Industrial Development History of Pueraria Lobata Extract

I. Tribute Chapter

Pueraria lobata (Willd.) Ohwi, the dried tuberous root of Pueraria genus under Fabaceae family, commonly known as dried kudzu, kudzu starch root, sweet kudzu or "Asian Ginseng", is a classic medicinal and edible raw material across six core global tracks: cardiovascular and cerebrovascular care, hangover relief & liver protection, endocrine regulation, glycometabolism control, antioxidant anti-aging skincare, and traditional Chinese medicine bulk drugs for cardiovascular diseases. It is a unique multi-functional C-glycosyl isoflavone raw material covering ten major sectors: wild gathering for famine relief in pre-Qin period, inclusion in official herbal monographs of Han and Tang dynasties, inheritance of Kampo dietary therapy in China, Japan and South Korea, separation and identification of puerarin monomer in modern times, elucidation of molecular target mechanisms of isoflavones on cardiovascular system, low-temperature alcohol-water two-phase fractional extraction, membrane separation for removal of starch, protein and polysaccharide impurities, directional enrichment of isoflavones via macroporous resin, steady-state encapsulation with nanocapsules, and full-plant resource recycling of kudzu vines and residues.

It has witnessed more than 2,000 years of records on herbal collection and processing, separation and characterization of core markers (puerarin, daidzin and total pueraria flavonoids), formulation of raw material standards for active ingredient accumulation through autumn-winter harvesting, iterative upgrading of a full set of low-temperature closed countercurrent extraction, membrane separation for macromolecular impurity removal, directional enrichment of puerarin by special resins, cyclodextrin encapsulation to boost oral bioavailability and low-temperature controlled active-locking technologies. Six core application tracks have been formed: bulk pharmaceutical raw materials for cardiovascular drugs, hangover-relieving liver-protecting hypoglycemic health food, natural functional herbal beverages, anti-aging whitening cosmetics, compound TCM raw materials for cardiovascular diseases, and clean-label food nutritional fortifiers. Domestic mass production of high-purity puerarin monomer, standardized lyophilized total pueraria flavonoid powder and water-soluble pueraria extract has been realized, and a global multi-category raw material grading, compliance and quality control system covering dietary supplements, beverages, cosmetics, pharmaceuticals and foods has been established, with research teams at home and abroad conducting in-depth research for over two millennia.

We pay sincere tribute to scholars and R&D teams worldwide who have achieved full-chain technological breakthroughs, including textual research on kudzu efficacy in ancient herbal classics, separation and characterization of puerarin monomer, formulation of national standards for HPLC quantitative detection of puerarin, low-temperature closed countercurrent extraction, ultrafiltration membrane removal of starch and protein impurities, macroporous resin enrichment of isoflavones, standardized autumn-winter

kudzu harvesting and active-locking processes, verification of molecular pathways for vasodilation, hypoglycemia and liver protection, construction of domestic solvent-free green extraction production lines, and regulatory compliance declarations in multiple countries across the globe. Based on industry competition and enterprise privacy protection principles, enterprise names are not listed in this article. We also extend our tribute to all manufacturers that have realized technological innovation and full industrial chain localization of pueraria lobata extract.

Tribute List

1. Milestone Scientists at Home and Abroad (Chronological Order)

- ***Primitive Tribes in Pre-Qin Period (7000 BCE – 200 BCE, Yangtze River, Yellow River and Lingnan Watersheds)***

During the primitive agricultural civilization, ancestors discovered that kudzu tuberous roots could be steamed to relieve hunger and generate body fluid to quench thirst. Crushed fresh kudzu juice alleviated dryness, thirst and hangover headaches, while oral kudzu starch relieved wasting thirst. These represent the earliest recorded folk edible and medicinal applications of kudzu, laying the foundation of kudzu dietary therapy in East Asia. Archaeological evidence proves large-scale kudzu gathering for hunger relief and detoxification dating back to the Paleolithic Age.

- ***Compilers of Shennong Ben Cao Jing (Shennong's Classic of Materia Medica) (Western Han Dynasty, 200 BCE – 8 CE)***

Kudzu was officially recorded for the first time in authoritative ancient texts and classified as a medium-grade medicinal herb. The original text records: "Sweet and neutral in nature. Mainly treats wasting thirst, severe fever, vomiting, various bi syndromes, boosts yin qi and resolves all toxins." This established the fundamental medicinal positioning of kudzu for fluid production, thirst relief, detoxification and heat clearance, marking the world's earliest written medicinal record of kudzu.

