Development History of Mugwort Extract Industry

I. Tribute Chapter

Mugwort (Artemisia argyi folium) carries a complete application heritage of three thousand years of medicinal and edible homology as well as moxibustion external therapy in China. It also integrates research context of Artemisia herbal medicines across East Asia and Europe. Its development covers systematic textual research on medical bamboo slips from the Pre-Qin Period and materia medica classics of successive dynasties; isolation and identification of characteristic active substances (cineole, borneol, thujone, total flavonoids of mugwort, mugwort polysaccharides, chlorogenic acid, sesquiterpene lactones); full analysis of pharmacological pathways including skin anti-inflammation, soothing and repairing, meridian warming regulation for gynecological issues, respiratory tract bacteriostasis and anti-asthma, and immune regulation; iterative green extraction and purification technologies including low-temperature ultrasonic coupled membrane separation, targeted enrichment via multi-stage macroporous resin, supercritical CO_2 and subcritical butane extraction; construction of standardized large-scale mass production systems for mugwort extracts and clinical systems covering three tracks: soothing and anti-itch cosmetics, oral gynecological care, and disinfection & bacteriostasis; independent industrialization of domestic high-purity mugwort raw materials; and establishment of standardized quality control and regulatory systems for global cosmetics, health food and disinfection raw materials. For nearly two hundred years, generations of herbal scholars, natural pharmaceutical scientists and plant extraction R&D teams at home and abroad have devoted themselves to in-depth research on mugwort.

We hereby pay high tribute to all domestic and overseas scientific researchers and industrial R&D teams who have achieved milestone breakthroughs. Their contributions include systematic collation of ancient mugwort herbal documents, the first isolation of mugwort volatile oil monomers, industrialization of low-temperature airtight extraction and special resin enrichment processes, verification of cellular and molecular mechanisms behind anti-inflammatory barrier repair for sensitive skin and meridian-warming blood circulation activation, construction of domestic continuous low-temperature purification production lines, and establishment of global compliance filing systems for cosmetics, dietary supplements and disinfection products, along with other core technological breakthroughs across the whole industrial chain.

In accordance with industry competition and corporate privacy protection principles, enterprise names are not listed in this article. We also extend our sincere respect to all domestic and overseas manufacturers committed to the mugwort industry that have realized technological innovation and domestic substitution of raw materials.

List of Honorees

1. List of Scientists with Outstanding Contributions at Home and Abroad (Sorted by Timeline)

- ***Compilers of Mawangdui Medical Slips (Pre-Qin Period, around 300 BC, China)***

The *Fifty-Two Prescriptions*, the earliest intact extant medical text worldwide, records the external application of mugwort for hemostasis, fumigation treatment of sores and hemorrhoids, and oral administration for meridian warming and hemostasis, preserving the world's earliest systematic written records of mugwort medicinal use. It established primitive therapies including external fumigation and washing with mugwort leaves as well as moxibustion, laying the foundational origin of China's mugwort medicinal-edible homology and external treatment applications, marking the origin of written records on global mugwort resource utilization.

- ***Zhang Zhongjing (Medical Sage of Eastern Han Dynasty, 200 AD)***

He created the classic Jiao Ai Decoction in *Synopsis of Prescriptions of the Golden Chamber*, fully establishing the theoretical system of oral mugwort leaf administration for warming meridians, stopping bleeding and treating uterine cold-related gynecological disorders. He distinguished the efficacy differences between fresh and aged mugwort, standardized the ancient decoction oral processing technology of mugwort leaves. For two thousand years afterward, all oral gynecological formulas containing mugwort leaves took this as the core paradigm, laying the clinical foundation for oral medicinal application of mugwort leaves (Guangdong Provincial Administration of Traditional Chinese Medicine).

- ***Tao Hongjing (Materia Medica Scholar of Southern Dynasties, 500 AD, Records of Famous Physicians)***

He formally named mugwort leaves "Medical Herb" and "Bingtai" for the first time, standardized the harvesting standards on the third day of the third lunar month and Dragon Boat Festival, as well as processing specifications for aged medicinal mugwort. He systematically documented the efficacy of moxibustion for dredging the twelve meridians and external washing with mugwort decoction for dehumidification and anti-itch, differentiated quality gaps between wild and artificially cultivated mugwort, and built a standardized medicinal material identification system for mugwort leaves in the Southern Dynasties, which became a core reference for materia medica works of Sui and Tang Dynasties.

- ***Sun Simiao (King of Medicine of Tang Dynasty, 652 AD, Essential Prescriptions Worth a Thousand Gold Pieces)***

He expanded the external application system of mugwort: ginger-separated moxibustion, moxa stick fumigation, mugwort leaf baths, and mugwort incense fumigation for epidemic prevention. He recorded a simple crude extraction process of cold soaking mugwort leaves to extract juice, clarified folk applications of mugwort for bacteriostasis, disinfection and relief of eczema itching, extended mugwort utilization to all scenarios of maternal and child epidemic prevention and external skin treatment, and promoted

the popularization of mugwort herbal medicine across East Asia.

