Safety Assessment, Product Applications and Recommended Dosages of Ginkgo Biloba Extract

Ginkgo Biloba Extract (GBE) is a concentrated natural active ingredient produced from the dried leaves of *Ginkgo biloba L.* (Ginkgoaceae family) through modern processes including extraction, multi-stage membrane separation and purification, deep ginkgolic acid removal, concentration and drying. Its core functional components are ginkgo flavonoid glycosides and terpene lactones (ginkgolides A/B/C, bilobalide), with auxiliary active components such as proanthocyanidins, organic acids, amino acids and trace elements including Zn and Se. Recognized internationally as a core natural raw material in the fields of cardiovascular, cerebrovascular and neuroprotection, GBE is listed in the *Chinese Pharmacopoeia*. It possesses comprehensive value in adjuvant medical treatment, health care, food antioxidation and daily chemical skin care, with wide applications and controllable safety. However, strict control over ginkgolic acid content and dosage is required, and special attention shall be paid to the usage risks for special populations.

I. Safety Assessment of Ginkgo Biloba Extract

(I) Conclusions of Toxicological Tests

1. **Acute Toxicity**

In accordance with GB 15193-2003 *Procedures and Methods for Toxicological Assessment of Food Safety*, oral gavage tests of Ginkgo Biloba Extract in mice showed that the oral LD_{50} > 5000 mg/kg body weight; the oral maximum tolerated dose (MTD) in rats > 10000 mg/kg body weight. No animal deaths or obvious toxic symptoms (e.g., abnormal behavior, weight loss, organ damage) were observed within two weeks, classifying it as a practically non-toxic substance. There is no risk of acute poisoning at conventional dosages, meeting the safety standards for natural raw materials.

2. **Subchronic Toxicity**

A 28-day gavage test in rats demonstrated that administration of standardized Ginkgo Biloba Extract (total flavonoid glycosides ≥24%, terpene lactones ≥6%, ginkgolic acid ≤5 ppm) at 15, 50, 100 mg/kg body weight/day caused no abnormalities in behavior, growth, food intake or blood biochemical indicators in male and female rats, with no lesions found in organ pathological sections. The no-observed-adverse-effect level (NOAEL) > 100 mg/kg body weight/day. Continuous 90-day intake of 0.5% GBE (approximately 450 mg/kg body weight) in rats resulted in no pathological abnormalities in core organs including the liver, spleen and kidneys, with no chronic cumulative toxicity, indicating high safety for long-term moderate intake. High-dose administration (300–500 mg/kg body weight/day for 6 months) only caused mild gastrointestinal reactions (nausea, abdominal distension) with no irreversible damage, which recovered after drug withdrawal.

3. **Genotoxicity and Carcinogenicity**

Multiple Ames tests, mouse bone marrow cell chromosome aberration tests and mouse sperm malformation tests showed that Ginkgo Biloba Extract has no mutagenicity or chromosome damage effect. Its core components, ginkgo flavonoid glycosides and terpene lactones, exert strong antioxidation, scavenge free radicals, inhibit carcinogen metabolism and possess potential antimutagenic activity. Long-term animal feeding tests found no tumor induction by GBE, no evidence of dose-dependent increase in tumor incidence, and no carcinogenic risk, meeting the genotoxicity control requirements for pharmaceutical-grade and food-grade natural raw materials.

4. **Reproductive and Developmental Toxicity**

Animal tests indicated that conventional dosage (≤100 mg/kg body weight/day) of GBE has no adverse effects on reproductive organs, embryonic development or offspring growth. High dosage (>300 mg/kg body weight/day) may slightly affect animal digestive function (e.g., diarrhea) but causes no embryonic malformations or abnormal offspring development. Due to insufficient human clinical trial data, pregnant women, lactating women and children (especially infants under 3 years old) are advised to use cautiously, avoiding long-term high-dose intake, and medical advice shall be sought if necessary.

(II) Risk Substances and Limit Control

1. **Core Risk Substance (Ginkgolic Acid) and Limits**

Ginkgolic acid is the main toxic/sensitizing component of GBE and its content must be strictly controlled: pharmaceutical-grade and food-grade GBE shall comply with the *Chinese Pharmacopoeia 2020 Edition*, requiring ginkgolic acid ≤5 ppm (0.0005%); cosmetic-grade GBE shall comply with CIR standards, requiring ginkgolic acid ≤10 ppm, with practical control recommended at ≤5 ppm to enhance safety. Multi-stage membrane separation combined with deep ginkgolic acid removal can completely eliminate ginkgolic acid and eliminate the risks of sensitization and liver damage.

