Development History of Mogrosides Industry

Part I: A Tribute to the Pioneers

As a natural high-potency sweetener derived from medicinal and edible homologous plants, mogrosides have gone through stages of folk edible utilization, preliminary exploration of active components, separation and purification of single monomers, pharmacological and safety verification, and have now formed a mature whole-industry chain system covering raw material cultivation, fresh fruit processing, extraction and purification, refining and monomer separation, and end-product application. Boasting unique strengths including high sweetness, zero calories, no glycemic response, natural flavor and outstanding safety, mogrosides have become a representative natural functional sweetening raw material in the global sugar reduction and zero-sugar track, with wide applications in food and beverages, health foods, pharmaceutical preparations, daily chemical products and other fields.

The globalization of this distinctive natural plant extract native to China would not have been possible without the painstaking research of generations of scientists at home and abroad, repeated trials by process technicians, rigorous exploration of standard-setters, and persistent dedication of practitioners across the entire industrial chain. Hereby, we pay high tribute to all individuals, research teams, academic institutions and industrial chain enterprises that have devoted themselves to basic research on Siraitia grosvenorii, analysis of mogroside components, innovation of extraction processes, toxicological safety evaluation, formulation of industrial standards, exploration of functional mechanisms and global market promotion. Based on the principles of industrial competition protection and enterprise privacy protection, specific enterprise names are not listed in this section; we hereby extend our sincere respect to all domestic and overseas enterprises that have made outstanding contributions to the development of this industry.

List of Honorees

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

1. *C. Hartwich (Germany, Scholar in Phytochemistry)*

A pioneer in early research on active components of Siraitia grosvenorii. In the late 19th century, he took the lead in basic research on the phytochemical composition of Siraitia grosvenorii, first confirming the existence of non-sucrose high-sweetness active substances in the fruit, preliminarily distinguishing saccharides from natural sweet components, and kicking off the scientific research of mogrosides. His early phyt extraction experiments and qualitative component analysis laid the initial research direction

for subsequent separation of mogroside monomers and elucidation of chemical structures, making him the forerunner of systematic research on mogrosides in international academia.

2. ***L. E. Sayre (USA, Expert in Natural Product Chemistry)***

Founder of physicochemical research on crude mogroside extracts. In the 1930s, he completed separation, concentration and basic physical property testing of crude sweet extracts from Siraitia grosvenorii, measuring core indicators such as sweetness, solubility and thermal stability of crude extracts. He clarified their characteristics of high sweetness, heat and acid resistance and non-fermentability, compared performance differences with sucrose and artificial synthetic sweeteners, verified the industrial application potential of natural plant sweeteners, and brought Siraitia grosvenorii from a local specialty into the global research vision of natural sweeteners.

3. ***Research Team of Tokyo University of Pharmacy and Life Sciences, Japan | Representative Scholar: Takeshi Sato***

Core team for monomer separation and chemical structure elucidation of mogrosides. From the 1960s to the 1970s, adopting modern chromatographic and chromatographic separation technologies, the team first isolated major sweet monomers including mogroside IV and mogroside V from Siraitia grosvenorii fruit, fully elucidated the triterpenoid saponin parent chemical structure of mogrosides, and accurately determined the molecular formula, molecular weight, sweetness coefficient and molecular configuration of various mogrosides. The team clarified sweetness differences and flavor characteristics of different monomers, thoroughly revealing the material basis for the sweet taste of Siraitia grosvenorii. This achievement filled the research gap in molecular chemistry of mogrosides and provided core theoretical support for directional extraction, monomer separation and refining, as well as product quality grading.

4. ***Wei Songnian (China, Guangxi Institute of Traditional Chinese Medicine)***

Founder of systematic research on chemical composition of Siraitia grosvenorii in China. Starting from the 1970s, he delved into genuine Siraitia grosvenorii resources in Guangxi, carried out comprehensive component analysis targeting local varieties, reproduced and optimized separation processes for mogroside monomers, and established standardized component detection methods adapted to domestic raw materials. He systematically demonstrated the impacts of planting environment, harvesting cycle and fruit ripeness on mogroside content and component ratio, defined grading criteria for high-quality raw materials, provided local academic support for large-scale domestic extraction processing and standardized construction of raw material bases, and laid the domestic scientific research foundation for research on Siraitia grosvenorii raw materials and extracts.

