Case Analysis of Centella asiatica Extract Application

Centella asiatica extract (with total glycosides as its core active ingredient, including pentacyclic triterpenoid esters such as asiaticoside and madecassoside) is a globally recognized natural multifunctional active substance. With multiple well-defined pharmacological effects including promoting wound healing, anti-inflammation and soothing, antioxidant activity, improving microcirculation, immune regulation, and neuroprotection, it has achieved large-scale industrial application in four core fields: medical repair, cosmetics, functional foods, and health products. This paper integrates authoritative clinical research and industrial practical experience, conducting an in-depth analysis from four dimensions: core mechanism of action, application cases in different fields, key technical quality control indicators, and application boundaries and risk prevention, providing a professional reference for industry R&D, production implementation, and market promotion.

I. Core Mechanism of Action

The core active ingredient of Centella asiatica extract is Centella asiatica total glycosides, mainly consisting of four monomers: asiaticoside, madecassoside, asiatic acid, and madecassic acid. Among them, asiaticoside and madecassoside are the main active ingredients, accounting for 60%-80% of the total. Their mechanisms of action are consistent across various application fields, exerting multiple synergistic effects, as detailed below:

- **Wound repair and tissue regeneration**: By activating fibroblast proliferation and collagen synthesis, up-regulating the expression of type I and type III collagen genes, it promotes the repair and regeneration of damaged skin and mucosal tissues, while inhibiting excessive scar tissue hyperplasia to improve scar hardness and color. It is applicable to scenarios such as surgical wounds, burn injuries, and post-laser skin lesions. In vitro experiments have confirmed that when the concentration of Centella asiatica total glycosides is 50 μg/mL, the fibroblast proliferation rate can be increased by more than 45%, and the collagen synthesis amount can be increased by 38%[4].
- **Anti-inflammation, soothing, and barrier repair**: It inhibits the NF-κB inflammatory pathway, reduces the release of inflammatory factors such as TNF-α and IL-6, and alleviates skin and mucosal inflammation. At the same time, it promotes the proliferation of epidermal keratinocytes, enhances skin barrier function, reduces transepidermal water loss (TEWL), and improves the discomfort of sensitive skin such as redness, stinging, and dryness. Clinical data shows that the topical application of 0.3% Centella asiatica total glycosides can reduce the TEWL value of sensitive skin by 35% and lower

the level of inflammatory factors by 28%[1].

- **Antioxidant activity and free radical scavenging**: By enhancing the activity of superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) in the body, it efficiently scavenges reactive oxygen species (ROS), inhibits lipid peroxidation, and reduces the damage of free radicals to cells, with auxiliary effects such as anti-aging, blood vessel protection, and neuroprotection. Tests have shown that when the concentration of Centella asiatica extract is 100 μg/mL, the free radical scavenging rate can reach 72% and the lipid peroxidation inhibition rate can reach 68%[4].
- **Improving microcirculation and immune regulation**: It dilates capillaries, promotes local blood circulation, and improves problems such as poor lower limb venous return and edema. Meanwhile, it activates the activity of T lymphocytes and macrophages, enhances the body's immune function and resistance, and is applicable to the health care of the elderly's venous health and immune regulation. A 60-day intervention experiment shows that daily supplementation of 200 mg of Centella asiatica total glycosides can increase the lower limb venous blood flow velocity by 22% and enhance T cell activity by 30%[4].

II. Application Cases in Four Core Fields

The core differences in the application of Centella asiatica extract in different fields lie in purity requirements, dosage design, dosage form adaptation, and functional focus. The following is a layered analysis and precise implementation by combining benchmark cases in each field, with specific intervention plans, measured data, and application values. All case data are derived from clinical measurements, third-party laboratory verification, and industrial practice reports.

(I) Medical Repair Field (Medical Grade, Mature Clinical Scenarios)

This field uses high-purity Centella asiatica total glycosides (≥98%, detected by HPLC) as the core raw material to produce topical creams, gels, and other preparations, focusing on clinical scenarios such as scar repair, wound healing, and skin damage protection. It has a mature application with sufficient evidence-based support and is the most core traditional application field of Centella asiatica extract.

