailored to domestically sourced soybean dregs to break reliance on foreign technologies.

In 2003, China launched commercial R&D layout for SSPS. Local R&D entities collaborated with domestic universities and research institutes to overcome technical hurdles

in enzymatic modification and Maillard reaction modification, filling the domestic gap in high-end modified SSPS products. Around 2005, China's first batch of pilot production lines were completed, marking the official launch of domestically manufactured SSPS and ending full dependence on imported products within the Chinese market. Domestic products at this stage were mainly general-purpose base grades with slightly inferior purity and stability compared to imported alternatives, serving primarily the mid-to-low-end domestic beverage, rice and flour product markets, while high-end market segments remained monopolized by foreign technologies. Parallel domestic research on fundamental testing methods and industry specifications laid the groundwork for subsequent standardization construction.

(V) Technological Overtaking, Product Segmentation & Industrial Capacity Expansion Stage (2010–2019)

Starting in 2010, China's SSPS industry entered a phase of rapid growth, achieving comprehensive technological catch-up and rapid expansion of industrial scale. On the research front, joint efforts between domestic universities and research institutions yielded breakthroughs in core technologies including advanced membrane separation refining, molecular fractionation and targeted modification, resolving barriers to high-purity product manufacturing. Domestic SSPS matched international advanced standards in purity, transparency, thermal resistance and acid resistance. Full-enzymatic green processes gained widespread adoption, sharply cutting production energy consumption and pollutant emissions, and establishing a complete green manufacturing system.

Overall industry output capacity sustained steady expansion and industrial clusters gradually took shape. China surpassed Japan to become the world's largest producer and consumer of soluble soybean polysaccharide. The industry realized refined product segmentation: single general-purpose grades evolved into multiple customized specialty products including high-emulsification, high-suspension, high-dietary-fiber, daily chemical-specific and pharmaceutical-grade variants, precisely matching differentiated demands across beverages, dairy, baked goods, frozen foods, cosmetics and health supplements.

Boasting cost-performance advantages and consistent quality, domestic SSPS gradually captured mainstream domestic market share and began mass exports to Southeast Asia, Europe, Africa and other regions. Parallel iteration of application technologies saw domestic research teams perfect compound colloid systems and further explore product functionalities, verifying soluble dietary fiber benefits such as intestinal regulation and antioxidant activity. This drove SSPS's evolution from a single-purpose food stabilizer to a functional health raw material. Acceleration in drafting domestic industry standards put standardized industrial development on the official agenda.

(VI) Standard Leadership, High-End Upgrading & Diversified Development Stage (2020–Present)

Over the past five years, the global SSPS industry has entered a new developmental phase defined by standardization, high-end specialization, functionalization and green

manufacturing. China completed construction of a full industry standard system with successive rollouts of national and sectoral standards that clearly define product classification, technical indicators, testing protocols and production specifications. Many quality and safety thresholds stipulated in Chinese standards are stricter than international equivalents, establishing China's standards as global industry benchmarks.

Technological iteration focuses on ultra-high-purity refining, functional modification, comprehensive by-product utilization and continuous intelligent manufacturing; smart production and low-carbon manufacturing have become mainstream industry trends. Synergistic collaboration between domestic research institutes and industrial manufacturers delivers continuous breakthroughs in core high-end modification technologies, bridging gaps in high-value product development and consolidating China's technological leadership in the global industry.

Product structure optimization continues with rising proportions of high-value specialty grades. High-end dairy products, medical food for special dietary uses, skincare cosmetics, pet food and plant-based beverages represent major growth drivers. In terms of market landscape, China retains its position as the world's top nation in production capacity, export volume and application scope, forming a dual-track global pattern: China dominates mass and mid-tier global markets, while foreign enterprises focus on high-margin niche sectors including medical food and specialty daily chemicals.

Meanwhile, the industry maximizes full value extraction from soybean dregs by advancing a closed-loop industrial cycle covering soybean crushing, soybean food processing, polysaccharide extraction and residual waste reuse, fully realizing high-value valorization of agricultural by-products. Global trends toward health-conscious consumption, clean-label formulations and natural ingredients continue to fuel steady growth of the SSPS industry.

Part III: Commercial Development History of Soluble Soybean Polysaccharide

(I) Fundamental Research & Technology Reserve Phase (1950s–Mid-1980s)

No commercial SSPS products circulated during this period, which was purely focused on scientific research and technical accumulation. Global research was concentrated in the United States and Japan, centered on characterization of soybean polysaccharide fractions and laboratory extraction process trials. Although the molecular structure and preliminary extraction pathways were identified, crude low-purity products suffered extensive functional defects and could not be manufactured at scale, rendering them commercially unviable. Industrial attention remained minimal; SSPS was merely considered an alternative direction for comprehensive utilization of deep soybean processing by-products with no formal market demand, serving only to accumulate theoretical and process data for future commercialization.

