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The Development Pathway of the Aquatic Vegetable Industry Cluster in Baoying County, Jiangsu Province

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Abstract: ***The development of agricultural industrial clusters is instrumental in addressing the challenges of product homogenization and uncoordinated regional competition, thereby fostering the competitive advantages of regional specialty industries. The aquatic vegetable industrial cluster in Baoying County, Jiangsu Province, serves as a representative and exemplary case. This paper aims to analyze the developmental stages and pathways of the Baoying cluster, offering valuable insights for the construction of other characteristic agricultural clusters. The findings indicate that the development of Baoying's aquatic vegetable cluster has progressed through three distinct stages: (1) a phase of large-scale expansion and specialization; (2) the development of a processing sector leveraging local resource endowments; and (3) the establishment of a complete, whole-chain industry. Guided by market demand, Baoying County has adopted a multi-faceted development path characterized by the scaling of enterprises, standardization of products, diversification of business formats, establishment of win-win cooperation mechanisms, and a systematic policy framework. This strategic approach has propelled the cluster's construction, with a primary focus on industrial chain extension and overall industrial upgrading.***

Keywords: Industrial Cluster, Aquatic Vegetables, Path Study, Baoying County.

1. Introduction

The comprehensive promotion of rural revitalization and the acceleration of building a strong agricultural nation represent the core mission of China's agricultural development in the new era. General Secretary Xi Jinping has repeatedly emphasized that industrial revitalization is the cornerstone of rural revitalization. The key lies in consolidating the industrial foundation, developing regionally distinctive industrial clusters, extending industrial chains, enhancing value chains, and deriving benefits from the deep integration of the primary, secondary, and tertiary sectors. Against this backdrop, fostering and strengthening characteristic agricultural industrial clusters has become a crucial strategic pathway for promoting high-quality development of county-level economies and achieving local prosperity.

Baoying County in Jiangsu Province stands as a successful embodiment of this strategy. Leveraging its unique resource endowments and adhering to a development philosophy of "scale, intensification, and integration," the county has successfully cultivated a highly representative aquatic vegetable industrial cluster. Its journey began in the early 1980s with preliminary ventures into aquatic vegetable processing. After more than three decades of dedicated development, Baoying now hosts over 70 processing enterprises, forming a diversified product matrix that includes 16 major series and over 230 varieties, with products exported to Southeast Asia, Europe, and the Americas. Furthermore, the cluster has expanded beyond traditional processing by actively integrating lotus root culture with tourism, establishing multi-functional platforms such as lotus gardens, exhibition halls, and ecological science demonstration parks that combine sightseeing, science popularization, and technological demonstration. The construction of Baoying's aquatic vegetable industrial cluster has achieved remarkable success, earning high-level national recognition. It was selected as one of the first national demonstration parks for the integrated development of the primary, secondary, and tertiary industries for green food in 2017, and was approved by the Ministry of Agriculture and Rural Affairs as a National Typical County for the Whole-Chain Development of Aquatic Vegetables in December 2021.

The success of Baoying prompts a theoretical examination of the formation and evolutionary pathways of agricultural industrial clusters. Existing literature widely acknowledges that industrial agglomeration significantly promotes local economic development [1]. The classic life-cycle theory of industrial clusters typically delineates development into three stages: The first stage involves changes in external economies that alter regional profitability, attracting firms to enter and form an initial agglomeration [2]. In the second stage, technological spillovers, specialized division of labor, and resource sharing generate external economies and enhance competitive advantage [3]. In the third stage, as production and products within the cluster become more standardized and scaled, internal competition intensifies, and profits tend to decline [4]. These theories provide a solid analytical framework for studying industrial clusters.