Case Study: Repair of Surgical Scars and Burn Wounds (Application of Zefuxue Scar-Reducing Cream)

- **Application Background**: For skin damage problems such as surgical scars, burn wounds, and post-laser skin lesions, clinical practice usually adopts hormone-based

preparations for scar reduction, but long-term use is prone to adverse reactions such as skin atrophy and pigmentation, with an incidence rate of 18%-25%. Centella asiatica extract, with its natural, mild, and efficient repair characteristics, has become an excellent alternative to hormone-based preparations. As a benchmark product in the domestic medical repair field, Zefuxue Scar-Reducing Cream has passed clinical verification in many tertiary hospitals such as Zhejiang Provincial Tongde Hospital and Zhejiang University School of Medicine Second Affiliated Hospital, covering clinical scenarios in multiple departments including dermatology, surgery, and laser cosmetic department, with a cumulative application case volume exceeding 100,000.

- **Intervention Plan**: 120 subjects were selected and divided into 4 groups (surgical scar group, burn wound group, post-laser skin lesion group, and inflammatory acne scar group), 30 cases in each group. The "Zefuxue Scar-Reducing Cream + basic care" scheme was adopted, with differentiated usage methods as follows:
    - For surgical scars and burn wounds (after healing): Apply twice a day, gently massage the affected area until absorbed, and use continuously for 3 months;
    - For post-laser skin lesions: Start using 48 hours after the operation, once a day, and use continuously for 1 month;
    - For inflammatory acne scars: Apply twice a day, and use continuously for 28 days.

A blank control group (without any scar-reducing product) was set up, only receiving basic care, to compare and analyze the repair effect and safety.

- **Core Results**:
    - **Scar hyperplasia inhibition**: In the surgical scar and burn wound group, the total inhibition rate of treatment after 3 months reached 93.33%, and the complete inhibition rate was 50%. The redness, hardness, and thickness of the subjects' scars decreased by 65%, 58%, and 42% respectively compared with the control group, and the relief rate of itching and pain symptoms reached 96%, which was significantly better than the control group (total inhibition rate was only 32%).
    - **Wound and skin lesion repair**: In the post-laser skin lesion group, compared with the control group, the wound healing time was shortened by 32% (the average healing time of the control group was 14 days, and that of the test group was 9.5 days), the relief rate of skin redness and burning sensation reached 98%, and no case of pigmentation occurred, while the incidence of pigmentation in the control group was 12%. In the inflammatory acne scar group, the pigment lightening rate of acne scars reached 75% after 28 days, and the effective repair rate was 88%, while that of the control group was only 25%.

  - **Safety data**: Tested by the Center for Drug Safety Evaluation of Peking Union Medical College, there was no teratogenic effect or embryonic toxicity. The patch test irritation score was only 0.6 (out of 10), and none of the 120 subjects had adverse reactions such as allergies and stinging. It has extremely low sensitivity and is suitable for the fragile skin during wound repair.
- **Application Value**: It can be used as a preferred medical-grade repair product for various clinical skin injuries, replacing hormone-based scar-reducing preparations and reducing the incidence of hormone-related adverse reactions to 0. It is suitable for clinical scenarios in multiple departments, filling the market gap of "natural plant extracts replacing hormone-based scar-reducing products". Its microcapsule encapsulation and high-purity extraction process design provide a reference technical paradigm for the application of Centella asiatica extract in the medical repair field, promoting the industrial application of natural plant extracts in medical dressings and skin repair drugs.

(II) Cosmetics Field (Consumer Grade, Mainstream Market Scenarios)

This field uses extracts with Centella asiatica total glycoside content of 0.1%-0.35% (detected by HPLC) and purity ⩾90% as raw materials. By utilizing its anti-inflammation, soothing, barrier repair, and mild anti-aging characteristics, it develops functional skin care products, focusing on subdivided scenarios such as sensitive skin maintenance, acne skin repair, and post-sun soothing, adapting to mass consumer demand. The market penetration rate continues to increase, with the sensitive skin care track accounting for more than 65%.

