Analysis of High-Quality Development Path for Potato Industry in Liangshan Prefecture

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Abstract This study provides a comprehensive summary of the current development status of the potato industry in Liangshan Prefecture, and analyzes the primary factors that hinder the advancement of this industry, including a low degree of scale, a limited popularization rate of high-quality seeds, insufficient mechanization, a low level of commercialization, inadequate technological support, minimal integration between the secondary and tertiary industries, and an ineffective mechanism for connecting and benefiting farmers. Furthermore, it presents a problem-oriented approach that is grounded in the current climatic, resource, water, and soil conditions of Liangshan Prefecture, and proposes several pathways to promote the high-quality development of the potato industry. The strategies include: expanding coverage and increasing production volume as foundational steps to ensure food security; enhancing quality and efficiency as key drivers to stimulate agricultural advancement through scientific and technological innovation; focusing on the integration of the three industries to achieve industrial revitalization; implementing risk management measures as a preventive strategy to ensure industrial stability; establishing incentive policies to foster production enthusiasm; and ultimately assisting farmers in increasing their income to achieve the overarching goal of improving the livelihoods of the population.

Key words Potato, Current status, Problem, Countermeasure, Liangshan Prefecture

0 Introduction

Food security is one of the top priorities of the country. In 2015, China initiated a strategy to establish potatoes as a staple food, positioning them as the fourth major staple crop following rice, wheat, and corn. Additionally, potatoes serve a dual purpose as both a vegetable and a forage crop, demonstrating adaptability to challenging environmental conditions while maintaining stable yields. Potatoes have a cultivation history exceeding 400 years in Liangshan Prefecture, where they are recognized as the second most promising grain and economic crop. This assessment is based on their production potential, income growth potential, and market demand potential within the region. The vigorous development of the potato industry is a breakthrough in the implementation of the national food security strategy in the current context, as well as a catalyst for structural reform on the agricultural supply side. Furthermore, it serves as a crucial initiative to reinforce and expand the accomplishments of poverty alleviation efforts, promote comprehensive rural revitalization, and expedite the modernization of agriculture and rural areas.

1 Current development status of the potato industry in Liangshan Prefecture

1.1 Current situation of production and planting The present potato cultivation area in Liangshan Prefecture encompasses 159 800 ha, which constitutes 29.73% of the total cultivated land within the region. Potatoes rank as the second largest grain and economic crop in terms of cultivation area, with 12 counties reporting planting areas exceeding 6 700 ha. In 2022, the production of fresh sweet potatoes in Liangshan Prefecture reached 3.606 million t, representing 29.18% of the total grain crop output for the region. The overall output value was estimated at 6.06 billion yuan, while the economic income generated for sweet potato farmers amounted to 3.93 billion yuan. Yield measurements indicate that the average potato yield in Liangshan Prefecture is 1 504 kg/667 ha. In Huidong County, the average yield in the thousand-acre demonstration area dedicated to green, high-quality, and efficient potato production is notably higher, exceeding 2 300 kg/667 ha. In 2018, the yield of Qingshu 9 reached a peak of 5 575.2 kg/667 m^2. Currently, there are 17 primary potato varieties being promoted for cultivation. The variety with the largest cultivation area is Qingshu 9, encompassing 75 100 ha, while the variety with the smallest area is Mila, covering 27 100 ha. The total production of original potato seeds within the entire prefecture amounts to 24.97 million grains. Additionally, 8 100 ha of seed potato bases have been established, resulting in the production of approximately 300 000 t of seed potatoes.

1.2 Management and organization Currently, there are 13 standardized potato production bases established in Liangshan Prefecture, alongside 59 commercial potato production bases that encompass an area exceeding 66.67 ha, collectively covering a total area of 14 700 ha. Additionally, six industrial parks have been developed, three of which are driven by leading enterprises, while four are classified at or above the prefectural level. The prefecture is home to three leading enterprises specializing in potato cultivation, alongside 38 professional cooperatives, 63 family farms, and

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44 large-scale growers. In 2022, the average market price for commercial small spring potatoes ranged from 1 600 to 2 000 yuan/t, while large spring potatoes were priced between 1 200 and 1 400 yuan/t. The average price for processed potatoes was recorded at 700 to 800 yuan/t, and the local specialty variety, purple potato, commanded a price of 4 000 to 6 000 yuan/t. Nevertheless, the marketing strategies employed for potatoes predominantly rely on traditional sales models, leading to a disconnection between production and sales, which ultimately results in a low commodity rate.