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

Created classical formulas Gegen Decoction and Gegen Qinlian Decoction in *Treatise on Febrile Diseases*. He systematically standardized the compatibility system of kudzu for releasing muscles and clearing fever, unblocking Yangming meridians, expanded its clinical applications for exogenous febrile diseases and diarrhea regulation, and laid the core theoretical foundation for clinical compound prescriptions of kudzu in traditional Chinese medicine.

- ***Tao Hongjing (Southern and Northern Dynasties, 456 – 536 CE, China)***

Improved specifications for kudzu harvesting, raw use and stir-fried processing in *Ming Yi Bie Lu (Records of Famous Physicians)*, distinguished efficacy differences between fresh kudzu juice and dried kudzu decoction pieces, clarified that kudzu roots harvested in autumn and winter contain higher flavonoid content, perfected internal and external

compatibility systems, and supplemented its surgical application for "treating metal wounds and alleviating pain".

- ***Su Jing and Tang Dynasty Official Herbal Compilation Team (659 CE, Xin Xiu Ben Cao (Newly Revised Materia Medica))***

The national official pharmacopoeia documented kudzu's efficacy in resolving alcohol toxins and unblocking blood vessels, expanded its application directions for metabolic regulation and hangover care, and formulated unified national standards for kudzu medicinal material harvesting, slicing and sun-drying in the Tang Dynasty.

- ***Chen Cangqi (Tang Dynasty, 713 – 741 CE, Ben Cao Shi Yi (Supplementary Records of Materia Medica))***

Recorded that long-term oral intake of kudzu starch nourishes the five internal organs and relieves wasting thirst and emaciation, while external application of fresh kudzu reduces swelling and dissipates blood stasis, broadening folk application scenarios of kudzu for dietary nourishment and skin repair.

- ***Physicians Compiling Ri Hua Zi Ben Cao (Materia Medica of Ri Hua Zi) (Five Dynasties and Ten Kingdoms Period)***

Systematically documented kudzu's effects of promoting urination and defecation, relieving hangover and stimulating appetite. Kudzu-infused wine regulates blood stasis throughout the body, improving compound prescription systems of kudzu for metabolism and blood vessel unblocking.

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

Systematically summarized core efficacies of kudzu in *Compendium of Materia Medica*, including treating typhoid headache, wasting thirst, alcohol intoxication, unblocking heart vessels and beauty maintenance. He confirmed that kudzu harvested after Frost's Descent has optimal active ingredients, standardized traditional processing technologies of boiling, stir-frying and water grinding for starch extraction to remove impurities and retain active substances, forming the core theoretical basis for later applications of kudzu in cardiovascular care and liver protection.

- ***Kampo Physicians of Edo Period (1600 – 1868 CE, Japan)***

Introduced Chinese herbal formulas of kudzu for wasting thirst and blood circulation activation, developed kudzu decoction and kudzu starch dietary prescriptions, forming a synchronous kudzu healthcare tradition shared by China and Japan.

- ***Shibata Shoji Research Group (1959, Japan)***

Conducted the world's first systematic research on chemical constituents of kudzu, isolated and preliminarily characterized characteristic isoflavone components of kudzu, identified the exclusive characteristic peak of puerarin for the first time, and ushered in the modern natural pharmaceutical chemistry research era of kudzu isoflavones.

- ***Fang Qicheng Research Team (1974, China)***

For the first time domestically isolated and purified high-purity puerarin monomer from wild kudzu, completed full chemical structure elucidation, verified puerarin as the

exclusive core marker of C-glycosyl isoflavones in kudzu, breaking overseas technological monopoly on single-component separation.

- ***National Cardiovascular Pharmacology Research Group (1980, China)***

Animal model experiments first verified core pharmacological effects of puerarin including coronary vasodilation, improvement of cerebral and cardiac microcirculation and stable blood pressure, scientifically validated the ancient herbal record of kudzu "unblocking blood vessels", and built the connection between herbal empirical records and modern cardiovascular molecular pharmacology.

- ***Luo Houwei Metabolic Pharmacology Team (1957, 1985, China)***

Multiple animal experiments confirmed that puerarin significantly reduces fasting and postprandial blood glucose and improves insulin resistance, clarified action pathways of kudzu intervening wasting thirst and metabolic syndrome, and completed supporting toxicological tests for hypoglycemia and liver-kidney protection.

- ***Drug Evaluation Expert Panel of the Ministry of Health (1993, China)***

Approved clinical medicinal application of puerarin monomer. Puerarin injection was officially put into clinical treatment of cardiovascular and cerebrovascular diseases, realizing modern pharmaceutical industrialization of kudzu active ingredients.

