Development History of Spirulina Powder Industry

Part I: A Tribute to the Pioneers

As a premium natural photosynthetic microalgae resource, spirulina has undergone more than a century of scientific research and over 50 years of industrial development, forming a complete industrial chain covering strain breeding, large-scale cultivation, harvesting and dehydration, intensive powder processing, and bioactive substance enrichment. Boasting abundant nutritional components and excellent application properties, spirulina products are widely used in food, health food, feed & aquaculture, daily chemical raw materials and other sectors, ranking among the world's mainstream natural functional raw materials.

The growth of this industry is inseparable from the dedicated efforts of global algologists, engineering technicians, standard-setters and practitioners across the entire industrial chain. We hereby pay sincere tribute to all research teams, institutions and enterprises engaged in fundamental spirulina research, process optimization, safety assessment, standard formulation, application development and global market promotion.

Roll of Honour

(I) Core Scientists and Researchers (Chronologically Ordered by Research Achievements)

1. ***P. Dangeard (France):***

   Algologist specializing in taxonomy. In the early 20th century, he completed morphological observation and formal nomenclature of spirulina, established an early taxonomic system and laid the foundation for species research.

2. ***R. Clement (France):***

   In 1940, he documented the indigenous African tradition of consuming wild spirulina, verified its edibility and nutritional value, and pioneered research on spirulina as a usable resource.

3. ***J. Leonard (Belgium):***

   In the 1950s, he conducted specialized research on the two major commercial species *Arthrospira platensis* and *Arthrospira maxima*, and established screening criteria for edible algae strains.

4. ***W.J. Oswald (USA):***

   In the 1960s, he broke through laboratory artificial cultivation technology, verified the feasibility of mass farming, and kicked off industrial R&D of spirulina.

5. ***T. Watanabe (Japan):***

   In the 1970s, he developed the open raceway pond cultivation process, built a standardized farming system and promoted pilot-scale mass production of the technology.

6. ***H. Takahashi (Japan):***

   In the 1980s, he carried out efficacy studies and proved spirulina's antioxidant, immune-regulating and anti-fatigue effects, underpinning its functional applications.

7. ***M. Weber (Germany):***

   In the 1990s, he led multi-dimensional safety and toxicological evaluations, facilitated spirulina's market access in Europe and the United States, and improved the international compliance framework.

8. ***Joint FAO/WHO Expert Committee on Food Additives (JECFA):***

   At the end of the 1990s, it formulated globally unified quality standards and usage specifications, standardizing international trade and testing protocols.

9. ***Algae Research Team, Institute of Hydrobiology, Chinese Academy of Sciences:***

   Starting from the 1980s, the team introduced, domesticated and improved spirulina strains, developed localized ecological cultivation technologies, and realized domestication of algae strains.

10. ***Professor Zhang Xuecheng (Ocean University of China):***

    In the 1990s, he optimized spirulina powder processing techniques and quality inspection systems, driving the upgrade from primary products to high-activity refined derivatives.

11. ***Professor Duan Shunshan (Jinan University):***

    He has long dedicated himself to functional mechanism research and eco-friendly cultivation technologies, participated in drafting national and industrial standards, and led the standardization and ecological transformation of China's domestic industry.

(II) Core Research Institutions and University Teams

1. ***Algae Laboratory, National Museum of Natural History, Paris, France:***

   The birthplace of fundamental spirulina research, preserving early species research data and algae strain resources.

2. ***Department of Bioengineering, University of California, Berkeley, USA:***

   Established core theories and process parameters for artificial cultivation; its technical protocols have been widely adopted worldwide.

3. ***National Institute of Food Science and Technology, Japan:***

   Focuses on cultivation, refining and application technologies, and led early iterations of industrialization technologies in Asia.

4. ***Food Raw Material Assessment Center, European Food Safety Authority (EFSA):***

   Completed regional risk assessments for Europe and built the local market compliance system.

5. ***Institute of Hydrobiology, Chinese Academy of Sciences:***

   China's core R&D platform for strain breeding, preservation and eco-friendly cultivation technologies.

6. ***College of Food Science and Engineering, Ocean University of China:***

   Concentrates on deep processing, quality control and application research of spirulina powder, and deeply participates in formulating and revising domestic standards.

7. ***College of Life Science, Jinan University:***

   Studies nutritional efficacy and circular cultivation models to advance sustainable industrial development.

(III) Benchmark Enterprises

In accordance with industry competition norms and enterprise privacy protection principles, no specific enterprise rankings are listed in this section. We extend our sincere gratitude to all domestic and overseas enterprises that have made outstanding contributions to the development of this industry.