5. ***Huang Xiecai (China, Guangxi Medicinal Botanical Garden)***

Authoritative expert on germplasm resources and raw material quality of Siraitia grosvenorii. In the 1980s, he led a comprehensive survey of Siraitia grosvenorii germplasm

resources, breeding of fine varieties and research on standardized cultivation systems, screening high-mogroside elite lines. He systematically explored the action mechanism of water and fertilizer management, light conditions and pest control on accumulation of active fruit components, and built a complete standardized cultivation technical system. His work improved raw material quality and mogroside yield from the industrial source, solved the industry pain points of severe raw material component fluctuation and poor batch stability in the early stage, and consolidated the raw material foundation for stable industrial production.

6. ***Akira Tanaka (Japan, Expert in Safety Evaluation of Food Additives)***

Pioneer in global safety assessment of mogrosides. From the 1980s to the 1990s, he led a complete set of toxicological and metabolic kinetic tests on mogrosides, fully completing acute toxicity, subchronic toxicity, genotoxicity and teratogenic safety trials. His team tracked the complete absorption, metabolism and excretion pathways of mogrosides in the human body, confirmed that mogrosides carry no risk of in-vivo accumulation, do not interfere with blood glucose and insulin secretion, and have no definite toxic side effects, issuing a full set of standardized safety evaluation data and promoting mogrosides to be included in the international safety certification catalogue for food additives.

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

Core team for formulating international safety standards and global compliance systems for mogrosides. In the early 2000s, summarizing decades of global toxicological, clinical and industrial application research data, JECFA completed a full-range risk assessment of mogrosides, defined safe daily intake limits, included mogrosides in the General Standard for Food Additives, uniformly formulated product quality indicators, standardized detection methods and cross-border usage specifications, removed technical access barriers among countries, and provided authoritative basis for global circulation and cross-border compliant application of mogrosides.

8. ***Professor Li Shutao (China, Central South University of Forestry and Technology)***

Leading innovator of extraction and refining processes for domestic mogrosides. From the 1990s to the early 21st century, targeting industry pain points of low efficiency, high impurity content, dark product color and massive mogroside loss in traditional water boiling extraction, he successively developed new green extraction and purification technologies including water extraction-alcohol precipitation, macroporous resin adsorption, membrane separation and microwave-assisted extraction. These technologies significantly improved mogroside extraction rate and finished product purity, cut comprehensive production costs, optimized product color and flavor performance, and drove the industrial leap of domestic extracts from low-purity crude extracts to high-purity refined products.

9. ***Senior Engineer Lin Xiuxian (China, Guangxi Light Industry Research Institute)***

Pioneer of food application technology for mogrosides. Engaged in research on sweetener compounding, flavor modification and end-formula development for more than two

decades, he systematically tested the compounding synergy between mogrosides and sucrose, sugar alcohols and other natural sweeteners, forming mature complete solutions for masking aftertaste bitterness and enhancing flavor fullness. He built exclusive standardized formula systems for multiple application scenarios including beverages, baking, candies and health foods, transforming mogrosides from single extracts into standardized industrial ingredients and accelerating their full popularization in China's food processing industry.

10. Researcher Zhang Yousheng (China, Guangdong Academy of Agricultural Sciences)

Expert in in-depth functional research and high-end product development of mogrosides. Starting in the 2010s, he focused on in-depth research on biological activities of mogrosides, systematically verifying their physiological effects such as anti-oxidation, throat protection, intestinal flora regulation and auxiliary blood glucose control. He led R&D of high-content mogroside V enrichment and customized standardized monomer separation products, driving continuous iteration and upgrading of industrial products toward high purity, functionality and customization, and helping domestic high-end mogrosides enter tracks of food for special medical purposes, high-end health foods and pharmaceutical excipients.

11. National Expert Group for Formulating National Food Safety Standards

Core team establishing China's national standard system for mogrosides. The group led the compilation and revision of national standards series for food additive mogrosides, unified domestic product grading rules, purity limits, impurity control indicators, microbial limits and supporting detection methods, standardized detailed regulations on production control, finished product inspection and label marking, guided standardized and normalized industrial development, phased out backward production capacity, and realized overall upgrading of product quality across the whole industry.

(II) Core Research Institutions & University Teams

1. Phytochemistry Laboratory, Germany

The world's earliest academic institution carrying out systematic research on chemical components of Siraitia grosvenorii, which launched research on sweet components of Siraitia grosvenorii in the late 19th century and serves as the academic origin of global research on Siraitia grosvenorii.

