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Review on Comprehensive Utilization of Hemp Seed with High Quality

Tianlu Liao, Jinjie Qu, Miaomiao Jia, Huiya Li, Min Zhang

College of Chemical Engineering and Technology, Tianshui Normal University, Tianshui, China
Email: liaotianlu@163.com

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Abstract

Hemp seed is the seed of *Cannabis sativa* L., which is a characteristic plant resource with outstanding nutritional and economic value. It is rich in high-quality protein, unsaturated fatty acids, dietary fiber and a variety of bioactive substances. The content of tetrahydrocannabinol (THC) meets the requirements of food and industrial safety. In this paper, the core criteria for "high-quality utilization" are nutrient retention rate, functional value release, economic value-added improvement, and the sustainability of the whole process. The nutritional composition and functional characteristics of hemp seeds are systematically reviewed. The progress of high-quality utilization in the fields of food, medicine and health care, daily chemicals, and industrial materials is summarized. The bottlenecks such as processing technology, market awareness, and policy standards are identified. Combined with the trend of green processing and functional development, the development path is proposed to provide theoretical support for the transformation of hemp seeds from primary utilization to high value-added full value utilization.

Keywords

Hemp Seed, Nutrients, High Quality Utilization, Functional Food, Bioactive Substances, Security

1. Introduction

Cannabis sativa L., an annual herb of the genus Cannabis in the cannabis family, is widely cultivated in China, Canada, India and other countries. Hemp seed has been used for more than a thousand years. It was listed as the "sixth Valley" in ancient China and belongs to the same source of medicine and food. Modern analysis confirmed that hemp seed is rich in α-linolenic acid (ALA), linoleic acid (LA), hemp seed protein, lignans and other components, and has multiple development

potential.

The high-quality utilization of hemp seeds defined in this paper refers to the high nutrient retention rate, high functional value release, high economic value-added, green and sustainable whole process as the core indicators, through advanced processing technology to achieve the efficient utilization of all components of hemp seeds, while ensuring the safety, stability and standardization of products, which is different from the traditional low value-added primary utilization such as oil pressing and milling.

Global health consumption and the demand for plant-based resources continue to grow, and hemp seed has become a hot spot for cross-border development due to its "full nutrition and multi-function". However, there are still some problems in the industry, such as backward processing technology, insufficient retention of nutrients and active ingredients, product homogeneity, and low utilization rate of by-products, which restrict the development of high quality. Based on the latest research at home and abroad, this paper systematically reviewed the nutritional characteristics, application fields, problems and challenges, development direction, safety and quality control, and provided a scientific basis for the efficient development and industrial upgrading of hemp seeds.

2. Overview Method

With the theme of "high quality utilization of hemp seeds", this paper retrieved four core databases, namely, web of science, PubMed, CNKI and Wanfang, from January 2018 to June 2025.

The key words are hemp seed, hemp seed, nutritional composition, high quality utilization, functional food, hemp seed protein, hemp seed oil, safety.

The research object was hemp seeds (seeds) according to the literature screening criteria, excluding the whole hemp research using only flowers, leaves and stems as materials, focusing on the topics of nutrition, processing technology, product development, safety and quality control.

Give priority to SCI/PKU core journals, Pharmacopoeia, official regulatory reports and industry authoritative data; Exclude repeated publication, unreliable data, and non-peer reviewed conference summaries. Finally, 42 effective literatures and 6 official standards and industry reports were included.

3. Main Nutritional Components and Functional Characteristics of Hemp Seeds

3.1. Fatty Acids: Source of High-Quality Unsaturated Fatty Acids

Hemp seed is a source of high-quality unsaturated fatty acids, and its fat content accounts for 30% - 35% of the total seed, of which the proportion of unsaturated fatty acids is as high as 85% - 90%, and the proportion of $\omega 3$ and $\omega 6$ polyunsaturated fatty acids is about 1:3, which is close to the ideal proportion of human physiological needs (1:2 - 1:4), which can better meet the needs of human lipid metabolism and provide an important guarantee for human health [1].

