Analysis of the Unique Properties of White Kidney Bean Extract

White Kidney Bean Extract (WKBE) is a standardized natural active complex prepared from the mature seeds of *Phaseolus vulgaris* Linn. (a plant of the Leguminosae family) through modern processes including crushing, water extraction, multi-stage membrane separation and purification, impurity removal and refinement, concentration, and drying. It is a recognized core natural raw material in the fields of weight management and postprandial blood glucose regulation, and currently the most widely used natural carbohydrate blocker in applications. Its core value stems from the collaborative support of three dimensions: physical and chemical properties, core components and efficacy, and unique properties. The three are progressive: physical and chemical properties determine the stability and application adaptability of components; core components form the material basis for efficacy and unique properties; and unique properties are the comprehensive embodiment of the first two, collectively laying its core competitiveness in the fields of food, health products, and special dietary foods. Based on three core themes, combined with application value and technical advantages, this article systematically analyzes its core value. All content refers to the *Plant Extract Industry Standard*, T/CNLIC 0164—2024 group standard, and authoritative pharmacological research literature.

I. Physical and Chemical Properties of White Kidney Bean Extract

The physical and chemical properties of white kidney bean extract directly determine its processing stability, solubility, and application adaptability, which are the prerequisite for exerting efficacy. The core properties are sorted as follows according to application relevance:

(I) Appearance and Solubility

Its appearance and solubility vary slightly with preparation process and purity, but the core performance is consistent, adapting to different application scenarios and meeting industry standardization requirements:

- **Appearance**: The standardized extract (with α-amylase inhibitor activity ≥ 10000 U/g) is a white to light yellow fine powder with good fluidity, no caking, and no visible foreign matter under normal vision. It has a faint fragrance, light taste, and no fishy or astringent odor; low-purity extracts are mostly yellow to dark yellow powder with a strong beany taste, which can be completely removed through deep deodorization. Extracts prepared from white kidney beans with plump grains, high maturity, and no mildew or insect infestation have higher content of active ingredients, more uniform color,

and better quality.

- **Solubility**: Mainly water-soluble, no additional solubilizer is needed. Its solubility in warm water at 25℃ is ≥ 6g/100mL. The aqueous solution is clear and transparent without precipitation, floccules, or delamination; slightly soluble in dilute ethanol, insoluble in strong organic solvents such as diethyl ether, acetone, and petroleum ether. It is perfectly compatible with mainstream dosage forms such as water-soluble solid drinks, tablet candies, oral liquids, and meal replacement powders, adapting to daily food and health product processing, and solving the pain points of poor solubility and easy caking of similar functional raw materials.

(II) Stability and Tolerance

The active ingredients have good stability, adapting to conventional mild processing technologies and convenient storage, while also having appropriate environmental tolerance, providing guarantee for industrial production and long-term application:

- **Thermal Stability**: The core active ingredient, α-amylase inhibitor, has an activity retention rate of ≥ 90% when processed at below 60℃ for 30 minutes; long-term heating at above 80℃ leads to gradual activity decay, and the activity retention rate drops to below 65% after boiling at 100℃ for 10 minutes. The process of low-temperature vacuum drying and instant sterilization can maximize the retention of activity, making it suitable for mild heating foods such as baked goods and drinks, and not recommended for high-temperature frying or long-time steaming and boiling scenarios.
- **pH Tolerance**: The active ingredients are highly stable in the pH range of 4.0~8.0, adapting to acidic and neutral formulas (such as drinks, tablets, powders, and oral liquids); in strong acid (pH < 3.0) or strong alkali (pH > 9.0) environments, protein-based active substances are prone to denaturation and inactivation, leading to decreased starch blocking efficiency. Therefore, it is necessary to strictly regulate pH value in formula design and avoid mixing with strong acid and alkali components.
- **Storage Stability**: Under the conditions of sealed, 避光, below 25℃, and relative humidity ≤ 60%, the powdery extract has a shelf life of 24 months. During storage, there is no obvious oxidation, caking, moisture absorption, odor, or activity loss; avoid direct strong light, high temperature, high humidity environments, and seal it in time after opening to further improve storage stability and reduce transportation and storage losses.