2. **Heavy Metals and Harmful Elements**

Compliance with corresponding industry standards is required, with core limits: Pb ≤2.0 mg/kg, As ≤1.0 mg/kg, Hg ≤0.1 mg/kg, Cd ≤0.3 mg/kg, ensuring no heavy metal contamination. High-quality ginkgo leaves from authentic producing areas (Shandong, Jiangsu, Zhejiang) are preferred to avoid raw materials from contaminated regions.

3. **Pesticide Residues and Microorganisms**

Compliance with GB 2763 (pesticide residue limits) and GB 4789 (microbial limits) is mandatory, with no detection of pathogenic bacteria (Salmonella, *Staphylococcus aureus*, etc.). Molds ≤25 cfu/g, yeasts ≤25 cfu/g, total aerobic microbial count ≤10^4 CFU/g (food/feed grade); cosmetic-grade products shall comply with microbial limits in the *Safety Technical Specifications for Cosmetics (2022 Edition)*; pharmaceutical-grade products shall meet microbial control standards for medicinal raw materials with no microbial contamination.

4. **Sensitization and Irritation**

Skin sensitization rate <0.3%, with no reports of skin allergy or photosensitivity. Topical application of 20% GBE

causes no irritation or sensitization to intact skin and is suitable for sensitive skin. High concentration (>30%) may induce transient skin dryness without corrosiveness. Eye irritation is extremely weak; diluent (<5%) causes no obvious irritation, while the stock solution may lead to mild conjunctival congestion, requiring avoidance of direct contact with ocular mucosa.

5. **Risks for Special Populations**

- **Population with abnormal coagulation function**: Terpene lactones in GBE exert anti-platelet aggregation effects. Concomitant use with anticoagulants (warfarin, aspirin, etc.) may enhance anticoagulant effects and increase bleeding risk. Use is strictly prohibited for individuals with coagulation disorders, bleeding tendency, gastric ulcer bleeding or thrombocytopenia. Those taking anticoagulant/anti-platelet medications shall use under medical guidance.
- **Population in acute cerebral hemorrhage stage**: Use is strictly prohibited for patients in acute cerebral hemorrhage stage or with recent surgery/trauma history, as it may aggravate bleeding risk.
- **Pregnant women, lactating women and infants**: Insufficient human safety data; cautious use is recommended. Infants shall use under guardian supervision to avoid long-term intake.
- **Population with weak spleen and stomach**: GBE tastes slightly bitter and astringent; high-dose intake may irritate the gastrointestinal tract and cause diarrhea or abdominal distension. Low-dose use or compounding with warm-natured ingredients is recommended.

(III) Safety Conclusions of Authoritative Institutions

- **China**: Listed in the *Chinese Pharmacopoeia 2020 Edition* and *Inventory of Used Cosmetic Raw Materials (2021 Edition)*, applicable as a raw material for medicines, health foods, food additives and cosmetics. Hygienic indicators comply with national standards including the *Chinese Pharmacopoeia*, GB 2762 and GB 2763; compliant with relevant industry standards as a feed additive, not a prohibited/restricted substance.
- **US FDA**: Classifies standardized GBE as a GRAS (Generally Recognized as Safe) substance, permitting its use as a food additive and dietary supplement raw material; US CIR: safe for use in cosmetics at ≤5.0% for rinse-off products and ≤3.0% for leave-on products, with ginkgolic acid ≤10 ppm.
- **EU SCCS**: No safety risks at conventional addition levels in food and cosmetics. Calculated based on toxicological NOAEL, the acceptable daily intake (ADI) for humans is 1.5 mg/kg body weight. Adult daily intake of GBE is recommended at ≤120–240 mg (calculated as standardized extract, containing flavonoid glycosides ≥28.8 mg, terpene lactones ≥7.2 mg).

II. Product Applications of Ginkgo Biloba Extract

(I) Pharmaceutical Industry

1. **Core Value**

As a natural medicinal raw material, it integrates adjuvant therapeutic and health-care effects with mild properties and no obvious toxic or side effects. Applicable in traditional Chinese medicine (TCM) preparations and chemical medicine excipients, it supports adjuvant treatment for various diseases including cardiovascular and cerebrovascular diseases, neurodegenerative diseases and ocular diseases, enriching pharmaceutical product categories and meeting clinical and daily medication demands. It is particularly suitable for populations sensitive to chemical drugs and is an internationally recognized core natural raw material for cardiovascular, cerebrovascular and neuroprotection.