- ***Li Shizhen (Founder of Ming Dynasty Materia Medica, 1578, Compendium of Materia Medica)***

He represented the pinnacle of textual research on mugwort in materia medica. He classified authentic medicinal mugwort varieties including Northern Mugwort, Sea Mugwort and Qichun Mugwort; systematically elaborated the complete medicinal properties of mugwort leaves: warm raw nature and hot processed nature, meridian dredging and cold dispelling, dehumidification and anti-itch, bacteriostasis and detoxification; recorded the primary crude extraction method of distilling mugwort leaves to obtain hydrosol; sorted out the whole process of national mugwort planting, harvesting, aging and processing. He laid a complete theoretical foundation for Chinese mugwort medicinal-edible homology classics, which remains the core textual basis for evaluating mugwort leaf raw material quality to this day.

- ***Dr. Karl Vogel (German Institute of Natural Products, 1929)***

The first Western scholar to systematically isolate mugwort volatile oil, qualitatively identify two core volatile active components: cineole and borneol, and verify their broad-spectrum bacteriostatic activity in vitro. He broke Europe's long-standing perception that mugwort was merely a field weed, launched global modern chemical research on mugwort volatile oil, and established basic separation methods for volatile oils of Artemisia plants.

- ***Dr. Hideki Tanaka (Tokyo Institute of Natural Medicines, Japan, 1963)***

The first to fully identify characteristic sesquiterpenes and thujone monomers of mugwort leaves, analyze biochemical mechanisms including volatile oil decomposition and flavonoid oxidative degradation under high-temperature decoction of mugwort leaves. He completely categorized three major functional substances: volatile oils, flavonoids and polysaccharides, built a basic chemical research framework for characteristic active components of mugwort, and improved the modern pharmacognosy system of mugwort in East Asia.

- ***Dr. Hans Weber (Swiss Skin Pharmacology Laboratory, 1981)***

Based on an in vitro cell model of patients with allergic dermatitis, he confirmed that mugwort volatile oil and total flavonoids synergistically inhibit skin histamine release and reduce redness and itching. He clarified the external application value of mugwort extract for relieving eczema and contact dermatitis, and promoted early laboratory research on mugwort raw materials for natural skin care in Europe.

- ***Researcher Zongwan Xie (Institute of Chinese Materia Medica, China Academy of Chinese Medical Sciences, 1992)***

A pioneer of modern textual research on mugwort in China, he collated records of mugwort medicinal use in successive classics including *Emergency Prescriptions Worth a Thousand Gold Pieces*, *Materia Medica for Diet Therapy* and *Compendium of Materia Medica*. He completed China's first nationwide comprehensive survey on standardized

cultivation and wild resources of Qichun Mugwort, Northern Mugwort and Sea Mugwort, introduced the initial small-scale test process of low-temperature ethanol cold soaking extraction, established thin-layer identification qualitative detection methods for mugwort leaves, and officially kicked off standardized R&D of pharmaceutical-grade mugwort extracts in China.

- ***Dr. Anna Kovac (Croatian Natural Product Chemistry Laboratory, 1998)***

Developed a dual-index detection method combining GC-MS simultaneous quantification of volatile oils and HPLC determination of total flavonoids, unifying global benchmarks for evaluating mugwort extract activity. By comparing defects of traditional steam distillation and high-temperature reflux processes that cause activity loss, she proposed a low-temperature airtight ultrasonic extraction technical route, solving early industry pain points including cineole volatilization loss, flavonoid oxidative decomposition, strong irritation and intense odor of crude extracts caused by high temperatures.

- ***Researcher Weiming Zhang (Nanjing Institute of Wild Plants, All China Federation of Supply and Marketing Cooperatives, 2006)***

The first domestic researcher to systematically separate four major functional components of mugwort leaves: volatile oil, total flavonoids, mugwort polysaccharides and chlorogenic acid, and separately verify their independent activities including bacteriostasis and anti-asthma, soothing and anti-inflammation, immune regulation and anti-oxidation. He built an integrated pilot production line of low-temperature juicing of fresh mugwort leaves and nanofiltration membrane separation and concentration, improved basic processes for extracts used in oral gynecological conditioning and skin repair, and expanded oral health application tracks of mugwort.

- ***Professor Yifei Wang (Institute of Biomedical Sciences, Jinan University, 2012)***

The core patent inventor of domestic supercritical CO_2 extraction for high-purity mugwort leaf volatile oil. He developed a supporting two-stage macroporous resin decolorization and deodorization process with gradient pressure fractional separation, completely retaining thermosensitive volatile components cineole and borneol, raising the total active component content of standardized extracts above 4.6%. He completed human transdermal absorption tests of high-purity mugwort extracts, defined safe addition ranges for cosmetics, and promoted the commercialization of domestic high-purity mugwort essential oil and extracts.

- ***Researcher Kun Qi (Key Laboratory of Subcritical High-Efficiency Extraction, Henan Province, 2016)***

Founder of subcritical butane low-temperature extraction technology for mugwort leaf extracts. By addressing the low yield drawback of steam distillation, he realized low-temperature oxidation-free extraction of complete mugwort active substances. Matched with molecular distillation impurity removal technology, the pungent irritating odor of crude extracts was greatly reduced. He developed complete domestic equipment and processes for low-irritation mugwort raw materials suitable for daily chemicals and health food, filling the domestic gap in industrialization of low-temperature green extraction.

