Industrial Development History of Ginger Extracts

I. Tribute Section

Ginger (*Zingiber officinale* Roscoe, a perennial herbaceous rhizome of the Zingiber genus under Zingiberaceae family, with the universal Latin name Zingiberis Rhizoma Recens) is a globally recognized core medicinal and edible homologous raw material. It is a multi-functional rhizomatic herb that spans ten major sectors: the three-thousand-year Chinese herbal materia medica system, ancient Indian Ayurveda, ancient Roman Mediterranean herbalism, modern natural product chemistry, gastrointestinal digestive pharmacology, anti-inflammatory and analgesic research, circulatory regulation, natural food preservation, scalp care, pet gastrointestinal conditioning, and antibacterial livestock and poultry feed.

Its full industrial evolution covers a complete chain spanning three millennia: recorded applications in ancient herbal texts, isolation and identification of two active components (terpenoid volatile oils / phenolic gingerols), multi-pathway in vivo and in vitro pharmacological evidence verification, low-temperature airtight synchronous fractional extraction, molecular distillation impurity removal and purification, macroporous resin targeted enrichment of gingerols, and vacuum freeze-drying stabilization embedding processes. Six core application tracks have been established: gastrointestinal health dietary supplements, anti-inflammatory and analgesic pharmaceuticals, soothing and repairing cosmetics, natural food preservatives, pet gastrointestinal conditioning products, and plant-derived antibacterial feed for livestock and poultry. Domestic mass production of high-purity 6-gingerol monomers and standardized ginger oleoresin has been realized, alongside the construction of a global multi-category graded compliance quality control system covering pharmaceuticals, health foods, cosmetics, feed, and food additives. Scientific research teams worldwide have devoted over three thousand years to in-depth research on ginger.

We hereby pay tribute to scholars and R&D teams at home and abroad who have achieved full-chain technological breakthroughs, including textual research on ancient herbal documents, isolation of gingerol/shogaol monomers, low-temperature synchronous fractional extraction, molecular distillation impurity purification, resin-based gingerol enrichment, molecular pharmacological mechanism verification, construction of domestic supercritical CO_2 airtight low-temperature extraction production lines, and regulatory compliance registration across numerous global regions. In accordance with industry competition and corporate privacy protection principles, no enterprise names are listed in this document. We also extend our sincere gratitude to all manufacturers that have realized process innovation and full domestic industrialization of the ginger raw material supply chain.

Roll of Honor

1. Milestone Scientists Worldwide (Chronological Order)

- ***Compilers of Pre-Qin Herbal Texts (1600–500 BCE, China)***

The *Analects of Confucius* records Confucius "never omitting ginger from his meals"; *Master Lü's Spring and Autumn Annals* and *The Book of Rites* systematically document ginger's edible and preliminary medicinal applications. *Shennong's Classic of Materia Medica* classifies dried ginger (including fresh ginger) as a top-grade medicinal herb, defining its core efficacies of warming the middle energizer, arresting vomiting, inducing sweating, and relieving bi pain. This laid the foundational framework for ginger's medicinal and edible utilization in the East, representing the world's earliest systematic written record of ginger's medicinal system.

- ***Ancient Indian Ayurvedic Physicians (800–200 BCE, Ancient India)***

They established ginger's application system as a "universal herbal remedy", distinguished the efficacies of fresh ginger, dried ginger, and ginger peel, and recorded compound formulas for anti-emesis, digestion promotion, blood circulation activation, and respiratory tract soothing. Ginger spread via the ancient Silk Road to West Asia and the Mediterranean, forming a cross-continental transmission network of ginger applications connecting the East and West.

- ***Zhang Zhongjing (150–219 CE, Eastern Han Dynasty, China)***

68 classical prescriptions in *Treatise on Febrile Diseases* and *Synopsis of Prescriptions of the Golden Chamber* incorporate ginger. He strictly differentiated the efficacy disparities among fresh ginger, dried ginger, and charred ginger, establishing classical compatibility paradigms for warming the middle energizer to stop vomiting and releasing the exterior to dispel cold. His work remains the core clinical basis for ginger application in traditional Chinese medicine to this day.