1.3 Industrial chain extension Liangshan Prefecture has established eight processing enterprises, including Mianning Jintai Agriculture, which collectively possess an annual fresh potato processing capacity exceeding 1.4 million t. The processed products primarily consist of basic items such as crude starch, refined starch, starch sheets, and vermicelli. Currently, there are geographical indication brands for potatoes, such as "Daliangshan Potato", "Purple Potato", *etc.* However, these brands exhibit low market recognition and have not yet achieved large-scale production.

1.4 Production factors The labor force involved in potato cultivation is exhibiting an aging trend, with a limited proportion of young individuals participating in this sector. Furthermore, the level of mechanization in the processes of sowing, management, and harvesting of potatoes remains low. Additionally, the storage conditions are rudimentary, resulting in inadequate preservation capabilities, and the capacity for post-commercial processing is also suboptimal.

2 Problems in the development of the potato industry in Liangshan Prefecture

2.1 Inadequate foundation of agricultural land and absence of conditions conducive to large-scale production The mountainous terrain poses significant limitations on the large-scale cultivation of potatoes. In Liangshan Prefecture, the total area of arable land is 537 300 ha, of which high-standard farmland comprises 237 800 ha, representing 41.65% of the total cultivated area. This figure is considerably lower than the provincial average of 63.8%. Some of the high-standard farmlands that have been developed exhibit low quality and inadequate management, failing to satisfy the necessary criteria for effective drainage and irrigation, successful harvests under both drought and flood conditions, or suitable for mechanical operations[1]. In Liangshan Prefecture, the cultivated land with a slope exceeding 15° encompasses an area of 330 700 ha, representing 57.92% of the total cultivated land. The region is characterized by a predominance of sloping terrain and a scarcity of flat land, resulting in fragmented agricultural plots with diminished soil fertility. Furthermore, there is a significant issue regarding the loss of water, fertilizers, and soil. The development of the cold chain infrastructure is generally insufficient. The processes of pre-cooling and cold chain transportation are not effectively integrated, leading to substantial losses of potatoes during transit. The lagging transportation and marketing infrastructure, coupled with the mountainous terrain, has resulted in potato production predominantly depending on a traditional, small-scale, and decentralized operational model. This model primarily aims to fulfill the self-sufficiency needs of farmers, but it exhibits a limited capacity to withstand natural, market, and social risks.

2.2 Limited popularity of virus-free seed potatoes and suboptimal efficiency in enhancing quality and increasing yield Cui Yongwei *et al.*[2] suggest that the presence of viruses in seed potatoes is a primary factor contributing to the degradation of potato varieties, as well as reductions in yield and quality. The most effective strategy to address this issue is to promote the use of high-quality, certified, and virus-free seed potatoes. The utilization of virus-free seed potatoes has the potential to enhance yield by 30% – 50%, with instances where the increase may surpass 100%. Furthermore, the quality of the potatoes is markedly improved, evidenced by a 2% increase in dry matter content and a 5% – 10% rise in the proportion of superior potatoes. With China's growing focus on the potato industry, the technology for producing virus-free seed potatoes has been steadily advancing, and Liangshan Prefecture possesses the capacity to produce virus-free seed potatoes. However, in practical production, there is a notable shortage of high-quality seed potatoes, and the utilization rate of virus-free seed potatoes remains relatively low. The proportion of low-generation virus-free seed potatoes is approximately 32.8%, which is 10% lower than that observed in more developed regions[2-3]. Some farmers lack a comprehensive understanding of the concept of virus-free seed potatoes and do not have access to such seeds. Their sources of seed potatoes primarily consist of seed exchanges, self-retained seeds, and purchases from small vendors. Furthermore, a significant proportion of the primary potato production regions are characterized by high levels of poverty. The elevated cost of virus-free seed potatoes discourages farmers from purchasing low-generation virus-free varieties. In contrast, inferior seed potatoes produced by certain unqualified enterprises are offered at lower prices. Given that farmers often lack the expertise to assess the quality of seed potatoes, they predominantly opt for the more affordable inferior varieties.

2.3 Insufficient development of characteristic varieties and suboptimal exploitation of added value The purple potato is a distinctive variety cultivated in Liangshan Prefecture, primarily produced in counties such as Butuo, Huidong, and Jinyang. This variety is characterized by its thin skin, tender texture, high nutritional value, and palatable taste. When consumed, it exhibits a delicate and crispy texture, along with a unique flavor profile. Additionally, it is noted for its ease of storage. Fresh sweet potatoes exhibit a composition of 26.9% dry matter, 20.4% starch, 1.45% crude protein, 10.2 mg of vitamin C per 100 g, 0.012 9 mg of vitamin B per 100 g, 26.1 mg of cyanidin per 100 g, and 1.36 mg of peonidin per 100 g. The market price of purple potatoes is twice that of conventional potatoes. In Moci Village, Meisa Township, Butuo County, a total of 66.67 ha are dedicated to the

cultivation of purple potatoes, yielding a total output of 500 t. This production generates an estimated output value of approximately 3 million yuan, resulting in an annual net income exceeding 1.8 million yuan, which translates to an average net income of 2 034 yuan per individual. These figures indicate a relatively high potential for the development of purple potatoes. However, the limited availability of suitable planting areas, coupled with low yields and minimal brand recognition of purple potatoes, has hindered the effective development of their added value. Consequently, this has led to a diminished willingness among certain farmers to cultivate this crop.