2. **Mechanism of Action**

- **Cardiovascular and cerebrovascular protection**: Terpene lactones specifically antagonize platelet-activating factor (PAF), inhibit excessive platelet aggregation, reduce blood viscosity and prevent microthrombosis; ginkgo flavonoid glycosides dilate microvessels, improve vascular endothelial function, promote nitric oxide (NO) synthesis, increase perfusion in the brain and peripheral tissues, and protect vascular endothelium and cardiomyocytes.
- **Neuroprotection**: Bilobalide and ginkgolides synergistically maintain blood-brain barrier integrity and reduce neuronal apoptosis; ginkgo flavonoid glycosides scavenge free radicals in the brain, improve cerebral energy metabolism, promote neurotrophic factor expression, enhance cognitive function and nerve conduction, exerting significant protective effects against cerebral ischemia-reperfusion injury and neurodegenerative diseases.
- **Ocular protection**: Improves retinal microcirculation, protects retinal cells, relieves visual fatigue, enhances ocular blood supply, and assists in ameliorating ocular disorders such as diabetic retinopathy and macular degeneration.
- **Chemical medicine excipient**: Serves as an excipient to improve drug bioavailability, reduce gastrointestinal irritation, and is compatible with cardiovascular, cerebrovascular and neurological pharmaceutical preparations.

3. **Recommended Dosage Forms/Specific Products**

♣ Recommended dosage forms focus on high-purity extract (total flavonoid glycosides ≥24%, terpene lactones ≥6%), tablets, capsules, drops, injections (intravenous infusion) and granules. Capsules and tablets are suitable for daily oral administration, injections for clinical intravenous delivery, and granules for children and patients with dysphagia.

♣ Specific products include TCM preparations (Ginkgo Biloba Extract Tablets, Ginkgo Biloba Capsules, Ginkgo Biloba Injection), chemical medicine excipients (excipients for cardiovascular and cerebrovascular drugs) and

topical preparations (soothing gels, eye drops), applicable for adjuvant treatment of stroke, cerebral insufficiency, coronary heart disease, vascular dementia, diabetic retinopathy, etc. Multiple related pharmaceutical preparations have been approved domestically and included in the Class B Medical Insurance Catalog.

4. **Application Solutions**

- **Cardiovascular and cerebrovascular adjuvant treatment solution**: Adopt high-purity GBE (total flavonoid glycosides ≥24%, terpene lactones ≥6%) to prepare tablets, capsules or injections with precise daily dosage control, suitable for populations with stroke or cerebral insufficiency. Compounding with Salvia miltiorrhiza extract and Ligusticum chuanxiong extract enhances blood circulation and microcirculation improvement, reducing chemical drug dosage and side effects.
- **Neuroprotection solution**: Compound GBE with ginseng extract and Ziziphus jujuba extract to prepare sustained-release tablets, prolonging efficacy duration, improving memory decline and cognitive impairment for adjuvant intervention in vascular dementia and Alzheimer's disease, with mild properties and no drug dependence.
- **Topical preparation solution**: Compound GBE with menthol and petrolatum to prepare topical soothing gels and eye drops for relieving skin inflammation and ocular fatigue, exerting effects via skin/mucosa penetration and avoiding gastrointestinal irritation of oral drugs.

(II) Health Food Industry

1. **Core Value**

With natural pharmaceutical-grade GBE as the core, it exerts definite health-care effects with no obvious side effects, suitable for long-term consumption. It can be formulated as single-component preparations or compounded with other natural ingredients to enhance synergistic effects, covering multiple health-care scenarios including cardiovascular protection, memory improvement, antioxidation, anti-aging and eye care. With mature market applications, it aligns with consumer demand for "natural, healthy and precise health care".

2. **Mechanism of Action**

- **Cardiovascular and cerebrovascular health care**: Synergistic effects of ginkgo flavonoid glycosides and terpene lactones dilate blood vessels, improve microcirculation, resist thrombosis, regulate blood lipids, increase cerebral and myocardial blood flow, protect vascular endothelium, suitable for daily conditioning of populations with hypertension, hyperlipidemia and cerebral insufficiency.
- **Memory improvement**: Protects neurons, improves synaptic transmission, maintains blood-brain barrier integrity, relieves memory decline and cognitive impairment, suitable for the elderly and working populations to assist in alleviating cerebral fatigue, dizziness and tinnitus.
- **Antioxidation and anti-aging**: Multi-components (flavonoid glycosides, proanthocyanidins) synergistically scavenge free radicals, reduce oxidative stress, delay cellular senescence, protect skin, blood vessels, liver and other tissues and organs, and slow the aging process.