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

De Materia Medica records ginger's introduction to Europe via Indian trade routes, documenting its oral use for digestion promotion and nausea relief, and external application to ease joint pain, laying the theoretical foundation for ginger utilization in ancient European herbal medicine.

- Tao Hongjing (Southern and Northern Dynasties, China)

Records of Famous Physicians independently listed ginger as a separate medicinal herb for the first time, detailing its specific indications for wind-cold headache, nasal congestion and cough, and vomiting suppression. It also distinguished processing efficacy differences: fresh ginger disperses exterior pathogens while dried ginger warms the interior.

- ***Su Jing (Tang Dynasty, China)***

Newly Revised Materia Medica, China's first officially compiled herbal monograph, officially designated authentic ginger producing regions in Qingzhou and Qianwei Circuit, standardized traditional crude processing workflows of harvesting and shade-drying, and included complete quality control criteria for ginger.

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

Compendium of Materia Medica consolidated herbal records from all previous dynasties, systematically sorting out the full indications of raw and processed ginger for oral and external use. He proposed the comprehensive utilization theory that ginger "can be consumed as vegetable, fruit, and medicine", and unified the botanical origin identification standard for ginger medicinal materials across China.

- ***Thresh (1879, United Kingdom)***

For the first time globally, the characteristic pungent active component was isolated from ginger rhizomes and formally named gingerols, marking the dawn of modern natural product chemistry research on ginger.

- ***Gornett & Grier (1908, United Kingdom)***

Confirmed that gingerols are not a single compound but a mixture of multi-component phenols, revising the early understanding of a single active ingredient and distinguishing two functional substance systems: volatile oils and gingerols.

- ***Lapworth, Nomura (1917, United Kingdom, Japan)***

Gradually resolved the chemical skeleton structure of gingerols and isolated its hydrolysate zingiberone. In the following year, Nomura successfully separated shogaols and clarified the core chemical mechanism by which gingerols undergo dehydration at high temperatures to convert into shogaols.

- ***Nomura & Tsurami (1925–1927, Japan)***

Synthesized shogaols artificially and fully verified their molecular structure, establishing the first laboratory-scale ethanol reflux extraction process for gingerols.

- ***Connell & Sutherland (1969, Australia)***

Successfully crystallized gingerol monomers, isolated and identified a series of homologues including [4]-, [6]-, [8]-, [10]-, and [12]-gingerol. They verified that 6-gingerol serves as the core active marker of ginger and established fundamental quantitative analytical methods for gingerol components.

- ***WHO Herbal Medicine Expert Group (1999)***

Released a monograph on ginger, systematically compiling human clinical evidence for its anti-emetic, anti-inflammatory, and digestion-promoting effects. Ginger was

incorporated into the global herbal pharmacopoeia standard system with defined safe oral dosage ranges for ginger raw materials.

- ***Domestic Expert Group on National Health Food Standards (2002, China)***

In accordance with Document No. Wei Fa Jian Fa〔2002〕51, ginger was included in the *List of Items Both Edible and Medicinal*. It was approved as a raw material for ordinary foods and health foods, with a capped safe oral addition dosage specified.

- ***Zeng Jianqing R&D Team (2017, China)***

Independently developed China's first full set of industrial large-scale supercritical CO_2 extraction equipment, breaking through the technical bottleneck of low-temperature synchronous fractional extraction for high-viscosity ginger materials. Integrated green mass production of ginger essential oil and ginger oleoresin was realized, filling the domestic gap in high-end extraction equipment.

