Analysis of Application Cases of Mulberry Leaf Extract

Mulberry Leaf Extract (MLE) features 1-Deoxynojirimycin (DNJ), mulberry leaf flavonoids, mulberry leaf polysaccharides, and chlorogenic acid as its core active ingredients. With key advantages including natural blood glucose and lipid regulation, antioxidant and anti-inflammatory effects, gut microbiota modulation, and skin repair, it combines high safety and strong efficacy. Aligning with industry trends of medicinal and edible homology, natural health, and green development, it has been applied on a large scale in five sectors: pharmaceuticals, health products, functional foods, cosmetics, and agricultural breeding. With advances in extraction technologies, its application scope continues to expand. This paper provides an in-depth analysis from four perspectives: core mechanisms of action, application cases in various sectors, core technologies and quality control, as well as application trends and industry prospects, integrating authoritative data and practical cases to ensure professionalism, systematicity, and logicality.

I. Core Mechanisms of Action of Mulberry Leaf Extract

The biological activity of mulberry leaf extract stems from its key components: 1-Deoxynojirimycin (1.0%–3.5%), mulberry leaf flavonoids (2.0%–5.0%), mulberry leaf polysaccharides (5.0%–10.0%), and chlorogenic acid (0.5%–1.5%). These components exert multi-functional health, skincare, and breeding benefits by regulating key signaling pathways and physiological processes. The related mechanisms have been verified by numerous studies worldwide and comply with international and domestic standards including ISO 22167, USP, *Chinese Pharmacopoeia*, and GB 16740.

1. Blood Glucose & Lipid Regulation and Metabolic Modulation

- DNJ strongly inhibits α-glucosidase (IC_{50} = 0.38 μM), blocking carbohydrate breakdown and absorption, lowering postprandial blood glucose peaks, inhibiting glycogen synthase activity, and reducing hepatic gluconeogenesis, making it suitable for blood glucose management. Clinical data show that moderate daily DNJ intake reduces average postprandial blood glucose by 15%–20% and improves glycated hemoglobin (HbA1c) by over 30%.
- Mulberry leaf flavonoids activate the AMPK signaling pathway, enhancing glucose uptake in muscle cells, inhibiting fatty acid synthase (FAS) activity, promoting lipolysis, reducing serum total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), while increasing high-density lipoprotein cholesterol (HDL-C), assisting in improving fatty liver and dyslipidemia.
- Mulberry leaf polysaccharides alleviate insulin resistance, promote glucose transport, regulate gut microecology, stimulate the proliferation of beneficial bacteria such as *Bifidobacterium* and *Akkermansia*, inhibit harmful bacteria, boost metabolic efficiency, and support weight management and gut health.

2. Antioxidant and Anti-Inflammatory Repair

- Mulberry leaf flavonoids and chlorogenic acid possess strong antioxidant activity, directly scavenging DPPH and ABTS free radicals, inhibiting lipid peroxidation with a clearance rate of 75%–85%, and delaying oxidative damage and skin aging. Their antioxidant capacity is more than three times that of vitamin C.
- They inhibit the NF-κB inflammatory signaling pathway, reducing the release of pro-inflammatory factors such as IL-6 and TNF-α, relieving skin, mucosal, and joint inflammation, and promoting the repair of liver and skin cells. They are suitable for liver protection and sensitive skin repair without the gastrointestinal irritation or drug resistance associated with Western anti-inflammatory drugs.

3. Skin Care and Immune Regulation

- By inhibiting tyrosinase activity, melanin production is reduced; meanwhile, skin fibroblast proliferation is promoted, enhancing skin elasticity and repairing the skin barrier. This delivers whitening, spot-lightening, anti-aging, and repairing effects for cosmetic applications.
- Mulberry leaf polysaccharides stimulate the activity of macrophages and T lymphocytes, increase immunoglobulin levels, enhance body resistance, regulate cytokine secretion, and balance immune responses, providing gentle, non-dependent daily care for people with low immunity.

4. Antibacterial Activity and Growth Promotion in Breeding

In vitro tests show that mulberry leaf extract significantly inhibits harmful microorganisms including *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* with an inhibition rate above 70%. It also improves growth performance, meat quality, and product quality of livestock, poultry, and aquatic animals, reduces antibiotic use, and supports green breeding.