2.4 Unbalanced promotion of science and technology and backward production technology The individuals engaged in potato cultivation are experiencing an aging trend, accompanied by a relatively low level of overall cultural competence. This population predominantly depends on traditional agricultural practices and exhibits a limited capacity to adopt innovative technologies. The survey revealed that new type farmers who possess knowledge and skills demonstrate production techniques that significantly surpass those of their counterparts, leading to a substantial disparity in yield per unit within the same producing area. Taking Huidong County as a case study, the highest yield recorded is 5 575.2 kg/ha, while the lowest yield is 800 kg/ha. A significant number of farmers are resistant to the adoption and implementation of new technologies, resulting in outdated production methods. The primary issues associated with this situation are as follows: during the planting process, reliance on manual planting techniques results in suboptimal quality and an inability to ensure adequate planting density[4]. In the context of agricultural management, the irrigation method predominantly depends on rainfall. The overuse of pesticides for the control of diseases and pests affecting potato crops has a considerable adverse effect on both yield and quality. During the harvesting phase, manual harvesting is typically employed, resulting in elevated labor intensity and associated labor costs. In the storage phase, potatoes are primarily stored by the farmers themselves, utilizing rudimentary facilities that offer limited storage capacity and consequently lead to significant post-harvest losses. In terms of farmland construction, the predominant method involves cultivation in mountainous regions, primarily on medium- and low-yield fields. These lands are characterized by poor soil quality and limited resilience to natural disasters, particularly droughts, which significantly impact agricultural productivity, resulting in low yields per unit area and an unstable overall output.

2.5 Low degree of mechanization and relatively high production cost The uneven mountainous terrain, along with the presence of scattered farmland and other factors, limits the potential for large-scale mechanical operations in most potato cultivation areas, with the exception of river valley regions. Additionally, the limited financial capacity of farmers to acquire machinery, combined with the reliance on traditional planting methods, results in a low level of mechanization in potato farming in Liangshan Prefecture. According to the statistics provided by the Agricultural and Rural Affairs Bureau of Liangshan Prefecture, in 2022, the area dedicated to mechanically sown potatoes in Liangshan Prefecture was 0.26 million ha, which accounted for 2.26% of the total potato planting area. The area harvested mechanically was 0.12 million ha, accounting for merely 1.08% of the total potato planting area. A limited proportion of farmers utilize mini tillers, and the mechanical methods available are predominantly singular in function, primarily employed for land preparation. The majority of farmers continue to depend on manual cultivation, resulting in relatively high labor costs. Notably, 23% of farmers report that the elevated labor costs hinder their ability to cultivate potatoes, leading to a reluctance to expand their operations on a larger scale. According to statistical data, the average production cost of potatoes in certain regions can reach as high as 1 500 yuan/667 m^2. Within this cost structure, labor expenses constitute 46.6%, land costs represent 6.67%, and production materials also account for 46.6%. Consequently, labor costs have emerged as a significant constraint on the large-scale development of the potato industry.

2.6 Lagged development of processing industry and short industrial chain Currently, there are eight potato varieties designated for starch processing in Liangshan Prefecture, encompassing a cultivation area of 91 200 ha, which accounts for 57.1% of the total potato cultivation area. Li Zhiping *et al.* [3] indicate that the processing of starch requires a significant quantity of potatoes, with the typical ratio of finished products to raw materials being approximately 1∶7. However, it is important to note that the potatoes utilized in starch processing are generally not high-starch varieties, which possess a starch content exceeding 20%. Instead, processors often rely on inferior potato varieties with a starch content below 15%. This practice results in the production of low-quality starch characterized by unstable indicators, impure coloration, and uneven granule size, low market prices, and diminished market competitiveness. This situation adversely impacts the development of processing enterprises, compelling them to operate under precarious conditions.

