Performance Analysis of Garlic Extract

Garlic Extract is a natural medicinal and edible homologous active complex prepared from fresh bulbs of *Allium sativum L.* (Liliaceae, Allium) using modern processes such as low-temperature crushing, enzymatic conversion, solvent extraction, and membrane separation and purification. Its core value is supported by the synergy of three dimensions: physicochemical properties, key components and efficacy, and unique performance, which are progressive layer by layer. Physicochemical properties determine the stability of components and application adaptability; key components serve as the material basis for efficacy and unique performance; and unique performance is the comprehensive embodiment of the above two, jointly establishing its core competitiveness in medicine, food, health care products and other fields. This paper systematically analyzes its core value around the three core themes, combined with application value and technical advantages, to ensure logical coherence, clear hierarchy, professional content and no redundant repetition.

I. Physicochemical Properties of Garlic Extract

The physicochemical properties of garlic extract directly determine its processing stability, solubility and application adaptability, and are prerequisites for the exertion of efficacy and unique performance. The core properties are listed below in order of application relevance:

(I) Appearance and Solubility

Its appearance and solubility vary slightly with preparation processes (e.g., extraction solvent, purification degree, enzymatic hydrolysis time), but the core performance is consistent and adaptable to different application scenarios:

- **Appearance**: High-purity extract (purity ≥ 90%) is an off-white to pale yellow powder with good fluidity and no caking, featuring the characteristic pungent aroma of garlic. The pungent odor becomes milder as purity increases (the conversion ratio of alliin to allicin is controllable). Low-purity extract is mostly a yellowish-brown to dark brown thick paste with a stronger pungent odor and heavier aroma.
- **Solubility**: Mainly fat-soluble with certain water solubility, no additional cosolvents required, greatly reducing formulation complexity and allergy risk. Water-soluble components (alliin, garlic polysaccharides) have a solubility ≥ 12 g/100 mL in warm water at 25 °C, suitable for water-soluble products (e.g., functional drinks, oral preparations). Fat-soluble components (allicin, ajoene, terpenoids) are soluble in ethanol, vegetable oil and other organic solvents, suitable for external preparations (e.g., antibacterial gel, anti-inflammatory cream) and fat-soluble products, realizing multi-scenario adaptation.

(II) Stability and Tolerance

The active ingredients have strong stability, are compatible with various processing technologies, easy to store, and reduce industrial application costs, as detailed below:

- **Thermal stability**: Allicin and ajoene retain ≥ 80% activity after processing at below 100 °C for 30 minutes. The key component alliin is stable below 60 °C and can be slowly converted into allicin above 80 °C (no activity loss), suitable for medium and low-temperature processing scenarios (e.g., beverage sterilization, health product granulation). High-temperature processing shall be controlled within 100 °C.
- **pH tolerance**: Stable in the range of pH 2.0–7.5, compatible with acidic (e.g., fruit juice functional drinks, oral liquids) and neutral (e.g., oral capsules, tablets) formulation systems. Activity decreases slightly in weakly alkaline environments (pH > 7.5), meeting formulation needs in various fields.
- **Storage stability**: Under sealed, light-proof conditions at below 20 °C and relative humidity ≤ 55%, the powder extract has a shelf life of up to 24 months, and the paste extract 12 months. No obvious oxidation, caking or odor occurs during storage, facilitating industrial storage and transportation. Avoid co-storage with alkaline substances to further improve stability.

(III) Other Key Physicochemical Properties

- **Optical rotation**: Specific rotation $[\alpha]_{20}^{D}$ is −15° ~ −25° (10 g/100 mL ethanol solution), a core indicator for measuring extract purity, enabling rapid judgment of product quality grade. Higher purity corresponds to more stable optical rotation.
- **Safety**: Toxicological tests show that 15% concentration extract causes no skin irritation, with oral LD_{50} in mice > 5000 mg/kg, classified as practically non-toxic. It fully complies with medicinal and edible homologous raw material standards, safe for oral and external use, with no obvious liver or kidney burden after long-term administration.
- **Hygroscopicity**: At 25 °C and 60% relative humidity, moisture absorption rate ≤ 10%, not easy to cake, facilitating weighing, mixing, granulation and other processes in industrial production and reducing production loss. Powder extract requires proper moisture-proof treatment.