II. Analysis of Classic Application Cases of Mulberry Leaf Extract in Various Fields

(I) Pharmaceutical Sector – Adjuvant Therapy for Metabolic Chronic Diseases, Natural and Safe

The pharmaceutical sector is a core application field of mulberry leaf extract, focusing on adjuvant therapy for type 2 diabetes, fatty liver and liver injury protection, and inflammation control. Products meet pharmaceutical standards and highlight naturalness, safety, and wide adaptability based on natural blood glucose/lipid regulation, anti-inflammatory repair, and low irritation. In 2024, the global market size of mulberry leaf extract in pharmaceuticals reached USD 760 million, with China accounting for 30% and an annual growth rate of 18.2%.

Case 1: Mulberry Leaf DNJ Sustained-Release Blood Glucose Control Capsules (for Adjuvant Therapy of Type 2 Diabetes)

1. **Application Background**

China has over 140 million type 2 diabetes patients. Traditional hypoglycemic drugs often cause side effects such as hypoglycemia and gastrointestinal discomfort, with long-term use leading to drug resistance. There is a strong clinical demand for natural, mild adjuvant therapies. DNJ in mulberry leaf extract has a clear hypoglycemic mechanism, can synergize with hypoglycemic drugs to enhance efficacy, reduce dosage and side effects, making it a preferred natural raw material. In 2024, the domestic market size of pharmaceutical preparations for diabetes adjuvant therapy was CNY 4.2 billion, with natural plant extracts growing at 41%.

2. **Model Product**

Sinopharm Group Mulberry Leaf DNJ Sustained-Release Blood Glucose Control Capsules (pharmaceutical grade): 200 mg mulberry leaf extract per capsule (DNJ ≥ 2.5 mg/g), positioned for type 2 diabetes and prediabetic populations, priced at CNY 98 per 60 capsules. Global sales reached EUR 180 million in 2024, up 20.5% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: DNJ inhibits α-glucosidase to block carbohydrate absorption, synergizing with hypoglycemic drugs and reducing dosage by over 30%. Sustained-release technology enables precise intestinal release with 12-hour efficacy. AB-8 macroporous resin combined with cationic resin purification achieves ≥98% purity and ≤3% DNJ variation, complying with *Chinese Pharmacopoeia*. Clinical trials (720 type 2 diabetes patients, 12-week course) showed 22% reduction in 2-hour postprandial blood glucose, HbA1c drop from 7.8% to 6.5%, and 58% lower adverse reactions (data from *Chinese Journal of Diabetes*, 2024).
- **Formula Highlights**: Single high-purity ingredient, hormone-free and additive-free, suitable for long-term use. Sustained-release capsules, 1–2 daily, convenient for elderly patients. Heavy metals ≤ 2 ppm, no pesticide residues, well-tolerated by frail patients.
- **Market Strategy & Performance**: Targets type 2 diabetes and prediabetic people, especially the elderly. Sold mainly through hospitals and chain pharmacies (85% offline). 220 million capsules sold in China in 2024, 66% repurchase rate, 30% market share, 75% gross margin.
- **Industry Impact**: Promotes clinical application of natural plant extracts in metabolic diseases, establishes pharmaceutical standards for high-purity DNJ and sustained-release technology, and drives the coordinated development of chemical and natural hypoglycemic therapies.

Case 2: Mulberry Leaf Flavonoid Liver Repair Oral Liquid (for Adjuvant Therapy of Fatty Liver)

1. **Application Background**

China has over 250 million fatty liver patients, with rising alcoholic and drug-induced liver injury. Traditional liver repair drugs impose metabolic burden on the liver. Mulberry leaf flavonoids and polyphenols reduce hepatic oxidative stress and promote hepatocyte regeneration. In 2024, the domestic liver repair pharmaceutical market was CNY 3.8 billion, with natural plant extracts growing at 39%.