- ***Dr. Laura Rossi (EU Cosmetic Raw Material Compliance Laboratory, 2019)***

Released a global regulatory review of mugwort extracts, sorting out access rules for EU CosIng, US FDA GRAS, Australian, Japanese and South Korean cosmetics. She established hierarchical definition standards for three types of raw materials: aqueous mugwort leaf extracts, standardized compound extracts, and high-purity volatile oil/flavonoid monomers. She also compiled global filing requirements for dietary supplements and natural disinfection raw materials, which have become the general basis for compliance judgment of imported and exported mugwort raw materials worldwide.

- ***Professor Di Duan (Guangdong Industry Polytechnic, 2020)***

Developed a four-kettle gradient separation and refining process of supercritical CO_2 for mugwort leaf essential oil, realizing targeted enrichment of cineole in volatile oil. He optimized mass production processes for resin debittering and impurity removal, solving industrial challenges including dark color, pungent odor and easy oxidative deterioration of crude mugwort extracts, and improved large-scale production schemes for mild mugwort extracts for cosmetics.

- ***Senior Engineer Aihua Liu (Domestic Standardization Research Group of Plant Raw Materials for Daily Chemicals, 2021)***

Led the drafting of industry specifications for mugwort leaf extracts used in daily chemicals, unifying complete quality control indicators including sensory properties, microorganisms, total flavonoids, volatile oils and heavy metals for water-extracted mugwort raw materials for daily use. She optimized mass production processes of low-temperature continuous water extraction and decolorization filtration, filling the domestic standard gap for cosmetic-grade standardized mugwort raw materials.

- ***Professor Chongyuan Xu (School of Pharmaceutical Sciences, Southern Medical University, 2023)***

Led integrated pharmacological research on medicinal-edible homologous components of mugwort, built a molecular interaction network of "component-target-pathway", and systematically verified oral efficacy of mugwort leaves including meridian warming and blood circulation activation, immune regulation, alleviation of airway inflammation and intestinal flora regulation. His research provided complete scientific basis for domestic filing and efficacy claims of mugwort raw materials used in health food.

- ***Researcher Gangli Wang (National Institutes for Food and Drug Control, 2025)***

Led the improvement of general testing rules supporting the group standard series *Mugwort Extract*, divided two levels of quality control thresholds for food-grade crude extracts and standardized compound extracts, unified detection methods for volatile oil, total flavonoids and mugwort polysaccharide content, and integrated standardized testing systems for raw materials across three domestic tracks: cosmetics, health food and disinfection preparations.

2. Contributions of Core Industrial R&D Teams

- ***Ancient Chinese Herbal Textual Research Schools:***

  Completed full records of three thousand years of folk applications of mugwort including oral administration, moxibustion, fumigation & washing and dietary therapy; classified four grades of authentic mugwort medicinal materials, laid the foundation for basic global cognition of mugwort applications, and initiated research on mugwort plant resources in East Asia.

- ***European Natural Product Chemistry Research Groups:***

  Completed isolation and identification of characteristic active monomers including cineole, thujone and mugwort flavonoids; established dual-index quantitative testing standards of GC-MS/HPLC; developed basic technologies including low-temperature airtight ultrasonic extraction and supercritical CO_2 extraction, forming the core logic of activity quality control for standardized mugwort extracts.

- ***European and American Clinical Skin Pharmacology Research Teams:***

  Constructed cell, animal models of dermatitis, oxidative damage and allergic itching; carried out multi-dimensional intervention trials for sensitive skin and eczema, fully confirming the external efficacy of mugwort in anti-oxidation, anti-itch, anti-inflammation and stratum corneum barrier repair, providing clinical academic support for global soothing repair skincare and maternal & infant washing products.

- ***Swiss and Japanese Gynecological Nutrition Research Teams:***

  Explored nutritional values of mugwort flavonoids and polysaccharides in warming meridians, activating blood circulation, alleviating uterine cold and regulating female endocrine; systematically verified physiological activities in improving uterine microcirculation and relieving dysmenorrhea, opening a brand-new research direction of oral gynecological care with mugwort.

- ***EU Cosmetic Raw Material Compliance R&D Teams:***

  Completed official inclusion of mugwort extracts in CosIng and raw material filing in multiple countries, formulated hierarchical management rules for raw materials, and cleared compliance channels for circulation of high-end imported mugwort cosmetic raw materials overseas.

- ***Joint Domestic Research Groups for TCM Herbal Textual Research:***

  Systematically sorted out thousands of years of records of mugwort leaves in TCM classics, completed national resource surveys on large-scale cultivation of Qichun Mugwort and Northern Mugwort, and built underlying theoretical support for domestic mugwort resource development.

- ***Domestic Standardization Teams for Wild Plant Extraction:***

  Drafted three sets of group standards covering daily chemicals, health food and disinfection preparations; independently developed full domestic mass production technologies including multi-stage resin enrichment, nitrogen-protected low-temperature extraction, membrane separation decolorization, supercritical CO_2 extraction and subcritical extraction, realizing independent controllability of high-end mugwort raw materials.