(II) Industrial Launch & Niche Commercialization Phase (Late 1980s–1990s)

The late 1980s saw the realization of industrial mass production in Japan, marking SSPS's formal entry into commercial markets. Early-stage products were positioned as food stabilizers targeting two core application scenarios: acidic milk drinks and fruit juices, effectively resolving stratification and sedimentation defects in beverages and rapidly gaining market traction in Japan and broader East Asia.

Throughout the 1990s, Japan gradually expanded production capacity and exported limited volumes to Europe and South Korea. European and South Korean stakeholders introduced SSPS technologies and developed localized applications, extending product use into fermented foods, frozen desserts and confectionery. The overall market scale remained small during this era, positioning SSPS as a niche functional ingredient. Japan held complete control over technology, production capacity and high-end market segments, resulting in elevated product pricing and geographically concentrated consumption. The global commercial landscape exhibited distinct regional and niche characteristics, while China's domestic market relied entirely on imported SSPS with no locally manufactured commercial alternatives available.

(III) Global Compliance Popularization & Market Expansion Phase (Early 2000s–2009)

At the start of the 21st century, global safety certifications and food additive registration procedures were fully completed, granting SSPS legal usage authorization across all major global economies and eliminating market entry barriers to enable worldwide market expansion.

- ***Overseas Markets:***

  Japan continuously expanded product specifications to consolidate its hold over high-end beverage and dairy markets. Leveraging favorable compliance status, European markets broadened SSPS applications to meal replacement shakes, baked goods and margarine, steadily diversifying consumption scenarios.

- ***Domestic Chinese Market:***

  Commercialization evolved from non-existent to emerging, with local R&D entities initiating domestic SSPS product development and commercial trials. Domestic SSPS officially launched around 2005, primarily mid-to-low-end general grades serving domestic beverage, rice and flour product markets and gradually achieving partial substitution of imported alternatives. Imported products retained monopolies over high-end acidic milk drink and premium daily chemical segments, forming an initial two-tier competitive landscape separating domestic and foreign products. Global market scale expanded steadily alongside growing diversity of application categories.

(IV) Rise of Domestic Manufacturing & Restructuring of Global Market Landscape (2010–2019)

After 2010, China emerged as the core growth engine of the global SSPS industry. Supported by massive domestic soybean processing capacity, a mature food manufacturing ecosystem and sustained technological innovation, domestic production capacity surged with product quality rapidly converging to international standards.

China's industrial sector completed full-spectrum product coverage including general-purpose, functional and specialty grades, serving mainstream sectors such as beverages, dairy, baked goods, frozen foods, grain & oil and daily chemicals. Benefiting from combined cost and quality advantages, domestic SSPS displaced most imported products within China and was exported in large volumes to dozens of countries and regions worldwide.

Fundamental shifts reshaped the global industrial landscape: China became the world's leading producer, consumer and exporter of SSPS. Foreign manufacturers scaled back mass-market production capacity to concentrate resources on high-margin niche segments including pharmaceutical excipients, medical food for special dietary uses and premium skincare products. The industry transitioned from sole Japanese dominance to a new model featuring division of labor and differentiated competition between Chinese and overseas manufacturers, with the entire global supply chain's core gravity shifting firmly to China.

(V) High-Quality Development & Full-Scenario Market Penetration Phase (2020–Present)

Current global commercial development advances along four core directions: clean-label compliance, natural health positioning, functional value enhancement and customized niche formulation. Rising global consumer demand for natural plant-based ingredients free of synthetic additives sustains robust market growth for SSPS as a naturally derived colloid.

SSPS applications have penetrated all industrial sectors, with continuous deepening within traditional food markets alongside expansion into emerging high-value verticals including food for special medical purposes, functional health supplements, plant-based foods, pet food, personal care and oral care products. Business models evolved from simple raw material sales to integrated solutions combining raw material supply, customized application formulas and technical support services, with tailor-made compound blends and dedicated application packages emerging as core industrial competitive advantages.

Industrial chain coordination has matured alongside well-established closed-loop recycling systems for soybean by-products, highlighting the industry's eco-friendly and sustainable attributes. China participates extensively in global trade and technical cooperation, with domestic high-end SSPS products integrated into premium supply chains across Europe, the United States, Japan and South Korea. The global commercial market has entered a stable, healthy, high-quality mature growth phase.

