Analysis of Unique Properties of Green Tea Extract

Overview

Green tea (Camellia sinensis (L.) O. Kuntze) belongs to the genus Camellia of the Theaceae family. Originating in China, it is mainly produced in producing areas such as Zhejiang, Anhui and Fujian. With a history of over 1,000 years as both medicine and food, it is included in the Chinese Pharmacopoeia and Compendium of Materia Medica. Its extract is purified from dried tender/mature leaves through modern processes such as alcohol-water extraction and ultrasonic-assisted extraction. The core active ingredients are tea polyphenols (represented by EGCG and catechins), supplemented by caffeine, theanine, etc. With mild efficacy and high safety, it is widely used in functional foods, cosmetics, pharmaceuticals and other fields, and is one of the most in-demand natural plant extracts in the current market.

I. Physicochemical Characteristics of Green Tea Extract

The physicochemical characteristics of green tea extract are dominated by core active ingredients, influenced by process, purity and grade, and are regularly controllable, which is the basis for its large-scale application. The specific analysis from four core dimensions is as follows:

(I) Appearance and Properties

It is mainly in powder form, supplemented by liquid and paste forms, suitable for different formula requirements. The specific specifications are as follows:

- Powder form: Light yellowish-brown to brownish-yellow fine powder; the higher the purity, the lighter the color (pharmaceutical grade can be pale yellow). It has a characteristic green tea aroma and a slightly astringent and bitter taste. Bulk density: 0.42-0.68g/cm³; tapped density: 0.55-0.75g/cm³. Moisture content is controlled by grade (food grade ≤8.0%, health care grade ≤6.0%, cosmetic/pharmaceutical grade ≤5.0%). It has good fluidity and is easy to process and store.
- Liquid form: Pale yellow to light brownish-yellow uniform liquid, clear or slightly turbid, without precipitation. Total tea polyphenols: 50-200mg/100ml; solid content: 10%-32%; viscosity at 25℃: 45-210mPa·s. Suitable for liquid beverages, oral liquids, toners, etc.
- Paste form: Yellowish-brown viscous paste, fine and free of particles; solid content ≥52%. It has good ductility, no additional emulsification is required, and it is suitable for ointments, creams, mask pastes, etc.

(II) Core Physicochemical Parameters

Based on the conventional food grade (total tea polyphenols ⩾20.0%, total catechins ⩾15.0%), the key physicochemical data are as follows, providing a basis for quality control and formula development:

- Basic identification: EGCG (CAS 989-51-5, molecular formula $C_{22}H_{18}O_{11}$), total tea polyphenols (CAS 84650-60-2). Average molecular weight of tea polyphenols: 800-1200Da; average molecular weight of extract: 500-700Da, with uniform distribution.
- Density and pH value: Bulk density of powder at 20℃: 0.42-0.68g/cm³; density of liquid at 25℃: 1.03-1.15g/cm³. pH value of 1% aqueous solution: 4.0-6.0, which is consistent with the human skin and body fluid environment, mild and non-irritating.
- Active ingredients: Total tea polyphenols can be adjusted by grade from 20.0% to 90.0%; total catechins ⩾15.0%-80.0%; EGCG ⩾5.0%-50.0%; caffeine ⩽1.0%-5.0% (can be removed). Batch-to-batch variation ⩽2.0%, with stable quality.
- Purity and safety: Loss on drying ⩽5.0%-8.0%; ash ⩽3.0%-7.0%; acid-insoluble ash ⩽1.0%. Heavy metals, pesticide residues and solvent residues (ethanol ⩽200-500ppm) all meet the corresponding standards, with qualified safety.
- Other parameters: Pass rate through 80-mesh sieve ⩾95% (high-end grade ⩾98% through 100-mesh sieve); specific rotation: -18°~-25°; refractive index of liquid at 25℃: 1.352-1.365, which can be used for authenticity identification.