(III) Other Key Physical and Chemical Properties

- **Purity and Detection Characteristics**: The mainstream industry standard specification is α-amylase inhibitor activity ≥ 10000 U/g, and high-activity products can reach 30000 U/g; protein (dry basis) ≥ 5.0%, moisture ≤ 7.0%, ash content ≤ 10.0%. The detection methods include DNS colorimetric method for determining amylase inhibition activity, Kjeldahl method for determining protein content, and the detection of heavy metals, microorganisms, and mycotoxins strictly follow national standard detection. The relative standard deviation (RSD) of components between batches is ≤ 2.0%, with outstanding quality stability, facilitating industrial quality control.
- **Safety**: The acute oral median lethal dose (LD_{50}) in mice is > 5000mg/kg, which is practically non-toxic; no skin irritation, mild and non-irritating oral administration, and no liver and kidney toxicity after long-term use. Allergenic and irritating impurities such as phytoagglutinin are strictly limited, meeting food-grade safety standards. The incidence of adverse reactions is less than 1%, and only a small number of people may experience mild abdominal distension in the early stage, which can be gradually relieved with the adaptation of the body.
- **Hygroscopicity**: The moisture absorption rate is ≤ 10% under the conditions of 25℃ and 60% relative humidity, slightly lower than similar plant extracts. The powder is not easy to absorb moisture and agglomerate, facilitating storage, transportation, and automated processing, reducing processing losses and industrial production costs.
- **Molecular Characteristics**: The core active substance is a natural glycoprotein with a molecular weight of about 30~50kDa. It contains specific binding sites on the molecular surface, with a specific spatial conformation, which can accurately target and bind to human salivary and pancreatic α-amylase. This unique molecular structure is the core physical and chemical basis for its specific carbohydrate blocking effect, and also the key sign distinguishing it from common dietary fiber and miscellaneous grain extracts.

II. Core Components and Corresponding Efficacy of White Kidney Bean Extract

White kidney bean extract contains dozens of chemical components, and the core active components account for more than 90%. Each component has clear efficacy and synergistic effect, providing a solid material foundation for unique properties. The component ratio and efficacy have been verified by authoritative research:

(I) Core Active Components

1. **α-Amylase Inhibitor (α-AI, Phaseolin, Core Functional Factor)**

A natural glycoprotein, the 标志性 active component of white kidney bean extract, and the core substance for carbohydrate blocking, sugar and weight control, without artificial chemical modification, and sourced from nature:

- **Core Efficacy**: Specifically binds to the active centers of human salivary amylase and pancreatic amylase, reversibly blocks the starch hydrolysis pathway, inhibits the conversion of starch into maltose and glucose, reduces the absorption of carbohydrate calories by the human body, lowers the postprandial blood glucose peak, stabilizes blood glucose fluctuations, and reduces the conversion of excess sugar into fat accumulation.

2. **High-quality Plant Protein (Auxiliary Functional Factor)**

- **Core Efficacy**: Supplement essential amino acids for the human body, enhance satiety, reduce food intake and craving for snacks, and assist in weight management; maintain normal body metabolism, enhance the nutritional value of formulas, and achieve weight control without losing nutrition or damaging physical fitness.

3. **Other Auxiliary Active Substances (Accounting for 5%~10%)**

- **Dietary Fiber**: Mainly composed of soluble dietary fiber, it delays gastric emptying, prolongs satiety, improves intestinal peristalsis, regulates intestinal flora balance, and assists in stabilizing postprandial blood glucose.
- **Trace Elements and Amino Acids**: Rich in potassium, magnesium, lysine and other nutrients, supplementing the body's needs, maintaining electrolyte balance, and synergistically improving the overall conditioning effect.
- **Impurity Control**: Harmful substances such as phytoagglutinin, heavy metals, aflatoxins, and pathogenic bacteria are strictly limited and deeply removed through multi-stage purification technology to eliminate the risk of gastrointestinal irritation and sensitization, ensuring eating safety.

(II) Summary of Core Efficacy

The synergistic effect of multiple components forms four basic efficacy, which accurately meet the needs of weight management and blood glucose regulation, and adapt to the daily conditioning of all groups, all verified by clinical and basic research:

- **Scientific Weight Management**: Targetedly block starch decomposition, reduce calorie intake, without affecting the absorption of protein, fat,

vitamins, minerals and other nutrients. Combined with a balanced diet and appropriate exercise, it can effectively reduce body fat, narrow the waist circumference, and avoid the discomfort and rebound problems of weight loss by dieting.