A-linolenic acid (ALA, *ω*3 polyunsaturated fatty acid) is the core functional fatty acid in hemp seed, and its content accounts for 15% - 20% of the total fat in hemp seed. It is an essential fatty acid that cannot be synthesized by human body and must be ingested through diet. Relevant human clinical studies have confirmed that ALA has a significant role in regulating blood lipids, reducing the levels of serum total cholesterol and low-density lipoprotein cholesterol, thereby reducing the risk of cardiovascular disease; At the same time, ALA can be metabolized into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in human body, which play anti-inflammatory, immune regulating and neuroprotective roles respectively, and are of great significance in maintaining brain function and retinal health [1].

Linoleic acid (LA, *ω*6 polyunsaturated fatty acid) is the highest content of fatty acid in hemp seed, accounting for 55% - 60% of the total fat. As one of the essential fatty acids in human body, its core physiological function is to participate in the synthesis and repair of cell membrane and regulate the balance of lipid metabolism in the body. *In vitro* cell experiments and human clinical trials have confirmed that LA can supplement the lipid components required by the skin barrier, enhance the integrity of the skin barrier, improve the ability of skin to lock water, and play an important role in maintaining skin health and alleviating skin dryness.

The content of saturated fatty acids in hemp seeds is low, accounting for only 10% - 15% of the total fat, and mainly composed of palmitic acid and stearic acid, which meets the requirements of low saturated fat intake in modern dietary guidelines. Long term consumption will not cause significant burden on human blood lipid levels, further highlighting the health advantages of hemp seed fatty acid composition [1]. The fatty acid composition and human absorption characteristics of hemp seed as a nutritional resource have been verified by classic reviews [2].

3.2. Protein: Low Sensitivity and High-Quality Plant Protein

Hemp seed is a high-quality plant protein source with low sensitivity. Its protein content accounts for 20% - 25% of the total seed. Its protein composition and structure are reasonable. It is mainly composed of 80% hemp globulin and 20% albumin. Its amino acid composition mode meets the human essential amino acid intake standard recommended by the food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO). It can provide comprehensive and balanced amino acid nutrition for the human body, and does not contain common anti nutritional factors such as gluten and soybean trypsin inhibitor. It is a low sensitivity protein and is suitable for a wide range of people [3]. The protein quality of hemp seed was systematically evaluated by the protein digestibility corrected amino acid score method to further confirm its protein nutritional value [4].

In terms of essential amino acid composition, hemp seed protein has significant advantages: the lysine content of hemp seed protein can reach 6.2 g/100g protein, which is significantly higher than that of wheat (2.5 g/100g protein), corn (2.3 g/100g protein), and other common grain proteins, effectively making up for the

shortage of lysine in grain protein; Methionine + cysteine content is 3.8 g/100g protein, which can form amino acid complementary effect with bean protein, further enhance the nutritional value of dietary protein, and is suitable for being an important part of plant protein diet [3].

Hemp seed protein also has good functional properties. Its emulsifying activity index can reach 50 - 60 m^2/g, and its water holding capacity is 3.5 - 4.0 g/g. its good emulsifying and water holding capacity makes it widely used in food processing, and can be used as emulsifier and thickener in meat products, dairy products, beverages and other products [5]; In addition, the active peptide obtained from hemp seed protein after enzymatic hydrolysis shows significant antioxidant activity and auxiliary antihypertensive activity *in vitro* [6]. The functional peptide with angiotensin I am converting enzyme inhibitory activity can be purified from hemp seed protein hydrolysate [7], which provides high-quality raw materials for the development of functional peptide products.

3.3. Dietary Fiber: Soluble and Insoluble Synergism

Hemp seeds are rich in dietary fiber. The total dietary fiber content accounts for 25% - 30% of the total seed content, and shows a reasonable composition ratio of "mainly insoluble and supplemented by soluble", in which the insoluble dietary fiber accounts for 85% - 90% and the soluble dietary fiber accounts for 10% - 15%. The two dietary fibers work together to play an important physiological function and application value [8].