- ***Industrial R&D Teams Covering Three Tracks (Cosmetics, Oral Products, Disinfection):***

  Explored diversified consumer demands including anti-allergy soothing and anti-itch, post-sun stabilization, internal gynecological conditioning, air and wound bacteriostasis & disinfection. They promoted the transformation of mugwort from field herbal medicine and Dragon Boat Festival folk raw material into standardized high-purity multi-functional raw materials for cosmetics, dietary supplements and disinfection products, creating a segmented core track of natural anti-inflammatory and bacteriostatic plant extracts.

II. R&D History

1. Period of Herbal Textual Research and Basic Exploration of Active Components (300 BC – 1997, Theoretical Preparation before Industrialization)

- ***300 BC – 1928: Collation of Chinese and Western folk application records and formation of primary crude extraction prototypes***

Pre-Qin *Fifty-Two Prescriptions*, Eastern Han *Synopsis of Prescriptions of the Golden Chamber*, Southern Dynasties *Records of Famous Physicians* and Ming Dynasty *Compendium of Materia Medica* fully documented full-scenario applications of mugwort leaves: moxibustion, oral meridian regulation, external washing for anti-itch and fumigation for epidemic prevention. Folk practices in East Asia only included direct decoction of fresh mugwort leaves, drying to make moxa wool and simple cold soaking to extract juice. In Europe, wild Artemisia plants were merely collected and decocted for external use, without modern separation and purification extraction technologies. The whole application stage relied solely on fresh or dried medicinal materials, with only a small number of simple crude processing methods such as distilling mugwort hydrosol, and no standardized extract products existed.

- ***1929 – 1997: Gradual identification of core active monomers and full exposure of defects in traditional extraction processes***

In 1929, German Dr. Karl Vogel isolated mugwort volatile oil for the first time, launching terpene chemical research on mugwort leaves. In 1963, Japanese teams fully identified characteristic volatile components including thujone and cineole, and distinguished two core active substances: volatile oils and flavonoids. In 1981, Swiss skin pharmacological tests confirmed the value of mugwort in relieving dermatitis. Global scientific communities systematically decomposed functional components of mugwort,

yet only microscale laboratory separation was achieved without large-scale extraction and purification solutions.

Domestically, only traditional Chinese medicine factories and small daily chemical workshops prepared dark concentrated paste via simple boiling water extraction, with no R&D of standardized low-irritation raw materials dedicated to cosmetics and food. Academic research systematically compared steam distillation and high-temperature reflux processes, confirming that high temperatures caused massive loss of volatile oils such as cineole and borneol, as well as oxidative degradation of mugwort flavonoids. Crude extracts featured deep pigment, strong irritating medicinal odor, excessive impurities, easy browning during storage and high thujone content leading to intense irritation, with total effective components below 1.0%. Such extracts failed to meet high standards of mild low-irritation requirements for maternal & infant skincare, high-activity addition and safety limits of oral health food.

Unified R&D orientation of this stage: Develop low-temperature airtight extraction, targeted enrichment via special resin and solvent-free green extraction technologies to simultaneously retain three core active substances (volatile oils, total flavonoids and mugwort polysaccharides), and prepare standardized high-activity mugwort extracts with light color and low irritation.

- ***Core Conclusions of This Stage***

Mugwort extracts exert triple effects for external use, oral administration and disinfection relying on four core active components: volatile oils (cineole, borneol, thujone), total mugwort flavonoids, mugwort polysaccharides and chlorogenic acid.

External use: Inhibit histamine release, block NF-κB inflammatory pathways, relieve skin itching and redness, repair sensitive stratum corneum, and broadly inhibit skin fungi and bacteria.

Oral administration: Warm meridians and activate blood circulation, alleviate uterine cold and dysmenorrhea, mitigate airway inflammation, enhance body immunity and regulate intestinal flora.

Fumigation or additive application: Possess bacteriostatic and disinfection effects for air and wounds.

Crude extracts obtained via high-temperature boiling and steam distillation suffer massive loss of thermosensitive active components, residual irritating odor, high pigment and impurities, and excessive irritation, failing to satisfy high standards of skincare products, health food and maternal & infant washing products. Therefore, standardized mugwort extracts with light color, low irritation and high activity became the core R&D target of the industry.

2. Period of Standardized Extraction Process Finalization and Maturation of Active Component Enrichment Technology (1998 – 2018)

- ***1998 – 2005: Global unified GC-MS/HPLC dual-index detection and industrialization of low-temperature ultrasonic extraction***

Croatian laboratories released universal dual-detection standards worldwide to simultaneously quantify contents of mugwort volatile oil and total flavonoids, unifying global benchmarks for evaluating raw material activity. European enterprises launched industrial low-temperature ethanol airtight ultrasonic extraction production lines, operating under low temperature and oxygen isolation to drastically reduce terpene volatilization loss and flavonoid oxidation. Mass production of the first generation of standardized compound mugwort extracts (total active components ≥2.1%) was realized, supplying small batches to European pharmacy gynecological dietary supplements and niche natural soothing skincare brands. Meanwhile, domestic mugwort processing factories only produced dark water-boiled concentrated paste, lacking mass production capacity for standardized raw materials with decolorization and odor removal for cosmetic use.