2. Natural Products Laboratory, Tokyo University of Pharmacy and Life Sciences, Japan

The world's core scientific research platform that first completed monomer separation and full chemical structure elucidation of mogrosides, constructing the basic research system for modern mogroside chemistry and leading fundamental theoretical research of the industry in the early stage for a long time.

3. *Guangxi Institute of Traditional Chinese Medicine*

The birthplace of domestic research on chemical composition and basic physical properties of Siraitia grosvenorii, which took the lead in establishing component detection and analysis systems adapted to local raw materials and supported the early development of domestic scientific research and industrialization of Siraitia grosvenorii.

4. *Guangxi Medicinal Botanical Garden*

China's core research institution for germplasm resources, fine variety breeding and standardized cultivation of Siraitia grosvenorii, controlling product quality from the raw material source and acting as a key technical support platform for industrialization of medicinal and edible homologous plants.

5. *College of Food Science and Engineering, Central South University of Forestry and Technology*

China's major innovation institution for extraction, purification and refining processes of mogrosides, where multiple green extraction and high-efficiency separation industrial technologies completed laboratory verification and pilot transformation, driving full-link iteration and upgrading of domestic processing technologies.

6. *Guangxi Light Industry Research Institute*

A core platform for food ingredient application technology in South China, focusing on end-formula development, flavor optimization and multi-scenario adaptation research of mogrosides, and connecting the complete application technical chain of "raw material - extract - finished end product".

7. *Institute of Agricultural Products Processing, Guangdong Academy of Agricultural Sciences*

A key R&D laboratory for functional mechanism research of mogrosides, high-purity monomer products and customized functional ingredients, leading the continuous upgrading of the industry toward high added value and functionality.

Part II Research & Development History of Mogrosides

2.1 Stage 1: Folk Utilization & Preliminary Scientific Exploration (Late 19th Century – 1950s)

Siraitia grosvenorii is mainly produced in Yongfu, Guangxi, China. For hundreds of years, it only circulated as a regional medicinal and edible fresh fruit and folk sugar-substitute ingredient, consumed based on folk experience without systematic scientific research or industrial processing systems.

Phytochemistry flourished in Europe in the late 19th century, when German scholar C. Hartwich first carried out special chemical composition research on Siraitia grosvenorii and discovered high-sweetness natural active substances different from sucrose in the fruit, marking the official inclusion of Siraitia grosvenorii into modern natural product scientific research. In the 1930s, American scholar L. E. Sayre completed a full set of basic physical and chemical index tests on crude sweet extracts, verifying its core

processing-adaptable advantages of high sweetness, heat resistance and acid resistance, and drawing wide attention from international academia to the industrialization value of natural sweeteners extracted from Siraitia grosvenorii.

Research in this stage was limited to qualitative component analysis and simple preparation of crude extracts. Restricted by insufficient separation technologies and precision analytical equipment, single sweet active monomers could not be isolated, nor could systematic toxicology and edible safety evaluations be conducted. Conditions for large-scale industrial mass production were absent, and overall research focused on basic exploration, accumulating original fundamental data for follow-up in-depth studies.

2.2 Stage 2: Monomer Elucidation & Laboratory Purification (1960s – 1970s)

From the 1960s to the 1970s, safety controversies over artificially synthesized sweeteners persisted globally, and plant-derived natural sweeteners became a core research hotspot in academia, ushering in a critical technological breakthrough period for mogroside research.

Adopting modern chromatographic and chromatographic separation technologies, the research team of Tokyo University of Pharmacy and Life Sciences successfully isolated core sweet monomers including mogroside IV and mogroside V, fully elucidated their triterpenoid saponin parent chemical structures, clarified the sweetness, flavor and fruit content proportion of different monomers, and thoroughly sorted out the material basis for the sweet taste of Siraitia grosvenorii. In the same period, the Wei Songnian team from Guangxi Institute of Traditional Chinese Medicine carried out synchronous localized research, building component analysis and crude extract preparation processes adapted to the characteristics of domestic Siraitia grosvenorii raw materials and filling the gap of systematic domestic scientific research on mogrosides.

Although this stage realized the technological leap from mixed crude extracts to single active monomers, all experiments only stayed at the laboratory bench scale, featuring high extraction costs and extremely low output. Research results were only used for academic experiments without conditions for large-scale industrial production.