In terms of physiological function, insoluble dietary fiber can effectively prevent constipation by promoting intestinal peristalsis, increasing fecal volume, shortening the residence time of feces in the intestine, and reducing the absorption of harmful substances in the intestine; Soluble dietary fiber can be fermented and decomposed by intestinal flora in the intestine to produce short chain fatty acids (such as acetic acid, propionic acid and butyric acid). Short chain fatty acids can not only be used as the energy source of intestinal flora, but also regulate the intestinal microecological balance and improve intestinal health. At the same time, relevant animal experiments and human cohort studies suggest that the intake of hemp seed dietary fiber can reduce the risk of colon disease and provide protection for intestinal health [8].

In terms of application characteristics, hemp seed dietary fiber has good oil holding capacity, and the oil holding capacity can reach 2.0 - 2.5 g/g. This property makes it possible to replace some fat in the processing of low-fat food, which can not only ensure the taste and flavor of food, but also reduce the fat content of food, which meets the needs of consumers for healthy low-fat food, and is widely used in the development of baked food, meat products, sauces and other products [8].

3.4. Bioactive Substances: High Value-Added Functional Components

Hemp seed contains a variety of unique bioactive substances, which have unique

physiological functions, providing an important basis for its high-value applications in medicine, daily chemical and other fields, and is also the core breakthrough of hemp industry to enhance added value.

Cannabinoid (CBD) is one of the important active ingredients in hemp seed, and its content is 0.1% - 0.5%, and the content is greatly affected by variety differences. It should be noted that CBD is a non-psychoactive ingredient, which is essentially different from tetrahydrocannabinol (THC) with psychoactive activity; In addition, the high-purity CBD raw materials are mainly from hemp flowers and leaves, and hemp seed itself is not the main supply part of CBD. At present, the research evidence on the anti-inflammatory and neuroprotective effects of CBD mainly comes from the animal and clinical trials of the whole hemp plant, and its role in hemp seed still needs to be further studied [9].

The content of ring opening isolarixindiglucoside (SDG) in lignans is 0.3% - 0.8%, which is a unique active component of hemp seed. *In vitro* and animal experiments show that SDG has significant antioxidant activity, which can scavenge free radicals in vivo and reduce the damage of oxidative stress to cells; At the same time, it also has estrogen regulating effect, which can alleviate the symptoms related to female menopause, and provides a new choice for the dietary regulation of menopausal people. The synergistic effect of α-linolenic acid and lignan amide in hemp seed on cardiovascular health has been supported by a systematic review [10].

In addition, hemp seed is also rich in a variety of vitamins and minerals, including vitamin E content of 50 - 80 mg/kg. Vitamin E, as a natural antioxidant, can protect unsaturated fatty acids in hemp seed from oxidation; In terms of minerals, magnesium content is 350 - 400 mg/100g, phosphorus content is 600 - 650 mg/100g, and potassium content is 800 - 850 mg/100g. these minerals participate in a variety of physiological metabolic processes of the human body and are of great significance to maintain the normal physiological function of the human body [11].

4. High Quality Utilization and Technology Progress of Hemp Seeds

4.1. Food Processing

In the field of food processing, the development of hemp related products aims to achieve high nutrient retention, high product stability and high added value. The technology research and development focuses on the optimization of low-temperature processing technology and functional modification of products, aiming to retain the nutritional active ingredients of hemp itself to the greatest extent, expand its application scenarios in various foods, and meet the needs of consumers for healthy functional foods.

As one of the core products of hemp processing, hemp seed oil processing technology has a decisive impact on the retention of nutrients. The hemp seed oil prepared by low temperature cold pressing process at ≤60˚C can effectively avoid the oxidative decomposition of α-linolenic acid (ALA) during high temperature pro-

cessing, so that the retention rate of ALA can reach more than 90%, and there is no need to add chemical antioxidants during processing, and the product does not generate trans fatty acids, which is in line with the processing concept of modern healthy food [11]. In order to further improve the portability and nutrient concentration of the product, the cold pressed hemp seed oil was refined and purified to prepare a capsule preparation. Its purity can be increased to more than 85%, which is convenient for precise control of intake. It is widely used in functional dietary supplements.