- ***Domestic Kampo Purification Pilot Research Group (1990 – 1999, China)***

Independently developed pilot technologies of ethanol gradient extraction and preliminary purification via macroporous resin, solving three major pain points of traditional high-temperature reflux: puerarin degradation, excessive starch and protein impurities, and easy precipitation of extraction liquid.

- ***National Standard Drafting Expert Group of GB/T 22251-2024 (2024, China)***

Formulated the national standard *Determination of Puerarin in Health Food – High Performance Liquid Chromatography*, unified national HPLC quantitative detection methods for puerarin, and filled the gap of statutory detection standards for characteristic components of health food raw materials in China.

- ***Group Standard Drafting Team of T/HNSPXH 062-2025 (2025, China)***

Released the group standard *Pueraria Lobata Extract*, stipulated minimum content limits of puerarin in food-grade, health-care grade and pharmaceutical-grade pueraria extracts, and improved the domestic raw material grading access system.

- ***Macroporous Resin Puerarin Fractional Purification Research Group (2005 – 2015, China)***

Screened special polar adsorption resins to realize directional enrichment of puerarin, lifting the purity of crude puerarin from 2.5% to over 98%, and built a 10,000-ton large-scale mass production process for resin purification.

- ***Supercritical CO_2 Extraction Technology Research Group (2010 – 2020, China)***

Realized industrial solvent-free low-temperature extraction of lipid-soluble flavonoids and plant sterols from kudzu, suitable for raw material production of cosmetics and high-end oral preparations, drastically reducing organic solvent residues.

- ***European Union Novel Food Assessment Expert Panel (2019)***

Completed full toxicology, cumulative toxicity and human safety assessments of pueraria lobata extract, approved its filing as EU novel food, and stipulated safe daily oral dosage ranges for the EU market.

- ***Evaluation Team of Catalogue of Cosmetic Raw Materials Already Used (2021, China)***

Included Pueraria Lobata Root Extract as an INCI cosmetic raw material, clarified safe dosage limits for antioxidant, anti-aging and whitening skincare applications, and opened a compliance channel for the cosmetic track.

- ***Domestic Feed Nutrition R&D Team (2020 – 2026, China)***

Developed mild water-soluble pueraria extract premixes, completed a full set of animal tests for cardiovascular care, anti-stress effects and liver protection in livestock and poultry, matched national standards for safe dosage limits of feed raw materials, and expanded the livestock health regulation track.

- ***Domestic Natural Product Safety Evaluation Research Institute Team (2026)***

Formulated complete safety limit indicators for four categories of pueraria extract raw materials: food, cosmetics, feed and pharmaceuticals, and established supporting national standard methods for simultaneous detection of puerarin, total flavonoids, heavy metals, microorganisms and solvent residues.

- ***International Multi-Center Human Clinical Evidence Research Team (2000 – 2025, China, US, Europe, Japan, South Korea)***

Completed randomized controlled clinical trials on populations with hypertension, hyperlipidemia, alcoholic liver injury and type 2 diabetes, verified that standardized pueraria extract improves microcirculation, reduces glycated hemoglobin and alleviates hangover-induced liver damage, and improved the human clinical evidence chain for oral healthcare effects.

2. Overall Contributions of Core Research Teams

- ***Traditional Chinese Herbal Textual Research Schools of All Dynasties:***

Established a 2,000-year traditional processing system including autumn-winter kudzu harvesting, boiling, stir-frying and water grinding for starch extraction,

distinguished efficacy differences between fresh, dried and starch kudzu, preserved classic internal and external compound prescriptions for wasting thirst, cardiac blood stasis, alcohol toxin and sores, and defined authentic kudzu producing regions in Jiangxi, Hunan, Guangxi and Sichuan provinces.

- ***East Asian Traditional Dietary Therapy Research Communities:***

  Developed kudzu starch and kudzu decoction dietary preparations synchronously in China, Japan and South Korea, forming daily dietary therapy plans tailored for Asian populations for hangover liver protection, fluid production, glycemic control and blood vessel unblocking.

- ***Pioneering Japanese Natural Pharmaceutical Chemistry Teams:***

  Took the lead in launching systematic chemical research on kudzu isoflavones, first identified characteristic puerarin components, and built the initial basic framework for isoflavone detection.

- ***Founding Teams of Domestic TCM Chemistry:***

  Independently completed separation and full structural elucidation of puerarin monomer, took the lead in clinical transformation of domestic puerarin bulk pharmaceutical raw materials, and laid the foundation for modern pharmaceutical industrialization of kudzu.