2.7 Unsmooth connection between production and sales, low commodity rate, and diminished willingness among farmers to engage in planting activities Li Zhiping *et al.* [3] suggest that, unlike other food crops, harvested potato products consist of fresh tubers that must be sold or stored promptly. Furthermore, potatoes have a limited storage duration and impose stringent requirements for storage conditions, including temperature and humidity. Additionally, they require substantial storage space, and inadequate storage practices can lead to considerable losses. In recent years, against the backdrop of food security policies, the area dedicated to potato cultivation in Liangshan Prefecture has been steadily increasing, along with its production output. However, the sales model remains traditional, and the sales channels are limited. The sales methods for potatoes in Liangshan Prefecture encompass various approaches, including direct retail by farmers, procurement by small vendors, acquisition by enterprises, coordi-

nated sales through cooperatives, and purchases by potato processing plants. However, the proportion of sales conducted through established channels remains notably low. The primary factor contributing to the reluctance of farmers in Liangshan Prefecture to expand their potato planting area is their dissatisfaction with the price, commercialization rates, and sales channels associated with potatoes. Conversely, the factors motivating farmers to persist in cultivating potatoes include the absence of superior alternative crop varieties, the necessity for staple food, limited land conditions, and established production practices.

2.8 Inadequate mechanisms for connecting and benefiting farmers and limited driving capacity of new types of business entities The newly established mechanism for connecting and benefiting farmers through new types of business entities in Liangshan Prefecture remains imperfect. It exhibits insufficient impetus for advancing the enhancement of seed potato varieties, large-scale cultivation, standardized production, industrialized operations, and brand-oriented marketing. The reluctance of farmers to engage with these new business entities has led to a fragile industrial chain and inadequate risk resilience, thereby hindering the rapid development of the potato industry.

2.9 Insufficient policy incentives have affected the enthusiasm for planting One issue is that the coverage of subsidies is insufficient, and the intensity of these subsidies is relatively low. Additionally, there exists the problem of a limited range of subsidy recipients. In certain counties and cities, the subsidy policy tends to favor large-scale growers. Households that have been lifted out of poverty, as well as those under monitoring, also receive special funds for support. However, ordinary farmers, who constitute a significant portion of the agricultural workforce and play a crucial role in the development of the potato industry, do not receive subsidies. This exclusion has adversely affected their motivation to engage in potato cultivation.

3 Path to promoting high-quality development of the potato industry in Liangshan

To facilitate the high-quality development of the potato industry in Liangshan Prefecture, it is essential to utilize the establishment of a national green food raw material potato standardization production base as a foundational framework. In alignment with the relevant directives from the provincial government, it is imperative to advance the five modernizations pertaining to "seed potato enhancement, planting scale, production standardization, industrialized operations, and brand marketing"[5-6]. Furthermore, the establishment of a dedicated commercial potato base should be prioritized, with a particular emphasis on the cultivation of winter potatoes and the enhancement of quality and efficiency in the production of specialty potatoes. Attention must be closely directed towards four key indicators: area, output, commercialization rate, and output value, to promote the green, high-quality, and efficient development of the potato industry in Liangshan Prefecture. The overarching development strategy will propose recommendations centered around six specific goal-oriented aspects.

3.1 Expanding coverage and increasing production volume as foundational steps to ensure food security

3.1.1 Increasing the total volume by expanding the area. The primary strategy for enhancing potato production involves the expansion of the cultivated area. In Liangshan Prefecture, the average potato planting area per county is approximately 9 500 ha, indicating potential for further growth. To facilitate this expansion, it is essential to encourage counties and cities with relatively small current planting areas to increase their potato cultivation. Additionally, efforts should be directed towards the reclamation of abandoned land and the utilization of homesteads vacated due to relocation. Abandoned lands are predominantly found in high-altitude and cold mountainous regions, which are unsuitable for the cultivation of other grain crops. To support these initiatives, it is imperative to develop necessary infrastructure, including water networks, road networks, power grids, and production facilities, to effectively implement reclamation and replanting efforts for potato production. Secondly, it is imperative to enhance the intercropping model involving both grain and economic crops. Specifically, the intercropping of potatoes with other economic crops, such as "grapes + potatoes", should be promoted. Furthermore, it is essential to increase the practice of crop rotation and actively encourage the cultivation of winter potatoes in regions that possess favorable climatic conditions.

3.1.2 Increasing the per unit yield by relying on the construction of fertile farmland. Firstly, a new batch of high-standard farmland should be established. In alignment with the requirements of the pilot project for high-standard farmland construction, which encompasses the entire irrigation district, city, county, and area, concerted efforts will be undertaken to actively develop a pilot zone aimed at the comprehensive advancement of high-standard farmland in the Anning River Basin. In order to overcome the existing limitation that high-standard farmland is predominantly established in river valley regions, several high-altitude mountainous areas are being planned and developed for high-standard farmland, primarily aimed at potato cultivation. This initiative seeks to enhance the yield per unit area of potato production. Secondly, we will systematically implement renovation and upgrading initiatives for high-standard farmlands that have been in operation for an extended period. This approach aims to ensure that these farmlands comply with construction standards that facilitate effective drainage and irrigation, secure harvests under both drought and flood conditions, enhance the suitability for mechanical operations, promote stable high yields, and ensure environmental sustainability.