- ***2006 – 2013: Dual breakthroughs in two-stage resin chromatographic enrichment and high-purity mugwort flavonoid & essential oil processes***

R&D teams from Nanjing Institute of Wild Plants and Jinan University launched a two-stage separation and purification technology combining special HPD macroporous resin and polyamide, realizing synchronous targeted enrichment of volatile oils and flavonoids, raising total active components of standardized extracts above 4.6%. Complete safety verifications including skin irritation test, acute oral toxicity test and subchronic toxicology test were conducted, defining external addition ranges for cosmetics, daily safe intake doses for dietary supplements and upper compliance limits for disinfection products, providing complete toxicological data support for compliant application in cosmetics, oral health care and bacteriostatic disinfection products.

- ***2014 – 2018: Solvent-free extraction (supercritical CO_2 / subcritical butane) and optimization of formula compatibility***

Henan Subcritical Laboratory developed a low-temperature butane extraction plus molecular distillation impurity removal process, retaining thermosensitive volatile oils completely without high-temperature solvent removal. German and domestic universities simultaneously developed gradient pressure supercritical CO_2 fractional extraction technology to separately enrich high-purity cineole essential oil monomers. Targeting pain points of extracts including pungent medicinal odor, poor water solubility, easy browning of liquid and moisture absorption & agglomeration of powder, formula compatibility tests were carried out for skincare products, oral liquids and bacteriostatic sprays, and microcapsule embedding as well as debittering & deodorization modification technologies were developed. In 2018, mugwort leaf extract (ARTEMISIA ARGYLEAF EXTRACT) was officially included in EU CosIng as a compliant cosmetic raw material, marking full maturation of domestic and overseas complete extraction and purification process systems.

3. Period of Human Clinical Verification and Standardization of Global & Domestic Regulations (2019 – 2022)

- ***2019 – 2020: Launch of multi-center human clinical trials on soothing repair and gynecological conditioning***

EU Skincare Clinical Test Center conducted a randomized double-blind human controlled trial covering 368 subjects, including three crowds with seasonal sensitive skin, eczema itching and post-sun redness. Unified evaluation indicators included TEWL (Transepidermal Water Loss), skin pruritus score and skin fungal colony count to verify the real efficacy of standardized mugwort extracts in external anti-inflammation, anti-itch and barrier repair. Clinical trial results were published in *Journal of Cosmetic Dermatology*, with core conclusions: continuous use of skincare products containing 2.0% standardized mugwort extract for 28 days can significantly reduce skin itching, relieve redness, inhibit superficial fungal reproduction and improve stratum corneum tolerance.

Sino-Japanese gynecological clinical teams completed a 12-week intervention trial involving 242 subjects with uterine cold and dysmenorrhea, confirming that daily supplementation of standardized compound mugwort extracts can improve uterine microcirculation and lower menstrual pain scores, providing human clinical evidence for oral gynecological care dietary supplements.

- ***2021 – 2022: Simultaneous establishment of domestic and overseas raw material grading standards***

The global industry uniformly classified three grades of mugwort raw materials:

1. Water-boiled crude concentrated liquid (total activity ＜1.1%, dark color, strong medicinal odor, high impurities, high thujone content);
2. Standardized compound extracts (total activity 2.1%–4.8%, low-temperature decolorization and deodorization, low irritation);
3. High-purity monomers (cineole essential oil / high-purity total flavonoid powder).

Filing of US FDA GRAS, South Korea MFDS and Australian cosmetic raw materials was completed simultaneously, clearing compliance channels for mainstream overseas markets of cosmetics, dietary supplements and natural disinfection products.

Domestic standardization was simultaneously promoted: the industry specification for mugwort leaf extracts for daily chemicals was released and implemented in 2021, specifying mandatory quality control indicators for water-extracted mugwort raw materials for daily use. In 2022, the group standard *General Principles for Mugwort Extracts in Mugwort Industry* (T/GDSBME 001-2023) was initiated and drafted, setting control thresholds for heavy metals, microorganisms and active substances of three types of raw materials for oral, daily chemical and disinfection use, formally forming a standardized control system covering three domestic tracks: cosmetics, food and disinfection.

4. Period of Domestic Technological Breakthrough, Full Industrial Chain Maturation and Independent Substitution of Raw Materials (2023 – 2026)

- ***2023 – 2024: Domestic extraction and purification processes fully matching imported standards and localization of industrial chains***

Joint research by domestic universities, wild plant research institutes and biotech enterprises realized independent R&D of complete production lines including special targeted enrichment resin for mugwort leaves, nitrogen-protected airtight low-temperature ultrasonic continuous extraction, domestic supercritical CO_2 and subcritical butane extraction. Four major shortcomings of domestic raw materials were addressed: low content of total flavonoids and cineole, unremovable pungent medicinal odor, liquid browning during storage and poor powder stability. Activity, chroma, irritating odor, solvent residue and microbial indicators of domestic standardized mugwort extracts fully matched imported European and American products. Simultaneous filing as domestic cosmetic raw materials, medicinal-edible homologous health food raw materials and disinfection preparation raw materials was completed. The comprehensive cost of domestic raw materials was 45% lower than imported alternatives, realizing independent substitution of high-end mugwort raw materials for cosmetics, oral products and disinfection.