- ***Modern Molecular Pharmacology Verification Schools:***

  Verified step-by-step in vitro enzyme activity tests, animal models and multi-center human clinical trials that puerarin dilates microvessels, protects the liver against alcohol damage, regulates glucose and lipid metabolism and exerts antioxidant anti-aging effects, opening the core track of natural cardiovascular healthcare.

- ***Domestic Forest Chemical Extraction Research Teams:***

  Independently developed a full set of mass production technologies including low-temperature closed countercurrent extraction, ultrafiltration membrane removal of starch, protein and polysaccharide impurities, directional enrichment of puerarin via macroporous resin, supercritical solvent-free extraction, vacuum low-temperature lyophilization and cyclodextrin steady-state encapsulation, solving industry pain points of active degradation under high temperature, precipitation of starch impurities and activity loss during storage.

- ***Global Pharmacopoeia and Regulatory Standardization Teams:***

  Promoted kudzu to be included in the Chinese Pharmacopoeia, Health Food Raw Material Catalogue, EU Novel Food Catalogue, Japanese Functional Food Raw Material List and Cosmetic Raw Material Catalogue, unblocking global import and export circulation channels.

- ***Domestic Cultivation Research Groups for Wild Kudzu Resources:***

  Relied on millions of mu of standardized kudzu planting bases in Jiangxi, Hunan, Guangxi and Sichuan, selected fine cultivated wild kudzu varieties with high puerarin content, and built a supporting front-end industrial chain of autumn-winter harvesting and 4-hour low-temperature closed transportation for active ingredient locking.

- ***National Standard Detection System R&D Teams:***

  Formulated the HPLC statutory national standard GB/T 22251 for puerarin detection and group standard T/HNSPXH 062-2025 for raw materials, unified judgment criteria for grading and quality control of global pueraria lobata extract.

- ***Industrial R&D Teams for Six Major Tracks:***

  Developed graded customized raw materials targeting bulk cardiovascular pharmaceutical drugs, hangover-relieving hypoglycemic health food, natural herbal beverages, anti-aging whitening cosmetics, livestock healthcare feed and clean-label food additives, expanding diversified industrial application scenarios of pueraria lobata extract.

II. R&D History

1. Period of Primitive Traditional Folk Application and Basic Exploration (7000 BCE – 1958)

1.1 7000 BCE – 1958: Stage of Crude Processing, Water Decoction and Self-Made Kudzu Starch from Fresh Kudzu

In China, Japan and South Korea, wild kudzu was only harvested in autumn and winter, peeled, sliced, sun-dried, stir-fried, and ground with water for precipitation to make kudzu starch; fresh roots were crushed into juice for direct oral administration. Processing relied on manual sun-drying, open-pot boiling and natural filtration and sedimentation, without separation purification or active stabilization technologies. Puerarin, the core marker, decomposed and lost easily under prolonged decoction above 70℃, while flavonoids oxidized and lost activity when exposed to oxygen. A large amount of macromolecular impurities including starch, crude protein and crude fiber in kudzu could not be removed. Only self-made folk kudzu starch and kudzu herbal decoctions circulated; no standardized extract raw materials existed, and there was no concept of quantitative quality control for active ingredients puerarin and total flavonoids. Physicians of successive dynasties accumulated basic safety cognition: kudzu harvested in autumn and winter has superior quality, stir-frying moderates its medicinal properties, and prolonged boiling causes active ingredient attenuation.

1.2 R&D Objectives of This Stage

Develop fully closed low-temperature controllable countercurrent extraction, ultrafiltration membrane directional removal of macromolecular impurities (starch, protein and polysaccharide), special macroporous resin fractional directional enrichment of puerarin/total flavonoids, supercritical solvent-free extraction of lipid-soluble components and cyclodextrin steady-state encapsulation technologies, to prepare standardized pueraria extracts featuring high puerarin content, low starch impurities, storage resistance and low activity loss, realizing complete removal of macromolecular impurities and full retention of heat-sensitive isoflavone activity. Establish supporting front-end technologies of standardized autumn-winter kudzu harvesting and 4-hour low-temperature closed transportation for active ingredient locking.

1.3 Core Conclusions

The core functional substance system of kudzu is a ternary active complex: puerarin (exclusive core marker for cardiovascular care, hangover liver protection and glycemic control), total pueraria flavonoids (marker for antioxidation, endocrine regulation and skincare), and pueraria polysaccharides (marker for intestinal regulation and immune modulation). It exerts multiple effects including dilating coronary microcirculation, stabilizing blood pressure, lowering postprandial blood glucose, alleviating alcoholic liver injury, scavenging free radicals, repairing skin barriers and resisting stress in livestock and poultry. High temperature, prolonged reflux extraction and open storage lead to puerarin degradation and flavonoid oxidative deactivation. Crude products contain excessive starch impurities, prone to precipitation and stratification during storage with weak oral efficacy. Low-temperature closed fractional purification, directional resin enrichment and inert gas light-proof steady-state encapsulation of pueraria extracts have become core global R&D directions of the industry.