- ***Zou Dongqian, Zhou Guisheng Research Group (2022, China)***

Systematically organized domestic patents and industrialization technology iteration pathways for ginger extraction, established a universal HPLC synchronous quantification method for 6-gingerol, 8-gingerol and 10-gingerol, and improved the graded quality control system for domestically produced raw materials.

- ***EU Feed Additives Expert Group (2021)***

Issued Regulation (EU) 2021/485, approving ginger essential oil as a sensory antibacterial additive for all categories of livestock and poultry feed, with clear feed addition limits and compliance judgment standards defined.

- ***Chinese Pharmacopoeia TCM Standards Research Group (2025 Edition)***

Revised the general assay for content determination of ginger medicinal materials with statutory indicators: volatile oils ≥0.12%, 6-gingerol ≥0.050%, total 8-gingerol and 10-gingerol ≥0.040%. Complete limit standards for heavy metals, pesticide residues and microorganisms were refined. The 2025 Edition of the Pharmacopoeia of the People's Republic of China was officially implemented in October 2025.

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

Completed comprehensive safety assessments of oral and external toxicity, cumulative toxicity, skin irritation, and drug interactions for ginger volatile oil and gingerol extracts. Mandatory maximum addition limits for food, cosmetics, pharmaceuticals and feed, alongside light-proof low-temperature storage specifications, were formulated.

2. Overall Contributions of Core Scientific Research Teams

- ***Chinese Herbal Textual Research School:***

  Established the three-thousand-year medicinal-edible homologous utilization system of ginger, divided authentic producing regions in northern and southern China, preserved complete traditional theories on ginger formulas, processing and harvesting from the Pre-Qin to Ming and Qing dynasties, and clarified the logical differentiation of efficacies for fresh ginger, dried ginger and ginger peel.

- ***Ancient Indian-Mediterranean Classical Herbal School:***

  Unblocked cross-continental trade and transmission channels for ginger, constructed two independent traditional herbal application systems for the East and West, and laid the foundation for early folk utilization of ginger worldwide.

- ***Pioneering European and American Natural Product Chemistry Teams:***

  Completed isolation and structural identification of full-series phenolic monomers including gingerols, shogaols and zingiberone, separated two independent functional component systems of terpenoid volatile oils and phenolic gingerols, and developed the first laboratory-scale organic solvent extraction processes.

- ***Gastrointestinal and Anti-Inflammatory Pharmacology R&D Teams:***

  Multi-center clinical trials confirmed that gingerols inhibit gastrointestinal spasms, relieve chemotherapy-induced nausea and suppress inflammatory factor pathways, supporting the development of oral health foods and anti-emetic pharmaceutical raw materials. The circulatory activation, joint soothing and scalp antibacterial effects of volatile oils were validated, opening up the skincare and hair care track.

- ***Green Extraction Process R&D Teams:***

  Compared the pros and cons of steam distillation, ethanol reflux, ultrasound-assisted extraction and supercritical CO_2 extraction, and confirmed that high-temperature processes cause degradation of 6-gingerol and its conversion into shogaols. A full set of purification technologies was developed, including low-temperature airtight synchronous fractionation, molecular distillation impurity removal and macroporous resin targeted enrichment.

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

  Promoted ginger’s inclusion in the Chinese Pharmacopoeia, EU HMPC, British Pharmacopoeia, US FDA GRAS inventory, CosIng, Australian TGA and Korean MFDS catalogs, opening cross-border compliance circulation channels for food, pharmaceutical, cosmetic and feed raw materials.

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

  Completed nationwide resource surveys of authentic ginger producing regions including Laiwu Shandong, Yunnan small yellow ginger and Guangdong large fleshy ginger, bred superior cultivated varieties with high 6-gingerol content, and built full-chain large-scale standardized contiguous planting bases.

- ***Domestic High-End Extraction Equipment & Production Line R&D Teams:***

  Independently developed industrial supercritical CO_2 integrated devices, ceramic membrane filtration, molecular distillation, vacuum freeze-drying stabilization and microcapsule embedding mass-production equipment. Technical monopolies on extraction equipment held by European and American manufacturers were broken, realizing full-process independent domestic control of high-end ginger extract production.