- **Eye care health care**: Improves retinal microcirculation, protects retinal cells, relieves visual fatigue, enhances ocular blood supply, suitable for populations with prolonged eye use and adjuvant conditioning of diabetic retinopathy.

3. **Recommended Dosage Forms/Specific Products**

♣ Recommended dosage forms include capsules (hard capsules, soft capsules), tablets, powders, oral liquids and gummies. Capsules and microencapsulated powders effectively enhance component stability for long-term storage and administration; tablets and oral liquids suit convenient consumption; gummies target young populations and children (under medical advice).

♣ Specific products mainly include Ginkgo Biloba Extract Capsules, Ginkgo Biloba Tablets, Ginkgo Biloba Oral Liquids, eye health granules and anti-aging gummies, meeting health-care demands of the elderly, working populations and patients with chronic diseases (hypertension, hyperlipidemia, diabetes). Multiple related health foods have been approved domestically.

4. **Application Solutions**

- **Single-component health care solution**: Use high-purity GBE (total flavonoid glycosides ≥24%, terpene lactones ≥6%) to prepare capsules or tablets with precise daily intake control (120–240 mg), suitable for populations requiring simple cardiovascular protection and memory improvement, with flexible dosage adjustment based on product specifications.
- **Compound health care solution**: Compounding GBE with Salvia miltiorrhiza and hawthorn extracts enhances cardiovascular protection and lipid regulation for hyperlipidemia and cerebral insufficiency populations; compounding with blueberry extract and lutein strengthens eye care for visual fatigue and ocular discomfort; compounding with grape seed extract and vitamin E enhances antioxidation and anti-aging for the elderly.
- **Special population solution**: For the elderly, adopt microencapsulated GBE to prepare sustained-release tablets, prolonging efficacy and reducing gastrointestinal irritation; for chronic disease patients, combine with probiotics to regulate intestinal flora and alleviate gastrointestinal discomfort during health care.

(III) Food and Beverage Industry

1. **Core Value**

Replacing synthetic antioxidants, it imparts natural herbal flavor while exerting antioxidation, vascular protection and nutrition fortification effects, extending food shelf life and enhancing natural health attributes. Aligning with consumer demand for "natural, healthy and functional" products, it boasts high compatibility with various food and beverage forms, especially suitable for cardiovascular-friendly and anti-aging foods.

2. **Mechanism of Action**

- **Flavor regulation**: GBE carries a faint herbal fragrance, masking off-flavors (e.g., beany taste of plant protein beverages, bitter taste of meal replacement powders), enriching taste layers and enhancing product

flavor recognition, suitable for various light and healthy foods.

- **Antioxidant preservation**: Flavonoids and proanthocyanidins scavenge free radicals, inhibit lipid oxidation and rancidity, reduce harmful substances (e.g., malondialdehyde) in food, delay quality deterioration, with effects superior to some synthetic antioxidants (e.g., BHA, BHT) while complying with natural food standards.
- **Nutrition fortification**: Rich in ginkgo flavonoid glycosides, polysaccharides, amino acids, trace elements and other nutrients, it supplements human nutritional needs and enhances product nutritional value, suitable for healthy foods especially for the elderly.

3. **Recommended Dosage Forms/Specific Products**

♣ Recommended dosage forms are powder, liquid and microcapsule. Powder suits solid products, liquid suits liquid and tea beverages, microcapsule enhances component stability and masks slight bitterness for products with mild taste requirements.

♣ Specific products cover solid beverages (ginkgo meal replacement powders, cardiovascular-friendly solid drinks), baked foods (ginkgo biscuits, bread, pastries), liquid beverages (ginkgo herbal teas, plant protein drinks), condiments (ginkgo seasoning powder, light meal sauces), dairy products (ginkgo yogurt, milk drinks) and elderly foods (ginkgo grain products, nutritional pastes), adapting to diverse consumption scenarios and taste demands.

