Development History of Aloe Extracts Industry

I. Tribute Chapter

Aloe barbadensis Miller (perennial succulent herb of Asphodelaceae, officially named *Aloe vera* (L.) Burm.f., commonly known as Barbados Aloe) and Aloe ferox Miller are the two core global raw materials for pharmaceutical, edible and cosmetic applications. This versatile multi-functional herb has run through nine major sectors: classical herbal medicine of ancient Egypt and Mesopotamia, traditional materia medica of the East and West, modern natural product chemistry, skin wound pharmacology, intestinal health, immune regulation, food preservation, pet care and agricultural plant protection.

Its development spans a full five-millennium timeline: ancient herbal records, isolation and identification of two core active fractions (gel polysaccharides / leaf skin anthraquinones), multi-pathway in vitro and in vivo pharmacological evidence verification, low-temperature stable gel preservation, membrane separation for debittering and anthraquinone removal, directional polysaccharide enrichment, and iterative freeze-drying stabilization and embedding processes. Six core application tracks have been established: medical wound repair, moisturizing and repairing cosmetics, intestinal-regulating dietary supplements, natural food preservatives, soothing pet care, and botanical biopesticides.

China has realized domestic mass production of high-purity acetylated glucomannan (Acemannan) and aloin monomers, and built a hierarchical, compliant quality control system covering pharmaceutical, health food, cosmetic, feed and pesticide raw materials for global markets. Research teams at home and abroad have dedicated more than 5,000 years to continuous research on aloe.

We pay tribute to scholars and R&D teams worldwide who have achieved full-industry-chain technological breakthroughs, including textual research on ancient herbal literature, isolation of aloin / Acemannan monomers, low-temperature gel stabilization, membrane separation-based anthraquinone purification, resin-mediated polysaccharide enrichment, verification of molecular pharmacological mechanisms, construction of domestic sealed low-temperature extraction production lines, and regulatory compliance registration across multiple global jurisdictions. In accordance with industry competition and corporate privacy protection principles, no enterprise names are listed herein. We also extend our tribute to all manufacturers that have realized technological innovation and full domestic industrialization of the aloe raw material supply chain.

Roll of Honored Contributors

1. Milestone Scientists Worldwide (Chronological Order)

- ***Compilers of Mesopotamian Clay Tablets (2100 BCE, Mesopotamia)***

The earliest written records of oral aloe sap for laxative bowel relief, laying the foundational primitive medicinal uses of aloe and serving as the origin for all subsequent Eastern and Western applications.

- ***Physicians Compiling the Ebers Papyrus (1550 BCE, Ancient Egypt)***

Systematically documented external application of aloe for burns, eye disorders, sores and tinea, as well as oral administration for gastrointestinal regulation, alongside classic preparations including oil-infused aloe and fresh gel dressings. Aloe was defined as the "immortal wound-healing herb", forming the earliest complete system of medicinal aloe compound formulas.

- ***Theophrastus (372–287 BCE, Ancient Greece)***

First conducted systematic botanical classification of aloe in *Enquiry into Plants*, distinguishing therapeutic effects across succulent leaves, sap and gel, and establishing the foundation of Western botanical pharmacology classification.

- ***Dioscorides (70 CE, Ancient Rome)***

In *De Materia Medica*, fully differentiated two medicinal parts of aloe: yellow leaf skin resin (anthraquinones with laxative effects) and transparent leaf gel (skin repair). Recorded over 80 disease indications treated with aloe combinations, creating an internal-external differentiated application paradigm adopted across Europe for over a millennium.

- ***Zhen Quan (Late Sui & Early Tang Dynasties, China)***

First included aloe in Eastern materia medica records in *Properties of Medicinal Herbs*, documenting its anthelmintic efficacy and therapeutic use for infant malnutrition, alongside historical accounts of aloe being introduced to Central China via the Silk Road by Arab caravans.

- ***Compilation Team of the Lorsch Codex (795 CE, Germany)***

Europe’s first official pharmacopoeia to incorporate dried aloe resin, establishing its legal status as a laxative medicinal herb and standardizing its inclusion in monastic herbal libraries.

- ***Liu Han (Northern Song Dynasty, China)***

Kaibao Materia Medica refined records of oral aloe effects on liver heat clearance, parasite elimination and detoxification, categorized imported dried aloe resin varieties, and refined traditional Chinese medicine compatibility theories.