- **Stabilize Postprandial Blood Glucose**: Delay sugar absorption, lower the blood glucose peak, reduce the amplitude of blood glucose fluctuations, reduce the burden on pancreatic β cells, improve insulin resistance, and is suitable for daily conditioning of people with prediabetes and high blood glucose, reducing the risk of chronic disease progression.
- **Regulate Appetite and Satiety**: The dual effect of plant protein and dietary fiber prolongs satiety, reduces overeating and excessive appetite, adapting to people with high-carbohydrate diets and sedentary lifestyles.
- **Care for Intestinal Health**: Undigested starch enters the colon and can act as prebiotics to nourish beneficial intestinal bacteria, promote the production of short-chain fatty acids, improve intestinal peristalsis, relieve bloating and constipation, and enhance overall metabolic level.

III. Unique Properties of White Kidney Bean Extract

The unique properties of white kidney bean extract are the collaborative embodiment of physical and chemical properties and core components. Distinguished from similar weight and blood sugar control raw materials such as konjac, dietary fiber, L-carnitine, and cassia seed, its core advantages are reflected in six dimensions, highlighting its irreplaceability:

(I) Precise Action Target, Specific Blocking of Starch, No Harm to Nutrition

Based on the specific molecular structure of α-amylase inhibitor, it achieves precise targeted regulation, which is the core advantage unmatched by similar raw materials:

- **Action Mechanism**: Only specifically inhibits the activity of human α-amylase, has no inhibitory effect on other digestive enzymes such as sucrase, maltase, and lipase, and does not block the absorption of monosaccharides, disaccharides, protein, fat, and minerals, realizing "only blocking carbohydrates, not nutrition".
- **Uniqueness**: It takes effect quickly after oral administration, and the action duration covers the peak period of postprandial starch digestion. It can block 60%~70% of starch calorie absorption. The effect is mild and non-irritating to the gastrointestinal tract, without the risk of nutrient loss or

electrolyte disturbance.

- **Comparison with Similar Products**: Common dietary fiber only delays absorption and has no blocking effect; konjac powder only increases satiety through physical expansion and has no enzyme inhibition effect; L-carnitine only promotes fat metabolism and cannot reduce calorie intake; this product blocks carbohydrate calories from the source, making weight control and blood sugar regulation more direct and efficient.

(II) Natural Source, High Safety, Adaptable to Long-term Use

Derived from traditional edible ingredients, without chemical additives, no dependence, and excellent tolerance, it is distinguished from chemical weight loss and hypoglycemic products:

- **Action Mechanism**: Pure ingredient extraction, refined through multi-stage impurity removal, without western medicine ingredients, hormones, laxatives, or irritating additives, in line with the concept of medicine and food homology, and has no metabolic burden on the gastrointestinal tract, liver, and kidneys.
- **Uniqueness**: Practically non-toxic, suitable for a wide range of people, including obese people, high-carbohydrate eaters, prediabetic people, fitness and calorie control people. Pregnant and lactating women can also take it under professional guidance. There is no dependence or drug resistance after long-term use.
- **Comparison with Similar Product**: Chemical weight-loss drugs are prone to cause diarrhea, steatorrhea, and fat-soluble vitamin deficiency; some hypoglycemic raw materials are highly irritating and easy to cause the risk of hypoglycemia; cassia seed is prone to cause gastrointestinal disorders after long-term use; this product is mild and safe, without side effects such as hypoglycemia and diarrhea, and is suitable for long-term daily conditioning.

(III) Mild and Long-lasting Efficacy, No Rebound, No Damage to Basal Metabolism

The conditioning method conforms to human physiological laws, does not inhibit appetite, does not accelerate metabolism, does not cause dehydration due to diarrhea, and stably maintains weight and blood glucose for a long time:

- **Action Mechanism**: Achieve weight and blood sugar control by reducing calorie absorption and stabilizing blood sugar, fully conform to the normal

digestive and metabolic laws of the human body, and do not damage basal metabolism.

- **Uniqueness**: No retaliatory overeating after stopping use, no rapid weight rebound. Persistent use can develop a healthy metabolic state, suitable for long-term maintenance of body shape and stable blood sugar.
- **Comparison with Similar Product**: Weight loss by dieting and laxative products will damage basal metabolism and cause severe rebound; potent hypoglycemic products are easy to cause sudden rises and falls in blood sugar; this product is mild and conditioning, stable for a long time, and has no damage to the body.