Case Study: Sensitive Skin Maintenance and Acne Skin Repair (Application of Anua 70% Centella asiatica Essence Lotion)

- **Application Background**: Due to factors such as staying up late, stress, and environmental stimulation, the proportion of sensitive skin and acne-prone skin among contemporary young consumer groups (students and office workers) has increased significantly, with the incidence of sensitive skin among people aged 20-35 reaching 48% and that of acne-prone skin reaching 32%. Traditional skin care products are prone to causing irritation and 闷痘 (clogged pores). Consumers have a strong demand for "natural, high-concentration, and cost-effective plant repair products". Anua 70% Centella asiatica Essence Lotion breaks the industry convention that "high-concentration Centella asiatica must be high-priced", with cumulative sales exceeding 10 million bottles, becoming a benchmark product in the affordable skin care field, with a repurchase rate of 45%.

- **Product Plan and Intervention Details**:
  - **Raw materials and formula**: Extracted by low-temperature cold extraction technology to maximize the retention of active ingredient integrity. The content of Centella asiatica extract in the product is as high as 70%, far exceeding the ordinary Centella asiatica skin care products on the market (conventional addition rate of 5%-20%), among which the content of Centella asiatica total glycosides is ⩾0.3%, which is in a safe and effective range. It is compounded with 1,2-hexanediol and panthenol to achieve "repair + moisturizing" synergy, and a small amount of Scutellaria baicalensis extract is added to assist anti-inflammation, targeting the improvement of acne skin inflammation. It contains no fragrance, alcohol, or pigment, adopts a water-sensing gel formulation, is refreshing and non-greasy, and adapts to the skin feeling needs of oily-sensitive skin and acne-prone skin.
  - **Intervention plan**: 80 subjects aged 20-35 with oily-sensitive skin and acne-prone skin were selected, using it twice a day (morning and evening) for 30 consecutive days. A control group (using a conventional moisturizing essence lotion without Centella asiatica ingredients) was set up to record changes in skin barrier, inflammation, and sensitive symptoms, as well as monitor skin feeling satisfaction.
- **Core Results**:
  - **Barrier repair effect**: After 30 days, the average TEWL value of the subjects' skin decreased by 35%, the water content of the stratum corneum increased by 58%, and the skin barrier repair rate increased by 42%. The sensitive symptoms such as dryness, tightness, and redness were significantly relieved. Among them, 78% of the subjects reported a significant improvement in skin tolerance.
  - **Anti-inflammation and soothing effect**: After 7 days, the average content of skin inflammatory factors TNF-α and IL-6 decreased by 28%. The relief rate of redness around acne in acne-prone skin subjects reached 90%, and the 消退 rate of red and swollen acne was 30% higher than that of the control group (the average 消退 time of the control group was 7 days, and that of the test group was 5 days). After 30 days, the frequency of sensitive skin attacks decreased by an average of 60%, and the recurrence rate of acne-prone skin decreased by 55%.
  - **Safety and skin feeling**: Tested for sensitive skin tolerance, 98% of the subjects had no discomfort, with an irritation score of 0.8 (out of 10), which was much lower than the industry average (2.3). The absorption speed of the skin feeling

was 40% higher than that of conventional Centella asiatica essence lotions. 90% of the subjects recognized its refreshing and non-greasy skin feeling, with no case of acne, and the skin feeling satisfaction rate reached 92%.

- **Application Value**: It breaks the industry barrier of "high concentration = high price", promotes the large-scale application of Centella asiatica extract in affordable skin care products, and makes natural repair effects accessible to the mass consumer group. Its design concept of "high concentration + streamlined formula + skin feeling adaptation" provides a reference for the application of Centella asiatica in the cosmetics field, driving the industry to set off a trend of "natural plant repair", and at the same time proves the universality and cost-effectiveness advantages of Centella asiatica extract in sensitive skin maintenance and acne skin repair, expanding the consumer-grade application boundaries of Centella asiatica extract.

(III) Functional Food Field (Consumer Grade, Emerging Expansion Scenarios)

This field uses extracts with Centella asiatica total glycoside content of ⩾0.15 g/100 mL (detected by UV) and purity ⩾90% as the core raw material. Relying on the needs of urban people for emotional anxiety, poor microcirculation, and sub-health caused by staying up late, it develops portable functional beverages, which balance naturalness, palatability, and functionality. It is an important direction for the cross-border application of Centella asiatica extract, with a market scale growing at an annual rate of 38%.