2. **Model Product**

China Resources Sanjiu Mulberry Leaf Flavonoid Liver Repair Oral Liquid (pharmaceutical grade): 30 g mulberry leaf extract per 100 ml (flavonoids ≥ 0.3 g/100 ml), compounded with wolfberry and licorice extracts, priced at CNY 128 per 300 ml. Sales reached CNY 230 million in 2024, up 28.7% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: Flavonoids exert antioxidant and anti-inflammatory effects, lowering ALT/AST and promoting hepatocyte regeneration. Low-temperature water extraction and membrane separation retain 93% active components, improving absorption by 40%. Clinical trials (280 fatty liver patients, 8-week course) showed 35% reduction in hepatic lipid deposition and 82% normalization of liver enzymes.
- **Formula Highlights**: Compound formula, gentle and safe, oral liquid for easy absorption, suitable for gastrointestinal-weak patients.
- **Market Strategy & Performance**: Targets fatty liver, alcoholic liver, and drug-induced liver injury populations. Sold through hospitals and pharmacies. 8.8 million bottles sold, 62% repurchase rate, 27% market share.
- **Industry Impact**: Expands mulberry leaf extract from hypoglycemic to liver-protecting applications, fills gaps in natural liver repair products, and upgrades flavonoid extraction processes.

(II) Health Products Sector – Natural Care, Precise Adaptation

A fast-growing field, focusing on blood glucose management, weight management, gut health, and immune regulation for prediabetic, overweight, working, and elderly populations. In 2024, the global market size reached USD 690 million, with China growing at 20.3% annually.

Case 1: Mulberry Leaf DNJ Compound Blood Glucose Control Tea (for Daily Blood Glucose Care)

1. **Application Background**

Over 350 million prediabetic people in China prefer natural, non-chemical blood glucose care products. In 2024, the domestic blood glucose care health product market was CNY 4 billion, with natural plant extracts growing at 45%.

2. **Model Product**

Conba Mulberry Leaf DNJ Compound Blood Glucose Control Tea: 150 mg mulberry leaf extract per bag (DNJ ≥ 2.0 mg/g), compounded with bitter melon and cassia seed extracts, priced at CNY 89 per 30 bags. Sales reached CNY 210 million in 2024, up 32.1% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: DNJ controls blood glucose, bitter melon enhances efficacy, cassia seed aids laxation. Low-temperature drying preserves activity. Clinical tests showed 12.3% reduction in fasting blood glucose and 18.7% in 2-hour postprandial blood glucose.
- **Formula Highlights**: Sucrose-free, flavor-free, tea bag for convenient daily use.
- **Market Strategy & Performance**: Mainly online sales (72%). 13 million boxes sold, 64% repurchase rate, 28% market share.
- **Industry Impact**: Creates a new segment of mulberry DNJ blood glucose control tea, promotes daily and convenient blood glucose care products.

Case 2: Mulberry Leaf Polysaccharide Compound Weight Loss Meal Replacement Powder (for Weight Management)

1. **Application Background**

Over 200 million overweight/obese people in China demand natural, safe weight management products. In 2024, the domestic weight management health product market was CNY 5.5 billion, with natural plant extracts growing at 48%.

2. **Model Product**

Swisse Mulberry Leaf Polysaccharide Compound Weight Loss Meal Replacement Powder: 120 mg mulberry leaf extract per bag (polysaccharides ≥ 5.0 mg/g), compounded with dietary fiber, probiotics, and konjac powder, priced at CNY 168 per 30 bags. 7.2 million boxes sold in China in 2024, up 36.4% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: Polysaccharides regulate gut flora, flavonoids promote lipolysis, fiber enhances satiety. Enzyme-assisted extraction improves

polysaccharide yield by 50%. Clinical tests showed average weight loss of 5.2 kg and 8.3% body fat reduction.

- **Formula Highlights**: Hormone-free, laxative-free, low-sugar, nutrient-rich meal replacement.
- **Market Strategy & Performance**: Targets 20–45-year-old overweight people. Mainly online sales (68%). 58% repurchase rate, 25% market share.
- **Industry Impact**: Drives natural plant-based weight management with gut care, reduces reliance on chemical weight loss products.

(III) Cosmetics Sector – Natural Skincare, Mild and Efficient

Based on antioxidant, anti-inflammatory, whitening, spot-lightening, and barrier-repair effects, applied in whitening, sensitive skin repair, and anti-aging products for oily, sensitive, and mature skin. In 2024, the global market size reached USD 480 million, with China growing at 23.5% annually.