4. **Application Solutions**

- **Cardiovascular-friendly food solution**: For lipid-controlling and vascular-protective foods and beverages, adopt GBE (total flavonoid glycosides ≥10%) compounded with hawthorn and Salvia miltiorrhiza extracts to enhance vascular protection, impart natural herbal flavor, reduce artificial additives, and meet demands of the elderly and chronic disease populations.
- **Antioxidant preservation solution**: For meat products, lipid products and baked foods, GBE replaces synthetic antioxidants, compounded with vitamin E and tea polyphenols to enhance preservative and antioxidant effects, extend shelf life and improve natural attributes.
- **Nutrition fortification solution**: For elderly foods and healthy beverages, select GBE with high polysaccharide content compounded with probiotics and dietary fiber to strengthen nutrition supply, meet elderly demands and enhance health added value.

(IV) Cosmetics and Daily Chemical Industry

1. **Core Value**

Natural and mild, it integrates multiple effects including antioxidation, anti-aging, soothing, skin microcirculation improvement and eye care, with no potential irritation risks of synthetic ingredients. Suitable for sensitive skin, dull skin and other special needs, it enhances product natural attributes and market competitiveness, aligning with the trend of "natural, mild and functional" daily chemicals, especially ideal for anti-aging, soothing and eye care products.

2. **Mechanism of Action**

- **Skin care mechanism**: Flavonoids and proanthocyanidins scavenge free radicals, inhibit lipid peroxidation, delay skin aging, improve dullness and reduce wrinkles; inhibit inflammatory factors, repair sensitive skin barriers, alleviate redness and roughness; improve skin microcirculation, enhance metabolism and restore skin radiance.
- **Eye care mechanism**: Improves periorbital microcirculation, relieves ocular fatigue, reduces dark circles and edema, protects periorbital skin, suitable for eye creams, eye essences and other products.
- **Oral care mechanism**: Polyphenols inhibit harmful oral bacteria (e.g., *Streptococcus mutans*, *Porphyromonas gingivalis*), reduce plaque formation, relieve gingival inflammation and freshen breath, meeting oral care product demands.

3. **Recommended Dosage Forms/Specific Products**

♣ Recommended dosage forms are liquid and powder. Liquid suits essences, shampoos, mouthwashes, toners and eye creams; powder suits facial masks, toothpastes and scalp essences.

♣ Specific products include skin care (ginkgo anti-aging essence, ginkgo cream, ginkgo facial mask), eye care (ginkgo eye cream, eye essence) and oral care (ginkgo toothpaste, ginkgo mouthwash), flexibly selectable based on product positioning, especially suitable for dull, sensitive skin and prolonged eye use populations.

4. **Application Solutions**

- **Skin care solution**: For dull and sagging skin, compound GBE with hyaluronic acid, vitamin C and retinol to prepare essences and creams, enhancing antioxidation and anti-aging effects with mildness and no irritation; for sensitive skin, combine with panthenol and ceramides to soothe and repair skin barriers, reducing redness and dryness.
- **Eye care solution**: For periorbital dullness, dark circles and edema, compound GBE with caffeine and vitamin K to prepare eye creams and essences, improving ocular microcirculation, relieving fatigue and reducing dark circles/edema, mild and non-irritating to delicate periorbital skin.
- **Oral care solution**: For gingival inflammation and bad breath, compound GBE with menthol and fluoride to prepare toothpastes and mouthwashes, inhibiting bacteria, reducing inflammation, freshening breath and preventing oral bacterial growth with mildness to gums.

(V) Feed and Other Industries

1. **Core Value**

Replacing antibiotic feed additives, it exerts natural antibacterial, anti-inflammatory and growth-promoting effects with no drug residues, improving the quality of livestock, poultry and aquatic products. It also serves as an industrial natural antioxidant and preservative, eco-friendly and compliant with sustainable development, reducing environmental pollution risks of synthetic chemicals, widely applied in breeding and industrial fields.

2. **Mechanism of Action**

- **Feed field**: Flavonoids and polyphenols in GBE inhibit the proliferation of harmful intestinal bacteria (e.g., *Escherichia coli*, Salmonella) in livestock, poultry and aquatic animals, regulate intestinal flora balance, improve feed digestibility and promote animal growth; enhance immunity, reduce the incidence of enteritis, diarrhea and other diseases, and improve the flavor of meat, eggs and aquatic products.
- **Industrial field**: Antioxidant properties of GBE inhibit oxidative deterioration of oils, coatings and wood, extending shelf life; inhibit microorganisms on wood, paper and leather surfaces, enhancing durability with eco-friendliness and no chemical residues.

3. **Recommended Dosage Forms/Specific Products**

♣ Recommended dosage forms are powder and liquid. Powder suits feed mixing and industrial preservative addition; liquid suits wood impregnation, textile finishing and water treatment.