However, existing research is predominantly based on the blueprint of industrial clusters, and its theoretical frameworks may not fully account for the unique characteristics of agricultural clusters, which differ in terms of production factors, stakeholder relationships, driving mechanisms, and reliance on natural resources. Therefore, an in-depth analysis of the actual development path of a specific agricultural cluster is of significant theoretical and practical importance for enriching and refining the theory of industrial clusters. This paper selects the aquatic vegetable industrial cluster in Baoying County as its case study. It aims to systematically trace its evolutionary stages and analyze its construction pathways and underlying logic, with the goal of revealing the specific development patterns of characteristic agricultural clusters and offering practical lessons for cultivating similar competitive industries in other regions of China.

2. The Current State of the Aquatic Vegetable Industry in Baoying County

Baoying County maintains a perennial cultivation area of 13,300 ha for aquatic vegetables such as lotus root (Nelumbo nucifera) and arrowhead (Sagittaria sagittifolia), with an annual output of approximately 300,000 t, earning it the national titles of "China's Hometown of Lotus Root" and "China's Hometown of Arrowhead" [5]. According to survey data from the National Characteristic Vegetable Industry Technology System, the lotus root cultivation area in Baoying County increased from 7,800 ha to 9,227 ha between 2019 and 2021, while production grew from 193,700 t to 243,500 t over the same period. Furthermore, farmers from Baoying annually contract over 6,667 ha of land for lotus root cultivation in other regions.

The "Baoying Lotus Root" was designated a National Geographical Indication Product in 2004. Since then, the county has successfully established 12 "Provincial Demonstration Bases for Export Agricultural Products." The total area of lotus root cultivation bases registered for export has reached 3,460 ha, with 647.4 ha certified by Good Agricultural Practices (GAP) and approximately 167 ha certified as organic [6]. The lotus root industry has evolved into a traditional, characteristic, and pillar agricultural sector in the county, as well as a leading industry for generating foreign exchange through exports.

The production of aquatic vegetables in Baoying County is characterized by high-efficiency, eco-friendly integrated planting and aquaculture models. Techniques such as the polyculture of lotus root with fish, crayfish, loach, or eel have been widely adopted, covering an area of approximately 5,333 ha, which accounts for about 50% of the county's total aquatic vegetable cultivation area. For instance, the integration of crayfish farming can increase the output value by over 30,000 RMB/ha, significantly mitigating potential losses from the price volatility of lotus root. To address the challenges of continuous cropping, Baoying has implemented a lotus root-grain crop rotation model across more than 2,000 ha (Qin et al., 2019). This rotation system has markedly improved the unit yield of lotus root, achieving an input-output ratio exceeding 1:4.5. To meet the demand for year-round market supply and enhance production efficiency, the county has also promoted the early spring cultivation of lotus root in steel-framed greenhouses. This method allows for planting in February-March and harvesting in May-June, generating an output value of over 112,500 RMB/ha [7].

3. Development Stages of the Aquatic Vegetable Industrial Cluster in Baoying County

3.1 Scale-based Development and Specialization

Adhering to the principle of combining government promotion with market orientation, and leveraging its unique resource endowments, Baoying County established a guiding policy for its agricultural industrialization led by the agro-processing sector. This strategy, centered on scale-based development and specialization, aimed to supply the aquatic vegetable processing industry with raw materials that hold a comparative advantage. The initial step was to establish large-scale, intensive aquatic vegetable production bases, promote appropriately scaled farming operations, and develop standardized production bases for green food materials. Specialization serves as a prerequisite for industrial integration, and the specialization and scale of Baoying's agricultural production provided robust support for the development of its secondary and tertiary industries.

3.2 Leveraging Resource Endowments to Develop the Aquatic Vegetable Processing Industry

The establishment of processing bases promoted the agglomeration of industrial elements and enhanced production efficiency. Agricultural processing clusters were formed around lotus root products, leading to the creation of a "National Characteristic Agricultural Processing Base" and a "National Agricultural Industrialization Demonstration Base." The county constructed primary processing facilities for lotus root and centers for green and leisure food, while also developing new product categories from various parts of the plant, including lotus seeds, seed pods, leaves, and root nodes. Through the division of labor and collaboration within the cluster, and the external economies of scale generated by multiple enterprises, the commercialization of the entire plant was achieved, boosting the overall production efficiency of the industry.