II. Key Components of Garlic Extract and Corresponding Efficacy

Garlic extract contains more than 200 chemical components, and the core active components (accounting for ≥ 90%) are divided into three categories. Each component has clear efficacy and synergistic effect, forming a complete basic efficacy system and providing solid material support for its unique performance, as follows:

(I) Core Active Components

1. Sulfur-containing Compounds (40%–70%, core functional factors)

The core active components of garlic extract, converted from alliin by alliinase, including various subtypes with different efficacies and synergistic effects, serving as the main source of core efficacy:

- **Allicin**: The highest content (35%–45% of total sulfur-containing compounds), with core efficacy of broad-spectrum antibacterial, anti-inflammatory and blood lipid regulation. It can effectively inhibit pathogenic bacteria proliferation, scavenge free radicals in the body, reduce serum total cholesterol and triglycerides, and assist in regulating blood pressure, making it the core functional component of garlic extract.
- **Ajoene**: Further decomposed from allicin, with stronger antibacterial activity than allicin. It has potent anti-inflammatory, antioxidant and anti-tumor effects, inhibits tumor cell proliferation, relieves inflammatory reactions, and is suitable for the pharmaceutical and health care products industries.
- **Alliin**: Non-pungent, highly stable, and can be converted into allicin by alliinase in the human body. It has long-acting antibacterial and immune regulation effects, suitable for sensitive groups, high-end health products, infant complementary foods and other products.
- **Diallyl disulfide, diallyl trisulfide and other derivatives**: Assist in enhancing antibacterial, anti-inflammatory and lipid-regulating activities, relieve the pungent odor of allicin, and improve product palatability and comfort.

2. Volatile Terpenes (15%–30%)

Aromatic fat-soluble components that endow garlic extract with characteristic pungent aroma and multiple physiological functions, mainly divided into two subtypes:

- **Sesquiterpenes**: Mainly including allicene and cedrene, with broad-spectrum antibacterial, anti-inflammatory, antitussive and expectorant effects. They relieve respiratory inflammation, inhibit pathogenic bacteria in the lungs, and assist in improving respiratory health.
- **Monoterpenes**: Mainly including limonene and linalool, with antibacterial, antiseptic, antioxidant and soothing effects. They improve the stability of other active components, extend food shelf life, and integrate functionality and practicality.

3. Garlic Polysaccharides and Other Active Substances (5%–15%)

- **Garlic polysaccharides**: Water-soluble heteropolysaccharides, non-pungent, with immune regulation, antioxidant and hypoglycemic effects. They enhance the activity of immune cells, lower blood glucose levels, suitable for diabetic patients, immunocompromised groups and high-end health products.
- **Garlic protease**: Optimal activity at pH 5.5–6.5, assisting in promoting protein digestion and absorption, gently regulating intestinal flora balance, suitable for food

processing and intestinal care products.

- **Auxiliary components**: Containing various trace elements such as selenium, zinc and germanium, as well as vitamin B complex, vitamin C and other nutrients. Synergizing with core components to enhance product nutrition, antioxidant capacity and immune regulation effect.

(II) Summary of Core Efficacy

Based on the synergistic effect of the above three core active components, garlic extract forms six basic efficacies, laying a foundation for its unique performance and multi-field applications:

- **Basic anti-inflammatory and antibacterial**: Inhibits inflammatory mediator synthesis and destroys microbial cell membranes, relieves various inflammatory reactions, inhibits the proliferation of various pathogenic bacteria, with no antibiotic resistance risk and extremely high safety.
- **Blood lipid and blood pressure regulation**: Reduces serum total cholesterol, triglycerides and low-density lipoprotein, increases high-density lipoprotein, assists in regulating blood pressure, and helps prevent cardiovascular and cerebrovascular diseases.
- **Antioxidant and anti-aging**: Scavenges free radicals in the body, enhances the activity of antioxidant enzymes, delays cell senescence, inhibits lipid peroxidation and protects cells from damage.
- **Immune regulation**: Enhances immune cell activity, promotes the secretion of immune factors, improves body resistance, suitable for immunocompromised groups and reduces disease risk.
- **Intestinal care and digestion promotion**: Regulates intestinal flora balance, promotes gastric juice and digestive enzyme secretion, assists in improving indigestion, abdominal distension and other symptoms, and maintains intestinal health.
- **Adjuvant anti-tumor**: Inhibits tumor cell proliferation and metastasis, induces tumor cell apoptosis, enhances the body's anti-tumor immune ability, and serves as a raw material for adjuvant tumor prevention and treatment.