♣ Specific products include feed (livestock and poultry compound feed, special aquatic feed) and industrial products (oil antioxidants, wood preservative impregnation solutions), meeting diverse industrial and breeding scenarios.

4. **Application Solutions**

- **Feed solution**: For pigs, poultry and ruminants, compound GBE with probiotics and amino acids for feed addition, improving appetite, exerting antibacterial and growth-promoting effects, replacing antibiotics and reducing drug residues; for aquatic animals, combine with ginger extract to enhance antibacterial effects, reduce enteritis incidence, improve survival rate and meat flavor.
- **Industrial solution**: For oils and coatings, add GBE as a natural antioxidant replacing synthetic antioxidants, extending shelf life and reducing environmental pollutants; for wood and textile materials, formulate GBE into impregnation solutions and finishing agents to enhance preservative and antibacterial properties, suitable for outdoor wood and functional textiles.

III. Recommended Dosages by Field

(I) Pharmaceutical Industry

In the pharmaceutical industry, GBE dosage shall be determined based on preparation type and clinical indications, with standardized extract (total flavonoid glycosides ≥24%, terpene lactones ≥6%) as the core, strictly complying with clinical dosage standards in the *Chinese Pharmacopoeia* to ensure efficacy and safety. Segmented recommendations are as follows:

1. **Oral preparations (tablets/capsules, 40 mg GBE per tablet/capsule: flavonoid glycosides 9.6 mg, terpene lactones 2.4 mg)**:

♣ Conventional dosage: 1–2 tablets/capsules, 2–3 times daily, total daily dosage 80–240 mg GBE, suitable for daily adjuvant treatment of cerebral insufficiency and memory decline;

♣ Severe case adjuvant treatment: 2 tablets/capsules, 3 times daily, total daily dosage 240 mg GBE, 1 month per

treatment course, 2–3 courses for better efficacy, with dosage adjusted under medical advice.

2. **Intravenous infusion (injection)**: 35–70 mg GBE, 1–2 times daily, switched to oral preparations after condition improvement, used under clinical supervision with strict infusion rate control.
3. **Topical preparations (soothing gels, eye drops)**: GBE addition 1%–5%, eye drops diluted to 0.5%–1% to avoid mucosa irritation, topical gels adjusted to 2%–5% based on soothing demands.

(II) Health Food Industry

In health foods, GBE dosage centers on standardized extract (total flavonoid glycosides ≥24%, terpene lactones ≥6%), controlling daily intake based on health-care effects and target populations to ensure efficacy and safety. Segmented recommendations are as follows:

1. **Single-component preparations**: Using GBE (total flavonoid glycosides ≥24%, terpene lactones ≥6%) as raw material, recommended daily intake 120–240 mg, equivalent to flavonoid glycosides ≥28.8 mg, terpene lactones ≥7.2 mg, flexibly adjustable based on product specifications.
2. **Cardiovascular protection and memory improvement**: Precise dosage control required, recommended daily intake 120–240 mg GBE, 8–12 weeks per cycle, dosage adjustable based on physical condition to avoid long-term high-dose intake.
3. **Antioxidation, anti-aging and eye care**: For daily health care, recommended daily intake 120–180 mg GBE, long-term moderate intake assists in enhancing antioxidation and improving ocular status, no excessive dosage required to avoid gastrointestinal burden.
4. **Special population health care**: For the elderly and chronic disease patients, recommended daily intake 120–180 mg GBE, administered in 2–3 doses for mild efficacy and reduced gastrointestinal irritation; children (under medical advice) with daily intake ≤80 mg GBE.
5. **Dosage by formulation**:

♣ Tablets/capsules: 40–120 mg GBE per unit, 1–3 units daily, precisely matching recommended daily intake;

♣ Oral liquids: 40–80 mg GBE per 10 mL, 1–2 times daily, convenient for dysphagia populations;

♣ Powders: 1–2 g daily (containing 120–240 mg GBE), mixable with warm water or milk for daily health care.

(III) Food and Beverage Industry

In food and beverages, GBE dosage is comprehensively determined by product category, functional demands and taste compatibility, adhering to the principle of "targeted addition, bitterness control, balancing efficacy and safety", using standardized GBE (total flavonoid glycosides ≥10%–24%). Segmented recommendations are as follows:

1. **Beverages (juices, plant protein drinks, functional drinks, solid beverages)**: For antioxidation, vascular protection and flavor enhancement,

♣ Liquid beverages: recommended addition 0.1%–0.5%, adjustable based on flavor to avoid excessive bitterness; cardiovascular-friendly beverages with 0.3%–0.5% addition, single-bottle GBE content ≤80 mg.