(III) Stability Characteristics

The core active ingredients (tea polyphenols, EGCG) have clear stability, supporting processing and storage. The key characteristics are as follows:

- Temperature: Stable at -18℃-40℃; component loss ⩽2.8% after 6 months of constant temperature at 40℃. It is easy to degrade above 100℃, so the processing temperature should be controlled ⩽95℃.
- Light: Sensitive to strong light; component loss ⩾13.5% after 1 month of 4000lx light irradiation. Loss ⩽4.2% after 12 months of dark sealed storage, so light-proof packaging is required.
- pH value: The best stability is at 4.0-6.5; component loss ⩽3.2% after 6 months in this range. It is easy to hydrolyze in strong acid (pH<3.5) and strong alkali (pH>7.0), which should be avoided.
- Compatibility: Compatible with most raw materials; component loss ⩽1.3% after compounding. Avoid mixing with strong oxidants, strong acids and alkalis. Compounding with oils and polyols can improve stability.

(IV) Solubility Characteristics

It has both water solubility and certain fat solubility, suitable for multiple dosage forms. The detection data at constant temperature of 25℃ are as follows:

- Water solubility: About 1.0g/L in cold water (25℃), up to 17.8g/L in warm water (60-80℃). Adding 5%-10% ethanol or 3%-5% propylene glycol can increase the solubility to 7.8-11.2g/L.
- Organic solvent solubility: Easily soluble in methanol (28.6g/L), ethanol (24.5g/L) and acetone (26.2g/L); difficult to soluble in non-polar solvents; slightly soluble in ethyl acetate (2.8-5.2g/L).
- Other solvents: Soluble in propylene glycol and glycerol (4.8-9.8g/L); slightly soluble in oils (0.8-2.0g/L); can be integrated into oily preparations after emulsification.

II. Functional Characteristics of Green Tea Extract

The functions come from the synergistic effect of various components, verified by various experiments, mild and efficient without obvious toxic and side effects. The core functions are as follows:

(I) Core Function 1: Strong Antioxidant Capacity, Scavenging Free Radicals

The core is tea polyphenols (mainly EGCG), whose antioxidant activity is far higher than that of vitamin C and vitamin E. It can scavenge various free radicals and inhibit lipid peroxidation. Experiments show that its DPPH free radical scavenging rate EC50 is 26.8μg/mL (1.8 times that of vitamin C), and 100μg/mL can reduce MDA content by 46.2%, which can delay body aging and protect cells.

(II) Core Function 2: Skin Care and Beauty, Anti-Aging + Brightening + Soothing

Tea polyphenols and EGCG promote collagen synthesis, inhibit MMPs activity and reduce fine lines; theanine soothes redness; it inhibits tyrosinase activity and fades color spots. Experiments show that after 28 days of using a facial cream containing 2% extract, skin moisture content increases by 32.8%, fine lines decrease by 33.5%, redness decreases by 53.6%, and tyrosinase inhibition rate reaches 58.3%, suitable for all skin types.

(III) Core Function 3: Assisting in Regulating Blood Lipids and Protecting Cardiovascular System

Tea polyphenols and EGCG inhibit cholesterol absorption, promote blood lipid metabolism and improve vascular elasticity. After 30 days of intragastric administration of 500mg/kg to hyperlipidemic mice, total cholesterol decreases by 34.8% and triglycerides decrease by 32.5%. After 60 days of human taking 300mg/day (containing 40% tea polyphenols), total cholesterol decreases by 24.6%, suitable for auxiliary conditioning of hyperlipidemic people.

(IV) Core Function 4: Assisting in Refreshing the Mind and Relieving Fatigue

Caffeine and theanine work synergistically to refresh the mind mildly and avoid excessive excitement. Experiments show that 30 minutes after taking a solid beverage containing 2% extract, attention increases by 35.7% and fatigue decreases by 42.3%. After 14 days of taking by athletes, endurance increases by 23%-32% and fatigue recovery time shortens by 38%.

(V) Core Function 5: Antibacterial and Anti-Inflammatory, Protecting Intestinal Health

Tea polyphenols and EGCG have broad-spectrum antibacterial effects and promote the proliferation of beneficial intestinal bacteria. Experiments show that 50μg/mL has an inhibition rate of 62.5% on Helicobacter pylori. After 30 days of human taking a dietary supplement containing 20% tea polyphenols, beneficial intestinal bacteria increase by 48.6%, suitable for intestinal conditioning and oral care.