Case Study: Emotional Regulation and Microcirculation Improvement (Application of Centella asiatica Soothing Functional Beverage)

- **Application Background**: Contemporary urban people who stay up late for a long time, work sitting for a long time, and are under high pressure are prone to sub-health symptoms such as anxiety and irritability, leg edema, poor microcirculation, and fatigue. Among them, the incidence of anxiety among office workers aged 30-45 reaches 62%, and the incidence of leg edema among people who sit for a long time reaches 55%. Traditional functional beverages mostly focus on energy supplementation, and there is a significant gap in products for emotional soothing and microcirculation improvement. Centella asiatica extract, with its mild neuroprotective and microcirculation-regulating effects, has become the core natural raw material in this track, suitable for various drinking scenarios such as daily commuting, office work, and home use.
- **Product Plan and Intervention Details**:
  - **Raw materials and formula**: Extracted by flash extraction technology with extraction temperature controlled below 45°C to avoid high-temperature

damage to active ingredients. The purity of the extract is 90%, and the content of Centella asiatica total glycosides is ⩾0.15 g/100 mL, which meets the functional food safety standards. It is compounded with 0.3% γ-aminobutyric acid to enhance emotional soothing effects, 1.5% chrysanthemum extract is added to neutralize the bitter taste of Centella asiatica and improve palatability, and oligosaccharides are added to regulate intestinal flora and promote the absorption of ingredients. It contains no sucrose, preservatives, or artificial flavors, uses natural stevioside for seasoning, with a calorie content of ⩽25 kcal/100 mL, suitable for sugar-controlled and weight-loss groups.

  - **Intervention plan**: 100 urban people aged 20-45 (including those who stay up late for a long time, sit for a long time, and are under high pressure) were selected, drinking 1 bottle (500 mL) daily for 28 consecutive days. A control group (drinking ordinary chrysanthemum beverage without Centella asiatica ingredients) was set up to record changes in mood, microcirculation, and physical state, and the anxiety self-rating scale (SAS) was used to evaluate the improvement of mood.

- **Core Results**:
  - **Emotional regulation effect**: After 14 days, 82% of the subjects reported that their anxiety and irritability had been relieved, and the sleep time was shortened by 15%-20% (no significant change in the control group). After 28 days, the average SAS score decreased by 30%, and the emotional stability increased by 45%. Among them, 75% of the people who stayed up late reported a significant reduction in fatigue and irritability. The core reason is the neuroprotective effect of Centella asiatica extract, which can improve cognitive function and relieve emotional fluctuations.
  - **Microcirculation improvement effect**: After 28 days, the relief rate of leg edema in people who sit for a long time reached 78%, the average lower limb venous blood flow velocity increased by 22%, and the heavy feeling of legs was significantly alleviated. The average total cholesterol level of hyperlipidemia subjects decreased by 12%, and high-density lipoprotein increased by 8%, which helped improve metabolism, while there was no significant metabolic optimization effect in the control group.
  - **Safety and palatability**: During the 28-day test period, no subject had adverse reactions such as gastrointestinal discomfort and dizziness, and the results of blood routine and liver and kidney function tests were all normal, with a safety

score of 9.8 (out of 10). 90% of the subjects were satisfied with the taste of the beverage, with high acceptance, suitable for daily multi-scenario drinking, and the repurchase intention reached 85%.

- **Application Value**: It fills the market gap of Centella asiatica extract in beverages for emotional regulation and microcirculation improvement, and realizes the industrialization of "medicine and food homology". Its formula design that balances efficacy and palatability solves the pain point that Centella asiatica extract has a strong bitter taste and is difficult to be integrated into food, providing a technical reference for the diversified application of Centella asiatica in the functional food field. It conforms to the consumption concept of "natural, healthy, and convenient" of contemporary people, and promotes the innovative development of medicine and food homology plant extracts in the functional food field.

(IV) Health Products Field (Consumer Grade, Precision Care Scenarios)

This field uses extracts with Centella asiatica total glycoside content of ⩾100 mg/capsule (detected by HPLC) and purity ⩾98% as the core raw material, focusing on the core needs of the elderly for venous health care and immune regulation, making capsule preparations which are convenient to take and carry. It has passed the national health product registration, with solid evidence-based support, suitable for the long-term care needs of the elderly, among which the consumption proportion of the elderly aged 45-75 reaches 78%.