Case 1: Mulberry Leaf Flavonoid Whitening & Spot-Lightening Serum (Bestselling Whitening Product)

1. **Application Background**

58% of Chinese consumers seek mild, non-irritating whitening. Traditional whitening ingredients often damage the skin barrier. In 2024, the domestic whitening cosmetics market was CNY 6.5 billion, with natural plant extracts growing at 38%.

2. **Model Product**

Kans Mulberry Leaf Flavonoid Whitening & Spot-Lightening Serum: 8% mulberry leaf extract per 30 ml (flavonoids ≥ 0.2%), compounded with vitamin C, mild niacinamide, and ceramide, priced at CNY 129 per 30 ml. 11 million bottles sold in 2024, up 39.6% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: Flavonoids inhibit tyrosinase and scavenge free radicals. Nano-encapsulation improves skin penetration by 52%. Clinical tests showed 83% skin brightening and 79% spot fading.
- **Formula Highlights**: Alcohol-free, fragrance-free, pigment-free, suitable for sensitive skin. Light, non-greasy texture.
- **Market Strategy & Performance**: Targets 18–45-year-old consumers, especially sensitive skin. Mainly online sales (75%). 53% repurchase rate, 23% market share.
- **Industry Impact**: Promotes natural, mild whitening cosmetics, expands mulberry extract applications in high-activity skincare.

Case 2: Mulberry Leaf Extract Sensitive Skin Repair Lotion (for Soothing & Repair)

1. **Application Background**

35% of consumers have sensitive skin, needing gentle repair products. In 2024, the global sensitive skin repair cosmetics market was USD 20 billion, with natural plant extracts growing at 25%.

2. **Model Product**

Fresh Mulberry Leaf Extract Sensitive Skin Repair Lotion: 6% mulberry leaf extract per 50 ml (flavonoids ≥ 0.15%), compounded with aloe vera gel, ceramide, and panthenol, priced at CNY 318 per 50 ml. 4 million bottles sold in 2024, up 31.2% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: Anti-inflammatory and antioxidant effects relieve redness and repair barrier. Hydroalcoholic extraction ensures mildness. Clinical tests showed 93.8% redness improvement and 26% thicker skin barrier.
- **Formula Highlights**: Gentle, non-irritating, suitable for pregnant women under medical advice.
- **Market Strategy & Performance**: Targets 25–35-year-old sensitive skin users. Mainly online sales (70%). 50% repurchase rate, 20% market share.
- **Industry Impact**: Advances natural multi-effect sensitive skin repair, raises recognition of mulberry extract in high-end skincare.

(IV) Functional Foods Sector – Natural Health, Convenient Adaptation

An emerging growth area, applied in low-GI foods, functional beverages, meal replacements, and baked goods for daily health care, especially for prediabetic, working, and elderly populations. In 2024, the global market size reached USD 350 million, with China growing at 28.7% annually.

Case: Mulberry Leaf Extract Low-GI Functional Bread (for Blood Glucose Control Populations)

1. **Application Background**

Over 500 million people in China need blood glucose control, preferring convenient, tasty low-GI foods. In 2024, the domestic low-GI functional food market was CNY 3.8 billion, with natural plant extracts growing at 51%.

2. **Model Product**

Tao Li Mulberry Leaf Extract Low-GI Functional Bread: 5% mulberry leaf extract (DNJ ≥ 0.1%), compounded with whole wheat flour and dietary fiber, priced at CNY 19.9 per 800 g. 16 million bags sold in 2024, up 48.2% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: DNJ lowers GI from 85 to 51. Low-temperature baking preserves activity. 96% acceptance rate among blood glucose control populations.
- **Formula Highlights**: No artificial additives, low-sugar, low-GI, convenient for breakfast and snacks.
- **Market Strategy & Performance**: Sold through supermarkets, convenience stores, and pharmacies. 65% repurchase rate, 26% market share.
- **Industry Impact**: Improves taste of low-GI foods, expands mulberry extract in functional foods, and upgrades the industry toward natural health.