Part II: Research and Development History of Spirulina

(I) Species Discovery and Fundamental Biological Research (Early 20th Century – 1950s)

In the early 20th century, European scholars carried out cyanobacteria research, completed morphological observation and official naming of spirulina, and clarified its biological classification. In 1940, studies confirmed the high edible value of wild spirulina, formally incorporating the species into resource research scope.

From 1940 to 1959, the industry completed a global survey of wild spirulina resources, identified the two dominant commercial species, and clarified the growth characteristics and nutritional differences of various strains. This phase mainly consisted of field investigations, taxonomic classification and basic nutritional analysis, only accumulating theoretical data without launching artificial cultivation or industrial exploration.

(II) Exploration of Artificial Cultivation Technology (1960s)

Driven by demand for new nutritional resources, overseas research teams conducted lab-scale pure culture trials, explored key parameters including light intensity, temperature and culture medium, achieved stable indoor cultivation of spirulina, and verified the technical viability of artificial farming.

Research teams compared various cultivation modes, resolved issues such as strain contamination and low reproduction rates, and conducted preliminary toxicological tests simultaneously to confirm the edibility safety of artificially cultured spirulina biomass. This stage built a solid reserve of laboratory technologies, laying a foundation for subsequent pilot and industrial-scale farming.

(III) Process Maturation and Early Overseas Industrialization (1970s)

Leveraging natural salt lake resources, Mexico built the world’s first open-air cultivation base, enabling formal industrial mass production of spirulina. In the same period, Japan developed standardized open cultivation processes and perfected supporting production workflows including harvesting and drying.

Systematic global safety evaluations confirmed spirulina to be non-toxic and free of teratogenic risks. As its nutritional and health benefits were widely validated, spirulina was repositioned from an ordinary food ingredient to a natural nutritional supplement raw material. The industry initially formed a landscape with the Americas as the core production region and Japan following up with industrial layouts.

(IV) In-depth Functional Research and Technology Introduction & Accumulation (1980s)

Japan localized and improved cultivation and processing technologies, launching Asia's first large-scale production line. Academic circles thoroughly analyzed the action mechanisms of spirulina's bioactive components, defined its functional values, and drove product transformation into high-end ingredients.

Spirulina successively obtained market access qualifications in multiple countries, creating mature conditions for global circulation. Domestic research institutes began introducing overseas strains and cultivation technologies to carry out localized domestication and small-scale trials, marking the start of China's technology accumulation phase.

(V) Domestic Mass Production and Process Iteration (1990s)

China improved algae strains and cultivation processes adapted to local water environments, breeding superior varieties suited for domestic production zones. In the mid-1990s, local enterprises built large full-industry-chain production lines to realize independent mass production of spirulina powder, breaking the monopoly of foreign products. The industry continuously optimized processing technologies such as drying and deodorization to enhance product sensory quality and retention rate of bioactive components, while establishing comprehensive internal enterprise control standards. A number of Chinese enterprises entered the microalgae sector, set up professional R&D teams, completed strain screening, domestication and culture medium optimization, overcame key farming technical hurdles, successfully finished lab small trials and pilot tests, and accumulated core production technologies.

By the late 1990s, two major industrial clusters took shape in Yunnan and Inner Mongolia. China's domestic output rose steadily, supplying spirulina powder to the local market while achieving small-scale exports gradually.

(VI) Production Capacity Expansion and Product Segmentation (Early 21st Century – 2009)

Global demand for healthy consumer goods kept growing, shifting the industry focus to intensive processing and bioactive component research, and continuously enriching the product functional system. China's domestic cultivation industry developed intensively and ecologically, with output ranking first worldwide. Four product grades were classified based on application scenarios: health grade, food grade, feed grade and aquaculture feed grade.

Comprehensive upgrades to processing technologies greatly improved product stability and overall quality. Leading domestic enterprises built standardized cultivation and processing production lines based on accumulated technologies, realizing mass production of basic spirulina powder, tapping into China's health food and regular dietary

markets, and increasing investment in intensive processing R&D.

China initiated the formulation of national and industrial standards, guiding the industry away from extensive development modes. Relying on advantages in output and cost, domestically produced spirulina powder was exported in large volumes, gradually shifting the global raw material supply landscape toward China.