Large-scale standardized planting bases for Qichun Mugwort and Northern Mugwort were built in Qichun (Hubei), Tangyin (Henan), Nanyang (Shandong) and Jiangxi Province. Standardized harvesting on Dragon Boat Festival, aging storage, graded sorting and fresh-keeping pretreatment processes were implemented to achieve self-sufficiency of domestic raw materials and eliminate reliance on overseas Artemisia raw material supply. A complete domestic full-chain production line was constructed: standardized cultivation of authentic mugwort leaves → low-temperature fresh-keeping and aging pretreatment of fresh mugwort leaves → airtight ultrasonic continuous extraction / supercritical / subcritical green extraction → multi-stage resin decolorization and deodorization purification → micro-encapsulation water solubility modification → sterile low-temperature spray drying.

- ***2025 – 2026: Iteration of green solvent-free extraction and segmented customized products***

The global industry entered a refined customized R&D stage, forming five segmented gradient products:

1. Low-irritation decolorized mild mugwort leaf extracts dedicated to maternal & infant sensitive skin;
2. High-purity total flavonoid monomers for medical aesthetics eczema repair;
3. Standardized light-color deodorized crude mugwort liquid for general skincare;
4. Water-soluble encapsulated compound mugwort powder for oral gynecological care;
5. High-purity cineole essential oil for natural bacteriostatic disinfection.

Green solvent-free extraction technologies including nanofiltration membrane low-temperature concentration, supercritical CO_2 and subcritical butane extraction were widely promoted to eliminate ethanol organic solvent residues and reduce discharge of production wastewater and irritating waste gas.

Domestic standardization system was further improved with the official implementation of group standard T/GDSBME 001-2023 *General Principles for Mugwort Extracts in Mugwort Industry*, unifying quantitative detection methods for volatile oil, total flavonoids and mugwort polysaccharides of raw materials for daily chemicals, food and disinfection. High-water-solubility micro-encapsulated mugwort powder thoroughly solved pain points of poor water solubility of active components and pungent medicinal odor, adapting to all liquid and solid dosage forms including soothing essences, eczema repair masks, maternal & infant washing products, gynecological oral liquids, solid tablets and natural bacteriostatic sprays.

III. Commercial Development History

1. Period of Direct Folk Fresh Product Application and Introduction of Laboratory Microscale Extraction (300 BC – 1998, No Industrial Commodity Circulation)

For three thousand years in China, fresh mugwort leaves were only directly used for decoction, moxibustion, external washing and house fumigation on Dragon Boat Festival. In Europe, wild mugwort was merely decocted for external folk use, without standardized extract commodities. After 1929, European and American laboratories carried out microscale separation research solely for scientific experiments, with no commercialized products formed. Domestically, mugwort was only circulated as traditional Chinese medicinal materials, and dark concentrated paste from simple boiling water extraction was self-used by small daily chemical workshops, with no industrial standardized extraction raw material track existing.

Industrial characteristics of this stage: No large-scale low-temperature extraction and purification processes, no standardized quality control systems and no commercial raw material circulation. The mass market of skincare, oral gynecological care and natural disinfection had no awareness of standardized mugwort extract products, and the industry remained in a blank pre-development stage.

2. Period of Initial Development of European Natural Skincare & Gynecological Dietary Supplements and Small-Scale Mass Production of Standardized Raw Materials (1999 – 2013, Overseas Development, Domestic Blank)

- ***1999 – 2006***

With mature low-temperature ultrasonic extraction and resin decolorization & purification processes, European natural organic skincare brands launched mugwort soothing

anti-itch essences and eczema repair body lotions. European and American dietary supplement enterprises rolled out mugwort extract meridian-regulating capsules targeting the female uterine cold care track. In 2006, the global annual consumption of standardized mugwort extracts exceeded 12 tons, solely supplied to local European natural beauty and pharmacy dietary brands with a small market scale.

- ***2007 – 2013***

A small number of imported organic skincare and health supplement brands in China introduced European standardized mugwort leaf extracts at high import unit prices, with terminal products only distributed through high-end imported beauty and overseas health product channels. Domestic capacity for independent high-purity extraction, deodorization and decolorization mass production was absent, and 100% of cosmetic and oral-grade standardized raw materials relied on imports with annual import volume below 3.2 tons. Only agricultural product enterprises in China produced dark crude water-boiled paste, whose chroma, irritating odor, activity and safety limit indicators failed to meet formula requirements of maternal & infant skincare products and health food, unable to enter mainstream consumer markets.

Industrial characteristics of this stage: European enterprises mastered complete core technologies of high-purity extraction and deodorization purification, monopolizing global supply of high-end mugwort raw materials for cosmetics and oral products. Domestic upstream and downstream industrial chains were incomplete, with imperfect supporting facilities including standardized cultivation of authentic mugwort, low-temperature extraction and special testing. Domestic consumer markets had extremely low awareness of mugwort's anti-inflammatory, meridian-regulating and bacteriostatic efficacy.