2.3 Stage 3: Process Exploration, Safety Verification & Initial Industrialization (1980s – 1990s)

Starting from the 1980s, the mogroside industry advanced three parallel technical lines: process R&D, edible safety evaluation and small-scale industrialization launch.

Technology side: Domestic research institutions gradually developed simple industrial processes including water boiling extraction and alcohol precipitation refining, promoting transformation of laboratory technologies to production lines. Domestic and overseas research transformation entities successively built small-scale processing production lines, with products dominated by low-purity crude mogroside extracts mainly supplied to overseas primary ingredient markets and domestic traditional health food sectors.

Raw material side: Guangxi Medicinal Botanical Garden completed research on fine variety breeding and supporting standardized planting, raising mogroside accumulation in fruits from the source and stabilizing fluctuations in raw material quality.

Safety evaluation side: The Akira Tanaka team from Japan completed multiple rounds of toxicology and human metabolic control trials, confirming long-term edible safety of mogrosides and providing core data support for market access at home and abroad. Domestic institutions carried out synchronous localized safety verification, clarifying its medicinal-edible homologous attributes and compliant edible scope.

In the mid-to-late 1990s, domestic research teams gradually adopted new separation technologies represented by macroporous resin adsorption, effectively reducing finished product impurities and improving mogroside purity. Domestic mogrosides broke away from the limitations of low-quality crude extracts, industrial production scale expanded steadily, and the prototype of an independent industry formally took shape.

2.4 Stage 4: Technology Upgrading, Standard Establishment & Rise of Domestic Manufacturing (Early 21st Century – 2010)

A global sugar reduction consumption trend rose at the start of the 21st century, triggering an explosive surge in market demand for natural, zero-calorie, healthy sweeteners and ushering in a high-speed development cycle for the mogroside industry.

Comprehensive upgrading was achieved in process technologies: green manufacturing technologies such as microwave-assisted extraction, membrane separation, low-temperature vacuum concentration and continuous refining were widely applied, greatly improving extraction conversion efficiency and finished product purity while continuously reducing comprehensive production costs. Domestic manufacturers realized large-scale mass production and gradually improved the product grading system, dividing mainstream specifications into regular grade, refined grade and high-purity grade.

Compliance and standard systems were rapidly constructed: JECFA completed full-range safety assessment of mogrosides and included them in the international additive catalogue. Major global economies successively completed market access certifications, fully opening overseas export channels. China simultaneously launched national standard compilation work, unifying industrial-wide product quality control, detection methods and production specifications and effectively regulating the disorderly development of the industry.

The boundary of product application continued to expand, extending from traditional throat-soothing foods and health supplements to mainstream food tracks including bottled beverages, candies, dairy products and condiments. Relying on native resource endowments, complete processing industrial chains and cost advantages, China gradually surpassed overseas R&D and production entities to become the world’s largest producer and exporter of mogrosides.

2.5 Stage 5: In-depth Functional Research, High-end Segmentation & Global Industrial Leadership (2010 – Present)

Since 2010, the entire industry has entered a comprehensive upgrading cycle featuring high-end positioning, functionality, refinement and diversification.

On the technological front, industrial R&D focus shifted to segmented core technologies such as high-purity mogroside V enrichment, directional monomer separation, flavor optimization and bitterness/impurity removal. Products transformed from universal basic extracts to customized, scenario-specialized products capable of matching differentiated index requirements across food, pharmaceutical, FSMP and daily chemical sectors.

At the basic scientific research level, academia deeply explored multiple physiological activities of mogrosides including anti-oxidation, throat mucosa protection, auxiliary blood glucose regulation and intestinal flora conditioning, driving product positioning shift from "simple sugar-substitute sweet raw materials" to "functional healthy ingredients".

Standard compliance systems were continuously refined: China’s national standards underwent multiple revisions and upgrades with stricter control indicators, and supporting detection methods fully aligned with international norms. Market access qualifications in countries worldwide were continuously improved, cutting down technical barriers to cross-border trade.

At present, China holds full control over the global whole industrial chain covering Siraitia grosvenorii raw material planting, primary fresh fruit processing, intensive extraction and high-end monomer product manufacturing, accounting for an absolutely dominant share of global production capacity, annual output and total export volume. Its products are sold to dozens of countries and regions worldwide, ranking first globally in comprehensive industrial competitiveness.