(IV) Strong Application Compatibility, Adaptable to Multiple Dosage Forms, Convenient Processing

With excellent solubility, stability, and fluidity, it adapts to the processing of all types of food and health products, with significant industrial advantages:

- **Action Mechanism**: Good water solubility, no caking or odor, can directly compound various auxiliary materials; temperature resistance and low moisture absorption adapt to conventional production processes, and active ingredients are not easy to lose.
- **Uniqueness**: The activity concentration can be flexibly adjusted to adapt to a variety of dosage forms such as tablet candies, solid drinks, meal replacement powders, oral liquids, functional snacks, and baked foods; excellent compounding property, can synergistically enhance with sugar and weight control raw materials such as probiotics, dietary fiber, chitosan, and mulberry leaf extract, without affecting the taste and flavor of the product.
- **Comparison with Similar Product**: Some functional raw materials have poor solubility, need solubilizers for assistance, and are difficult to process; konjac powder is easy to agglomerate, affecting taste and appearance; this product does not need special preprocessing, is convenient for processing, and adapts to large-scale industrial production.

(V) High Standardization Degree, Controllable Quality, Stable Source

Mature technology, unified standards, sufficient raw material supply, prominent industrial advantages, and extremely high cost performance:

- **Action Mechanism**: Adopt water extraction + multi-stage membrane separation coupling process, with high active ingredient enrichment efficiency and complete impurity removal; implement the unified industry standard T/CNLIC 0164—2024, with high batch stability and full traceability of quality.
- **Uniqueness**: White kidney beans are widely planted, with sufficient and cost-controlled raw material supply. The extraction process is green and

environmentally friendly, without organic solvent residues, meeting the requirements of green production; the product has a complete range of specifications, and different activity levels can be customized to meet the customized needs of various customers.

- **Comparison with Similar Product**: Some high-end functional raw materials rely on imports, with high prices and unstable supply; the cost of raw materials such as L-carnitine and conjugated linoleic acid is relatively high; this raw material is easy to obtain, the process is mature, and the cost performance is outstanding, suitable for universal popularization.

(VI) Diverse Conditioning Scenarios, Balancing Prevention and Improvement, with a Wide Audience

Not only suitable for obese and hyperglycemic people, but also for daily health care, covering the needs of all age groups, with rich application scenarios:

- **Action Mechanism**: Multi-efficacy synergy, not only blocking excess calories, preventing and controlling obesity and high blood sugar, but also regulating appetite and caring for the intestines, balancing the dual role of prevention and improvement.
- **Uniqueness**: Workplace people, students, middle-aged and elderly people, fitness enthusiasts, and high-carbohydrate eaters can all take it. It can not only control calories daily, but also provide emergency care during meals, with flexible application scenarios.
- **Comparison with Similar Product**: Most weight control raw materials are only for obese people, and hypoglycemic raw materials are only suitable for hyperglycemic people, with a narrow audience; this product has a wide audience and diverse scenarios, with both daily health care and chronic disease conditioning value.

IV. Synergistic Relationship and Summary of the Three Core Themes

The three core themes of white kidney bean extract form a logical closed loop of "foundation support - material core - competitive advantage", which together constitute its core value, distinguishing it from similar plant extracts and highlighting its irreplaceability:

- **Physical and Chemical Properties as the Foundation**: Excellent water solubility, medium-low temperature stability, low moisture absorption, and high safety ensure the stable retention of core active ingredients, adapt to multi-scenario processing and long-term storage, and lay a solid foundation for industrial application.

- **Core Components and Efficacy as the Core**: With α-amylase inhibitor as the core, combined with high-quality plant protein and dietary fiber, it forms a specific, efficient, and mild weight and blood sugar control efficacy, without side effects and without harming nutrition, accurately meeting the needs of modern healthy consumption, and is the material root of its core competitiveness.

- **Unique Performance as the Extension**: Based on excellent physical and chemical properties and efficient synergistic components, it forms differentiated advantages such as precise blocking, natural safety, long-term stability, and wide adaptability, solving the industry pain points of single efficacy, high irritation, and inconvenient processing of similar raw materials, and becoming the preferred natural raw material in the field of weight management and blood glucose regulation.

In summary, white kidney bean extract, with "excellent physical and chemical properties + efficient and specific components + unique core performance", has become a multi-functional natural raw material focusing on "weight management, blood glucose regulation, and intestinal care". It has prominent competitiveness in the food and health product fields with efficacy advantages, application flexibility, high safety, and high cost performance