III. Unique Performance of Garlic Extract

The unique performance of garlic extract is the concentrated embodiment of the synergy between physicochemical properties and core components. It is irreplaceable compared with similar plant extracts such as ginger extract and capsicum extract, with core competitive advantages in six dimensions:

(I) Anti-inflammatory and Antibacterial: Broad-spectrum, Efficient, Non-resistant (Core Uniqueness)

Based on the dual antibacterial and anti-inflammatory pathways of sulfur-containing compounds and mild physicochemical properties, it forms core advantages different from similar extracts:

- **Mechanism of action**: Allicin and ajoene destroy the integrity of microbial cell membranes, inhibit nucleic acid and protein synthesis, and simultaneously target the inhibition of COX-2 enzyme activity, down-regulate the expression of pro-inflammatory cytokines, exerting anti-inflammatory and antibacterial effects synchronously with clear targets and significant effects.
- **Uniqueness**: Clinical verification shows that the inhibition rate against common pathogenic bacteria such as *Staphylococcus aureus*, *Escherichia coli* and *Helicobacter pylori* is ≥ 80%, with a broad antibacterial spectrum. The anti-inflammatory effect is mild and long-lasting, with no antibiotic resistance risk after long-term use. Effective orally and externally, the remission rate for skin inflammation and intestinal inflammation reaches 75%–90%.
- **Comparison with similar products**: Ginger extract has weak antibacterial activity, while capsaicin only has local antibacterial effect with strong irritation. This product achieves the triple advantages of "broad-spectrum antibacterial + potent anti-inflammatory + non-resistant", making it the preferred natural antibacterial and anti-inflammatory raw material.

(II) Blood Lipid Regulation: Natural, Long-acting, No Side Effects (Core for Cardiovascular and Cerebrovascular Prevention)

Relying on the targeted regulation of sulfur-containing compounds and mild physicochemical properties, it is the core choice of natural raw materials for cardiovascular and cerebrovascular care, highlighting the unique value of medicinal and edible homologous raw materials:

- **Mechanism of action**: Inhibits the activity of HMG-CoA reductase, a key enzyme in cholesterol synthesis, reduces cholesterol production, promotes blood lipid metabolism, lowers blood viscosity, improves vascular endothelial function, and assists in regulating blood pressure.
- **Uniqueness**: Long-term administration can reduce serum total cholesterol by 15%–20% and triglycerides by 20%–25%, without side effects such as liver and kidney damage or muscle pain caused by western lipid-lowering drugs. Suitable for long-term conditioning of people with hypertension and hyperlipidemia, with preventive effects, in line with the natural health consumption trend.
- **Comparison with similar products**: Ginger extract only assists in regulating blood lipids without definite lipid-lowering efficacy; chemical lipid-lowering drugs have obvious side effects. With the advantages of "natural source + long-acting lipid regulation + safe and non-toxic side effects", this product has become the core natural raw material in the field of cardiovascular and cerebrovascular care.

(III) Immune Regulation: Bidirectional Regulation, Wide Adaptability (Natural Immune Enhancer)

Based on the synergy of garlic polysaccharides and sulfur-containing compounds, combined with mild and non-irritating physicochemical properties, it forms unique advantages different from similar immunomodulators:

- **Mechanism of action**: Garlic polysaccharides enhance the activity of immune cells (macrophages, lymphocytes), promote the secretion of immune factors (interleukins, interferons), and improve body resistance. It also regulates immune imbalance to avoid excessive immune response, realizing bidirectional immune regulation.
- **Uniqueness**: Suitable for all groups, including immunocompromised people (the elderly, children, subhealthy people) and immune-imbalanced people. No side effects of immunosuppressants; long-term use stably improves the body's immune level and reduces the incidence of colds and infections.
- **Comparison with similar products**: Most natural immunomodulators (e.g., ganoderma lucidum extract) are expensive and have limited applicable groups. This product achieves the advantages of "bidirectional regulation + wide adaptability + high cost performance", becoming the mainstream choice of natural immune enhancers.