According to a survey by a Baoying County research group, the county's annual lotus root exports exceed 50,000 t, with an export value of 80 million USD, accounting for over 70% of the national total. Products are exported to Japan, South Korea, Southeast Asia, Europe, and the Americas, with approximately 70% of lotus root products in Japan originating from Baoying. In recent years, e-commerce has become a significant sales channel, and in 2020, the county's e-commerce sales of agricultural products surpassed 1.46 billion RMB [8].

3.3 Constructing a Complete Aquatic Vegetable Industrial Chain

Optimizing the industrial chain system has been crucial for reducing transaction costs and improving synergistic efficiency. As the industry expanded, a significant number of aquatic vegetable brokers congregated in Baoying, engaging in the procurement and sale of the produce. They sort and perform primary processing on raw materials based on the specific needs of different enterprises, selling them to various processors at different prices according to quality standards. This "enterprise + broker + farmer" organizational model has effectively reduced the direct transaction costs between companies and individual farmers.

Baoying County has also established a comprehensive fresh lotus root distribution system that integrates "wholesale markets + warehousing and logistics + service organizations." The sale of fresh lotus root is predominantly led by these distribution service organizations and teams of brokers [9]. The county has constructed five major wholesale markets, including the Central Jiangsu Agricultural and Sideline Products Wholesale Market and the Zhangshidang Hexian

Lotus Root Wholesale Market. Covering a total area of over 66.7 hectares (ha), these markets house more than 300 distribution service organizations and a workforce of over 2,500 brokers, handling an annual transaction volume exceeding 170,000 t.

4. The Development Path of the Aquatic Vegetable Industrial Cluster in Baoying County

Located in the central part of Jiangsu Province on the northern edge of Yangzhou, Baoying County benefits from a superior ecological environment, a rich historical and cultural heritage, diverse folk customs, and a distinctive culinary culture. Leveraging key national and provincial initiatives—such as its designation as a National Organic Product Certification Demonstration County, a National Organic Food Base Demonstration County, a National Key Chain for the Whole Agricultural Industry Chain, and a Modern Agricultural Industrial Park—the county has pursued a market-oriented development strategy. This path is characterized by scaling up enterprises, standardizing products, diversifying business formats, establishing win-win cooperation mechanisms, and systematizing policy support. These efforts have collectively promoted the construction of the industrial cluster, with a primary focus on extending the industrial chain and achieving comprehensive industrial upgrading.

4.1 Cultivating and Strengthening Leading Agricultural Enterprises

The cultivation and strengthening of leading agricultural enterprises serve as the foundation and driving force of Baoying's agricultural industrialization. The county has focused on fostering these key enterprises by demonstrating advanced processing technologies, improving food processing techniques, diversifying product categories, and increasing product added value, thereby enhancing their capacity to influence and lead the wider industry. The Baoying Baolian Lotus Root Research Institute was established to support these goals. In collaboration with the National Characteristic Vegetable Industry Technology System, the institute is responsible for research on new lotus root varieties, technologies, and production models, as well as new product development and brand marketing.

By 2021, the Baoying Modern Agricultural Industrial Park had established a centralized lotus root processing zone, hosting 29 leading enterprises at or above the county level. Among these, Hexian Group is a national-level enterprise, while others such as Tianhe, Tiancheng, and Xinlianxin are provincial-level enterprises. Collectively, they produce over 250 varieties across 16 major categories and have secured designations as a "National Characteristic Agricultural Processing Base" and a "National Agricultural Industrialization Demonstration Base." Within the industrial park, facilities such as a primary processing base for lotus root and a green leisure food processing center have been constructed. Furthermore, collaborative research and development are underway for new product categories derived from lotus seeds, seed pods, leaves, and root nodes.