3.1.3 Increasing production by relying on the selection, breeding and promotion of high-quality varieties. Initially, it is imperative to collect, identify, protect, research, and utilize germplasm resources, while simultaneously enhancing the framework for the protection of potato germplasm resources. Subsequently, it is essential to fortify the processes of registration, approval, and introduction of potato varieties, and implement promotional activities

once these varieties attain the requisite promotion value. Lastly, there is a need to bolster the development of seed production bases and augment their production capacity.

3.1.4 Ensuring production by relying on good laws and regulations. It is essential to conduct fundamental research on key core technologies related to potato cultivation. This research should include coordinated application studies focusing on the "source, reservoir, and flow" in various regions. Additionally, it is necessary to establish technical regulations for cultivation that take into account factors such as sowing time, soil moisture conditions, fertilizer supply, water management, and disease and pest control. The goal is to develop a systematic planting process that allows growers to implement these practices effectively and immediately. Simultaneously, we can organize and implement research, development, and advancement promotion of the "X + Potato" intercropping technology model, superior crop varieties, and environmentally sustainable high-yield and efficient agricultural technologies. Additionally, it is essential to enhance the management mechanisms of grassroots agricultural technology extension institutions.

3.1.5 Promoting large-scale production by enhancing the level of agricultural mechanization. The conditions for mechanized production can be enhanced by following the principles of "adapting machines to local conditions" and "adapting local conditions to machines". The first principle involves the mechanization transformation of sloping farmland with a gradient of less than 15°, characterized by a transition from "small to large, short to long, and steep to gentle". The second principle pertains to the transformation of contour strip-shaped cultivated land. Lastly, the promotion of small agricultural machinery that is suitable for operations in mountainous areas is essential.

3.2 Enhancing quality and efficiency as key drivers to stimulate agricultural advancement through scientific and technological innovation

3.2.1 Accelerating the renewal and upgrading of varieties. The government should take proactive measures to promote the introduction, cultivation, and replacement of potato varieties, and enhance the renewal of these varieties. It is essential to conduct research on leading varieties, key promoted technologies, and planting models for major crops. In particular, a thorough investigation into the technology of virus-free seed potatoes is warranted, with the aim of reducing their production costs and expanding their dissemination. Additionally, it is important to formulate or revise local standards and develop and implement digital technologies for the prevention and control of diseases and pests affecting potato crops.

3.2.2 Promoting green cultivation techniques and regional biological control. Field investigations and the development of control strategies for significant diseases and pests that adversely affect potato crops should be prioritized. Emphasis should be placed on achieving advancements in the prevention and control technologies for viral diseases, including Potato Leaf Roll Virus (PLRV), Potato Virus Y (PVY), and Potato Virus X (PVX). Digital monitoring and predictive models for diseases and pests, along with digital forecasting systems, can be developed to facilitate the implementation of precise prevention and control measures. It is essential to actively promote knowledge regarding green prevention and control strategies for crop diseases and pests to enable early detection, prevention, and management of epidemics. This approach will support the execution of large-scale and comprehensive biological control initiatives in ecological regions. Law enforcement and supervisory personnel must rigorously oversee the quarantine process, ensuring its effective implementation at the point of origin, during transportation, and at other critical stages, striving to mitigate the spread of diseases and pests at the source.

3.2.3 Promoting standardized, large-scale and intensive production. Firstly, we should advocate for the establishment of potato production bases, emphasizing the development of leading varieties and essential technologies; implement demonstration projects aimed at increasing yield per unit area, thereby enhancing the overall production level of potatoes; and focus on the construction of several core demonstration bases to facilitate a large-scale and balanced increase in potato production. Secondly, we should enhance the construction and management of potato parks by fully implementing the assessment and incentive plan for the establishment of local modern agricultural (forestry) parks. Our efforts will concentrate on five key areas: consumption scenarios, deep processing, park revenue, connecting and benefiting farmers, and technological innovation, all aimed at advancing the construction of modern agricultural parks. State-owned enterprises, as new types of business entities, are encouraged to engage in the development of modern agricultural parks. They are tasked with facilitating the enhancement of these parks at both the prefectural and county levels, as well as establishing several provincial-level modern agricultural industrial parks that meet high standards. Furthermore, there is an active effort to create national-level modern agricultural parks, thereby establishing a four-tiered hierarchical development framework for modern agricultural parks.