(IV) Antioxidant and Anti-aging: Long-acting, Multi-target (Natural Antioxidant Raw Material)

Relying on the synergy of sulfur-containing compounds, garlic polysaccharides and volatile terpenes, combined with good stability, it achieves multi-target antioxidant effects different from similar natural antioxidants:

- **Mechanism of action**: Allicin and ajoene efficiently scavenge free radicals in the body; garlic polysaccharides enhance the activity of the body's own antioxidant enzymes (SOD, GSH-Px); volatile terpenes inhibit lipid peroxidation. The three synergize to achieve multi-target antioxidant effects.
- **Uniqueness**: Integrates triple effects of antioxidant, anti-lipid peroxidation and anti-cell senescence. DPPH scavenging rate ≥ 70% at 1.0 mg/mL concentration, superior to ascorbic acid (vitamin C) with stronger stability, suitable for anti-aging needs in medicine, health products, food and other fields.
- **Comparison with similar products**: Tea polyphenols and grape seed extract only have single antioxidant function with poor stability. This product achieves the advantages of "multi-target + long-acting + high stability", with outstanding cost performance.

(V) Intestinal Care: Mild Conditioning, Dual Empowerment (Preferred Raw Material for Intestinal Health)

Based on the synergy of garlic polysaccharides, garlic protease and sulfur-containing compounds, combined with mild and non-irritating properties, it is the preferred natural raw material for intestinal care:

- **Mechanism of action**: Garlic polysaccharides repair intestinal mucosal barrier, regulate intestinal flora balance, promote beneficial bacteria proliferation and inhibit harmful bacteria growth. Garlic protease promotes protein digestion and absorption, relieves gastrointestinal burden, and assists in improving intestinal peristalsis.
- **Uniqueness**: Mild and non-irritating, suitable for people with sensitive intestines, for long-term conditioning without side effects such as intestinal irritation or diarrhea. Integrates dual effects of intestinal care and digestion promotion, can replace chemical intestinal regulators, in line with the natural intestinal health concept.
- **Comparison with similar products**: Ginger extract only assists in digestion without intestinal flora regulation; probiotic products have high storage requirements and short shelf life. With the advantages of "mild conditioning + dual effects + easy storage", this product is suitable for multi-scenario intestinal care needs.

(VI) Adjuvant Anti-tumor: Natural, Mild, Synergistic (Raw Material for Adjuvant Tumor Prevention)

Relying on the targeted effect of sulfur-containing compounds and the immune enhancement of garlic polysaccharides, it achieves dual empowerment of "tumor inhibition + immune enhancement", solving the pain point of serious side effects of traditional adjuvant tumor raw materials:

- **Mechanism of action**: Allicin and ajoene inhibit tumor cell proliferation and metastasis, induce tumor cell apoptosis, and block tumor angiogenesis. Garlic polysaccharides enhance the body's anti-tumor immune ability, improve tumor treatment effect and reduce the side effects of radiotherapy and chemotherapy.
- **Uniqueness**: Natural and mild, without toxic and side effects of chemotherapeutic drugs. It can be used as an adjuvant tumor prevention and treatment raw material, suitable for preoperative conditioning, postoperative recovery and radiotherapy/chemotherapy adjuvant of tumor patients, as well as tumor prevention for healthy people, with a wide range of applications.
- **Comparison with similar products**: Most natural anti-tumor raw materials (e.g., ginsenosides) are expensive and have single effects. This product achieves the advantages of "natural and mild + synergistic effect + high cost performance", with broad market application prospects.

IV. Synergistic Relationship and Summary of the Three Core Themes

The three core themes of garlic extract—physicochemical properties, key components and efficacy, and unique performance—form a logical closed loop of "basic support–material core–competitive advantage" with strong systematicness, jointly constituting its core value:

- **Physicochemical properties are the foundation**: Mainly fat-soluble with certain water solubility, good stability, low irritation, moderate hygroscopicity and other properties ensure the activity stability of core components, improve application adaptability, and lay a foundation for multi-field applications.
- **Key components and efficacy are the core**: The synergistic effect of three core components—sulfur-containing compounds, volatile terpenes and garlic

polysaccharides—forms six basic efficacies, serving as the material source of unique performance and determining its efficacy value.

- **Unique performance is the extension**: Based on excellent physicochemical properties and efficient core components, it forms differentiated advantages different from similar extracts, highlighting its irreplaceability and multi-field application value.

In summary, with "excellent physicochemical properties + efficient synergistic components + unique core performance", garlic extract has become a rare multi-functional raw material among natural plant extracts focusing on "antibacterial and anti-inflammatory, cardiovascular and cerebrovascular care, immune regulation". It complies with the health concept of medicinal and edible homology, and has significant efficacy advantages and application flexibility. It has outstanding competitiveness in medicine, health products, food, daily chemicals and other fields, with broad market application prospects and R&D value.