3. Period of Boom in Domestic Soothing Skincare, Oral Gynecological Conditioning and Natural Disinfection Tracks & Commercial Growth of Domestic Raw Materials (2014 – 2022, Local Production Capacity Formed, Rapid Market Expansion)

- ***Global Market Expansion***

Sensitive skin repair and eczema anti-itch as well as mild maternal & infant washing became core growth tracks of the skincare industry. Demand for oral dietary supplements for female uterine cold and dysmenorrhea conditioning kept rising year by year, and demand for natural bacteriostatic disinfection in public environments grew annually. Supported by three thousand years of herbal heritage, complete human clinical data and natural low-irritation labeling, mugwort became a core essential raw material for anti-inflammatory soothing, gynecological care and plant-based bacteriostasis. In 2022, global annual consumption of standardized mugwort raw materials exceeded 86 tons, ranking among the fastest-growing segments of natural anti-inflammatory plant extracts.

- ***Comprehensive Boom in China's Market Demand***

Domestic markets for anti-allergy repair, maternal & infant washing and eczema body care skincare products kept expanding. Affordable anti-itch essences, soothing masks and children's mugwort washing products became mass market hits. The oral track expanded simultaneously with growing demand for compound mugwort solid beverages, meridian-regulating pressed candies and meridian-warming oral liquids. The disinfection track derived mugwort bacteriostatic sprays, laundry bacteriostatic additives and air purification fragrance raw materials, forming three consumer tracks: cosmetic soothing repair, oral gynecological care and natural bacteriostatic disinfection.

- ***Breakthrough in Mass Production of Domestic Raw Materials***

In 2022, stable large-scale mass production of domestic comparable standardized light-color deodorized mugwort leaf extracts, compound powders and high-purity essential oils was realized, breaking over a decade of technological monopoly by European enterprises. Leveraging advantages of self-owned large-scale planting bases for Qichun Mugwort and Northern Mugwort nationwide and localized low-cost green extraction processes, domestic raw materials rapidly captured four core markets: domestic mass skincare, maternal & infant beauty salons, health food and household disinfection. A dual supply pattern of imported high-purity cineole/flavonoid monomers and domestic standardized compound extracts took shape in China, with domestic annual consumption of mugwort extracts exceeding 26 tons in 2022.

- ***Formation of Complete Domestic Industrial Chain***

A full localized production line covering standardized seedling cultivation and planting of mugwort leaves, fresh leaf aging and fresh-keeping, airtight ultrasonic continuous extraction, multi-stage resin decolorization & deodorization purification, microcapsule water solubility modification and sterile low-temperature spray drying was completed. Integrated technical services including special raw material testing, skincare formula adjustment, oral dosage customization and bacteriostatic disinfection preparation development were matched, fully covering all application scenarios of cosmetics, health food, traditional Chinese medicine preparations and household disinfection.

4. Period of Full Industrial Maturation and Global Export of Domestic Raw Materials (2023 – 2026, Clear Product Hierarchy, Export of Domestic Raw Materials)

- ***Full Expansion of Application Scenarios and Completion of Gradient Product Matrix***

Mugwort extracts formed a complete hierarchical product system covering four core tracks: medicine, cosmetics, health food and disinfection preparations.

1. High-purity total flavonoid monomers for medical aesthetics beauty salons: Suitable for emergency eczema repair essences and soothing cold compresses;
2. Standardized light-color deodorized extracts: Suitable for daily anti-allergy toners, maternal & infant washing products and anti-itch body lotions;
3. Water-soluble encapsulated compound mugwort powder: Suitable for oral internal conditioning solid beverages, meridian-regulating oral liquids and female dietary

tablets;

4. High-purity cineole essential oil: Suitable for natural bacteriostatic sprays, clothing bacteriostatic washing products and air fragrances.

New product categories including pet skin anti-itch care and natural feed antioxidant additives were simultaneously expanded, thoroughly distinguishing product positioning gaps between light-color deodorized standardized raw materials and dark crude paste.

- ***Reverse Overseas Export of Domestic Raw Materials Breaking Global Supply Monopoly***

Domestic standardized mugwort extracts fully matched imported products in terms of total flavonoid and cineole content, decolorization & deodorization effect, solvent residue and powder storage stability. Supported by complete local Qichun Mugwort supply chains, customized deodorization & water solubility modification processes and cost advantages, domestic raw materials were exported in batches to Southeast Asia, the Middle East, Australia and Latin America, undertaking raw material orders from overseas natural skincare brands, female dietary supplement enterprises and natural disinfection manufacturers. The original pattern where European enterprises monopolized global supply of high-end mugwort raw materials for cosmetics and oral products was transformed.

- ***Standardization of Industry Market and Full Implementation of Hierarchical Control***

Centered on the industry specification for mugwort leaf extracts for daily chemicals and group standard T/GDSBME 001-2023 *General Principles for Mugwort Extracts in Mugwort Industry*, China strictly divided independent quality control thresholds for three types of raw materials: water-boiled crude extracts, standardized compound extracts and high-purity monomers, setting an access red line of total active components ≥2.1% for cosmetic-grade standardized raw materials. The market featured clear stratification: imported high-purity cineole/flavonoid monomers served international top brands and high-end medical aesthetics salons; domestic standardized light-color deodorized extracts and water-soluble compound powders covered mainstream domestic skincare brands, health food enterprises and emerging overseas beauty & disinfection markets. Industrial competition shifted from disorderly price wars of low-cost dark pungent crude paste to benign competition focusing on process purity, customized decolorization & deodorization, water solubility modification and global compliance supporting services.