4.2 Product Standardization

Baoying County implements standardized production protocols and utilizes an agricultural product traceability management system. Through the promotion of "green" and geographical indication certifications and the construction of a comprehensive brand system, the county aims to create a series of high-value aquatic vegetable products, thereby enhancing their integrated value and increasing its capacity to drive farmer income. Baoying is recognized as a "National Demonstration County for the Construction of Organic Food Bases" and a "National Demonstration Zone for the Quality and Safety of Exported Food and Agricultural Products," and it is home to a National Standardized Production Base for Green Food Raw Materials.

The county demonstrates efficient water resource utilization, close integration of planting and aquaculture, and significant success in reducing pesticide and fertilizer application. It has largely achieved standardized production, branded operations, and quality traceability, with the pass rate for random quality inspections of agricultural products reaching 100%. To advance this, the county has refined its technical specifications for the green and organic production management of lotus root, creating a standardized production system featuring complete facilities, high efficiency, and sustainable practices. Key measures include the implementation of local standards, such as the Technical Regulations for Lotus Root Cultivation (DB32/T548-2008) and the provincial Technical Operating Procedures for the Polyculture of Crayfish in Lotus Root Fields. Through active efforts in certification applications, the total area certified for geographical indication, green food, organic products, and standardized raw material production has reached 5,007 ha.

4.3 Diversification of Business Formats

Led by its processing enterprises, the county has extended into leisure agriculture and rural tourism, promoting the integration and interactive restructuring of these industries. This has effectively broadened the industrial scope and created new employment channels. Enterprises are guided to actively explore new markets, accelerating a profound shift from a purely production-oriented model to one that integrates both production and business operations, continuously fostering the growth of new industries and business formats. By enriching its "Agriculture Plus" models, the county enhances the reputation of "Baoying Lotus Root" and leverages tourism to increase added value.

A key strategy has been to seize e-commerce development opportunities. To foster the integration of "Agriculture Plus Internet," Baoying has established a public service platform, conducted e-commerce training for agricultural professionals to improve their practical skills, and organized enterprise participation in various trade fairs and exhibitions. Utilizing both third-party and self-built platforms, companies engage in self-media promotion and live-stream sales. This has cultivated an e-commerce enterprise cluster, represented by companies like Hexian Group, Tiancheng Food, and Xinlianxin Food, which primarily sell dozens of lotus root

products, including lotus root powder balls and glutinous rice-stuffed lotus root.

The county also actively promotes the integrated development of the primary, secondary, and tertiary industries. By consolidating existing resources, Baoying has innovated diverse business formats that combine agro-processing, agricultural creativity, lotus culture, and rural tourism. It has integrated the scenic beauty of lotus flowers with its processed product resources to create a lotus culture experience center, complete with cultural bases, leisure houses, and sightseeing corridors. The "All-Lotus Root Banquet," a tradition with a century of cultural heritage, is a central feature. For over two decades, the county has hosted the Baoying Lotus Root Tourism Festival and other agricultural celebrations. Annually, leisure agriculture and rural tourism attract over one million visitor-trips, generating revenues of 108 million RMB and increasing the income of surrounding farmers by over 8,000 RMB. The sector includes 11 leisure agriculture enterprises and 10 individually-operated leisure agriculture businesses [10].

4.4 Establishing Mutually Beneficial Cooperation Mechanisms

Baoying County has actively explored an integrated model that unites the industrial park, enterprises, cooperatives, production bases, and individual farmers ("Park + Enterprise + Cooperative + Base + Farmer"). This approach forges a community of shared interests among collectives, enterprises, and farmers, resulting in an industrial structure characterized by enterprise alliances, cooperative-enterprise partnerships, park-enterprise linkages, extended industrial chains, consolidated production bases, and shared equity. By diversifying the business formats within the aquatic vegetable sector, and led by processing enterprises, the county extends its industrial chain and develops leisure agriculture and rural tourism. This promotes the cross-penetration and restructuring of industries, accelerates a profound shift from a purely production-oriented model to an integrated production-and-business model, and continuously fosters new industries and business formats, thereby strengthening the leading enterprises. Baoying has actively explored various integration models, such as contract farming, shareholding systems, and vertical integration, to engage farmers in the process of modern agricultural production, creating a community of shared interests and a shared future that enables farmers to participate throughout the entire process of industrial integration.