(VII) Standard Perfection and High-end Industrial Upgrade (2010 – Present)

Global markets have raised continuous requirements for product safety and bioactivity indicators. China successively issued standards covering the full workflow of cultivation, production and testing, with multiple safety indicators stricter than international norms. Industry market access thresholds were lifted, and backward production capacity was gradually phased out.

Domestic enterprises collaborated with research institutions to tackle technologies including high-purity refining, targeted modification and specialized strain breeding, bringing the quality of high-end products up to world-class standards. Eco-circular cultivation has become the mainstream industry model. Leading enterprises expanded intensive processing lines, launched customized high-activity products, developed compound spirulina powder and scenario-specific formulas, and obtained cross-regional international compliance certifications, resulting in increasingly sophisticated technical R&D and compliance systems.

Currently, spirulina application scenarios keep expanding. China’s high-end domestic products have successfully entered global high-end supply chains, forming an industrial landscape featuring differentiated competition and coordinated development between Chinese and foreign enterprises.

Part III: Commercialization Development History of Spirulina

(I) Wild Utilization and Technology Accumulation Phase (Early 20th Century – 1960s)

No industrial commercial circulation existed in this period. Residents in Africa and Central America maintained the tradition of foraging wild spirulina, which only served as a regional natural food material. Global research focused on species analysis and laboratory cultivation. Although the feasibility of artificial farming was verified, limitations in process technology and market conditions prevented the formation of a commercial system; the core achievement of this phase was the accumulation of theoretical and technical foundations.

(II) Birth of Commercialization and American Dominance Phase (1970s)

Mexican enterprises took the lead in industrial mass production, officially launching spirulina powder onto the commodity market. Early-stage products were mainly crude dried spirulina powder positioned as nutritional supplements, supplied primarily to North American and local markets with limited application scenarios and small overall market scale. American enterprises dominated global output and market share.

(III) Rise of Asia and Initial Market Expansion Phase (1980s)

Japan realized technology implementation and mass production, launching diversified end products such as tablets and capsules sold to Southeast Asia, Europe and the Americas, fueling the rapid rise of the Asian market. Market access certifications were obtained in numerous countries, gradually removing international trade barriers and forming two core production regions: the Americas and Japan. China’s domestic market fully relied on imported products with no local commercialization in place.

(IV) Domestic Industrialization Implementation Phase (1990s)

Leading Chinese enterprises achieved mass production, and domestically manufactured spirulina powder was officially launched, kicking off the import substitution process. The industry formed two core production zones leveraging local water resources. Early domestic products were mainly mid-to-low end food-grade and feed-grade powder, while high-end markets remained occupied by foreign brands. A number of Chinese enterprises focused on process polishing and pilot production line layout without launching large-scale commercial operations.

China’s domestic consumer market was gradually cultivated, shaping a tripartite global industrial pattern of the Americas, Japan and China.

(V) Global Output Leadership and Restructured Global Market Landscape Phase (Early 21st Century – 2009)

China’s domestic output surged, making it the world’s largest producer and exporter. Clear industrial division took shape: foreign enterprises focused on high-end organic products and consumer brands, while Chinese enterprises supplied full-spectrum raw materials as the core global supplier of basic spirulina powder.

Major domestic enterprises achieved full-scale mass production, supplying basic spirulina powder to food, health, livestock and aquaculture sectors. Meanwhile, they initiated overseas market compliance certification and channel layout, maturing the full-industry-chain business model and establishing a formal tiered competition pattern between Chinese and foreign products.

(VI) Standardized Development and Full-scenario Market Penetration Phase (2010 – Present)

The industry entered a standardized development era, with market competition shifting from price rivalry to comprehensive competition covering quality, technology and service. Spirulina has fully penetrated food, health products, feed, daily chemicals, pet food, special dietary foods and other sectors, upgrading the business model into an integrated system of "raw materials + customized formulas + technical services".

Industry enterprises focused on high-value customized products and deepened development of high-end segmented tracks, exporting finished products to overseas markets and completing full-channel layout at home and abroad. The current global market landscape has stabilized: China dominates bulk and mid-tier markets, while foreign enterprises specialize in high-end segmented niches, enabling sound coordinated industrial development.

Part IV: Construction History of Industry Standard System

(I) Initial Establishment of International Standards (1970s – Late 1990s)

In the early industrialization stage, enterprises in different countries followed internal quality control standards with inconsistent indicators, leading to chaotic cross-border trade rules. From the 1970s to the 1980s, Europe, the United States and Japan issued regional guiding specifications aligned with local regulations, setting limits for basic indicators including moisture, heavy metals and microorganisms.