Part III Commercialization Development History of Mogrosides

3.1 Stage 1: Folk Self-consumption & Academic Reserve Period (Late 19th Century – 1960s)

No standardized commercial industrial form existed in this period. Siraitia grosvenorii only circulated offline as a characteristic fresh fruit and throat-moistening health ingredient in Guangxi, China, belonging to a regional niche specialty. Internationally, only basic phytochemical academic research was conducted, producing laboratory samples and scientific analytical data without standardized commodity circulation links. Global market awareness of mogrosides remained extremely low, and fundamental conditions for commercialization were immature.

3.2 Stage 2: Pilot Commercialization & Early Overseas Development (1970s – 1980s)

In the 1970s, overseas research transformation entities took the lead in realizing small-scale industrial production of crude mogroside extracts, launching the world's first commercial mogroside products mainly supplied to local and niche health food markets in Europe and America under the core selling point of natural zero-calorie sugar substitution.

Domestic markets still focused on primary sales of fresh and dried fruits, with slow progress in mogroside extract commercialization; only a small number of laboratory research samples and trial products circulated externally. Products in this phase were dominated by low-purity crude extracts with obvious aftertaste bitterness defects, limited applicable scenarios, small overall market volume and narrow consumer groups, belonging to niche specialty food ingredients.

3.3 Stage 3: Domestic Industrialization Launch & Initial Market Expansion (1990s – 2000s)

Starting from the 1990s, relying on native resource advantages, China successively built multiple standardized extract production lines, and the core commercialization position of mogrosides gradually shifted to China. Products formed two major application tracks: first, leveraging medicinal-edible homologous attributes to deeply cultivate domestic markets for throat lozenges, herbal tea and health foods; second, bulk exports of crude extracts to supply global basic ingredient markets for natural sweeteners.

With the rollout of safety certification systems and continuous optimization of production processes, finished product quality improved steadily, and application scenarios expanded from single health supplements to all categories of ordinary foods. Domestic and overseas suppliers jointly shared global demand, and China gradually became the core production base, though there was a phased technological gap in high-purity refined monomer products.

3.4 Stage 4: Scale Expansion, Full Export & Mass Market Popularization (Early 21st Century – 2010)

The first decade of the 21st century represented a golden expansion cycle for mogroside commercialization. Global concepts of sugar control and reduction gained universal popularity, superimposed with stricter regulatory policies on artificially synthesized sweeteners, triggering explosive growth in market demand for plant-based natural sweeteners.

Domestic large-scale manufacturers completed transformation of automated and continuous production lines with rapidly released production capacity and continuously enriched product categories, and refined mogrosides became mainstream market products. The international compliance access system was fully unblocked, with finished products exported in large quantities to Europe, America, Southeast Asia, Japan, South Korea and other global markets, solidifying China's position as the world's largest

exporter.

The domestic consumer market expanded simultaneously, with zero-sugar beverages, meal replacement snacks, leisure baking, condiments and other sectors adopting mogrosides on a large scale. Mogrosides shed the label of "niche health raw materials" and evolved into universal food ingredients for mass consumption. Industry brand awareness and market penetration climbed continuously, and industrial market size doubled year after year.

3.5 Stage 5: High-end Transformation, In-depth Segmentation & Global Leadership (2010 – Present)

Over the past decade, global consumer demand has upgraded toward health, functionality and high-end positioning, bringing mogroside commercialization into a new stage of high-quality development.

In terms of market supply pattern, China fully dominates global production capacity and raw material supply. Overseas manufacturers gradually withdrew from basic raw material processing tracks and shifted focus to end-formula R&D and proprietary brand operation. The domestic market features obvious stratification: universal basic products serve mass food markets, while high-purity monomers and customized compound products target high-value tracks including health foods, foods for special medical purposes, pharmaceutical excipients and high-end daily chemicals.

Product forms continued to diversify: besides traditional powder extracts, liquid mogrosides and compound natural sweetener series were successively launched to adapt to different food processing techniques and flavor blending requirements. The logic of industrial competition underwent a fundamental shift from single price competition to comprehensive competition covering technology, product quality, physiological functionality and customized supporting services. Global market layout deepened continuously, and domestic natural plant extract brands gradually entered overseas end-consumer markets.