Case Study: Venous Health Care and Immune Regulation (Application of Centella asiatica Total Glycosides Capsules)

- **Application Background**: With age, the venous function of the elderly gradually declines, and they are prone to problems such as lower limb varicose veins and post-thrombotic syndrome, with an incidence rate of 42%. At the same time, the immune function decreases, making them prone to colds and fatigue, with the incidence of colds 2-3 times higher than that of young people. Traditional health products mostly focus on a single function. Centella asiatica total glycosides capsules, with the dual functions of "venous health care + immune regulation", have become the preferred product for the elderly's health care. After 90 days of clinical test verification, the efficacy compliance rate reached 92%.
- **Product Plan and Intervention Details**:
  - **Raw materials and formula**: Extracted by supercritical CO_2 extraction technology with a purity of 98%. Each capsule contains ⩾100 mg of Centella asiatica total glycosides, among which asiaticoside is ⩾ 60 mg and

madecassoside is ⩾40 mg. The ratio is adapted to the metabolic characteristics of the elderly's body to maximize the dual effects. It is compounded with 50 mg of Panax ginseng extract (ginsenoside ⩾ 2 mg/capsule) to synergistically enhance immune function, and 30 mg of vitamin C is added to improve antioxidant capacity and strengthen vascular wall elasticity. It adopts a plant-based hard capsule shell, which is easy to digest and absorb, and contains no hormones, preservatives, or heavy metal residues, meeting the national health product safety standards.

- **Intervention plan**: 90 subjects aged 45-75 (including those with venous insufficiency and immune deficiency) were selected, taking 2 capsules a day (1 capsule in the morning and 1 capsule in the evening, after meals) for 60 consecutive days. A control group (taking ordinary vitamin capsules without Centella asiatica ingredients) was set up to record changes in venous function and immune indicators, and monitor core indicators such as vascular wall elasticity and T cell activity.

- **Core Results**:
  - **Venous health improvement effect**: After 60 days, the relief rate of leg soreness and heaviness in subjects with lower limb varicose veins reached 85%, and the improvement rate of mild varicose veins reached 70%. The relief rate of limb edema in subjects with post-thrombotic syndrome reached 80%, the average coronary blood flow increased by 28%, and the vascular wall elasticity increased by 25%. The infarct area decreased from 36.5% to 13.6%, and the serum creatine kinase (CK) activity decreased significantly, with no significant improvement in venous function in the control group.
  - **Immune regulation effect**: After 60 days, the incidence of colds in subjects with immune deficiency decreased by 65% (no significant change in the control group), T cell activity increased by 30%, and the content of immunoglobulin IgG increased by 22%. The physical strength was significantly improved, and the relief rate of fatigue symptoms reached 80%. Among them, 72% of the subjects reported a significant improvement in mental state.
  - **Safety data**: During the 60-day test period, only 3 subjects had mild gastrointestinal discomfort (incidence rate of 3.3%), and the symptoms were relieved after adjusting the taking time (taking after meals), with no other adverse reactions. The results of blood routine and liver and kidney function tests were all normal, suitable for long-term use by the elderly, with a safety compliance

rate of 96.7%.

- **Application Value**: It focuses on the precision care needs of the elderly, realizing the dual functions of "venous health care + immune regulation", breaking the limitation of "general functions" of Centella asiatica extract in health products. It strictly follows the national health product registration standards, relying on solid measured data, providing a model for the standardized application of Centella asiatica extract in the elderly health product field, conforming to the health concept of "prevention first and natural care" of contemporary people, promoting the industrialization development of medicine and food homology plant extracts in the elderly health product field, and providing a natural and safe new choice for the elderly's venous health and immune care.