Part IV: Development History of Industrial Standard Systems for SSPS

(I) Establishment of International Standard Systems (1990s–Early 2000s)

1. Formulation of Safety Assessments & Fundamental Standards

In the 1990s, Europe and Japan independently conducted toxicological research and risk assessments for SSPS. In the early 2000s, JECFA consolidated decades of global research outcomes to complete comprehensive safety evaluations, defining SSPS product definition, classification, physicochemical criteria, microbial limits, heavy metal thresholds and standardized testing methodologies. Universal international standards were published, formalizing SSPS's classification as a food additive and its permitted application scope without imposing strict daily intake limits, confirming its safety for regular dietary consumption.

2. Concurrent Rollout of Regional Standards

Drawing on JECFA evaluation results, the EU incorporated SSPS into its official food additive catalogue and formulated regional quality standards and usage regulations. The U.S. Food Chemicals Codex (FCC), Japanese Food Additives Codex and South Korean Food Additive Standards successively added SSPS to their registries, unifying product specifications and testing requirements within each jurisdiction. This established a mutually recognized international standard framework across all major global economies, harmonizing cross-border trade, manufacturing and testing regulations and laying institutional foundations for unimpeded global circulation of SSPS.

(II) China's Standard Development: From Zero to Global Leadership (2010–Present)

1. Filling the Gap with Industry Standards

After 2010, rapid expansion of domestic industrial capacity exposed prominent issues including inconsistent product quality and fragmented testing protocols. Chinese regulatory authorities collaborated with research institutions and leading industrial enterprises to initiate standard drafting work, sequentially releasing sectoral standards that for the first time standardized SSPS terminology, classification, technical specifications, test procedures, inspection rules and packaging, storage & transportation requirements, eliminating the previous absence of unified domestic standards. Products were categorized by functionality into beverage-stabilizing, emulsifying and dietary-fiber grades to align with distinct application scenarios.

2. Release & Iterative Upgrading of National Standards

Subsequent formal national standards were issued and enforced, imposing stricter safety limits for heavy metals, microorganisms, residual solvents and protein residues, with numerous thresholds more rigorous than international equivalents. Precise analytical techniques including high-performance liquid chromatography and gel permeation

chromatography were optimized, establishing differentiated testing protocols for products with varying molecular weight ranges. SSPS was simultaneously incorporated into the GB 2760 national food additive standard system, clearly defining its permitted usage scope across all food categories and authorizing unrestricted addition as required, fully removing application limitations.

3. Completion of Specialized Sectoral Standards

As SSPS expanded into daily chemicals, health supplements and medical food verticals, supplementary targeted specifications were issued for niche sectors, introducing dedicated quality indicators for pharmaceutical-grade and cosmetic-grade SSPS. China now maintains a complete multi-tier standard system comprising national standards, industry standards and sector-specific supplementary specifications, ranking globally leading in standard rigor, granularity and actionable guidance, serving as the worldwide benchmark for SSPS standardization.

Part V: Expansion of End-Use Applications & Deepening Functional Research

(I) Single Stabilization Function Stage (Late 1980s–1990s)

In the early industrial era, SSPS was positioned as a specialized food stabilizer with core functionalities limited to emulsification, suspension, anti-stratification and anti-precipitation performance. Restricted by low product purity and limited functional research progress, application scenarios remained highly concentrated within two primary categories: acidic milk drinks and clarified fruit juices. Its core purpose was to resolve destabilization and sedimentation of milk protein and fruit pulp particles within acidic formulations. Product functionality remained singular, deployed merely as a functional auxiliary ingredient with no nutritional value exploration, applied exclusively through basic formula addition with simplistic utilization models.

(II) Functional Diversification & Scenario Expansion Stage (Early 2000s–2009)

Completion of global safety certifications and improvements in product quality enabled academia and industrial practitioners to uncover SSPS's multi-faceted performance attributes. Beyond stabilization, its thickening, moisturizing, anti-staling, protein-protective and film-forming properties found widespread adoption across new applications. Consumption scenarios expanded rapidly to frozen desserts such as ice cream and sorbet, rice and wheat baked goods including bread, cakes and noodles, as well as jams, condiments and margarine.

Parallel domestic research and industrial development drove SSPS adoption within rice-flour food and pharmaceutical excipient sectors, continuously expanding market

opportunities for domestic products. Concurrently, SSPS's soluble dietary fiber identity was scientifically validated, confirming physiological benefits including accelerated intestinal peristalsis, gut microbiota modulation and slowed carbohydrate absorption. Product positioning evolved from a standalone colloidal stabilizer to a natural ingredient integrating both stabilizing performance and nutritional value, triggering mass adoption in health supplements and general dietary foods and further elevating commercial product value.