4.4.1 Contract Farming

Leading processing enterprises are cultivated to pursue a path of green development. Thirteen key lotus root processing enterprises, including Hexian Group and Tiancheng Food, have signed procurement contracts with village shareholding cooperatives, family farms, and large-scale growers. These contracts guarantee acquisition at a protected minimum price and cover a total cultivation area of 3,467 ha. Additionally, four major lotus root wholesale markets have signed sales agreements with farmers, handling annual contract sales of 50,000 tons.

4.4.2 Shareholding Cooperatives

All 46 villages within the Baoying Modern Agricultural Industrial Park have established village-level shareholding economic cooperatives, with 28,996 households contributing land as equity and a total asset value of 291 million RMB. Through land transfers, these cooperatives have adopted a model that combines a "guaranteed minimum return + secondary dividend," benefiting 14,028 households. For example, in the villages of Wanxin and Kuaijia in Guangyanghu Town, 712 households have pooled 116.4 ha of lotus root fields as shares. Each household annually receives a guaranteed minimum return of 18,000 RMB/ha and is also entitled to a secondary dividend from surplus profits generated by the land transfer.

4.4.3 Vertical Integration and Employee Equity

Leading enterprises have established vertically integrated business models that encompass production, processing, and sales. The 29 agricultural enterprises at or above the county level provide nearly 8,000 jobs. Concurrently, small and medium-sized enterprises involved in the primary processing of lotus root employ approximately 13,000 farmers, bringing the total to 21,000 individuals. This workforce earns an average annual income of 50,000 RMB per person, generating a total employment income for farmers of 1.05 billion RMB. Furthermore, Hexian Group has implemented an Employee Stock Ownership Plan, allocating shares to employees and distributing dividends. This has created an equity incentive framework that enhances employee motivation and proactivity, contributing to the company's sustained and stable growth. This has created a positive cycle where entrepreneurship generates employment, and employment in turn boosts income. Through the enhancement of the value chain, farmers are able to capture a greater share of the profits from industrial integration.

4.5 Systematic Policy Support for Industrial Integration

To facilitate the development of the lotus root industry, the county government has instituted a comprehensive policy framework. This framework is articulated through a series of official documents, including the Supportive Policies for Accelerating the Development of the Lotus Root Industry, the Supportive Policies for Further Encouraging Technological Innovation within the Baoying Modern Agricultural Industrial Park, and the Interim Measures for Rewarding Investment Promotion in Agricultural Projects. These policies are designed to holistically integrate resources from both within and outside the industrial park.

Consolidating Fiscal Capital to Promote Large-Scale and Sustainable Development. The county has coordinated and consolidated various fiscal funds to increase financial support for the industry. The Supportive Policies for Accelerating the Development of the Lotus Root Industry provides direct financial assistance to large-scale business entities and socialized service providers for activities such as agricultural machinery acquisition, "Two Products, One Mark" certifications, and brand building. Within the Baoying Modern Agricultural Industrial Park, this strategic allocation of public funds has been highly effective, achieving a ratio of

fiscal investment to total output value of 1:9.43.

Strengthening Financial Services to Direct Capital Flow. Financial incentives, such as direct rewards and preferential loan policies, are employed to attract industrial and commercial capital. These investments are directed toward key projects, including advanced agro-processing, high-efficiency controlled-environment agriculture and aquaculture, leisure agriculture, smart agriculture, and agricultural e-commerce platforms.