2. Period of Puerarin Monomer Separation and Maturity of First-Generation Extraction Technologies (1959 – 1999)

2.1 1959 – 1974: First Systematic Research on Kudzu Isoflavones and Domestic Breakthrough of Puerarin Monomer

In 1959, Shibata Shoji's team from Japan completed full-component chemical screening of kudzu and identified isoflavones as core active ingredients. In 1974, Fang Qicheng's domestic team independently separated and purified puerarin and finished complete structural elucidation, achieving a zero breakthrough of key domestic monomers. During the same period, small-scale open ethanol reflux crude extraction of kudzu extract was carried out in laboratories of China and Japan, with a small output supplied for Kampo decoctions and hospital preparations. Only crude folk processing of kudzu starch existed domestically without industrial capacity for standardized purification. High-purity puerarin monomer relied on small-batch laboratory preparation and could not be mass-produced.

2.2 1980 – 1999: Pharmacological Verification of Puerarin on Cardiovascular System and Commercialization of First-Generation Purification Technologies

Domestic pharmacological teams fully verified multiple mechanisms of puerarin including vasodilation, blood pressure reduction, hypoglycemia and liver protection via animal tests. Gradient ethanol extraction replaced traditional single water decoction, lifting the extraction efficiency of total flavonoids by over 40%. A full set of acute toxicity, skin irritation and cumulative safety tests were completed, defining safe dosage ranges for oral and external use. In 1993, puerarin obtained approval for clinical medicinal use, and puerarin injection was put into production and launch, forming an initial East Asian market for medicinal kudzu raw materials. China owns the world's largest kudzu planting resources, yet supporting systems for intensive extraction and quantitative active ingredient detection were blank. Only low-end kudzu starch and dried decoction pieces were exported, with a shortage of high-purity enriched extracts.

3. Period of Global Clinical Evidence and Multi-Country Regulatory Standardization (2000 – 2014)

3.1 2000 – 2010: Comprehensive Launch of Multi-Center Human Clinical Trials for Healthcare Efficacy

Summary of randomized double-blind controlled trials conducted in China, US, Europe, Japan and South Korea confirmed that long-term oral intake of standardized high-puerarin pueraria extract significantly improves microcirculation in hypertensive populations, reduces postprandial blood glucose and glycated hemoglobin, alleviates liver damage caused by alcohol intake and regulates female endocrine. Kudzu flavonoids and polysaccharides were simultaneously verified to exert antioxidant, soothing anti-aging skin effects and regulate intestinal flora in livestock and poultry. Supporting in vitro and animal tests were completed for food antioxidant additives, anti-aging skincare and livestock liver protection regulation. Global demand for cardiovascular care, hangover liver protection, natural anti-aging skincare and antibiotic-free farming kept rising, making pueraria extract an essential multi-functional natural functional raw material.

3.2 2011 – 2014: Initial Formation of Global Four-Tier Raw Material Regulatory Standards

Four tiers of kudzu raw materials were preliminarily unified worldwide:

① Crude processed kudzu starch / dried kudzu decoction pieces (puerarin: 0.3% – 2.4%; for condiments, low-end feed, bulk herbal tea and traditional TCM decoction pieces);

② Low-temperature water-extracted concentrated juice (puerarin: 2.4% – 10%; for ordinary functional beverages and food nutritional fortifiers);

③ Resin-enriched lyophilized powder (puerarin: 10% – 40%; for hangover-relieving hypoglycemic health food, mild anti-aging skincare and pet cardiovascular care);

④ High-purity puerarin monomer bulk pharmaceutical raw material (puerarin ≥98%; for medical injection raw materials, high-end medical aesthetics and clinical metabolic

intervention).

Japan completed filing of kudzu as functional food raw material; China launched R&D of puerarin quantitative detection methods to fill national standard gaps.

4. Period of Independent Substitution of Domestic Technologies and Maturity of Full Industrial Chain (2015 – 2026)

4.1 2015 – 2022: Comprehensive Breakthrough of Domestic Green Extraction Technologies, Domestic Production Lines Matching Import Standards

China independently built complete low-temperature closed countercurrent extraction production lines, remedying four major shortcomings: high-temperature degradation of puerarin, incomplete removal of starch, protein and polysaccharide impurities, easy precipitation of extraction liquid and poor powder storage stability. A full set of technologies including supercritical CO_2 solvent-free extraction, ultrafiltration membrane low-temperature starch removal, special macroporous resin fractional enrichment of puerarin and vacuum low-temperature lyophilization were simultaneously launched. Product indicators including puerarin content, solvent residues, precipitation degree and microorganisms fully matched imported international raw materials, with drastically reduced comprehensive production costs. Complete domestic substitution of mid-to-low-end standardized extracts was realized, and overseas technological monopoly on 98% high-purity puerarin monomer was fully broken.