Hemp protein is a high-quality plant protein source, and the optimization of its extraction process is the key to its industrial application. At present, two mainstream extraction processes, alkali soluble acid precipitation and enzymatic hydrolysis, are mainly used in the industry. The extraction rate of hemp protein by alkali soluble acid precipitation can reach 70% - 75%, while the extraction rate can be increased to 80% - 85% by protease assisted enzymatic hydrolysis, which significantly improves the resource utilization rate of hemp protein [3]. The physicochemical, functional and microstructure characteristics of hemp seed protein isolate provide support for its food application [12]. In the development of plant meat products, hemp protein has become one of the core raw materials of plant meat by virtue of its good emulsifying and water holding properties. Relevant product standards show that the protein content of hemp protein-based plant meat is ≥15%, and the content of $\omega 3$ polyunsaturated fatty acids can reach 2.5 g/100g, effectively making up for the shortage of $\omega 3$ fatty acids in traditional plant meat and improving the nutritional value of the product [13].

In the development of whole seed food, hemp seed is widely used in the nutritional fortification of cereal products because of its rich dietary fiber, high-quality protein and unsaturated fatty acids. The results showed that adding 10% - 15% of hemp seeds in the cereal bar could increase the dietary fiber content of the product to 6 - 8 g/100g, which was significantly higher than that of the ordinary cereal bar. At the same time, the natural antioxidant components in hemp seeds could effectively delay the oxidative deterioration of the product and extend the shelf life of the cereal bar to more than 12 months, which not only improved the nutritional function of the product, but also reduced the storage loss of the product.

4.2. Medical and Health Care

In the field of medicine and health care, the application of hemp related products needs to strictly distinguish the raw material differences between hemp seed source and the whole hemp source, clarify the efficacy positioning and application boundary of products from different sources, and ensure the safety and legitimacy of products. Relevant research and application are supported by the test data and clinical research of authoritative institutions.

In terms of pharmaceutical products related to cannabinoid (CBD), it is necessary to clearly distinguish the source of its raw materials: epidiolex (CBD preparation for the treatment of epilepsy) approved by the U.S. Food and Drug Admin-

istration (U.S. FDA). The CBD raw materials used are all from hemp leaves, not hemp seeds, so as to avoid regulatory risks and efficacy deviations caused by the confusion of raw materials. The preparation adopts supercritical CO_2 extraction process, which can achieve efficient extraction of CBD under the pressure of 30-40 MPa and temperature of 40˚C - 50˚C, and the extraction rate can reach more than 90%. After further purification, the purity of CBD can be increased to more than 99.5%, ensuring the stability and safety of the preparation [9].

Hempseed (the processed medicinal part of hempseed), as a traditional Chinese medicine, its laxative effect has been included in the Chinese Pharmacopoeia (2020 Edition), and it is clear that its fatty oil is the core drug source component [14]. The processed hemp seed is extracted and refined into soft capsules, granules and other modern dosage forms, which are convenient for clinical application and patients. Clinical observation data show that the effective rate of this kind of preparation in the treatment of constipation can reach more than 85%, and there is no obvious dependence on long-term use. Compared with chemical laxative drugs, it has the advantages of high safety and less side effects, and is suitable for the long-term conditioning of patients with chronic constipation.

In terms of regulating blood lipid, the application of hemp seed extract showed good clinical effect. Studies have shown that daily intake of 2 g hemp seed extract (the main component is the compound system of ring opening isolarix diglucoside (SDG) in lignans and vitamin E) can reduce the human serum total cholesterol level by 12% - 15%, and the low-density lipoprotein cholesterol level also shows a significant downward trend, while the high-density lipoprotein cholesterol level slightly increases, indicating that hemp seed extract can play an auxiliary role in reducing blood lipids by regulating lipid metabolism [10], providing a new choice for the dietary adjustment of hyperlipidemic people.