- ***Six-Track Industrial Application R&D Teams:***

  Developed graded customized raw materials targeting gastrointestinal health dietary supplements, anti-inflammatory analgesic pharmaceuticals, soothing repairing cosmetics, natural food preservatives, pet gastrointestinal conditioning products and antibacterial livestock feed, expanding diversified industrial application scenarios for ginger extracts.

II. R&D History

1. Period of Traditional Folk Utilization & Fundamental Exploration (1600 BCE – 1878)

1.1 1600 BCE – 1878: Direct utilization of native rhizomes and manual crude processing stage

In ancient China, India and Rome, ginger was only consumed raw by slicing fresh rhizomes, decocted orally or applied externally as fresh juice. Traditional processing methods included sun-drying, open-pot water decoction and simple steam distillation, with no technologies for component separation, low-temperature stabilization or impurity purification. Long-duration high-temperature boiling and distillation triggered massive degradation of the thermosensitive core marker 6-gingerol, converting it into irritating shogaols. No standardized extracted raw materials circulated in the market, and there existed no concept of quantitative quality control for active ingredients; only native medicinal rhizomes, dried ginger and crude unrefined ginger oil circulated among folk communities.

1.2 Core Pain Points and Deficiencies of This Stage

Traditional open high-temperature processing featured three critical drawbacks:

① High temperatures destroy 6-gingerol, drastically attenuating core gastrointestinal and anti-inflammatory activity;

② Volatile oils and gingerols coexist without separation, failing to meet graded application demands of food, cosmetics and pharmaceuticals;

③ Crude extracts retain unremoved impurities, pesticide residues and plant fiber, prone to oxidative browning and short shelf life, unable to satisfy stringent industrial standards for food, cosmetics and pharmaceuticals.

1.3 R&D Objectives of This Stage

Develop low-temperature airtight synchronous fractional extraction, molecular distillation selective impurity removal, macroporous resin targeted gingerol enrichment and vacuum freeze-drying stabilization processes to achieve precise graded separation of ginger essential oil and gingerols, producing standardized ginger extracts with high activity, low impurities and excellent storage stability.

1.4 Core Conclusions

Ginger extracts contain two independent functional substance systems:

① Volatile terpenoid components (α-zingiberene, citral, eucalyptol): activate local circulation, exert antibacterial effects, soothe the scalp and provide aromatic flavoring, suitable for personal care products, fragrances and feed;

② Phenolic gingerol components (dominated by 6-gingerol, including 8-gingerol, 10-gingerol and shogaols): core active substances for gastrointestinal conditioning, anti-inflammation, analgesia and anti-oxidation, serving as primary markers for oral health foods and pharmaceutical raw materials.

Traditional high-temperature processing causes irreversible degradation of 6-gingerol. Low-temperature graded separation and green solvent-free extraction have become the core global R&D direction of the industry.

2. Period of Single Active Ingredient Isolation & Mature Traditional Solvent Extraction (1879–2016)

2.1 1879–1969: Full identification of gingerol components and formation of laboratory solvent extraction

Gingerols were first isolated in 1879; molecular structures of gingerols and shogaols were fully resolved between 1917 and 1927; serial gingerol monomer crystals were separated in 1969, establishing 6-gingerol as the core quantitative detection marker. Ethanol and diethyl ether reflux extraction processes were widely adopted in European and American laboratories, solely for trace sample preparation in pharmacological research without industrial mass-production lines. In China, only manually distilled crude ginger oil circulated among folk communities, lacking standardized purification capacity; high-end research reference standards relied entirely on imports.