♣ Solid beverages: converted by dilution ratio, addition 0.5%–5.0%, meeting effective concentration of liquid beverages after dilution, microcapsule formulation recommended to mask bitterness.

2. **Baked foods (cakes, biscuits, bread, pastries)**: For flavor regulation, preservation and nutrition fortification, recommended addition 0.1%–0.5%.

♣ Herbal-flavored products (biscuits, bread): 0.3%–0.5% to enhance flavor and extend shelf life;

♣ Delicate products (cakes, pastries): 0.1%–0.2% to avoid bitterness affecting overall taste.

3. **Meat products (sausages, cured meats, marinated foods, braised meats)**: For antioxidation, preservation and flavor improvement, recommended addition 0.1%–0.3%.

♣ Long-stewed products (marinated/braised meats): 0.2%–0.3% for effective preservation and herbal flavor;

♣ Sausages: 0.1%–0.2% to preserve meat taste while achieving preservation.

4. **Condiments (sauces, soy sauce, marinades, light meal sauces)**: For flavor regulation and nutrition fortification, recommended addition 0.1%–0.3%.

♣ Liquid condiments (soy sauce, sauces): 0.1%–0.2% to avoid masking original flavor;

♣ Light meal sauces/marinades: 0.2%–0.3% for synergistic flavor and health attributes.

5. **Lipid products (vegetable oils, edible fats, frying oils)**: For antioxidation replacing synthetic antioxidants, recommended addition 0.01%–0.1%, compounded with vitamin E for synergistic effects.
6. **Dairy products and elderly foods (yogurt, milk drinks, grain products, nutritional pastes)**: For nutrition fortification, antioxidation and preservation, recommended addition 0.1%–0.4%.

♣ Yogurt/milk drinks: 0.1%–0.2% for taste improvement and nutrition enhancement;

♣ Elderly grain products/nutritional pastes: 0.2%–0.4% for herbal flavor and vascular protection.

(IV) Cosmetics and Daily Chemical Industry

In cosmetics and daily chemicals, GBE dosage is controlled by product type (rinse-off/leave-on), function and skin/mucosa irritation, using standardized GBE (ginkgolic acid ≤5 ppm). Segmented recommendations are as follows:

1. **Rinse-off products (shampoos, body washes, hand sanitizers)**: For antibacterial, nourishing and soothing effects, recommended addition 0.5%–5.0% (maximum historical use 5.0%).

♣ Shampoos: 1.0%–3.0% to improve scalp microcirculation and relieve itching;

♣ Body washes/hand sanitizers: 0.5%–1.0% for mild antibacterial and nourishing effects.

2. **Leave-on products (creams, essences, emulsions, facial masks)**: For antioxidation, anti-aging and soothing, recommended addition 0.5%–3.0% (maximum historical use 3.0%).

♣ Sensitive skin products: 0.5%–1.0% to avoid irritation;

♣ Dull/sagging skin products: 1.0%–3.0% for enhanced efficacy.

3. **Eye care products (eye creams, eye essences)**: For periorbital microcirculation improvement and dark circle/edema reduction, recommended addition 0.5%–2.0% (maximum historical use 2.0%).

♣ Routine care: 0.5%–1.0% for mild efficacy;

♣ Dark circle/edema products: 1.0%–2.0% compounded with soothing ingredients.

4. **Oral care products (toothpastes, mouthwashes)**: For antibacterial, breath-freshening and gingival inflammation relief, recommended addition 0.1%–0.3% (maximum historical use 0.5%).

♣ Toothpastes: 0.1%–0.2% for antibacterial effects;

♣ Mouthwashes: 0.2%–0.3% for antibacterial and taste balance.

(V) Feed Industry

In feed, GBE dosage is based on animal species and growth stage, focusing on antibacterial growth promotion and palatability, using standardized GBE (total flavonoid glycosides ≥10%). Segmented recommendations are as follows:

1. **Pig, poultry and ruminant feed**:

♣ Piglets, fattening pigs, broilers, layers, beef cattle, dairy cows: recommended addition 0.05%–0.1% (500–1000 g/ton).

♣ Young animals (piglets, chicks): 0.05%–0.07% (500–700 g/ton) for mild palatability improvement;

♣ Growing animals: 0.07%–0.1% (700–1000 g/ton) for antibacterial growth promotion.