4.3. Daily Chemical Products

With its good biocompatibility, moisture retention and active function, hemp related raw materials are increasingly widely used in the field of daily chemical products, mainly focusing on skin care, hair care and cleaning products. The core of its research and development is to use the natural activity of hemp ingredients to achieve the product positioning of mild skin care, high-efficiency hair care and green cleaning.

In the field of skin care, hemp seed oil is one of the core raw materials. It is rich in unsaturated fatty acids such as ala, linoleic acid, vitamin E, phytosterol and other nutrients. It can quickly penetrate into the deep layer of the skin, supplement the lipids required by the skin, repair the damaged skin barrier, and improve the dry and rough skin. It is suitable for sensitive muscle, dry skin and other skin types. In addition, CBD (mass fraction of 5% - 10%) extracted from hemp leaves is widely used in facial mask products, which has significant anti-inflammatory and soothing effects, can alleviate inflammatory reactions such as skin redness and pruritus, and improve skin sensitivity. According to the authoritative report

of the industry, the annual growth rate of the skin care mask Market containing CBD ingredients has reached 30%, showing a broad market prospect [15].

In the field of hair care, the hydrolysate of hemp protein (molecular weight ≤ 3000 Da) has become a high-quality raw material for hair care products due to its good water solubility and adsorption. Research shows that adding 3% - 5% of hydrolyzed hemp protein in hair conditioner, hair film and other products can reduce the breaking strength of hair by 20% - 25%, improve the flexibility and glossiness of hair, and reduce the problems such as bifurcation and drying of hair. Long term use can improve the quality of hair and enhance the anti damage ability of hair.

Among the cleaning daily chemical products, the modified dietary fiber scrub particles prepared from the by-product of hemp seed, with its advantages of natural environmental protection and biodegradability, replace the traditional chemical scrub particles and are used in facial cleanser, body scrub cream and other products. This kind of scrub particles has a mild texture, can effectively remove the old waste horniness on the skin surface, and the biodegradation rate is more than 95%, which will not cause pollution to the environment, and is in line with the development trend of green and environmental protection of modern daily chemical products [15].

4.4. Industrial Materials: Full Value Utilization of By-Products

The by-products of hemp processing, such as shelled cake and shell residue, can realize "turning waste into treasure" and expand its application in the field of industrial materials through resource utilization technology, which not only improves the resource utilization rate of hemp industry, but also reduces the environmental pressure of industrial waste, and realizes the green and sustainable development of the industry.

In the field of feed industry, hemp hulled cake is a high-quality feed raw material, its protein content can reach 35% - 40%, and it is rich in a variety of amino acids, minerals and dietary fiber, which can replace some traditional feed raw materials such as soybean meal and fish meal. Research shows that adding 8% - 10% hemp hulled cake in broiler feed can significantly improve the growth performance of broilers, increase the weight gain of Broilers by 5% - 8%, improve the meat quality of broilers, reduce the feed cost, and have significant economic and social benefits [16].

In the field of biofuels, hemp shell residue, as a renewable biomass raw material, can be used to prepare bioenergy through pyrolysis, fermentation and other processes. The hemp shell residue can be transformed into biochar by high temperature pyrolysis process at 500˚C - 600˚C. Biochar can be used as solid fuel, soil improvement, adsorbent and other fields; Through the microbial fermentation process, hemp shell residue can be converted into ethanol, and its conversion rate can reach 15% - 18%, which provides a new raw material path for the development of renewable energy and helps to achieve the goal of "double carbon".

In the field of composites, hemp shell fibers can be used as reinforcement materials for the preparation of composites after modification. The tensile strength of the modified hemp shell fiber can reach 25 - 30 MPa, which has the advantages of light weight, high strength and biodegradability. It is widely used in packaging materials, automotive interior parts and other products to replace traditional plastics, glass fibers and other materials, which not only reduces the production cost of products, but also reduces the pollution of non-degradable materials to the environment, which is in line with the development trend of green and lightweight industrial materials. The whole plant utilization and environmental impact of industrial kenaf as a sustainable crop have been systematically studied [17].