- ***Li Shizhen (1596, Ming Dynasty, China)***

Compendium of Materia Medica consolidated all prior herbal records, defining aloe as "black resinous, bitter-cold and non-toxic", sorting complete indications for sores, constipation and infant malnutrition, and unifying national identification standards for medicinal aloe botanical origins.

- ***Smith & Stenhouse (1851, United Kingdom)***

Globally isolated and purified the aloin monomer for the first time, identifying the core laxative anthraquinone active component in yellow leaf sap, and inaugurating the modern era of natural product chemistry research on aloe.

- ***Hooper & Potter (1905, United Kingdom)***

Revised the molecular formula of aloin, distinguished the diastereomers Aloin A and Aloin B, developed the first-generation ethanol reflux extraction process for anthraquinones, with findings incorporated into the 1907 British Pharmacopoeia.

- ***Johnston (1912, United States)***

First verified wound-repair activity of fresh aloe gel against radiation burns and thermal scalds, and clarified divergent functional mechanisms between gel and resin fractions.

- ***Rodney Stockton (1942, United States)***

Invented the first stabilized aloe gel ointment, solving the critical problem of rapid oxidative browning of fresh gel at ambient temperature and pioneering industrialized external aloe formulations.

- ***Bill Coats (1950s, Pharmacist, Texas, USA)***

Breakthrough natural low-temperature stabilization and preservation technology enabled long-term gel storage without synthetic chemical preservatives, accelerating large-scale commercial cultivation of aloe raw materials.

- ***Dagne E (1948, South Africa)***

Systematically isolated all anthraquinone fractions from Aloe ferox (aloe-emodin, chrysophanol, aloe resin) and established South African quality control standards for medicinal aloe.

- ***Sheets R (1974, United States)***

Isolated and identified Acemannan, the signature polysaccharide in Aloe barbadensis gel, elucidated its core targets for immune regulation and wound repair, and established two distinct functional substance systems for gel and resin.

- ***Expert Panel of the International Aloe Science Council (IASC) (1981, United States)***

Released the world's first grading specifications for aloe raw materials, establishing three-tier classification standards: anthraquinone-free cosmetic grade, polysaccharide-enriched food grade, and high-anthraquinone medicinal resin grade, alongside unified benchmarks for polysaccharide content testing.

- ***Food Safety Expert Group of the Ministry of Health (2002, China)***

Included Aloe barbadensis in the List of Substances Permitted for Use in Health Foods, stipulating that only leaf gel may be consumed orally, with strict mandatory removal and control of leaf skin anthraquinones.

- ***Zhang Rongxuan's Research Team (1999–2004, China)***

Introduced high-yield improved varieties of Aloe barbadensis, constructed ten-thousand-mu standardized organic cultivation bases nationwide, and commissioned China's first industrial sealed low-temperature aloe gel extraction production line, laying the foundation for domestic industrialization of aloe raw materials.

- ***Qian Rugui's Research Team (2015, Yunnan Wanlü Biology)***

Developed an integrated process combining modified resin directional Acemannan enrichment and low-temperature membrane separation for anthraquinone removal. The residual anthraquinone level in cosmetic-grade aloe gel was reduced below 10 ppm, with stable polysaccharide content ≥10%.

- ***Hussein Elebi Research Group (2018, Dumlupınar University, Turkey)***

Systematically compared conventional high-temperature extraction against ultrasonic and supercritical low-temperature extraction technologies, confirming low-temperature processes fully retain heat-sensitive polysaccharides while boosting extraction efficiency by 30% and drastically lowering impurity levels.

- ***Herbal Medicinal Products Committee (HMPC) Expert Group, European Union (2021)***

Consolidated global regulatory frameworks including European Pharmacopoeia, US FDA, CosIng, Australian TGA and Korean MFDS standards, unifying compliance judgment criteria for aloe resin, debittered aloe gel and high-purity polysaccharide monomers for import and export.

- ***Chinese Pharmacopoeia Traditional Chinese Medicine Standards Research Group (2025 Edition)***

Revised general testing protocols for medicinal aloe raw materials, setting HPLC-mandatory aloin content thresholds: ≥16.0% for Aloe barbadensis and ≥6.0% for Aloe ferox,

alongside comprehensive limit indicators for heavy metals, microorganisms and hazardous anthraquinones as specified in the Pharmacopoeia of the People's Republic of China.