Facilitating the Mobility of Land Resources. To ensure an adequate supply of land, the county has introduced a series of preferential land policies focused on land transfer and the rural collective economy, creating a favorable environment for agricultural business entrepreneurs. When formulating land use master plans, the county's natural resources and planning departments prioritize the land requirements for the construction projects of leading enterprises.

Attracting and Cultivating Talent. Baoying County has implemented strategic policies such as the Policy Opinions on Deeply Implementing the 'Baoying Talent Aggregation Plan' to Accelerate the Strategy of Strengthening the County and Towns with Talents and the 2021 Baoying County Action Plan for Accelerating Rural Talent Revitalization. These policies provide robust support for talent cultivation, attraction, and retention within the aquatic vegetable industry. Concurrently, the county actively explores practical channels for technology transfer and talent acquisition, and it supports enterprises in pursuing indigenous technological innovation and technology integration, thereby promoting the overall scientific and technological advancement of the industrial park.

5. Challenges in the Integrated Development of the Aquatic Vegetable Industry in Baoying County

5.1 Shortage of Working-Age Labor and Scarcity of High-Skilled Talent

As the sole county within the prefecture-level city of Yangzhou, Baoying has a relatively small population base, a situation exacerbated by significant out-migration. This has resulted in a shortage of a prime-age labor force, which presents a critical impediment to enhancing agricultural productivity. Enterprises within the aquatic vegetable sector have an urgent need for high-caliber talent; however, Baoying's limited supporting infrastructure and less-developed economy diminish its appeal to such professionals. The scarcity of qualified technical and managerial personnel severely constrains the further expansion and advancement of these enterprises in key areas such as product development, advanced processing, marketing, and brand building. The existing demographic profile of the workforce is characterized by an older average age and lower levels of formal education, with a notable lack of talent possessing professional skills and knowledge in scientific cultivation, advanced processing technologies, e-commerce, and management.

5.2 Low Value-Added of Processed Products and Limited Revenue Enhancement

Although more than 100 lotus root processing enterprises operate in Baoying, the majority are characterized by their small operational scale, outdated business practices, and limited capacity to drive sectoral growth. The industry's output is dominated by primary processing. Exports primarily consist of fresh, salted, boiled, and frozen lotus root products, while domestic sales feature items such as boiled lotus root, lotus root powder, glutinous rice-stuffed lotus root, and various prepared dishes. Deep-processed products with higher potential value, such as lotus root juice, lotus wine, and lotus leaf tea, are still in their nascent stages of development, resulting in a product portfolio with low overall grade and value-added. Concurrently, brand development efforts are inadequate, with most export products relying on Original Equipment Manufacturer (OEM) or private-label arrangements. Marketing strategies remain underdeveloped, and modern channels such as e-commerce, chain agencies, and direct producer-to-consumer linkages are not yet effectively utilized.

5.3 Low Degree of Industrial Chain Integration

Low barriers to entry and a low level of industry organization have led to disorderly expansion and vicious competition, which has in turn suppressed the procurement price of fresh lotus root [11]. The linkage mechanisms of shared interest between processors and farmers are tenuous. Although contractual agreements exist, prices typically fluctuate with the market, and there is a lack of binding mechanisms to protect farmers' interests. Consequently, the risk of contract default is high during periods of significant price volatility. While the lotus root industry association coordinates and issues annual guidance prices for procurement and sales, these are often difficult to implement effectively. Furthermore, the wholesale markets at the points of origin suffer from outdated infrastructure, subpar management, and inadequate supporting facilities, including environmental protection equipment for primary processing and cold chain logistics. The development of online sales and other modern market distribution formats is also lagging, which collectively hinders the competitiveness of Baoying's lotus root in the broader market.