2.2 1970–2002: Small-scale industrial extraction in Europe and America, initial development of domestic industry

Small-scale organic solvent extraction production lines were built in Europe and America for mass production of ginger oleoresin used in food flavoring and daily chemical fragrances. The WHO released its ginger herbal monograph in 1999 to standardize clinical dosages. In 2002, China listed ginger as a medicinal-edible homologous raw material. Small-scale crude ginger extraction factories were constructed in Shandong and Yunnan provinces, only producing low-purity ginger oil and crude ginger powder. Technologies for targeted gingerol enrichment and low-temperature green extraction were absent, and high-end functional raw materials remained fully imported.

2.3 2003–2016: Industrialization of ultrasound/microwave-assisted low-temperature extraction and breakthroughs in resin enrichment technology

Domestic universities and enterprises jointly developed ultrasound and microwave-assisted low-temperature ethanol extraction to reduce gingerol degradation rates. Macroporous adsorption resins realized selective enrichment of gingerols, with freeze-dried powder stably containing ≥5% 6-gingerol. Supercritical CO_2 extraction entered laboratory pilot testing, yet full large-scale industrial equipment depended on expensive imports from Europe and America. Domestic HPLC laboratory systems for gingerol quantification were established, forming preliminary testing standards for health food and cosmetic raw materials.

3. Period of Green Low-Temperature Extraction & Global Regulatory Standardization (2017–2023)

3.1 2017–2020: Industrialization of domestic supercritical CO_2 integrated equipment and popularization of green processes

Domestically manufactured industrial supercritical CO_2 extraction equipment achieved mass production. Airtight extraction proceeds under low temperature (35–45°C) and low pressure with zero organic solvent residues. The extraction yield of 6-gingerol increased by over 22% compared with traditional ethanol reflux, fully retaining

thermosensitive active components. Supporting online impurity removal via molecular distillation separates light ginger essential oil and high-pungency ginger oleoresin, enabling differentiated raw material output from a single production line. Large-scale standardized ginger planting bases in China exceeded one million mu, forming a closed-loop raw material supply chain covering three major producing regions: Shandong, Yunnan and Guangdong.

3.2 2021–2023: Full implementation of global multi-track regulations

In 2021, the EU approved ginger essential oil as an additive for all livestock and poultry feed categories. EU CosIng included ginger root extract, ginger essential oil and ginger oleoresin. The US FDA granted GRAS safety certification to ginger and its extracts, permitting applications in food, dietary supplements and daily chemical products. China's *Catalogue of Cosmetic Raw Materials in Use (2021 Edition)* officially incorporated ginger root extract. Group standards for ginger used in health foods were issued with graded 6-gingerol indexes defined. Completed multi-center human clinical trials verified the safety and efficacy of standardized gingerol extracts for relieving morning sickness, irritable bowel syndrome and mild joint inflammation.

A unified four-tier global grading standard for ginger raw materials was established:

① Crude distilled ginger essential oil (terpene-dominant, for daily chemicals and feed flavoring);

② Food-grade ginger oleoresin (6-gingerol ≥3%, for condiments and functional beverages);

③ Health-grade gingerol freeze-dried powder (6-gingerol ≥5%, for oral dietary supplements);

④ Pharmaceutical high-purity gingerol monomers (6-gingerol ≥98%, for pharmaceutical manufacturing and pharmacological reference standards).

4. Period of Full Independent Domestic Process Substitution & Mature Iteration of Full Industrial Chain (2024–2026)

4.1 2024–2025: Domestic full-chain technologies matching imported equivalents and formation of complete closed-loop industrial chain

Domestic enterprises resolved four core drawbacks of traditional processes: high-temperature 6-gingerol degradation, incapability of component graded separation, excessive solvent residues, and oxidative moisture absorption of powder products. A full suite of mature technologies including supercritical low-temperature extraction, molecular distillation impurity removal, resin targeted enrichment and vacuum freeze-drying microcapsule embedding delivers products whose 6-gingerol content, solvent residues, microbial limits and irritation indicators fully match imported European and American raw materials. Comprehensive production costs decreased by 38%, achieving 100% domestic substitution for high-end gingerol freeze-dried powder and high-purity monomers.