5. Safety and Quality Control

5.1. THC Residue and Compliance

Tetrahydrocannabinol (THC) is a psychoactive component in hemp. Its residue in industrial hemp seeds and products is the core indicator to measure product compliance and safety, and also the key content of industry regulation. At present, the international general standard clearly stipulates that the content of THC in industrial hemp seeds and their processed products should be ≤0.3%. This standard has become the core access condition for industrial hemp products to enter the food and feed fields worldwide, which can effectively ensure the safety of product use and avoid the potential risks caused by concentrating active ingredients. From the perspective of China's regulatory policies, hemp seed has been clearly listed as a common food raw material, which can be used in various food processing and production according to law; However, cannabinoid diphenol (CBD) is not allowed to be added to food temporarily. It can only be legally applied in the fields of medicine, daily chemical industry and so on after the application and approval are completed in accordance with the requirements of relevant laws and regulations, so as to ensure the compliance and standardization of applications in various fields. The systematic safety assessment of the contents of heavy metals, mycotoxins, pesticides and THC in hemp seed and cold pressed hemp seed oil provides the basis for quality control [18].

5.2. Oxidation Stability

As the core category of hemp related products, the stability of hemp seed oil is mainly affected by its composition characteristics. Because it is rich in polyunsaturated fatty acids such as α-linolenic acid and linoleic acid, the chemical properties of these components are active, and they are prone to oxidative rancidity under normal temperature storage conditions, resulting in deterioration of oil flavor, loss of nutrients, and production of harmful substances, which seriously affect the quality and safety of products. Research data show that the shelf life of hemp seed oil without stabilization treatment is only 3 - 6 months at room temperature, which is difficult to meet the needs of industrial storage and market circulation [1]. Natural antioxidants can effectively improve the oxidative stability of

cold pressed hemp seed oil [19]. To solve this problem, microencapsulation technology is widely used in the industry to modify hemp seed oil. By forming a protective film to isolate oxygen, light and other oxidation factors, it can effectively delay the oxidation process of oil, extend its shelf life at room temperature to 12 - 18 months, and significantly improve the stability and market applicability of products [20].

5.3. Allergens and Toxicology

In the safety evaluation of hemp seeds and its products, allergens and toxicological characteristics are important considerations, which are directly related to the applicable population of the product. The research showed that hemp seed did not contain common allergenic ingredients such as gluten and soybean inhibitor, and its protein was low sensitive protein. Compared with traditional plant proteins such as soybean protein and peanut protein, the allergenic risk was significantly reduced. Up to now, there have been no clear reports of allergic reactions caused by hemp seeds and its products in relevant studies at home and abroad. Its safety has been verified by relevant studies, especially suitable for people with gluten intolerance and allergic constitution, which further expands the application scope of hemp related products [3].

5.4. Quality Indicators

The quality control of hemp related products should cover the whole industry chain, and clear quality indicators should be formulated for different product types to ensure uniform, safe and controllable product quality. For hemp oil products, the core quality indicators include acid value, peroxide value, content of heavy metals and pesticide residues. All indicators should strictly comply with the relevant national and industrial standards for edible vegetable oil. The acid value and peroxide value reflect the freshness and oxidation degree of oil, while the content of heavy metals and pesticide residues is directly related to the edible safety of products, and should be strictly controlled within the limit.

For hemp protein products, the focus of quality control is on protein content, ash content, moisture and microbial limit. The protein content should meet the requirements of product standards to ensure its nutritional value; The ash content and moisture content shall be controlled within a reasonable range to avoid moisture absorption and deterioration of the product; Microbial limit shall comply with relevant standards in the field of food, feed or medicine to prevent safety risks caused by microbial pollution.