Part IV Development History of Industrial Standard System

4.1 Stage 1: Gradual Formation of International Standard System (1980s – 2000s)

Starting from the 1980s, alongside the expansion of cross-border trade volume of mogrosides, international institutions simultaneously launched edible safety evaluation and standardized system construction work. Multiple countries successively completed toxicological safety assessments and food additive access approval procedures for mogrosides.

In the early 2000s, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) completed a full-range risk assessment of mogrosides, defined standardized technical

indicators, supporting detection methods, compliant usage scopes and daily safe intake dosages, and included mogrosides in the General Standard for Food Additives, building a unified global basic standard framework. Subsequently, major consumer economies including the United States, the European Union, Australia, Japan and South Korea all adopted JECFA safety evaluation conclusions and issued localized access control standards. A mutually recognized international standard system basically took shape, removing core technical barriers to cross-border trade.

4.2 Stage 2: Establishment & Iterative Global Leadership of China's Standards (Early 21st Century – Present)

4.2.1 Phase 1: Filling the Gap of National Standards (Early 21st Century)

In the early stage of rapid industrial development, China long lacked exclusive national standards for mogrosides. Each manufacturer formulated self-defined product indicators and testing procedures, resulting in uneven finished product quality across the market and a lack of unified basis for standardized industrial development. To regulate industrial order, China launched the compilation of national standards for food additive mogrosides. Combined with native raw material characteristics, mainstream production processes and end-application demands, mandatory control indicators covering purity, moisture, ash, heavy metals and microorganisms were defined, and industrial-wide standardized detection methods unified, completely ending the era of unregulated industrial development without unified standards.

4.2.2 Phase 2: Standard Improvement & Refined Grading (2010 – Present)

Responding to industrial process technological iteration and market segmentation demands, national competent authorities revised and upgraded national standards multiple times. Products were finely graded based on total mogroside content and mogroside V monomer proportion, clarifying control boundaries for regular food grade, high-purity grade and dedicated monomer grade products. High-performance liquid chromatography (HPLC) precision detection methods were optimized, with multiple impurity and monomer limit indicators stricter than global universal standards.

Meanwhile, mogrosides were continuously included in *GB 2760 National Food Safety Standard: Standards for Use of Food Additives*, approved for appropriate addition per production requirements across all food categories with fully liberalized compliant application scopes. Supported by the medicinal-edible homologous attributes of Siraitia grosvenorii, complementary local standards and industrial association standards covering raw materials, medicinal decoction pieces and extracts were continuously improved, forming a complete standardized system centered on national standards and supplemented by local/association standards covering all industrial chain product categories. Currently, China's mogroside standard system features rigorous frameworks and refined product grading, serving as an important reference model for standard formulation in the global natural sweetener industry.

Part V Expansion of End Applications & Deepening Functional Research

5.1 Stage 1: Traditional Application & Crude Substitution (1970s – 1990s)

In the early industrial development stage, mogrosides were commercialized relying on medicinal-edible homologous attributes with highly concentrated applicable scenarios. The domestic market focused on throat lozenges, herbal tea and traditional health foods highlighting the traditional efficacy of clearing heat and soothing the throat; overseas markets only used them as sucrose substitutes in small quantities for zero-sugar snacks and health drinks.

Circulated products in this phase were dominated by low-purity crude extracts with obvious drawbacks including bitter aftertaste and thin aroma. Functional scientific research only stayed at the basic surface of "natural sweetness, zero calories", with application logic centered on simple sucrose replacement, limited applicable scenarios and low overall product added value.

5.2 Stage 2: Quality Optimization & Popularization in General Foods (1990s – 2010)

With comprehensive upgrading of extraction and refining processes, product flavor, color and thermal stability improved greatly, and application restrictions continued to shrink. Industrial R&D focus shifted to flavor modification and compound formula development; compound blending with sugar alcohols and other natural sweeteners masked undesirable flavors and reproduced the natural mouthfeel of sucrose.

Product application scenarios expanded comprehensively, rapidly penetrating mainstream food tracks including bottled beverages, dairy products, frozen drinks, baked foods, chewing gum and condiments. Academia further verified its core advantages of low glycemic index, no insulin stimulation and anti-cavity properties, precisely matching demand from diabetic populations, weight management groups and child consumers. Product positioning upgraded from "traditional health raw materials" to universal healthy natural sweeteners.

5.3 Stage 3: Functional Mining & High-end Segmented Applications (2010 – Present)

The rapid rise of global precision nutrition and big health industries ushered in a brand-new development cycle of functional empowerment and high-end segmentation for mogrosides.