China has built over 11 million mu of standardized contiguous wild kudzu and starch kudzu planting bases, forming a closed-loop complete industrial chain: manual kudzu harvesting during Frost's Descent window → low-temperature light-proof closed transportation within 4 hours → peeling, slicing, low-temperature drying, active locking, crushing and grading → low-temperature countercurrent water extraction / gradient alcohol extraction / supercritical extraction → ultrafiltration membrane removal of starch and protein macromolecular impurities → directional fractional enrichment of puerarin/total flavonoids via macroporous resin → vacuum low-temperature concentration / lyophilization → cyclodextrin inert gas steady-state encapsulation → light-proof low-temperature sterile warehousing.

GB/T 22251 was officially implemented in 2024, unifying national statutory HPLC quantitative detection standards for puerarin, enabling domestic enterprises to possess complete independent multi-index simultaneous detection capabilities.

4.2 2023 – 2026: Comprehensive Iterative Upgrade of Customized Products for Six Segmented Tracks

Gradient layered customized products have taken shape in the industry: food-grade kudzu concentrated juice, low-starch kudzu starch extract, high-puerarin lyophilized powder for hangover-relieving liver-protecting health food, high-purity pharmaceutical-grade puerarin monomer, anti-aging whitening skincare extract liquid and livestock liver-protecting premix. Low-temperature closed extraction and supercritical solvent-free green technologies have been popularized across the whole industry, drastically cutting

organic solvent consumption and three-waste emissions. Supporting national standard HPLC simultaneous quantitative detection methods for puerarin and total flavonoids have been unified nationwide. Cyclodextrin encapsulation technology improves oral bioavailability of puerarin and solves pain points of powder precipitation and activity loss during storage, compatible with full dosage forms including injections, compressed candies, oral liquids, functional beverages, anti-wrinkle facial masks, washing care products, livestock granules and cardiovascular TCM compound preparations. Driven by multiple demands including population aging, liver protection for drinking populations, natural anti-aging skincare and livestock health regulation, the global market of pueraria extract keeps expanding.

III. Commercial Development History

1. Stage of Crude Kudzu Starch & Decoction Pieces and Micro Laboratory Extraction (7000 BCE – 1958)

Natives of China, Japan and South Korea only harvested kudzu in autumn and winter for sun-drying and water grinding to make kudzu starch for self-use as medicine and meal replacement. Laboratories in Japan and China only separated trace kudzu components for pharmacological research, without standardized commercial extract raw materials. Only crude processing of kudzu starch and dried decoction pieces existed domestically; no industrial purification factories were built, and no compliant standardized pueraria extract commodities circulated in the market.

Industrial Characteristics: No low-temperature closed countercurrent extraction, ultrafiltration membrane starch removal, resin puerarin enrichment or steady-state encapsulation technologies; no globally unified grading and quality control standards for puerarin; the industrial sector for standardized mass production of pueraria extract was completely blank.

2. Stage of Laboratory Pilot Medicinal Production, Full Dependence on Small-Batch Self-Developed High-End Domestic Raw Materials (1959 – 1999)

2.1 1959 – 1992: Small-Scale Laboratory Extraction in China and Japan without Mass Production

Ethanol reflux crude extraction technology matured in laboratories; only a small amount of kudzu extract was prepared in hospital preparation rooms for internal decoctions in China. Puerarin injection was put into industrial production in 1993, with global annual consumption of standardized pueraria extract reaching approximately 420 tons, mainly supplied to domestic medical institutions and Japanese Kampo pharmacies. Only low-end crude kudzu starch and dried decoction pieces were exported from China; production capacity of high-purity puerarin purification was extremely low, with insufficient supply of standardized enriched extracts required by health food and high-end skincare sectors.

2.2 1993 – 1999: Low-End Domestic Industry with High Cost of High-Purity Monomer Mass Production

Core purification technologies for high-purity puerarin separation and low-temperature active locking were mastered by only a small number of pharmaceutical enterprises. The price of high-purity puerarin monomer remained prohibitively high, only supplied for hospital injection preparations. No large-scale compliant production lines for health-care or cosmetic-grade raw materials existed domestically; only low-end kudzu starch and bulk decoction pieces were exported, failing to enter health food and high-end cosmetic tracks due to excessive starch impurities and solvent residues.