Complete localized closed-loop industrial chain workflow:

Standardized light-shielded temperature-controlled cultivation of authentic ginger → low-temperature airtight transportation within 24 hours post-harvest → cleaning and crushing → supercritical CO_2 low-temperature synchronous fractionation → molecular distillation graded separation of ginger essential oil / ginger oleoresin → macroporous resin gingerol enrichment → vacuum low-temperature concentration / freeze-drying → nano-microcapsule stabilization embedding → sterile light-proof low-temperature warehousing. Ginger residue by-products undergo resourceful fermentation to produce dietary fiber and plant protein, realizing full-plant circular green production.

4.2 2026: Comprehensive upgrading of customized products for six segmented tracks and official enforcement of national standards

The 2025 Edition of the Chinese Pharmacopoeia was formally implemented in October, unifying the statutory HPLC synchronous detection method for 6-, 8- and 10-gingerol in ginger medicinal materials and extracts. Gradient tiered industry products achieve full coverage: pharmacopoeia-grade high-purity 6-gingerol monomers for pharmaceuticals, soothing repairing skincare stock solutions for medical beauty clinics, oral gastrointestinal regulatory freeze-dried powder, natural preservative ginger oleoresin for food, pre-mixed feeds for pet gastrointestinal conditioning, and antibacterial feed additives for livestock and poultry. Solvent-free supercritical green extraction has been widely adopted across the industry, drastically cutting organic solvent consumption and three-waste discharge. Acid and alkali-resistant nanoliposome embedding technology addresses gingerol's vulnerability to oxidation and poor water solubility, compatible with all dosage forms including oral liquids, chewable tablets, facial masks, skincare creams and granular feed.

III. Commercial Development History

1. Stage of Crude Native Medicinal Material Processing & Laboratory Trace Extraction (1600 BCE – 1878)

In ancient China, India and Mediterranean regions, only fresh ginger, dried ginger and manually crude-distilled ginger oil circulated commercially; no standardized purified extract products existed. European and American laboratories solely isolated trace gingerol samples for chemical research without industrial commercial raw material production capacity. No professional extraction factories operated domestically; dried ginger and crude ginger oil circulated only on a small scale among folk vendors and herbal shops, lacking active ingredient quantitative control and grading standards, with a complete absence of mature industrialization.

Industrial characteristics: No low-temperature airtight extraction, molecular distillation grading, resin enrichment or freeze-drying stabilization processes; no unified global raw material grading or content testing standards; zero market recognition of standardized ginger extract commodities; deep processing industry entirely undeveloped.

2. Stage of Pioneering European and American Industrialization & Full Import Reliance for Domestic High-End Raw Materials (1879–2002)

2.1 1879–1999: Small-scale standardized raw material mass production in Europe and America

Organic solvent reflux extraction and steam distillation technologies matured. European and American manufacturers launched ginger oleoresin flavorings, topical joint-soothing ointments and anti-emetic dietary supplements. Global annual consumption of standardized ginger oleoresin reached 2,100 tons in 1999, with the market dominated by European and American food, daily chemical and health food brands. Domestic manufacturers only produced crude dried ginger and low-purity crude ginger oil without gingerol enrichment and purification capacity; standardized ginger oleoresin and high-activity gingerol freeze-dried powder required by food, cosmetic and high-end health food sectors were 100% imported.

2.2 2000–2002: Budding domestic industry with exorbitant imported raw material costs

European and American enterprises monopolized core technologies for gingerol enrichment and low-temperature purification. Imported high-purity gingerol freeze-dried powder carried premium pricing, exclusively supplied to high-end overseas dietary supplement and clinical skincare brands. Domestic crude processed products contained less than 1% 6-gingerol with excessive impurities and irritating shogaols, only sold at low prices to low-end condiment and crude livestock feed manufacturers, barred from oral health food and high-end cosmetic tracks.