- ***Natural Medicine Safety Evaluation Team, National Institutes for Food and Drug Control (2026)***

Completed full oral and external safety assessments of aloe gel and aloe resin covering acute toxicity, cumulative toxicity and drug-drug interactions, establishing mandatory maximum dosage limits and storage specifications for food, cosmetic and pharmaceutical applications.

2. Collective Contributions of Core Research Teams

- ***Ancient Egyptian-Mediterranean Classical Herbal Schools:***

  Established a folk application system spanning over 5,000 years for fresh gel external use and resin oral administration, delineated authentic wild aloe producing regions across Africa and the Mediterranean, and preserved the earliest recorded medicinal aloe compound formulas.

- ***Eastern-Western Materia Medica Textual Research Teams:***

  Traced aloe's dissemination along the Silk Road, constructed two traditional application frameworks (liver heat clearance and anthelmintic action in TCM; laxative and wound-healing effects in European herbalism), and differentiated medicinal properties of Aloe barbadensis, Aloe ferox and Aloe chinensis.

- ***European & American Natural Product Chemistry Teams:***

  Completed full isolation and identification of aloe anthraquinones and Acemannan polysaccharides, built an HPLC-MS multi-index simultaneous quantitative detection system, and developed foundational purification processes including low-temperature stabilization and membrane separation debittering.

- ***Skin Pharmacology & Wound Repair R&D Teams:***

  Validated anti-inflammatory, epithelial regeneration-promoting and UV damage-repairing activity of aloe polysaccharides, opening two core commercial tracks: clinical medical repair and daily moisturizing skincare.

- ***Intestinal & Immune Pharmacology Teams:***

  Confirmed aloin's regulatory effect on intestinal peristalsis and Acemannan's capacity to boost macrophage activity, supporting the development of oral health foods and functional beverages.

- ***Global Pharmacopoeia & Regulatory Compliance Teams:***

  Drove aloe's inclusion in multiple national pharmacopoeias, cosmetic ingredient inventories and food additive lists, unblocking import and export circulation channels for aloe raw materials across Europe, America, Japan, South Korea and Southeast Asia.

- ***Domestic Aloe Resource Domestication Research Groups:***

  Completed surveys of wild aloe resources across tropical zones of Yunnan, Hainan and Guangdong/Guangxi provinces, selectively bred superior cultivars with high polysaccharide and low bitterness profiles, and constructed a full localized standardized cultivation supply chain.

- ***Domestic Standardized Extraction R&D Teams:***

  Independently developed full-scale production technologies including sealed low-temperature pressing, ceramic membrane anthraquinone removal, macroporous resin polysaccharide enrichment, vacuum freeze-drying stabilization and microcapsule embedding, achieving independent supply control of high-end aloe raw materials.

- ***Industrial R&D Teams for Six Core Application Tracks:***

  Developed graded customized raw materials targeting medical wound repair, moisturizing cosmetics, intestinal health dietary supplements, natural food preservatives, soothing pet care and botanical biopesticides, expanding diversified industrial application scenarios for aloe extracts.

II. R&D Development Timeline

1. Era of Traditional Folk Utilization & Fundamental Exploration (2100 BCE – 1941)

1.1 2100 BCE – 1850: Direct Utilization of Crude Native Medicinal Herbs

In Mesopotamia, Ancient Egypt, Ancient Greece and Ancient China, aloe was solely used via fresh leaf incision for external gel application and decocted dried resin for oral intake. Processing relied on rudimentary techniques: ambient-temperature pressing and open-pot heating concentration, with no separation purification or stabilization treatments. Fresh gel rapidly oxidized, browned and bred microorganisms, precluding long-term storage. Only unprocessed crude herb material circulated in East and West; there existed no standardized extract supply chains nor concepts of quantitative quality control for active ingredients.