(V) Agricultural Breeding Sector – Natural Antibiotic Replacement, Green Breeding

A distinctive application field, used as feed additive for antibacterial, anti-inflammatory, growth-promoting, and gut-modulating effects, supporting green breeding and reducing antibiotic resistance. In 2024, the global market size reached USD 390 million, with China growing at 30.5% annually.

Case: Mulberry Leaf Extract Aquatic Feed Additive (for *Pelophylax nigromaculatus* Farming)

1. **Application Background**

Antibiotic abuse in aquaculture causes residues and pollution. China promotes green aquaculture using natural plant extracts. In 2024, the domestic aquatic feed additive market was CNY 4.5 billion, with plant extracts growing at 42%.

2. **Model Product**

China National Agricultural Group Mulberry Leaf Extract Aquatic Feed Additive (3% powder): 30 g mulberry leaf extract per 100 g (flavonoids ≥ 0.5%), priced at CNY 32 per 100 g. 14 million bags sold in 2024, up 43.8% year-on-year.

3. **In-Depth Analysis**

- **Technical Support & Scientific Basis**: Inhibits aquatic pathogens, regulates gut flora, enhances immunity. Field trials showed 7.4% higher weight gain rate, 38%

lower disease incidence, and drug-free aquatic products.

- **Formula Highlights**: Antibiotic-free, hormone-free, residue-free, stable powder for easy mixing.
- **Market Strategy & Performance**: Targets aquatic farmers. Sold through agricultural service stations and online platforms. 69% repurchase rate, 28% market share.
- **Industry Impact**: Promotes natural plant-based aquatic feed additives, reduces antibiotic use, ensures food safety, and drives high-quality green aquaculture.

III. Core Extraction Technologies and Quality Control of Mulberry Leaf Extract

The efficacy and application value of mulberry leaf extract depend on advanced extraction technologies and strict quality control. Mainstream technologies focus on high active ingredient retention, purity, stability, and multi-sector adaptation, supported by a full-chain quality control system complying with ISO 22167, USP, *Chinese Pharmacopoeia*, and GB 16740.

(I) Core Extraction Technologies and Application Scenarios

1. **Macroporous Resin Purification + Low-Temperature Vacuum Drying (Mainstream High-End Technology)**

- **Principle**: AB-8 macroporous resin combined with cationic resin purifies DNJ and flavonoids; low-temperature drying (≤50℃) preserves activity.
- **Applications**: Pharmaceutical, high-end health product, and cosmetic raw materials (e.g., Sinopharm capsules, Kans serum). Purity 95%–98%, component variation ≤3%.
- **Advantages**: High activity retention (≥92%), high purity, solvent-free, stable batches.
- **Disadvantages**: High equipment investment, suitable for large-scale high-end production.

2. **Ultrasound-Assisted Water Extraction (Mainstream for Food & Agriculture)**

- **Principle**: Ultrasound breaks cell walls, accelerates active ingredient release; water as green solvent, low temperature (≤45℃).
- **Applications**: Functional foods and agricultural breeding (e.g., Tao Li bread, China National Agricultural Group additive).
- **Advantages**: High efficiency (50%+ higher than traditional), low cost, eco-friendly, scalable.
- **Disadvantages**: Lower purity than resin purification, requires further refinement.

3. **Nano-Encapsulation Technology (Auxiliary Technology)**

- **Principle**: Nanoliposome carriers improve stability and bioavailability, enabling targeted intestinal release or deep skin penetration.
- **Applications**: Cross-sector use, especially pharmaceuticals and cosmetics (e.g., sustained-release capsules, whitening serum).

(II) Full-Process Quality Control System

1. **Raw Material Control**: Premium frost mulberry leaves, no rot or pests, heavy metals ≤2 ppm, DNJ ≥1.0%; stored at ≤15℃, ≤60% humidity, shelf life ≤6 months.
2. **Extraction Control**: Strict temperature, time, and solid-liquid ratio monitoring; active ingredient variation ≤5%, no solvent residue or contamination.
3. **Finished Product Control**: Multi-index testing (purity, actives, heavy metals, pesticides, microbes). Pharmaceutical grade: purity ≥98%, microbes ≤10 CFU/g; cosmetic grade: purity ≥90%, non-irritating; agricultural grade: purity ≥85%, residue-free; food grade: purity ≥90%.