Industrial characteristics: Overseas enterprises held full core technologies for graded purification and stabilization; domestic supporting systems for standardized planting, industrial deep extraction and multi-index precision testing were incomplete; domestic market awareness of graded active ginger extracts remained extremely low.

3. Stage of Formed Domestic Production Capacity & Rapid Expansion of Six Application Tracks (2003–2023)

Global demand surged simultaneously for gastrointestinal health, natural anti-inflammatory skincare, clean-label food preservation, pet gastrointestinal care and green antibacterial livestock farming, establishing ginger extracts as indispensable natural functional raw materials. Global annual consumption of all-category raw materials exceeded 17,800 tons in 2023.

Six core domestic application tracks were fully established: anti-inflammatory analgesic pharmaceutical raw materials, gastrointestinal regulatory health foods, circulatory soothing daily chemical care products, natural food preservative additives, pet gastrointestinal conditioning feed, and plant antibacterial pre-mixes for livestock and poultry.

In 2023, domestic graded ginger oleoresin and gingerol freeze-dried powder achieved stable large-scale mass production, breaking the long-term technological monopoly of

Europe and America. Domestic annual market consumption reached 5,600 tons, with 9,300 tons of standardized ginger extracts exported worldwide that year.

A complete localized full industrial chain supporting system took shape, delivering integrated technical services including raw material testing, terminal formula compounding and dosage form development, fully covering all application scenarios for pharmaceuticals, cosmetics, health foods, ordinary food and feed.

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

4.1 Clear product stratification with precise coverage of all application scenarios

Four-tier raw materials feature clear gradient positioning and differentiated competitive advantages: high-purity 6-gingerol monomers exclusively serve pharmaceutical manufacturers and pharmacological laboratories; food-grade ginger oleoresin targets condiment and functional beverage markets; health-grade gingerol freeze-dried powder caters to oral dietary supplements and clinical repairing skincare; light ginger essential oil applies to daily chemical care and livestock feed flavoring, fully covering high-end and mass-market global demand.

4.2 Mass export of domestic raw materials and steadily rising global market share

Domestic ginger extracts match top-tier European and American brands in 6-gingerol activity, low solvent residues and low irritation safety indicators. Supported by the world's largest domestic ginger planting supply chain, independent supercritical green low-temperature purification, customized nano-stabilization embedding technologies and cost advantages, domestic extracts are exported in bulk to the EU, North America, Southeast Asia, Japan, South Korea and Australia, continuously eroding market share of traditional overseas raw material suppliers. Domestic ginger extract exports accounted for 62% of total global trade volume in 2025.

4.3 Formation of standardized healthy industrial competition landscape

Industry supervision centers on the 2025 Edition of the Chinese Pharmacopoeia, US FDA GRAS certification, EU CosIng inventory, feed additive regulations and health food group standards, establishing a market access threshold of ≥5% 6-gingerol for health-grade raw materials. Imported high-purity gingerol monomers are only minimally supplied to high-end specialty pharmaceuticals, while domestic graded standardized raw materials dominate the domestic mass market and emerging overseas markets. Industry competition has shifted from the past chaotic low-price competition over crude dried ginger and crude ginger oil to comprehensive strength competition covering 6-gingerol purity, active ingredient retention via low-temperature extraction, customized grading processes and cross-border multi-region compliance supporting capacity.

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

- ***Full-process airtight green solvent-free production widely popularized***

Large-scale promotion of supercritical CO_2 / subcritical low-temperature extraction, ultrasound-assisted extraction, ceramic membrane low-temperature impurity removal and biological enzymatic pretreatment technologies. Full-process airtight inert temperature control eliminates thermal degradation of 6-gingerol. Ginger rhizome residue by-products are comprehensively developed into dietary fiber, plant protein and organic fertilizer, realizing zero-waste circular green production of full ginger plants.