In addition, in order to realize the whole process quality control of hemp related products, it is necessary to establish a full chain traceability system from variety breeding, planting management, processing and production to terminal products, clarify the quality control standards and responsible subjects of each link, realize the traceability of each batch of products, further improve the stability and safety of product quality, and promote the standardization and high-quality develop-

ment of hemp industry.

6. Bottlenecks and Challenges in High-Quality Utilization of Hemp Seeds

6.1. Bottleneck of Processing Technology

In the industrialization process of hemp related products, the core technology bottleneck restricts the high-quality development of the industry, mainly focusing on protein extraction, CBD processing equipment, product stability and by-product utilization. In the extraction process of hemp protein, although the current mainstream alkali soluble acid precipitation method has low cost, it is easy to cause protein molecular denaturation, destroy its functional properties and affect the product quality in the extraction process; Although enzymatic hydrolysis can effectively improve the protein extraction rate and retain the protein activity, the cost of enzyme preparation is high, accounting for 30% - 40% of the total extraction process cost, which significantly increases the production cost of enterprises and limits its large-scale application [3].

In terms of CBD extraction and processing, although the current mainstream supercritical CO_2 extraction process in the industry has the advantages of high extraction efficiency and solvent-free residue, the corresponding production line equipment investment cost is high, and the cost of a single production line can reach 5 - 8 million yuan. The high equipment threshold makes it difficult for small and medium-sized enterprises to bear, resulting in the monopoly of large-scale enterprises and the difficulty of small and medium-sized enterprises to participate in the CBD processing industry, which restricts the diversified development of the industry.

The lack of product stability is also an important technical problem faced by hemp processing at present. Hemp seed oil is rich in polyunsaturated fatty acids and has unstable chemical properties, which is prone to oxidative rancidity; Liquid products such as hemp protein drinks are prone to stratification and precipitation, which requires the addition of chemical stabilizers to maintain product uniformity, which not only increases product costs, but also lags behind consumers' demand for natural health products.

In addition, the problem of insufficient high-value utilization of hemp processing by-products is prominent. At present, by-products such as hemp shelled residue and protein extracted cake are mostly used in feed, fuel and other fields in the form of low value. The high value-added components such as dietary fiber and lignans contained in them have not been effectively exploited, and the utilization rate of resources is low, which fails to fully maximize the value of the whole chain of hemp industry.

6.2. Market Cognition Deviation

Market cognition bias is an important factor restricting the market-oriented development of hemp industry, which is mainly reflected in two levels: public cog-

nition and product positioning. In terms of public cognition, as hemp and drug marijuana belong to the same genus of cannabis plants, some people have cognitive confusion and mistakenly equate industrial hemp seeds with drug marijuana. They are overly worried that the THC content contained in hemp seeds will lead to addiction, which will lead to resistance to hemp related products and greatly affect the market acceptance and promotion speed of products.

In terms of product market positioning, at present, the homogenization of hemp related products is serious. The products on the market are mainly hemp seed oil, hemp protein powder and other basic raw materials. The product form is single, lacking in in-depth mining and precise positioning of functional characteristics, and failing to develop differentiated products in combination with the needs of different consumer groups, resulting in insufficient product competitiveness and difficulty in forming brand advantages, which further restricts the expansion of market scale.

6.3. Imperfect Policies and Standards

The imperfection of policy supervision and quality standards has brought many challenges to the standardized development of Kenaf Industry. At the international level, there are significant differences in the regulatory policies of hemp and related products in different countries and regions, especially the inconsistent provisions on THC residue limits and CBD application scope, which lead to many barriers in the international trade of hemp related products, which is not conducive to the international development of the industry.

At the domestic level, the lag of policies and standards is obvious: on the one hand, China has not yet liberalized the application of CBD in the field of food, only allowing it to be applied for use in the fields of medicine and daily chemicals according to laws and regulations, limiting the market expansion of CBD related products; On the other hand, the national standards of hemp seed oil, hemp protein and other core products are still missing, and there is a lack of unified quality control norms in the industry, resulting in uneven product quality in the market and flooding the market with some low-quality products, which not only affects the trust of consumers, but also is not conducive to the benign competition and high-quality development of the industry.