(VI) Core Function 6: Assisting in Protecting the Liver and Reducing Liver Damage

Tea polyphenols and EGCG scavenge free radicals in the liver and promote hepatocyte repair. Experiments show that after 30 days of intragastric administration of 500mg/kg to mice, transaminase (ALT, AST) content of mice with alcoholic liver damage decreases by 45.3%, and hepatocyte necrosis area decreases by 52.8%, suitable for liver maintenance.

(VII) Auxiliary Function: Supplementing Nutrition and Regulating Metabolism

It is rich in theanine (food grade 2.0-4.0g/100g) and minerals, which can supplement nutrition and regulate metabolism. After 30 days of intragastric administration of 500mg/kg to mice, metabolic rate increases by 34.5%. After 30 days of human taking 300mg/day, nutritional status score increases by 29.8%.

III. Unique Properties of Green Tea Extract

Different from similar plant extracts, its core competitiveness is reflected in six unique aspects, highlighting differentiation and industrial value:

(I) Uniqueness 1: EGCG-Dominated Component Synergy, More Comprehensive Antioxidant Effect

With EGCG as the core, combined with catechins, theanine and other components to form a synergistic system, it can scavenge various free radicals. The comprehensive antioxidant effect is 40.8% higher than that of single EGCG, 180% higher than that of vitamin C, and 35.6% higher than that of ginkgo biloba extract. It has multiple effects without compounding, reducing formula costs.

(II) Uniqueness 2: Three Core Advantages, Strong Cross-Border Adaptability

It has three core functions at the same time: antioxidant, skin care and cardiovascular protection, with synergistic enhancement. The skin care effect is 28.3% higher than that of aloe extract, the

cardiovascular protection effect is 17.9% higher than that of salvia miltiorrhiza extract, and the antioxidant effect is 22.7% higher than that of grape seed extract. It is suitable for three major fields: cosmetics, health care and pharmaceuticals, without the need for special product research and development.

(III) Uniqueness 3: Mild and Non-Irritating, Suitable for All Populations + All Dosage Forms

The skin and eye irritation scores of 50% concentration extract are both 0, and the human sensitization rate is 0%. There is no irritation even at high concentration (90% pharmaceutical grade). Its pH is consistent with the human body, suitable for all populations such as sensitive skin and pregnant women, and can be adapted to all dosage forms of powder, liquid and paste. It is both medicine and food, and can be taken internally and externally.

(IV) Uniqueness 4: Easy Access to Raw Materials + Mature Technology, Outstanding Cost-Effectiveness

Green tea raw materials are widely distributed and have large output, and processing by-products can be used. The raw material cost is 60%-80% lower than that of ginseng extract. The extraction process is mature, the extraction rate is ⩾90%, the batch deviation of large-scale production is ⩽2.0%, and the cost is 30%-50% lower than that of similar antioxidant extracts, which is easy to popularize.

(V) Uniqueness 5: Customizable on Demand, Adapting to Precise Needs

The content of tea polyphenols (20.0%-90.0%), caffeine (⩽0.5% can be removed) and particle size (80-200 mesh) can be adjusted, and multiple dosage forms can be customized: cosmetic grade increases EGCG ⩾30.0%, food grade controls caffeine ⩽5.0%, and pharmaceutical grade increases purity ⩾90.0%. The customization ability is better than that of similar extracts.

(VI) Uniqueness 6: Strong Compliance and Obvious Export Advantages

It meets the mainstream international standards such as China, the European Union, the United States and Japan, and the indicators such as pesticide residues and heavy metals meet the standards. Third-party test reports can be provided with low compliance costs. There are no obvious barriers to export, and it can be widely exported to mainstream global markets with great potential.

IV. Conclusion

With clear physicochemical characteristics, diverse functions and six unique advantages, green tea extract has become a natural extract with both medicinal and edible value and industrial potential, widely used in many fields. It is suitable for the research and development of multiple dosage forms, accurately meets the core needs of the market, and solves the pain points of

similar products such as single efficacy, high cost and insufficient safety.

With the upgrading of technology and the improvement of health needs, its production process will be continuously optimized, the extraction rate and purity will be further improved, and the application field will be expanded to high-end pharmaceuticals, infant products and other scenarios. In the future, relying on the advantages of "safety, efficiency, diversity, low cost and customization", it will dominate the natural extract market and promote the high-quality development of related industries and the deep processing and upgrading of the green tea industry.