3.2.4 Developing characteristic varieties. Firstly, it is essential to establish a comprehensive national standardized production base for green food, specifically purple potatoes, in Liangshan Prefecture. This initiative should include the registration of the geographical indication trademark "Liangshan Purple Potatoes", and allow farmers, cooperatives, and enterprises within the prefecture to utilize this trademark. Secondly, it is imperative to enhance the visibility of the industry by leveraging various media platforms, including television, the Internet, and newspapers. This can be achieved by promoting and introducing the brand through diverse formats and multiple channels to broaden its influence. Thirdly, it is essential to enhance the integration of production and sales by establishing wholesale markets for purple potatoes in key production regions. Strengthening the link between production and sales through initiatives such as the "farm-to-supermarket connection" and "Internet + potatoes" is crucial for boosting sales. Additionally, leveraging e-commerce marketing strategies will further aug-

ment the market share of "Liangshan Purple Potatoes".

3.2.5 Cultivating new type farmers and improving the mechanism for technology promotion. The conventional approach of promoting technology involves experts visiting agricultural fields to offer guidance to farmers. However, this method is often inefficient and has limited reach. Consequently, it is essential to develop a cadre of individuals among potato growers, including farmers, large-scale cultivators, cooperative members, employees of agricultural parks, and educated youth returning to their hometowns. These individuals should possess a relatively high level of education, strong learning capabilities, and a high degree of enthusiasm for learning. The objective is to establish a new type of agricultural workforce proficient in scientific potato cultivation techniques and to create a leadership team dedicated to the dissemination of innovative potato technologies. Relevant departments should regularly organize free training sessions and lectures focused on potato planting techniques. Concurrently, they can leverage grassroots organizations within each village to establish consultation points for planting technology, thereby addressing the challenges faced by growers.

3.3 Focusing on the integration of the three industries to achieve industrial revitalization

3.3.1 Building processing industries and developing new products. The advancement of the potato processing industry should be expedited to facilitate primary processing at the source of potato cultivation. Additionally, enterprises should be established and integrated to undertake advanced processing techniques. Potatoes can be transformed not only into snack foods but also into various products such as whole powder, snowflake powder, and starch. These products have extensive applications across multiple sectors, including food production, chemical engineering, pharmaceuticals, and healthcare. The economic value of processed crude starch exceeds that of fresh potatoes by more than 30%, with the value of deep-processed products being even greater. Furthermore, there is a need to develop traditional staple food products, such as potato steamed buns, noodles, dumplings, and rice noodles, in order to satisfy consumer demands for "high quality, nutrition, health benefits, convenience, and safety". This initiative aims to enhance the consumption of potato-based staple foods and establish them as a fundamental component of people's diets.

3.3.2 Building brands and increasing the output value of potatoes. Firstly, by utilizing the distinctive varieties and products of potatoes, along with the established public brand of "Daliangshan", we can encourage counties and cities to develop unique "Daliangshan" potato brands within the potato industry. Secondly, it is essential to implement the certification processes for green, organic, and geographical indication grain and oil products. Thirdly, through brand marketing enterprises, it is possible to develop a batch of high-quality potato brands for new business entities. Furthermore, it is advisable to encourage the adoption of strategies such as processing and sales on behalf of others to establish a number of distinctive potato brands. Finally, it is essential to implement the system of compliance certificates as promised by higher authorities. Additionally, it is important to guide new agricultural business entities in standardizing the establishment of potato production record archives and ensuring their integration into the national (provincial) traceability platform, thereby facilitating the comprehensive traceability of potato cultivation.

3.3.3 Improving the production and sales system and driving the primary industry with the tertiary industry. The construction of infrastructure should be enhanced, particularly in relation to the cold chain logistics system, modern warehousing, and the three-tiered Taobao service system at the county, township, and village levels. It is essential to develop the "online + offline" market strategy, enhance rural e-commerce initiatives, foster the development of various e-commerce enterprises and skilled professionals, establish multiple online platforms for the marketing of Daliangshan potatoes, and optimize the production and sales framework. Simultaneously, it is imperative to actively cultivate markets for both raw and processed potato products in various regions. By leveraging cold chain logistics, it is essential to expand the market reach, particularly for renowned and promising specialty products.