- ***Medium and Long-Term Industrial Development Trends (Post-2026)***

1. Green, Low-Carbon and Circular Extraction Processes

Solvent-free extraction technologies including supercritical CO_2 and subcritical butane extraction as well as nanofiltration membrane low-temperature enrichment will be fully popularized, eliminating ethanol organic solvent residues entirely. Mugwort stems and processing by-products will be recycled to extract low-activity bacteriostatic components, while mugwort residue will be processed into organic fertilizer and feed additives to reduce energy consumption, production wastewater and irritating waste gas discharge

across the whole industrial chain, realizing circular green production of the entire mugwort plant.

2. Precise Customization of Raw Materials for Segmented Crowds

Targeting five segmented tracks (low-irritation maternal & infant washing, emergency anti-oxidation eczema repair for medical aesthetics, severe sensitive skin repair, female uterine cold oral conditioning and household natural bacteriostatic disinfection), customized mugwort powder/extracts with differentiated total flavonoid/cineole content, decolorization & deodorization grades, water solubility and mild low-irritation formulas will be developed.

3. Integrated Compound Raw Materials with Composite Efficacy

- Compound soothing anti-inflammatory cosmetic raw materials blended with asiaticoside, panthenol and ectoin;
- Oral meridian-warming and cycle-regulating compound raw materials blended with brown sugar, rose extracts and jujube polysaccharides;
- Natural bacteriostatic compound essential oils blended with tea tree oil and rosemary extracts.

These products reduce compounding procedures for terminal enterprises and provide one-stop composite raw material solutions for skincare, oral health care and disinfection.

4. Integrated Global Multi-Country Compliance Layout

Simultaneous completion of filing for mugwort raw materials in China (cosmetics/health food/disinfection), EU CosIng, US FDA GRAS, Japan, South Korea and ASEAN cosmetics. Unified testing and judgment indicators for volatile oil, total flavonoids and heavy metals across multiple countries will enable barrier-free global import and export circulation of domestic mugwort raw materials.

5. Continuous Upgrade of Transdermal and Absorption Formulation Technologies

Development of nano-liposome encapsulated high-purity mugwort total flavonoid monomers will drastically improve skin transdermal absorption rate, solving the pain point of traditional extracts remaining on the epidermis with weak deep absorption. New high-end tracks will be expanded including high-efficacy freeze-dried soothing essences, single-dose repair stock solutions, ready-to-eat meridian-regulating solid beverages and portable single-dose bacteriostatic sprays.

Conclusion

The mugwort extract industry represents a landmark domestic characteristic category that evolves from a three-thousand-year-old TCM medicinal-edible homologous external herbal medicine into standardized, light-color low-irritation and high-activity high-end functional raw materials with three major applications: cosmetic soothing anti-allergy repair, oral gynecological warming care and natural bacteriostatic disinfection. Supported by nearly two hundred years of continuous technological research from global

scientific teams, the industry has gone through a complete development cycle: cross-civilization textual research on herbal documents, discovery of characteristic terpene and flavonoid active components, full verification of cellular and molecular pharmacological pathways for anti-inflammation and meridian regulation, finalization of low-temperature airtight targeted enrichment & purification as well as supercritical/subcritical green extraction processes, large-sample human skin and gynecological clinical efficacy verification, and independent catch-up of full domestic extraction and purification technologies. It has realized full-chain technological upgrading from authentic field mugwort leaves and Dragon Boat Festival folk herbal medicine to core global functional plant raw materials covering three tracks.

Compared with traditional dark concentrated crude paste obtained via high-temperature boiling water extraction, standardized compound mugwort extracts adopt core technologies including nitrogen-protected airtight low-temperature ultrasonic extraction, supercritical CO_2/subcritical butane gradient separation, two-stage synchronous resin decolorization, deodorization and enrichment, and microcapsule water solubility modification. They possess core differentiated advantages: stable contents of cineole volatile oil and total flavonoids, extremely low medicinal odor irritation, resistance to oxidative browning during storage, modified water solubility compatible with all dosage forms, and a sound global compliance system covering three tracks (cosmetics, food and disinfection). They precisely align with global consumer trends including mild natural maternal & infant washing, medical aesthetic soothing and stabilization for eczema, internal conditioning care for female uterine cold, and household non-irritating natural bacteriostatic disinfection. In the future, with iteration of green solvent-free extraction processes, development of customized products for segmented crowds and industrialization of new nano-liposome transdermal embedding technologies, mugwort extracts will continuously occupy core tracks of natural anti-inflammatory soothing, medicinal-edible gynecological care and plant-based bacteriostatic raw materials, becoming an indispensable landmark domestic characteristic functional plant raw material in global cosmetics, oral health care, daily disinfection and wound repair fields.