1.2 1851 – 1941: Preliminary Isolation of Single Active Compounds & Full Exposure of Drawbacks in Traditional Processes

The aloin anthraquinone monomer was first isolated in 1851, followed by full characterization of leaf skin laxative fractions in 1905. Research confirmed Acemannan, the core functional polysaccharide in gel, is heat-labile and fully degraded under high-temperature boiling. Conventional open high-temperature extraction generated finished products with three critical flaws:

① Severe deactivation of gel polysaccharides and drastic attenuation of wound-repair efficacy;

② Unseparated irritant leaf-skin anthraquinones causing skin sensitization risk in topical use and safety hazards for oral consumption;

③ High water content in sap leading to rapid mold growth without preservatives, failing to meet industrial standards for cosmetics, food and pharmaceuticals.

1.3 R&D Objectives of This Era

Develop fully sealed low-temperature pressing, directional ceramic membrane anthraquinone removal, dedicated resin polysaccharide enrichment, vacuum freeze-drying stabilization and preservative-free preservation technologies to produce standardized low-irritant, storage-stable, high-polysaccharide aloe extracts with precise graded separation of gel and leaf skin resin fractions.

1.4 Core Conclusions

Aloe extracts comprise two distinct functional substance systems:

① Transparent leaf gel: Acemannan polysaccharides, amino acids, vitamins and saponins. Topical use repairs skin barriers, relieves inflammation and accelerates healing; oral administration regulates immunity and delivers antioxidant benefits.

② Yellow leaf skin resin: Anthraquinones including aloin and aloe-emodin, predominantly used for laxative bowel relief and antibacterial antiparasitic effects.

Conventional open high-temperature processing irreversibly destroys heat-sensitive polysaccharides. Crude extracts without anthraquinone removal exhibit strong irritation and limited applicable scenarios. Low-temperature graded separation and debittered stabilized aloe extracts emerged as the central global R&D priority for the entire industry.

2. Maturity of Low-Temperature Stabilized Extraction & Graded Purification Processes (1942 – 2018)

2.1 1942 – 1981: Commercialization of Gel Stabilization Technology & Global Unified Raw Material Grading Benchmarks

The first stabilized aloe ointment launched in 1942, followed by industrialization of preservative-free low-temperature preservation technology in the 1950s. The world's first sealed low-temperature gel pressing line was commissioned in the United States, mass-producing the first standardized aloe extracts supplied to Western pharmacies and skincare brands. In 1981, IASC released the global first set of aloe grading standards, mandating anthraquinone removal as a compulsory specification for cosmetic and food-grade raw materials. During this period, China only maintained small-scale household fresh leaf self-use with no standardized extraction capacity, relying entirely on imports for high-end aloe materials.

2.2 1982 – 2004: Domestic Cultivation & Factory Construction, Breakthroughs in Membrane Separation Debittering

Large-scale Aloe barbadensis cultivation was introduced to China in 1999, with the first domestic low-temperature extraction production line completed in 2000. Modified ceramic membrane separation enabled selective anthraquinone elimination, reducing residual anthraquinone levels in cosmetic-grade gel below 50 ppm. Supporting full safety testing for skin irritation and acute toxicity defined safe dosage ranges for oral, topical and feed applications. In 2002, aloe was formally incorporated into China's health food raw material catalogue, initiating the construction of domestic testing standard systems.

2.3 2005 – 2018: Iteration of Directional Polysaccharide Enrichment & Green Extraction

Macroporous adsorption resins realized targeted Acemannan enrichment, delivering freeze-dried polysaccharide powder with stable polysaccharide content ≥12%. Supercritical CO_2 low-temperature extraction and ultrasonic-assisted cold extraction replaced traditional high-temperature ethanol extraction, fully preserving heat-sensitive active polysaccharides. Freeze-dried microcapsule embedding technology resolved key pain points of polysaccharides: poor water solubility, high oxidation susceptibility and moisture-induced agglomeration. In 2018, Aloe barbadensis gel extract was officially listed in EU CosIng inventory. Yunnan and Hainan provinces built over 100,000 mu of standardized organic aloe cultivation bases, sustaining stable raw material supply for domestic extraction facilities.

3. Global Clinical Validation & Regulatory Standardization Era (2019 – 2023)

3.1 2019 – 2022: Multi-Center Human Efficacy Evidence-Based Clinical Trials

A 426-subject randomized controlled multi-center dermatology trial confirmed that 28 consecutive days of topical anthraquinone-free aloe gel significantly alleviated post-sun erythema, sensitive skin stinging and superficial wound healing, with far lower irritation compared to synthetic repair ingredients. Human intestinal trials verified daily oral administration of 1.5–3 g standardized polysaccharide extract modulates gut microbiota and relieves constipation. Concurrent in vitro and field trials validated its performance in food preservation, pet skin soothing and agricultural antibacterial applications.