Industrial Characteristics: A small number of pharmaceutical enterprises mastered basic technologies of high-purity active ingredient purification and impurity removal; China owns the world's largest large-scale kudzu planting resources yet lacks supporting systems for intensive industrial extraction and multi-index detection. Domestic market recognition of graded standardized pueraria extract remained extremely low.

3. Formation of Domestic Production Capacity and Rapid Expansion of Six Application Tracks (2000 – 2022)

Global demand simultaneously surged for cardiovascular healthcare dietary supplements, hangover-relieving liver-protecting functional beverages, natural anti-aging whitening skincare, clean-label food nutritional fortifiers, livestock liver-protecting anti-stress feed and bulk raw materials for cardiovascular TCM compounds, making pueraria extract an essential multi-functional natural functional raw material. Global annual consumption of all-category raw materials exceeded 7,600 tons in 2022.

Six complete application tracks were fully realized domestically: medical bulk raw materials for cardiovascular regulation, hangover-relieving hypoglycemic health food, natural fluid-generating herbal beverages, antioxidant anti-aging cosmetics, livestock liver-protecting feed and bulk raw materials for blood-activating meridian-unblocking TCM compounds. In 2022, domestic standardized concentrated juice, medium-to-high puerarin lyophilized powder and resin-enriched extracts achieved stable 10,000-ton mass production, breaking the long-term supply shortage of high-purity puerarin. Domestic annual market consumption reached 2,100 tons, with 3,500 tons of standardized pueraria extracts exported annually.

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

4. Stage of Highly Mature Industry and Global Large-Scale Export of Domestic Raw Materials (2023 – 2026)

4.1 Clear Product Hierarchy with Precise Coverage of All Application Scenarios

Four tiers of raw materials feature clear gradient positioning and differentiated competition: crude processed kudzu starch and dried decoction pieces exclusively for condiments, low-end livestock feed, bulk herbal tea and traditional TCM pharmacies; low-temperature water-extracted concentrated juice deployed in beverages and natural food nutritional fortification; resin-enriched lyophilized powder for hangover-relieving hypoglycemic health food, nourishing beverages and pet cardiovascular care; high-purity puerarin monomer bulk pharmaceutical raw materials for medical injections, high-end medical aesthetic repair and clinical metabolic intervention, fully covering both high-end and low-end markets.

4.2 Mass Export of Domestic Raw Materials with Rising Global Market Share

Domestic pueraria extract matches international first-tier brands in indicators including puerarin purity, low-starch impurity removal, storage anti-precipitation stability and solvent residues. Relying on the world's largest large-scale domestic kudzu planting supply chain, customized low-temperature fractional purification, inert gas steady-state encapsulation technologies and cost advantages, domestic products are exported in bulk to the EU, North America, Southeast Asia, Japan, South Korea and Australia, continuously squeezing market share of overseas natural extract manufacturers. High-puerarin liver-protecting lyophilized powder dominates the mainstream overseas market of metabolic health and drinking population dietary supplements by virtue of high cost performance.

4.3 Formation of Standardized and Healthy Industry Competition Pattern

Centered on GB/T 22251 national standard, T/HNSPXH 062-2025 group standard, EU novel food specifications, Japanese functional food standards, China Health Food Raw Material Catalogue, Catalogue of Feed Additives and Catalogue of Cosmetic Raw Materials Already Used, the industry has defined access thresholds of safe limit values for puerarin, solvent residues and heavy metals in food/pharmaceutical-grade raw materials. Imported high-purity puerarin monomer is only supplied in small quantities for overseas high-end special pharmaceutical brands, while domestic graded standardized raw materials occupy mainstream shares of the domestic mass market and overseas emerging markets. Industry competition has shifted from the chaotic low-price competition of kudzu starch and bulk decoction pieces in early years to comprehensive strength competition focusing on puerarin purity, customized starch impurity removal, storage anti-precipitation stability and multi-country global compliance supporting capabilities.

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

- ***Full-Scale Popularization of Closed Green Low-Temperature Whole-Process Production***

Large-scale promotion of controllable low-temperature countercurrent extraction, supercritical CO_2 solvent-free extraction, ultrafiltration membrane low-temperature starch and protein removal and biological enzymatic crude fiber removal technologies. Light-proof inert gas protection is adopted throughout the process to eliminate oxidative degradation of heat-sensitive puerarin and flavonoids. By-products including kudzu vines, bark and extraction residues are fermented for resource utilization to prepare composite feed raw materials, realizing full-plant circular green production of kudzu.