2. **Aquatic feed**:

♣ Fish: 0.03%–0.05% (300–500 g/ton) for immunity enhancement;

♣ Shrimp and crustaceans: 0.05%–0.08% (500–800 g/ton) for antibacterial effects and survival rate improvement.

(VI) Industrial Application Field

For industrial use, GBE dosage is determined by application scenario and function, focusing on antibacterial, antioxidation and preservation, using standardized GBE (total flavonoid glycosides ≥10%). Segmented recommendations are as follows:

1. **Industrial oils and coatings**: Recommended addition 0.02%–0.1% to inhibit oxidation and extend shelf life, adjustable by product type and storage conditions.
2. **Wood preservation, leather/paper mildew prevention**: Recommended addition 1.0%–5.0% via impregnation/spraying; outdoor wood: 3.0%–5.0% for enhanced preservative effects.

IV. Application Precautions and Quality Control

(I) Raw Material Standards

Prioritize ginkgo leaf raw materials complying with the *Chinese Pharmacopoeia 2020 Edition*, ensuring core component standards: total flavonoid glycosides ≥24.0%, terpene lactones ≥6.0%, ginkgolic acid ≤5 ppm. Raw materials shall be mold-free, odor-free and impurity-free, with heavy metals and pesticide residues meeting corresponding industry standards (food/feed/cosmetic grade). High-quality ginkgo leaves from authentic producing

areas (Shandong, Jiangsu, Zhejiang) are preferred to ensure safety and efficacy from the source; crude extracts (ginkgolic acid >5 ppm) are strictly prohibited.

(II) Extraction Process

Adopt water extraction, multi-stage membrane separation or supercritical CO_2 extraction. Water extraction is mild, retaining active components with no solvent residues; membrane separation purifies extracts and deeply removes ginkgolic acid; supercritical CO_2 extraction preserves active ingredients at low temperatures for high-purity products. Avoid extraction temperature >60℃ to prevent component degradation. De-bittering treatment is required post-extraction to improve palatability.

(III) Compatibility Contraindications

- **Food field**: Avoid alkaline substances (sodium bicarbonate, calcium hydroxide) causing component degradation; avoid strong oxidants to ensure stability.
- **Cosmetics field**: Avoid retinoic acid, fruit acids and high-concentration alcohol (≥70%) increasing irritation; compound with soothing agents (panthenol, ceramides) to reduce irritation.
- **Pharmaceutical field**: Avoid concomitant use with anticoagulants (warfarin, aspirin) to prevent bleeding risk; avoid strong acid/alkali drugs, use under medical guidance.

(IV) Storage Conditions

GBE shall be stored sealed, light-proof in a cool and dry place (≤25℃, relative humidity ≤60%) to avoid moisture absorption, oxidation and photodegradation. Powder: moisture and caking prevention; liquid: sealing for leakage/volatilization prevention; microcapsule: high temperature and humidity avoidance. Shelf life: 12–24 months (powder 24 months, thick paste 12 months). Discontinue use immediately if deterioration (caking, odor, discoloration) occurs.

V. Summary

As a natural active ingredient record in the *Chinese Pharmacopoeia*, Ginkgo Biloba Extract has been proven by toxicological tests to have extremely low acute/subchronic toxicity and no genotoxicity or carcinogenicity, with controllable safety at conventional dosages. Its core active components, ginkgo flavonoid glycosides and terpene lactones, exert multiple effects including cardiovascular, cerebrovascular and neuroprotection, antioxidation and anti-inflammation, applicable in pharmaceuticals, health foods, food, cosmetics, feed and industry.

In practical applications, dosage shall be strictly controlled based on efficacy demands, product form and target populations, with ginkgolic acid ≤5 ppm as a key control index. Raw material quality and extraction process stability shall be ensured to balance safety, efficacy and product stability. Special populations (pregnant women, infants,

coagulation disorders) shall control dosage or avoid use. Microencapsulation and compounding technologies effectively mask bitterness, enhance stability and synergistic efficacy.

Overall, Ginkgo Biloba Extract boasts broad application prospects across industries with its natural, safe and multi-functional advantages. Rational and standardized use achieves the goal of "natural replacement of synthetic products", replacing synthetic antioxidants and antibiotics to enhance product quality and competitiveness, aligning with green, healthy and sustainable development trends, while providing natural solutions for cardiovascular, cerebrovascular and neuroprotection demands.