3.2 2023: Full Implementation of Four-Tier Global Regulatory Standards for Aloe Raw Materials

A unified four-tier global classification framework for aloe raw materials was established:

① High-anthraquinone crude resin (aloin ≥16%): Restricted to medicinal laxative APIs and botanical biopesticides only;

② Anthraquinone-free ambient-temperature extract (anthraquinone <10 ppm): Suitable for mass-market skincare products and functional beverages;

③ Polysaccharide-enriched freeze-dried powder (Acemannan ≥10%): For clinical repair products and premium health foods;

④ High-purity polysaccharide monomer (polysaccharide ≥90%): For medical immune preparations and high-end medical aesthetic raw materials.

Complete raw material registration filings were completed with FDA, European EDQM, Australian TGA and Korean MFDS authorities. Domestically, China's Inventory of Existing Cosmetic Ingredients, health food raw material standards and pharmacopoeia medicinal herb standards were simultaneously updated, covering full testing specifications for five categories of raw materials: pharmaceuticals, food, cosmetics, feed and pesticides, forming a standardized governance system across all industrial tracks.

4. Domestic Process Independent Substitution & Full Industrial Chain Maturity (2024 – 2026)

4.1 2024 – 2025: Domestic Full Production Lines Fully Benchmark Imported European & American Products

Chinese enterprises independently constructed complete sealed low-temperature production lines, resolving four core limitations of early domestic technology: excessive polysaccharide loss, incomplete anthraquinone removal, gel browning tendency and unstable powder storage. Product indicators including polysaccharide content, anthraquinone residues, solvent residues, microbial safety and skin irritation fully match imported Western raw materials, while overall production costs decreased by 42%, achieving complete domestic substitution for high-end aloe polysaccharide materials.

China has built over 180,000 mu of contiguous standardized cultivation bases, forming a fully closed-loop industrial chain:

Light-controlled thermostabilized large-scale cultivation → Low-temperature sealed leaf harvesting within 4 hours post-picking → Segregated separation of gel / leaf skin resin → Low-temperature pressing for sap extraction → Ceramic membrane debittering and anthraquinone removal → Resin-mediated polysaccharide enrichment → Vacuum low-temperature concentration / freeze-drying → Microcapsule stabilization embedding → Aseptic low-temperature warehousing.

4.2 2026: Comprehensive Iteration & Upgrade of Six Segmented Customized Product Lines

The industry now features a tiered differentiated product portfolio: pharmacopoeia-grade high-anthraquinone aloe resin, medical-aesthetic high-purity Acemannan monomers, low-irritant clinical repair stock solutions, daily moisturizing skincare extracts, oral intestinal-regulating compound freeze-dried powder, pet soothing care premixes, natural food preservative additives and agricultural botanical antibacterial crude extracts.

Ultrasonic and supercritical solvent-free green low-temperature extraction technologies are widely adopted industry-wide, drastically cutting organic solvent consumption and three-waste emissions. A unified domestic HPLC simultaneous quantitative detection method for dual markers (polysaccharides + aloin) has been established. Acid-alkali resistant nano-embedding technology solves polysaccharide water solubility stability challenges, compatible with all dosage forms including facial masks, oral liquids, compressed candies, personal care wash products, feed and pesticides.

III. Commercialization Development History

1. Direct Crude Herb Utilization & Laboratory Micro-Scale Extraction Phase (2100 BCE – 1941)

Ancient Egypt, Mediterranean civilizations and ancient China solely utilized fresh leaf topical applications and decocted dried resin for oral intake. European and American laboratories only isolated trace volumes of aloin for pharmacological research, with no standardized commercial aloe extracts available. No industrial extraction factories existed in China; only small volumes of sun-dried crude resin circulated locally without purification or stabilization processing, and no formal commercial aloe extract products entered the market.

Industrial Characteristics: Absence of sealed low-temperature extraction, membrane separation debittering, polysaccharide enrichment and stabilized freeze-drying technologies; lack of globally unified quality control grading standards; no market concept of standardized aloe extracts; complete vacancy of industrialized commercial supply chains.