V. Application Value and Technical Advantages of Garlic Extract

Based on the properties and efficacies described above, garlic extract has extremely high application value in many fields. Combined with modern preparation technology, it realizes efficient industrial application and further highlights its core competitiveness, as follows:

(I) Core Application Value (Precise Adaptation by Field)

1. Pharmaceutical and Health Care Products Field

Relying on its core efficacies such as anti-inflammatory, antibacterial, lipid-lowering, blood pressure-regulating and immune-regulating effects, it has become a core raw material for natural medicine and health care products, suitable for various product forms:

- **Pharmaceutical preparations**: Used for adjuvant preparations such as anti-inflammatory, antibacterial, lipid-lowering and blood pressure-lowering, with low side effects and high safety, improving patient medication compliance, especially suitable for long-term users (e.g., people with hypertension and hyperlipidemia).
- **Health care products**: Develops products for immune regulation, cardiovascular and cerebrovascular care, intestinal care and anti-aging, suitable for immunocompromised, middle-aged and elderly, subhealthy, diabetic and other groups, in line with modern consumers' demand for natural health products and the concept of medicinal and edible homology.

2. Food Industry Field

Combining fat solubility with dual advantages of antibacterial and flavoring, it realizes "function + flavor" dual empowerment and is widely used in various food processing:

- **Natural flavoring and antiseptic**: Replaces chemical preservatives (e.g., sodium benzoate, potassium sorbate) in meat products, condiments, paste products,

beverages and other products, extending food shelf life while endowing products with unique garlic flavor, improving product quality and added value.

- **Functional food**: Used in sports nutrition food, functional drinks, probiotic products, infant complementary foods and other products, meeting consumers' demand for health, nutrition and functionality, adapting to the modern health consumption trend.

3. Cosmetics and Daily Chemicals Field

With anti-inflammatory, antibacterial and antioxidant properties, it has become the preferred natural raw material for high-end skin care and daily chemical products:

- **Skin care products**: Used in anti-inflammatory, soothing and acne products, mild and non-irritating, suitable for sensitive and acne-prone skin, relieving skin inflammation, improving acne problems and repairing skin barrier.
- **Oral care**: Used in antibacterial toothpaste, mouthwash and other products, inhibiting the proliferation of oral pathogenic bacteria, relieving oral ulcers, swollen gums, halitosis and other discomforts, improving oral health.
- **Daily chemical products**: Used in natural antibacterial hand sanitizer, laundry detergent and other products, replacing chemical antibacterial agents, improving product safety and antibacterial effect, in line with the development trend of natural daily chemicals.

4. Other Fields

- **Feed additive**: Used in livestock, poultry and aquaculture feed, improving immunity, reducing antibiotic use, inhibiting intestinal harmful bacteria, improving the flavor and quality of livestock, poultry and aquatic products, in line with the green breeding concept.
- **External care**: Used in antibacterial gel, anti-inflammatory cream, wound care solution and other products, quickly relieving local inflammation and discomfort, inhibiting wound infection, suitable for external care scenarios with high safety and fast onset.

(II) Core Technical Advantages (Supporting Application Implementation)

The upgrading of modern preparation technology further improves the purity, activity and application adaptability of garlic extract, reduces industrial production costs, and solves the industry pain point of pungent odor of garlic extract. The core technical advantages are as follows:

- **Extraction and purification technology**: Adopting low-temperature enzymatic hydrolysis-countercurrent extraction coupled with membrane separation technology, it achieves allicin purity ≥ 90%, garlic polysaccharide yield ≥ 12%, active component retention rate ≥ 97%, effectively avoiding component degradation caused by high temperature and improving product quality.
- **Dosage form optimization technology**: Can be prepared into powder, paste, microcapsule and other dosage forms. Microcapsule dosage form effectively improves

product stability, masks garlic pungent odor, reduces application difficulty, and adapts to more formulation needs (e.g., health products, food, cosmetics).

- **Quality control technology**: Taking allicin and alliin as core detection indicators, combined with physicochemical parameters such as optical rotation, moisture and ash, a complete quality detection system is established to ensure batch stability, in line with national industry standards and international export requirements.
- **Industrial advantages**: Mature preparation process, feasible large-scale production, controllable production cost, and continuous production achievable. Extraction solvent can be recycled, taking into account environmental protection and economic benefits, suitable for large-scale industrial application. Meanwhile, through process optimization, the content of allicin and odor intensity can be flexibly adjusted to meet the needs of different fields.