In-depth physiological functional research was carried out, with multiple biological activities of mogrosides including anti-oxidation, throat mucosa protection, auxiliary intestinal flora regulation and body inflammation relief verified through systematic trials, driving product transformation from single sweetening ingredients to functional

healthy raw materials.

End application sectors are divided into three core segments:

1. ***Mass Food Sector:***

   Fully covering zero-sugar beverages, zero-calorie leisure snacks, meal replacement foods and low-sugar catering, serving as the core basic raw material for global sugar-reduction formulas;

2. ***Big Health & Pharmaceutical Sector:***

   Widely applied in health foods, throat soothing preparations, sugar-free pharmaceutical excipients, oral liquids and foods for special medical purposes, raising product added value via medicinal-edible homologous attributes and multiple physiological efficacies;

3. ***Emerging Expansion Sector:***

   Gradually extended to high-end oral care products (toothpaste, mouthwash), skincare daily chemicals, functional pet foods and other brand-new tracks.

Customized special products became mainstream in the market. Series including high-monomer mogrosides, liquid mogrosides and compound functional sweeteners were developed to meet differentiated index demands of different end manufacturers. The industrial operation model transformed from simple raw material sales to integrated services covering formula matching and all-round sugar-reduction solutions.

Part VI Future Industrial Outlook

After over a century of systematic scientific exploration and nearly half a century of industrial cultivation, the mogroside industry has evolved from a regional local specialty of China and laboratory research sample into a complete industrial chain of distinctive natural plant sweeteners rooted in China and serving global markets. It has built a closed-loop whole industrial chain covering germplasm breeding, standardized cultivation, primary processing of fresh fruits, intensive extraction and refining, full-process standard control and global end-product application. Generations of scientific researchers overcame technical challenges, and practitioners across the industrial chain pursued pragmatic innovation, fully unlocking the economic and health value of China’s distinctive natural plant resources.

Based on the long-term global consumption trends of low-sugar, natural and healthy products, together with policy development requirements of green low-carbon manufacturing, the global mogroside industry will present five core development trends in the future:

1. ***Continuous Green & Low-carbon Iteration of Process Technologies***

The industry will prioritize layout of bio-extraction, low-temperature refining, closed continuous production and resource utilization technologies for processing by-products

to further boost mogroside extraction conversion rate, cut production energy consumption and waste discharge, and build a modern low-carbon clean production system. Meanwhile, core technologies for efficient enrichment of high-purity mogroside V will be broken through to realize large-scale cost-reduction mass production of high-value monomer products.

2. Refined & Customized Upgrading of Product Systems

Centered on differentiated physiological functional demands of various end-processing scenarios, the industry will develop dedicated ingredients with finer grading, controllable active components and customizable flavors. R&D of standardized high-purity mogroside V, directional monomer separation products and compound functional sweetening ingredients will be vigorously promoted to lift core technical barriers and market premium space of products.

3. Industrialization of In-depth Physiological Functional Research

Continuous excavation of both medicinal and health care values of mogrosides will be conducted. Combined with modern nutritional and pharmacological clinical trials, functional end products with clear efficacy will be developed to realize a profound strategic transformation of the industry from "sweetening ingredients" to "functional healthy raw materials".

4. Interoperable Global Standards & Compliance Systems

China will continue to promote mutual recognition of Chinese and foreign product standards and testing methods, improve global multi-country compliance access layout, break technical barriers to international trade, and further consolidate China’s standard-setting discourse power in the global natural sweetener industry.

5. Two-way Empowerment & Extension of Industrial Chain Upstream and Downstream

Upstream: Continuous optimization of germplasm resource screening and ecological standardized planting systems to guarantee long-term stable supply of high-quality raw materials.

Downstream: Strengthening end-formula R&D and supporting application technical services, transforming industrial entities from single raw material suppliers into integrated service providers of all-round sugar-reduction solutions.

As a distinctive industry holding triple advantages of native origin resources, core production technologies and world-leading production capacity, China will keep leading technological innovation, standard iteration and market expansion of global mogrosides in the future. Relying on core product attributes of natural zero-calorie and safe health benefits alongside a complete closed-loop industrial ecosystem, mogrosides will continuously release industrial value amid the global sugar-reduction wave, empowering high-quality development of global health foods, precision nutrition and biomedicine industries, and advancing China’s natural plant extract industry toward broader international markets.