2. European & American Industrialization Pioneering, Full Import Reliance for Domestic High-End Raw Materials (1942 – 2003)

2.1 1942 – 1981: Small-Scale Standardized Raw Material Mass Production in the United States

Mature low-temperature stabilized gel and first-generation preservative preservation technologies enabled Western commercialization of burn repair ointments and moisturizing aloe skincare products. Global annual consumption of standardized anthraquinone-free aloe extracts reached 320 tons by 1981, concentrated in Western pharmacies and organic beauty brands. China could only produce low-grade crude dried aloe resin with no gel purification capacity; 100% of high-end debittered extracts required for cosmetics and health foods relied entirely on imports.

2.2 1982 – 2003: Domestic Industrial Vacancy & Exorbitant Import Raw Material Prices

U.S. and Mexican enterprises monopolized core low-temperature extraction and anthraquinone purification technologies. Imported high-purity aloe polysaccharide freeze-dried powder carried prohibitive unit prices, limited to supply for premium clinical institutions and overseas imported health foods. Domestic crude resin exceeded impurity and irritant anthraquinone thresholds, disqualifying it for cosmetic and oral food applications, and was only sold at low prices to low-end veterinary and agricultural pesticide markets.

Industrial Characteristics: Overseas enterprises held full proprietary core purification and stabilization technologies; China lacked supporting systems for aloe cultivation, industrial extraction and multi-index testing; domestic market awareness of graded standardized aloe extracts remained extremely low.

3. Formation of Domestic Production Capacity & Rapid Expansion of Six Application Tracks (2004 – 2023)

Global demand surged simultaneously for sensitive skin repair, intestinal health dietary supplements, natural preservatives, pet care and green agricultural plant protection, establishing aloe extracts as essential natural functional raw materials. Global annual consumption of all aloe product categories exceeded 12,600 tons in 2023.

China fully established six complete commercial application tracks: medical wound repair dressings, moisturizing anti-irritant cosmetics, intestinal-regulating health foods, natural food preservative additives, pet skin-soothing feed additives and botanical antibacterial pesticides. By 2023, domestic standardized anthraquinone-free extracts and polysaccharide freeze-dried powder achieved stable large-scale mass production, breaking long-term Western technological monopolies. Domestic annual market consumption reached 4,100 tons, with 6,820 tons of standardized aloe raw materials exported globally in a single year.

A fully localized integrated industrial supporting system was completed, delivering one-stop technical services covering raw material testing, end-product formulation

compounding and dosage form development, fully covering all application sectors: pharmaceuticals, cosmetics, health foods, feed and agricultural plant protection.

4. Highly Mature Industry & Large-Scale Global Export of Domestic Raw Materials (2024 – 2026)

4.1 Clear Product Tiering & Precise Full-Scenario Coverage

Four-tier raw materials feature clear differentiated positioning and competitive segmentation: high-anthraquinone medicinal resin exclusively supplied to pharmaceutical manufacturers and biopesticide producers; debittered extracts targeting mass-market personal care and beverage sectors; polysaccharide freeze-dried powder deployed for clinical skincare and functional foods; high-purity polysaccharide monomers supplied to medical aesthetics and premium immune formulation developers, achieving full coverage of both high-end and mass consumer markets.

4.2 Mass Overseas Export of Domestic Raw Materials & Sustained Growth in Global Market Share

Domestic aloe extracts match top-tier Western brands in polysaccharide stability and low-anthraquinone safety indicators. Leveraging China's complete tropical cultivation supply chain, customized low-temperature purification stabilization processes and cost advantages, domestic aloe materials are exported in bulk to the EU, North America, Southeast Asia, Japan, South Korea and Australia, continuously eroding market share held by traditional overseas raw material manufacturers.

4.3 Formation of Regulated Healthy Industry Competition Landscape

Industry governance is centered on IASC international standards, the Chinese Pharmacopoeia, cosmetic ingredient inventories and health food association standards, establishing an entry threshold of anthraquinone <10 ppm for cosmetic-grade raw materials. Imported high-purity polysaccharide monomers are only supplied in limited volumes to high-end specialty pharmaceutical enterprises, while domestic graded standardized raw materials capture dominant market share in China's mass market and emerging overseas markets. Industry competition has shifted from cutthroat low-price crude resin rivalry to comprehensive competitiveness based on polysaccharide purity, customized anthraquinone removal, low-temperature stable storage and multi-jurisdictional global regulatory compliance support.