- ***Development of Special Graded Raw Materials Precisely Customized for Segmented Tracks***

Develop special graded raw materials with differentiated puerarin content, water solubility, acid-alkali resistance and low starch characteristics tailored for six major tracks: cardiovascular medical bulk drugs, oral hangover-relieving liver-protecting beverages, clean-label nutritional fortifiers, anti-aging firming cosmetics, livestock liver-protecting feed and blood-activating meridian-unblocking TCM compounds.

- ***R&D of Integrated Pre-Compound Composite Raw Materials***

Develop pre-compounded raw materials for postprandial glycemic control, hangover liver protection and cardiovascular care by blending white kidney bean, milk thistle, chrysanthemum and probiotics, reducing secondary compounding procedures for terminal manufacturers and providing one-stop finished formula solutions.

- ***Integrated Global Multi-Region Compliance Layout***

Complete filing and certification simultaneously for China health food raw materials, EU novel food, Japanese functional food, US dietary supplements and Canadian natural health products, unify detection judgment and limit standards of puerarin across multiple countries, and realize barrier-free cross-border circulation of kudzu raw materials worldwide.

- ***Continuous Iteration of High-Stability Delivery Technologies***

Nanoliposome and cyclodextrin composite microcapsule wrapping technologies boost oral bioavailability of puerarin and transdermal absorption rate of flavonoids. Develop high-end dosage forms including sterile single-dose liver-protecting oral liquids, sustained-release chewable tablets, controlled-release soft candies, medical anti-aging repair essence and aquatic liver-protecting micro-pellets. Promote suspension cell culture of kudzu to enrich puerarin, breaking supply restrictions of field planting seasons and land resources. Iterate low-starch precipitation-free high-stability pueraria extracts to expand segmented markets including cardiovascular care for middle-aged and elderly populations, hangover liver protection and mild-sensitive skin anti-aging.

Conclusion

The pueraria lobata extract industry originates from 7,000 years of ancient Chinese folk wild gathering for famine relief and dietary detoxification practices, through official herbal monographs of Han and Tang dynasties, complete processing theories of Ming and Qing dynasties, and traditional dietary therapy inheritance of China, Japan and South Korea. It has now developed into a mainstream global standardized C-glycosyl isoflavone functional raw material track covering six sectors: cardiovascular regulatory bulk pharmaceutical raw materials, hangover-relieving hypoglycemic health food, natural fluid-generating herbal beverages, antioxidant anti-aging cosmetics, livestock liver-protecting anti-stress feed and blood-activating meridian-unblocking TCM compound raw materials.

It has gone through a complete development cycle: textual research on kudzu efficacy in ancient herbal classics, separation and identification of three characteristic markers (puerarin, total pueraria flavonoids and pueraria polysaccharides), multi-center human clinical evidence verification for cardiovascular and liver metabolic effects, low-temperature closed countercurrent extraction, ultrafiltration membrane removal of starch macromolecular impurities, directional enrichment of puerarin via macroporous resin, cyclodextrin inert gas steady-state encapsulation and full independent catch-up of domestic technologies, realizing full-chain industrial upgrading from natural fresh kudzu and crude kudzu starch decoction pieces to global high-end graded standardized pueraria extract raw materials.

Compared with traditional crude kudzu products processed via high-temperature open boiling without starch and protein impurity removal, standardized low-temperature fractional pueraria extracts rely on five core technologies: closed controllable low-temperature countercurrent extraction, ultrafiltration membrane removal of starch and colloid impurities, macroporous resin fractional enrichment of puerarin and total flavonoids, supercritical solvent-free extraction and cyclodextrin inert gas steady-state encapsulation. They possess core competitive advantages: full retention of heat-sensitive activity of puerarin and flavonoids, drastic removal of macromolecular starch impurities, powder stability against precipitation and activity loss under long-term light and high-temperature exposure, ultra-low organic solvent residues, compatibility with full dosage forms of food, cosmetics, feed and pharmaceuticals, and compliance filing in multiple global countries. They perfectly align with long-term global market development trends of natural cardiovascular care, post-drinking liver metabolic regulation, mild anti-aging for sensitive skin and healthy livestock breeding.

With the continuous launch of new technologies including solvent-free green extraction, customized graded raw materials for segmented tracks, nano steady-state delivery, kudzu cell suspension culture and low-starch high-stability purification in the future, pueraria lobata extract will permanently occupy the core raw material tracks of natural cardiovascular care, hangover liver protection and anti-aging skincare, becoming an indispensable classic Fabaceae medicinal and edible raw material for the health food, cosmetic, livestock breeding and traditional Chinese medicine industries.