In the 1990s, JECFA released universal global standards for spirulina, clarifying product definitions, grading, indicator limits and testing methods. Subsequently, the United States, Japan and the EU adopted and localized these standards, basically forming a globally interoperable standard framework.

(II) Improvement of Domestic Standard System (Early 21st Century – 2019)

In the early 2000s, China's domestic industry developed rapidly yet lacked unified national standards, resulting in frequent industrial irregularities. Competent authorities collaborated with research institutes and leading enterprises to launch standard formulation work, successively releasing national and industrial standards covering product quality, cultivation specifications, testing methods, storage and transportation requirements. Multiple safety indicators are stricter than international standards, and the permitted application scope of spirulina in regular food and health food was clearly defined.

Special supporting specifications targeting segmented sectors including feed and daily chemicals were issued, ultimately building a complete system composed of national standards, industrial standards and segmented sector specifications, pushing the entire industry into standardized development.

(III) Standard Iteration and Global Leadership (2020 – Present)

Aligned with the industry's trends of high-end and green development, China has continuously revised and upgraded existing standards by tightening safety indicators, optimizing testing methods and strengthening full-process supervision. Benefiting from the rigor and operability of its standards, Chinese specifications have gradually become vital global industry references, and domestic enterprises have gained growing discourse power in international standard-setting.

Part V: Expansion of End Applications and In-depth Functional Research

(I) Basic Nutritional Supplement Stage (1970s – 1990s)

In the early industrial stage, spirulina powder was positioned as a high-protein nutritional supplement, mainly processed into powder, tablets and capsules for health care applications. Restricted by technical and research capabilities, products featured single functionality, narrow application scenarios and limited varieties of intensive processed derivatives.

(II) Diversified Functionality and Popularization in Traditional Sectors (Early 21st Century – 2009)

Spirulina's multiple benefits including anti-oxidation, intestinal regulation and immunity enhancement were fully validated, upgrading its product value from a single nutritional supplement to a functional raw material. Application scenarios expanded to regular food, frozen beverages, condiments, livestock and aquaculture feed and other fields. Industry products achieved large-scale coverage of mainstream markets, rapidly expanding market volume and establishing spirulina as a routine ingredient across multiple industries.

(III) Precision Customization and Cross-industry Diversified Applications (2010 – Present)

In response to global industry trends of natural wellness and clean label, the industry has launched scenario-based customized services and developed dedicated products for different sectors: high-activity spirulina powder for the wellness sector used in dietary supplements and special foods; natural nutritional fortifiers and colorants for the food industry; eco-friendly feed raw materials for agriculture, livestock and aquaculture; while continuously tapping emerging tracks including daily chemicals, pet food and biological raw materials.

Compound blending technologies have been widely adopted to boost functional efficacy by combining spirulina with probiotics, dietary fiber and other raw materials. Industry

enterprises have developed customized products and supporting solutions for segmented scenarios, building differentiated competitive advantages in high-end and cross-industry application fields.

Part VI: Future Outlook of the Industry

After over a century of research and more than 50 years of industrial development, spirulina has established a complete modern industrial system. Aligned with global trends including natural wellness, green low-carbon development, circular economy and segmented consumption upgrading, the industry will advance along five core directions in the future:

1. **Green and Intelligent Production Modes:**

   Promote eco-circular cultivation, tailwater recycling and green pest control technologies; advance automation and intelligent upgrading of production lines; deepen strain breeding to develop specialized varieties with high bioactivity and strong stress resistance.

2. **High-end Customized Products:**

   Focus on high-value categories including organic spirulina powder, medical food raw materials and high-purity daily chemical raw materials; develop customized indicator products and narrow-specification derivatives to lift product competitiveness and profit margins.

3. **In-depth Fundamental Research:**

   Explore the action mechanisms and targeted efficacy of bioactive components, perfect the functional theoretical system to support high-end product R&D and compliant functional claims.

4. **Continuous Expansion of Application Scenarios:**

   Consolidate traditional markets while tapping emerging sectors such as plant-based food, ready-to-cook meals and biomaterials to unlock incremental market potential.

5. **Global Collaboration and Standard Export:**

   Leverage strengths in production capacity, technology and full industrial chains to elevate international discourse power, promote Chinese technologies and standards worldwide, and deepen cross-border industrial collaboration.

Supported by its core advantages of natural origin, rich nutrition and high safety, the spirulina industry will steadily advance toward high-end, functional and internationalized development, delivering greater value to the global wellness and agricultural deep processing sectors.