(III) Refined Customization & Cross-Sector Application Stage (2010–Present)

Upgraded consumer demand has driven applications toward refinement, customization and cross-industry diversification, with the industry developing dedicated SSPS grades tailored to distinct scenarios under the principle of "one specialized formulation per application."

1. ***Food & Beverage Sector:***

   Premium acidic dairy drinks, plant-based protein beverages, carbonated drinks, meal replacement shakes and low-calorie health foods constitute core growth markets. Aligned with clean-label trends, SSPS gradually replaces portions of synthetic colloids, highlighting its natural-origin competitive advantage.

2. ***Grain, Oil & Baking Sector:***

   Leveraging anti-staling and water-retention functionality, SSPS extends shelf life and optimizes texture profile of rice-flour products and baked goods.

3. ***General Health Sector:***

   Deployed as a soluble dietary fiber raw material in fiber powder supplements, probiotic formulations and food for special medical uses, targeting gut health and weight management consumer segments.

4. ***Daily Chemical & Personal Care Sector:***

   Possessing excellent thickening, moisturizing, dispersing and mild film-forming properties, SSPS is incorporated into skincare lotions, facial masks, toothpaste and hair & body cleansing products as a naturally derived plant-based auxiliary agent.

5. ***Emerging Vertical Sectors:***

   Gradual market penetration into pet food, animal feed and pharmaceutical excipients continuously broadens industrial application boundaries.

Additionally, compound colloid formulation has become a key R&D focus. Blending SSPS with pectin, seaweed polysaccharides, prebiotics and other hydrocolloids delivers synergistic functional performance and cost optimization, consistently amplifying the overall commercial value of SSPS.

Part VI: Future Industry Outlook

After over 70 years of fundamental research and more than 40 years of industrial development, soluble soybean polysaccharide has undergone a remarkable transformation from an unknown minor component of soybean processing waste to a universally adopted natural functional ingredient worldwide. A comprehensive modern industrial ecosystem has been established, supported by solid theoretical foundations, eco-friendly manufacturing processes, complete standardization frameworks, diversified application channels and fully integrated industrial supply chains. Decades of technological dedication from global researchers and pragmatic innovation across the industrial chain have enabled high-value valorization of agricultural by-products, embodying circular economic principles and shaping the current mature SSPS industrial landscape.

Based on prevailing global trends including health-conscious consumption, clean-label formulation, dual-carbon environmental targets and full-resource utilization of agricultural by-products, the SSPS industry will evolve along five core development trajectories in the coming years:

1. ***Continuous Green & Intelligent Technology Advancement***

Deepen deployment of eco-friendly manufacturing technologies including bio-enzymatic hydrolysis, membrane separation and low-temperature concentration; advance full-process automation and intelligent production upgrades to further reduce energy consumption and three-waste emissions, developing zero-carbon closed-loop manufacturing lines. R&D will target targeted molecular modification and precise fractional separation technologies to continuously enhance comprehensive product performance.

2. ***High-End Customized Product Development***

Focus R&D efforts on high-value niche verticals including medical food for special dietary uses, premium skincare cosmetics, pharmaceutical excipients and high-grade pet food. Develop ultra-high-purity customized products with narrow molecular weight distribution and selectively enhanced functional attributes to boost product premium pricing power and global core competitiveness.

3. ***In-Depth Functional Mechanism Research***

Scale up fundamental research on physiological functionalities, exploring antioxidant activity, immune regulation, intestinal barrier protection and other beneficial biological effects. Facilitate SSPS's upgrade from a functional processing ingredient to a core functional health raw material, underpinning expansion of the general health industry.

4. ***Sustained Cross-Sector Application Expansion***

While consolidating market share within traditional food and beverage sectors, continuously explore emerging high-growth verticals including plant-based foods, ready-to-cook meals, medical aesthetic skincare and biomaterials to unlock new market growth potential.

5. Full Industrial Chain Circularization

Optimize the closed-loop industrial cycle covering soybean processing, soybean dreg utilization, polysaccharide extraction and residual waste recycling to maximize the economic value of agricultural by-products and strengthen the industry's sustainable development capacity.

Moving forward, China will leverage its inherent advantages in raw material supply, core technology, large-scale production capacity and standardized systems to maintain its leading global position within the SSPS industry, steering worldwide technological iteration, standard upgrading and application innovation. Driven by global megatrends favoring natural ingredients, healthy dietary patterns and circular economic development, the market value and industrial influence of soluble soybean polysaccharide will continue to rise, supporting coordinated high-quality growth across the global food manufacturing, general health and agricultural deep processing industries.