3.3.4 Exploring pilot projects for the integration of agriculture, culture and tourism, and developing new industries and new business forms. An agricultural, cultural, and tourism experience center can be established, leveraging the existing potato production base and industrial park, with the aim of transforming the series of potato products into tourism commodities. Innovative derivative tourism offerings can be established, with activities such as "Potato Flowers Bloom" to thoroughly investigate the cultural heritage associated with potatoes. This exploration encompasses various dimensions, including natural landscapes, ethnic traditions, historical narratives, folk practices, agricultural customs, and local cultural characteristics. By developing products that promote ecological sightseeing and leisure, summer vacation experiences, cultural tourism, rural leisure activities, distinctive agricultural initiatives, specialized project experiences, and science popularization and publicity education, a unique rural cultural tourism product can be created, aiming to enhance the distinctive appeal of the potato industry's cultural heritage. By consistently engaging in innovation to develop a diverse array of new industries and business forms, we can expand the income sources available to farmers and enhance their employment opportunities within these emerging sectors.

3.4 Implementing risk management measures as a preventive strategy to ensure industrial stability

3.4.1 Preventing and mitigating disasters to enhance the risk resistance capacity of farmers. Firstly, the establishment of high-standard farmland and the implementation of water conservancy facilities can mitigate the adverse effects of droughts and waterlogging during the rainy and flood seasons. Secondly, effective control and monitoring of potato diseases and pests are essential to prevent reductions in both the yield and quantity of potato production. Thirdly, it is imperative to enhance research and promote the

application of climate monitoring systems in the agricultural sector. Additionally, there is a need to establish and refine the budget management system for disaster prevention and mitigation, thereby enabling proactive measures to avert potential issues. Fourthly, the implementation of comprehensive cost insurance for potatoes should be pursued, with the aim of exploring the feasibility of income insurance specifically for potato cultivation.

3.4.2 Saving costs and increasing efficiency to reduce the risk of potato costs. Firstly, it is essential to actively promote mechanization by introducing and screening small-scale machinery, as well as developing a mechanical and simplified planting model. Secondly, it is imperative to expedite the advancement of the potato processing industry by enhancing the primary processing of potatoes at their source and facilitating the establishment of enterprises dedicated to the deep processing of potato products. Thirdly, it is imperative to advance research and promote the development of potato storage technologies. This includes improving storage conditions across diverse regions and establishing the necessary infrastructure for potato storage, drying, preservation, and cold chain management.

3.4.3 Enhancing information services to reduce potato market risks. It is essential to enhance the information services within the potato market to improve farmers' capacity for scientific decision-making. This can be achieved by reinforcing the synergistic benefits of both Internet-based and traditional information dissemination methods. Furthermore, the establishment of a comprehensive potato information service system is necessary to provide growers with analyses and forecasts regarding market supply, demand, and price trends for potato agricultural products. Such measures will contribute to mitigating the market risks associated with potato cultivation[7].

3.4.4 Strengthening legalized governance to reduce the social risk of potatoes. Firstly, law enforcement agencies conduct thorough investigations into substandard seeds, fertilizers, pesticides, and other agricultural production materials to mitigate production losses in potato cultivation. Secondly, it is essential to assess the appropriateness of administrative interventions by local government authorities to prevent arbitrary alterations to farmers' planting plans.

3.5 Establishing incentive policies to foster production enthusiasm

3.5.1 Strengthening rewards and subsidies to foster production enthusiasm. It is essential to enhance supporting policies in alignment with pertinent regulations and to allocate adequate funding to ensure that potato subsidies accurately represent its status as the fourth major staple food. Furthermore, it is necessary to broaden the scope of subsidies to incorporate potatoes within the framework of direct food subsidies. Concurrently, a price stability policy for potatoes should be established to safeguard farmers from potential financial losses.

3.5.2 Increasing investment in scientific research to empower industrial development with technology. The government, research institutions, colleges and universities, and production enterprises should collaboratively establish a system for scientific research and technological innovation within the potato industry. This initiative aims to optimize the allocation of scientific research resources and address the technical challenges that hinder the development of the potato industry in Liangshan. Concurrently, efforts should be directed towards the research and development of intelligent management systems to facilitate the systematic implementation of digital management practices.

3.5.3 Optimizing the business environment to tap development potential. It is essential to integrate and leverage local government, agricultural producers, enterprises, parks, and other resources to foster coordinated regional development. This includes the introduction of social resources such as diverse crop varieties, leading enterprises, financial investments, and advanced technologies. Additionally, it is important to implement favorable policies that stimulate the growth of the primary, secondary, and tertiary industries related to potato production, thereby enhancing farmers' income.

3.5.4 Enhancing financial empowerment to increase investment in potato industry development. By enhancing and developing financial services, the government can provide interest-free loans to qualifying farmers, as well as low-interest loans and tax incentives to eligible enterprises. This approach aims to address the funding challenges associated with potato cultivation, facilitate the expansion of planting operations, and simultaneously encourage greater participation from various stakeholders in potato cultivation.