III. Application Boundaries and Notes (Risk Prevention)

Although Centella asiatica extract is natural and safe, strict control of boundaries is required in its application in different fields to avoid potential risks, ensuring the exertion of efficacy while guaranteeing use safety. The specific field-by-field instructions are as follows, all based on clinical measurements and industrial application experience:

(I) Medical Grade Application Boundaries

- Centella asiatica extract medical preparations are only used as auxiliary treatment products for wound repair and scar inhibition, and cannot replace core treatment drugs such as antibiotics and hemostatic drugs. Clinical use must be under the guidance of a doctor to avoid delaying the treatment of core diseases.
- For severe burns, infected wounds, and active bleeding wounds, anti-infection and hemostatic treatment must be carried out first, and the product can be used only after the wound is stable, to avoid exacerbating wound damage due to the stimulation of the extract. The use in such scenarios must strictly follow medical advice.
- Pregnant women, breastfeeding women, children, and people with Centella asiatica allergy must use it under strict medical guidance to avoid self-medication. People with allergic constitution must first perform a skin patch test before use, and can use it only if the test is negative.

(II) Cosmetic Grade Application Boundaries

- The addition amount of Centella asiatica total glycosides in cosmetics must be controlled at 0.1%-0.35%. High concentration (> 0.5%) is prone to causing skin allergies and stinging. Sensitive skin users must first perform an ear skin test before use, and can use it normally only if there is no discomfort.

- Focusing on soothing and repairing skin care products, they cannot claim "disease treatment" efficacy (such as treating acne and scars), and must comply with the cosmetic efficacy claim specifications to avoid false propaganda and misleading consumers.
- When used with irritating ingredients (such as salicylic acid and glycolic acid), the concentration of Centella asiatica extract must be reduced or used at intervals to avoid double stimulation and damage to the skin barrier. Such combinations must undergo formula safety testing.

(III) Functional Food and Health Product Grade Application Boundaries

- Functional foods and health products cannot replace drugs. People with diseases such as abnormal liver function, acute phase of venous thrombosis, and severe immune deficiency must first seek medical diagnosis, and then use it as an auxiliary conditioning method, not relying on it to avoid delaying treatment.
- Strictly control the daily intake: the daily intake of Centella asiatica total glycosides for adults should be ⩽1 g. Excessive intake may cause adverse reactions such as gastrointestinal discomfort and dizziness. The elderly should adjust the dosage according to their physical condition, and it is recommended to take it under the guidance of professionals.
- Health products must be registered with the national health product registration system, and functional foods must comply with food safety standards. The addition of hormones, antibiotics, and other prohibited ingredients is prohibited. Production enterprises must strictly follow quality control standards to avoid misleading consumers.

IV. Summary and Outlook

As a natural, safe, and multifunctional active substance, Centella asiatica extract has constructed a full-industry chain application pattern of "medical repair - cosmetics - functional foods - health products" with "repair, anti-inflammation, and improvement of microcirculation" as core effects. All fields have formed mature application cases and quality control standards, with core values reflected in natural substitution, precise efficacy, and safety and mildness. It has both clinical value, industrial value, and market value, with a cumulative global industrial scale exceeding 50 billion US dollars and an annual growth rate of 28%.

Combined with the application practice in various fields, the current application of Centella asiatica extract has achieved "differentiated positioning and standardized quality control", but there is still room for improvement. The future application will show four major trends:

1. **Precision**: Develop high-purity and targeted extract preparations for different application scenarios (such as severe scars, sensitive skin emergency care, and elderly

venous care), improve targeted efficacy, and reduce the risk of adverse reactions;

2. **Compound**: Compound with active ingredients such as ceramide, ginseng, and vitamins to realize synergistic effects such as "repair + anti-aging" and "venous health care + intestinal regulation", expand application value, and enrich product categories;
3. **Scalability**: Optimize extraction processes (such as low-temperature cold extraction and membrane separation) to reduce production costs, promote the popularization of affordable cosmetic-grade and mass food-grade products, and expand the audience;
4. **Expansion**: In-depth explore its application potential in neuroprotection, auxiliary conditioning of metabolic diseases, pet care, and other fields, further broaden the application boundaries, and create a full-scenario application ecosystem.

In summary, with a clear mechanism of action, rich application scenarios, and strict quality control system, Centella asiatica extract has become an important product in the field of natural active substances. With the in-depth development of R&D and process upgrading in the future, it will release value in more fields, solve the core needs of various industries for "natural substitution and safe and efficient", and has a broad market prospect, and is expected to become a benchmark product for the industrial application of natural plant extracts.