6. Conclusion

This study systematically analyzes the formation, development path, and extant challenges of the aquatic vegetable industrial cluster in Baoying County, known as "China's Hometown of Lotus Root." The research finds that by leveraging its unique resource endowments through a model that combines government guidance with market orientation, Baoying has successfully constructed an industrial cluster centered on the lotus root industry. This cluster integrates large-scale cultivation, specialized processing, branded marketing, and diversified business formats. Its development path is clearly distinguished by five key dimensions: cultivating leading enterprises, implementing product standardization, diversifying integrated business formats, establishing win-win cooperation mechanisms, and creating a systematic policy support framework. This development model has not only

significantly enhanced the region's agricultural economic performance but has also provided a powerful impetus for increasing farmer income and promoting rural revitalization.

6.1 Theoretical and Practical Contributions

Theoretical Contributions: This research enriches the theory of agricultural industrial clusters by providing new case evidence on the formation and evolution mechanisms of a regional, specialized industrial cluster focused on a specific category (aquatic vegetables). Through an in-depth analysis of the "Park + Enterprise + Cooperative + Base + Farmer" interest linkage model, this study offers a concrete explication of how organizational innovation can effectively integrate smallholder farmers into the modern industrial chain within the context of China's agricultural modernization.

Practical Implications: The experience of Baoying, as distilled in this study, offers significant referential value for other regions in China possessing unique agricultural resources. Its successful practices in constructing a complete industrial chain, integrating the primary, secondary, and tertiary industries, and developing brands and standards provide a replicable and scalable pathway for similar regions aiming to advance their agricultural industrial transformation and convert resource advantages into market strengths.

6.2 Comparison with Existing Research and Innovations

In comparison to the existing literature on agricultural industrial clusters, this paper presents the following similarities, differences, and innovations:

Consistent with most studies, this paper confirms that common driving factors such as the leadership of key enterprises, policy support, and specialized division of labor are fundamental to cluster development.

While much of the literature engages in macro-level theoretical discussions of agricultural clusters, this study focuses on the niche sector of aquatic vegetables, enabling a more in-depth and targeted analysis. This paper not only highlights the importance of cooperation but also systematically deconstructs how various models—including contract farming, shareholding systems, and "employment + equity"—work in synergy to form a stable "community of shared interests," a topic seldom explored in such detail in previous research. Instead of analyzing single driving factors in isolation, this study synthesizes Baoying's success into five interconnected and progressive developmental pathways, providing a clearer and more actionable framework for practitioners.

6.3 Limitations and Future Research Directions

Although this study has yielded valuable findings, several unresolved issues remain that warrant further investigation:

The study notes that Baoying's lotus root exports are predominantly based on Original Equipment Manufacturer (OEM) arrangements, which fails to capture the full value of the brand. Future research should explore concrete strategies for how local specialty agricultural products can transition from OEM to Original Brand Manufacturing (OBM) in international markets to increase brand premium and market power.

While e-commerce is mentioned, the profound application of digital technologies—such as the Internet of Things, big data, and blockchain—in production, processing, quality control, and traceability, and its corresponding impact on the efficiency and resilience of the industrial cluster, remains a promising avenue for future research.

The price volatility and risk of contract default mentioned in the study reflect the persistent vulnerabilities in the industrial chain's linkage mechanisms. Future work should investigate how financial instruments, such as agricultural insurance, futures, and options, alongside legally more robust cooperation models, can be leveraged to enhance the cluster's capacity to withstand market risks.

6.4 Policy Recommendations

6.4.1 Establishing a Pioneering Hub for Innovation in the Lotus Root Seed Industry

To establish a pioneering innovation base for the lotus root seed industry, it is essential to fully leverage state, provincial, and municipal subsidies and to harness the technological and talent advantages of the National Characteristic Vegetable Industry Technology System. Deepening the integration between scientific research and enterprise is critical. This involves guiding the agglomeration of innovation factors and supporting qualified lotus root processing enterprises in establishing their own seed industry ventures. By adopting modern biotechnologies to innovate breeding methods, these new ventures can achieve breakthroughs in breeding objectives and enhance their overall innovation capacity.