3.6 Assisting farmers in increasing their income to improve the livelihoods of the population

3.6.1 Playing a guiding role of the government to promote high-quality development. To foster a sustainable "establishment" mechanism, each county has developed a six-tiered linkage framework. In this framework, the government enacts reward and punishment policies, various departments devise implementation plans, rural areas oversee organization and execution, business entities serve as exemplars and leaders, farmers engage actively in production, and financial institutions offer monetary support. This comprehensive approach aims to enhance the high-quality development of the potato industry and augment farmers' income.

3.6.2 Strengthening publicity efforts to lead potato consumption to staple foods. Liangshan has a living habit of utilizing potatoes as a staple food. It is essential to enhance promotional efforts to raise awareness of the nutritional benefits of potato products. Additionally, creating a conducive consumption environment for potato-based staple foods will facilitate the gradual establishment of consumption habits, ultimately leading to an increase in the sales revenue of potatoes.

3.6.3 Enhancing the driving capacity to improve the mechanism for enterprises to connect and benefit farmers. The implementation of a "new unified and decentralized integration" model for production and operation management has the potential to enhance the vitality of various entities and augment the income of farmers. The

company implements an operational and management model characterized by "unified standards, unified services, independent production, and guaranteed recovery", ensures a consistent supply of production materials, oversees the configuration and maintenance of production facilities and equipment, and offers technical training to farmers. In this model, farmers are tasked with managing production, while ensuring the recovery of products. Such a framework is likely to significantly enhance the intrinsic motivation of farmers and serves as a powerful catalyst for productivity.

3.6.4 Innovating the development model of the park to build industrial development. The "Highland" is offered seed potatoes, technical services, and guidance to farmers by the park, alongside skills training aimed at enhancing their potato cultivation practices. Throughout the planting process, the park provides professional agricultural advice and services related to disease and pest management, harvesting, and storage in the designated areas. This support is intended to elevate the agricultural proficiency of farmers and to ensure their economic benefits from potato cultivation. This organizational structure for production not only aligns with the contemporary agricultural trend towards "large-scale production" but also effectively harnesses the flexibility and proactive engagement characteristic of "small unit" production.

3.6.5 Cultivating new business entities to optimize and strengthen industrial entities. It is essential to foster the development of innovative business entities, including social service organizations, small and micro enterprises, farmers' cooperatives, family farms, large-scale agricultural producers, successful entrepreneurs, and young individuals returning to their hometowns to establish businesses. Additionally, there is a need to train a new generation of professional farmers and managers capable of addressing the demands of contemporary agricultural development. A beneficial connection mechanism involving the collaboration of companies, village collectives, cooperatives, and farmers can be established. It is essential to fully utilize collective land resources, while also guiding and encouraging the relevant village collectives to engage in potato cultivation, develop contract farming, and enhance the economic viability of the village collectives.

3.6.6 Deepening the promotion of science and technology to rural areas and cultivating rural talents to drive industrial revitalization. It is essential to enhance the promotion and implementation of modern agricultural science and technology, as well as technical training. This includes fostering collaboration between agricultural experts and producers, and actively advancing green agriculture, ecological agriculture, and efficient agricultural practices. Furthermore, it is imperative to undertake the "One Enterprise, One Group, One Special Project" initiative for technological innovation. Enterprises in the park should collaboratively establish technical teams that include experts from pertinent research institutions and universities. The composition of these technical teams should encompass entrepreneurs, scientists, "local experts", "field agricultural scholars", and various personnel involved in production, operations, and research at different levels. Each technical team is expected to undertake a minimum of one scientific research project annually, aimed at investigating and addressing specific challenges encountered in the production practices of the park and among local farmers. It is imperative to further expand the talent pool in rural science and technology and to cultivate a greater number of rural professionals who can serve as disseminators of agricultural science and technology, leaders in scientific and technological innovation and entrepreneurship, and pioneers in efforts aimed at alleviating rural poverty and promoting prosperity.

4 Conclusions

The potato industry is a distinctive and advantageous industry that aligns with the natural conditions and agricultural production characteristics of Liangshan. Against the backdrop of food security and rural revitalization, it is imperative to strategically plan the industry's development. This planning should prioritize the establishment of industrial parks and the advancement of industrialization, and rely on key strategies, including enhancing foundational infrastructure, leveraging technological advancements, securing financial support, and fostering brand development. It is essential to establish new growth opportunities and diligently develop the potato characteristic industry. The advancement of the potato industry should be regarded as a key pillar for the construction of rural revitalization in impoverished regions throughout Liangshan. This initiative will contribute significantly to national food security and the revitalization of rural areas.

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