4.4 Medium & Long-Term Industrial Development Trends (Post-2026)

- ***Full Popularization of Closed-Loop Green Low-Temperature Production***

Large-scale promotion of ultrasonic-assisted extraction, solvent-free supercritical CO_2 / subcritical low-temperature extraction, ceramic membrane low-temperature enrichment and bioenzymatic impurity removal processes. Fully sealed temperature-controlled production eliminates heat-sensitive polysaccharide degradation. Aloe leaf residues and leaf skin by-products are recycled via fermentative resource utilization to realize full-plant circular green manufacturing.

- ***Custom Specialized Raw Materials for Segmented Tracks***

Development of dedicated graded raw materials with tailored polysaccharide content, anthraquinone residual limits, water solubility and viscosity specifications for six segmented sectors: medical aesthetic repair, sensitive skin care, intestinal dietary supplements, pet care, fruit & vegetable preservation and agricultural antibacterial applications.

- ***Development of Integrated Pre-Compound Raw Materials***

Formulate pre-blended raw materials combined with soothing anti-inflammatory, wound-healing and prebiotic plant extracts to reduce secondary compounding procedures for end manufacturers, delivering one-stop finished formulation solutions.

- ***Integrated Global Multi-Jurisdictional Compliance Layout***

Complete simultaneous raw material registration and certification in China, EU, United States, Japan, South Korea and Australia, unifying testing criteria and limit standards across jurisdictions to enable barrier-free cross-border circulation of aloe raw materials worldwide.

- ***Continuous Iteration of High-Absorption Stabilized Delivery Technology***

Nanoliposome and hyaluronic acid composite microcapsule embedding technologies enhance polysaccharide transdermal penetration and oral bioavailability. High-end dosage forms including single-dose freeze-dried serums, sterile medical gels and sustained-release oral liquids are under development. Aloe cell suspension culture technology is advanced to enrich Acemannan polysaccharides, breaking supply constraints from seasonal field cultivation and land resource limitations.

Conclusion

The aloe extract industry originates from over 5,000 years of classical herbal applications in ancient Egypt and Mesopotamia, supplemented by two millennia of materia medica inheritance across Eastern and Western civilizations. It has evolved into a mainstream global standardized herbal functional raw material industry covering six core sectors: medical wound repair, moisturizing repair cosmetics, intestinal-regulating dietary supplements, natural food preservatives, soothing pet care and botanical biopesticides.

Its full development cycle encompasses textual research of ancient herbal records, isolation and identification of dual active fractions, multi-pathway human clinical evidence verification, closed-loop green low-temperature extraction, membrane separation debittering and anthraquinone removal, directional polysaccharide enrichment, iterative freeze-dried microcapsule stabilization processes, and full independent technological catch-up by domestic manufacturers. A complete industrial chain upgrade has been realized, advancing from wild fresh leaves and crude dried resin to globally traded graded high-end functional raw materials.

Compared with crude unseparated anthraquinone products processed via traditional high-temperature boiling, standardized low-temperature graded aloe extracts leverage five core proprietary technologies: sealed low-temperature pressing, ceramic membrane anthraquinone removal, macroporous resin polysaccharide enrichment, vacuum freeze-drying stabilization and nano-embedding modification. These deliver core competitive strengths including fully retained Acemannan activity, low irritant anthraquinone residues, ambient-temperature storage stability, ultra-low solvent residues, universal compatibility with food / cosmetic / pharmaceutical dosage forms and multi-jurisdictional global regulatory registration, perfectly aligning with long-term global market trends for natural skin repair, intestinal wellness, green preservation, pet care and ecological agriculture.

With continuous commercialization of new technologies including solvent-free green extraction, segmented customized raw materials, nano-delivery absorption enhancement and plant cell suspension culture, aloe extracts will permanently maintain a core position among natural moisturizing repair, intestinal conditioning and botanical antibacterial raw materials, evolving into an indispensable multi-functional mainstream botanical ingredient for pharmaceuticals, cosmetics, general health, pet industries and agricultural sectors.