- ***Customized specialized graded raw materials for segmented tracks***

Differentiated specialized raw materials with tailored 6-gingerol content, shogaol control thresholds, water solubility, viscosity and odor grades will be customized for six segmented tracks: oral gastrointestinal dietary supplements, medical beauty soothing repair, mild maternal and infant care, young pet conditioning, fruit and vegetable preservation, and livestock antibacterial feed.

- ***Development of pre-compounded integrated composite functional raw materials***

One-stop pre-compounded raw materials formulated with probiotics and soothing anti-inflammatory plant extracts reduce secondary compounding procedures for terminal manufacturers, delivering complete formula solutions for tablets, oral liquids, facial masks and granular feed finished products.

- ***Integrated global multi-region compliance layout***

Simultaneous completion of raw material registration and certification in China, EU, the United States, Japan, South Korea and Australia; unified global limit standards for 6-gingerol, pesticide residues, heavy metals and microorganisms to enable unobstructed cross-border circulation of ginger extracts worldwide.

- ***Continuous iteration of high-absorption stable delivery and cell culture technologies***

Nanoliposome and hyaluronic acid composite microcapsule embedding technologies enhance transdermal absorption rate and oral bioavailability of gingerols. High-end dosage forms including single-dose oral freeze-dried powder, sterile soothing essence and sustained-release gastrointestinal granules are developed. Suspension cell culture technology for ginger is advanced to enrich 6-gingerol, breaking supply restrictions imposed by planting seasons and land resources to achieve stable year-round supply of high-purity active monomers.

Conclusion

The ginger extract industry originates from over three thousand years of medicinal-edible homologous herbal applications in China, integrated with the classical herbal heritage of ancient India and Rome. It has evolved into a mainstream global standardized rhizome functional raw material track covering six sectors: anti-inflammatory analgesic pharmaceuticals, gastrointestinal regulatory dietary supplements, soothing repairing cosmetics, natural food preservatives, pet gastrointestinal conditioning products, and antibacterial livestock feed.

Its complete development cycle spans textual research on ancient herbal documents, isolation and identification of dual active components (volatile oils / gingerols), multi-center human clinical evidence verification, supercritical airtight green low-temperature extraction, molecular distillation graded impurity removal, macroporous resin targeted gingerol enrichment, iterative optimization of vacuum freeze-drying nano-microcapsule stabilization processes, and technological catch-up of full domestic extraction equipment and production lines. The full-chain industrial upgrading journey extends from native fresh ginger, crude dried ginger and simple crude ginger oil to globally graded high-end functional extracts.

Compared with crude products manufactured via traditional high-temperature steam distillation and open ethanol reflux, standardized low-temperature graded ginger extracts adopt five core technologies: airtight supercritical CO_2 extraction, synchronous molecular distillation fractionation, macroporous resin gingerol enrichment, vacuum freeze-drying stabilization and nanoliposome embedding modification. Their core competitive advantages include complete retention of the marker 6-gingerol, controllable levels of irritating shogaols, zero organic solvent residues, stable storage under normal temperature and light shielding, compatibility with all dosage forms for food/cosmetics/pharmaceuticals/feed, and cross-border compliance registration across multiple global regions. These strengths perfectly align with long-term global market trends for natural anti-inflammation, digestive health, clean-label preservation, natural pet care and ecological antibiotic-free livestock farming.

With continuous commercialization of new technologies including solvent-free green extraction, customized graded raw materials for segmented tracks, high-absorption nano-delivery systems and plant cell suspension culture, ginger extracts will permanently occupy the core raw material tracks of natural gastrointestinal regulation, mild anti-inflammation and plant antibacterial agents, evolving into an indispensable multi-functional mainstream botanical raw material across pharmaceuticals, cosmetics, big health, pet industries and livestock breeding.