7. Future Development Direction of High-Quality Utilization

7.1. Technological Innovation: Green, Efficient, Stable and Quality Improvement

Technological innovation is the core driving force to promote the high-quality utilization of hemp industry. In the future, it will focus on three directions: green and efficient processing, product stability improvement and full resource utilization. In terms of hemp protein extraction technology, new green extraction technologies such as ultrasonic/microwave-assisted extraction will be vigorously promoted. This technology can destroy the cell wall structure of hemp seeds through

physical effects and promote protein dissolution. It can not only increase the protein extraction rate to more than 90%, but also effectively reduce the extraction cost. Compared with traditional enzymatic hydrolysis, the cost can be reduced by 20% - 25%, taking into account the efficiency and economy [6].

In terms of product stability improvement, microcapsule embedding technology will be further optimized. By selecting natural edible embedding materials and building an efficient protection system, it can not only effectively extend the shelf life of hemp related products, but also protect active ingredients such as ala and SDG from damage, preserve the nutritional value and functional characteristics of products, and meet the needs of industrialized storage and market circulation [20].

In terms of full utilization of resources, it will promote the high-value utilization mode of hemp whole seed, deeply explore the value of hemp shell residue, cake and other by-products, and extract dietary fiber from shell residue, lignans and other high value-added components from cake through targeted extraction process, so as to achieve "zero waste" in hemp processing, enhance the overall added value of the industry, and promote the green and sustainable development of the industry [17].

7.2. Market Cultivation: Popular Science + Segmented Products

The core of market cultivation is to crack cognitive bias and create differentiated products. In the future, efforts will be made from the two dimensions of popular science publicity and product segmentation. In terms of popular science publicity, the essential difference between industrial hemp seeds (THC ≤ 0.3%) and drug cannabis will be clarified through various channels such as industry associations, enterprise promotion, academic popular science, etc., so as to popularize the nutritional efficacy and safety characteristics of hemp, eliminate the misunderstanding of the public, and improve the market acceptance of hemp related products.

In terms of product segmentation, we will abandon the current homogeneous product development mode and develop customized functional products in combination with the demand characteristics of different consumer groups: for the elderly, we will develop health products with the functions of assisting in lowering blood lipids, moistening intestines and defecating; Develop sports nutritional supplements with high protein and easy absorption for sports people; For mothers and infants, develop low sensitivity and high nutrition complementary food and nursing products, improve product competitiveness and expand market scale through precise positioning.

7.3. Policy Standards: Unified Norms and International Standards

A sound policy and standard system is an important guarantee for the standardization and high-quality development of Kenaf Industry. In the future, we will focus on promoting standard formulation and policy improvement to achieve international integration. In terms of quality standards, we will speed up the formu-

lation of national standards for core products such as hemp seed oil and hemp protein, clarify key indicators such as THC residue, ALA content, and heavy metal limits, standardize quality control in production and processing, improve product quality uniformity, and protect consumers' rights and interests.

In terms of policy supervision, it will further improve the regulatory policy of hemp related products, promote the compliance declaration and supervision of CBD in the fields of medicine and daily chemical, and clarify its declaration process, application scope and safety requirements; At the same time, actively participate in the formulation of international standards, promote the integration of China's hemp industry standards with international general standards, break international trade barriers, help China's hemp related products to the international market, and promote the internationalization of the industry.

8. Conclusion

Hemp seed has broad prospects for high-quality utilization with high nutrient retention, function release, added value improvement and sustainability as the core. It has formed multiple applications in food, medicine, daily chemicals and industrial materials, but it is still restricted by processing technology, market cognition and policy standards. In the future, green processing technology should be used to break through the bottleneck, improve the safety and quality control system, strengthen the construction of science popularization and standards, and promote hemp seeds from primary processing to full component, high added value and standardized utilization, so as to become a new growth point of characteristic agriculture and health industry.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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