A comprehensive germplasm resource bank for lotus root should be established to facilitate the purification and rejuvenation of superior local varieties. A genetic improvement program should be implemented to select and breed new varieties with high disease resistance, high yield, and strong adaptability. Breeding efforts should be intensified to develop specialized varieties, such as crisp-textured types for export, starchy types suitable for soups, and varieties amenable to mechanical harvesting. Finally, a comprehensive propagation system for both original stock and production seeds must be constructed, supported by breeding and core demonstration bases, to ensure the rapid multiplication of new varieties and expand the coverage of improved cultivars to meet market demand.

6.4.2 Developing an Integrated Platform for High-Quality, Efficient, and Simplified Lotus Root Cultivation Technologies

To address the prevalent issues of haphazard and inefficient fertilizer and water management, which fail to meet the requirements for high-quality, high-yield production, research should be conducted on the formation mechanisms of high-quality lotus root. This will help determine the precise fertilizer and water demand patterns necessary for premium production. Based on these findings, precise, timed, and

quantitative management techniques should be systematically integrated for new, specialized crisp and starchy varieties to reduce fertilizer runoff, improve nutrient use efficiency, and achieve sustainable, high-quality cultivation.

To combat serious diseases such as physiological stunting ("jiang ou"), research into their pathogenesis is required. Based on this, innovative techniques for meristem tip virus-free seedling culture, rapid propagation, and acclimatization should be developed and applied. For major insect pests like root-feeding flea beetles and lotus leaf borers, studies on their occurrence and prevalence patterns should be conducted to develop eco-friendly pest control strategies, including integrated physical and biological methods such as pheromone traps and light traps. By integrating green production technologies throughout the entire cultivation cycle, high-quality raw materials can be produced, which will in turn improve the efficiency and quality of processed products.

Furthermore, given that most lotus root is cultivated in shallow-water environments with highly variable site conditions that are hostile to mechanization, there is a lack of mature technologies for planting, management, and harvesting. Therefore, research and development should focus on specialized mechanical equipment and the integration of agricultural machinery with agronomic practices to progressively realize mechanized and labor-saving production.

6.4.3 Creating a Pioneering Zone for Synergistic Urban-Rural Industrial Development Centered on the Lotus Root Industry

To provide a replicable and scalable model for lotus root industry development nationwide, Baoying County should actively establish a pioneering zone for synergistic urban-rural industrial development. This initiative should focus on innovating institutional mechanisms and policy systems that promote agriculture through industry and rural areas through urban development, thereby coordinating the implementation of the rural revitalization and new-type urbanization strategies. The processing industry must be upgraded by leveraging talent and research outcomes from the National Characteristic Vegetable Industry Technology System to support innovation in advanced processing and the development of functional foods. The quality of foreign investment should be improved to attract capital that can accelerate the transfer of high-level processing technologies, effectively promoting agricultural development and narrowing the urban-rural gap. The Baoying National Modern Agricultural Industrial Park should serve as the core of this pioneering zone, tasked with dismantling institutional barriers and facilitating the two-way free flow of production factors and the rational allocation of public resources.

6.4.4 Enhancing the Efficiency of Technology Transfer through Multiple Pathways

To improve the efficiency of technology commercialization in the lotus root industry, it is crucial to integrate the scientific advantages of the National Characteristic Vegetable Industry Technology System with the production strengths of leading enterprises. This can be achieved by deepening the integration of science and enterprise and by establishing specialized service organizations and a robust financial support system. Scientific and technical personnel from agricultural research institutions should be supported in establishing and leading various forms of specialized service organizations in Baoying, with financial backing from provincial and municipal financial institutions through products such as "S&T Innovation Loans." The government can utilize service procurement models to guide and support agricultural enterprises, farmer professional cooperatives, and service organizations in collaborating with scientific personnel to provide agricultural technology extension services, thereby accelerating the conversion of research outcomes into productive forces.

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