

Future Directions of Quinoa Research and Innovation

Yan QIN¹, Jing YANG¹, Qiaoying ZHANG¹, Yueyou LI¹, Wei LYU¹, Zhimin WEI^{2*}

1. Hebei Provincial Science and Technology Innovation Service Center, Shijiazhuang 050035, China; 2. Institute of Millet Crops of Hebei Academy of Agriculture and Forestry Sciences, Cereal Crops Research Laboratory of Hebei Province, National Foxtail Millet Improvement Center, Shijiazhuang 050035, China

Abstract Quinoa research aims to deeply understand its nutritional value, develop planting techniques, and explore food applications to promote quinoa industry development and improve human health. Future research directions include further exploring nutritional functions, adaptive breeding, cultivation techniques and food processing of quinoa, so as to promote innovation and development in the quinoa industry. Expected outcomes include increased production, improved quality, expanded markets, diversified food sources, reduced environmental impact, and biodiversity protection. There are still challenges such as fluctuating market demand, resource constraints, insufficient nutritional knowledge, and fierce competition. Solutions may include education and publicity, diversified product lines, health certification and brand building, partnerships, new variety cultivation and sustainable farming, and resource sharing. Future research and practice will further promote innovation and development in the quinoa industry, making it one of the most important food and functional ingredients globally.

Key words Quinoa; Nutrition; Innovation; Sustainable development; Market demand

DOI:10.19759/j.cnki.2164-4993.2024.04.004

Quinoa (*Chenopodium quinoa* Willd.) is an ancient crop rich in nutrition, belonging to *Chenopodium* of Amaranthaceae. It is native to the Andes in South America and has high nutritional value and medicinal value. In recent years, as people pay more attention to healthy food and whole grains, quinoa has begun to be welcomed by more people. The seeds of quinoa are very small and round, and there are varieties of different colors such as black, red and yellow^[1]. It is rich in protein, fat, dietary fiber, vitamins and minerals, especially high-quality protein and a variety of essential amino acids. It is an ideal source of protein. In addition, quinoa is also rich in vitamin B group, vitamin E, vitamin K, calcium, magnesium, iron, zinc and other minerals. Quinoa has many health functions, such as regulating blood sugar, lowering cholesterol, promoting digestion and enhancing immunity. It is also a gluten-free food, suitable for people who are sensitive to gluten or have celiac disease. In terms of eating, quinoa seeds can be cooked and used to make various dishes, such as quinoa porridge, quinoa salad and quinoa fried rice. Its taste is full of chewiness, and it can add a sense of depth when matched with other ingredients. In addition, quinoa can also be used to make pasta, bread, cakes and so on, providing people with more choices. The cultivation and processing of quinoa also have great development potential. It has strong adaptability, short growth cycle, good drought tolerance and cold tolerance, and low dependence on chemical fertilizers and pesticides, and is conducive to the development of ecological agriculture. At present, many countries are actively promoting the cultivation and development of quinoa to meet people's demand for healthy and nutritious food. To sum up, quinoa, as a nutritious food crop, has great development potential in edible,

planting and processing. It not only provides people with a healthy and delicious food choice, but also contributes to sustainable agriculture and ecological environment protection^[2].

Research Purpose and Significance of Quinoa

The purpose of studying the nutritional value of quinoa, developing its planting techniques and developing its food application is to deeply understand its characteristics and potential, promote the development of quinoa industry and improve human health. First of all, it is very important for human health to explore the nutritional value of quinoa. Quinoa is rich in high-quality protein, fat, dietary fiber and various minerals, among which protein is high in content and has balanced amino acid ratio. In-depth study on the nutritional components of quinoa can provide a scientific basis for people's nutritional needs and effective utilization of quinoa, which is helpful to adjust the daily diet structure and improve the nutritional level of diet. Secondly, the development of quinoa planting techniques is of great significance for promoting the healthy development of quinoa industry. Studying the adaptability, growth law and cultivation techniques of quinoa can provide scientific planting guidance for growers and promote the improvement of yield and quality of quinoa. Meanwhile, a deep understanding of the adaptability and stress resistance of quinoa can explore the adaptive cultivation of quinoa in different regions and harsh environments, and provide feasible solutions for agricultural production in arid areas. Finally, the development of food application of quinoa is of great significance for promoting the development of quinoa industry, increasing market demand and improving human health. Studying different processing techniques and food formulas of quinoa can enable the development of a variety of innovative quinoa foods and satisfaction of different consumers' needs. It not only helps to improve the utilization rate and added value of quinoa, but also promotes the further development of quinoa industry and provides people with more healthy and convenient food choices^[3].

Received: June 3, 2024 Accepted: August 6, 2024

Supported by Beijing Science and Technology Program (Z201100008020006). Yan QIN (1978 –), female, P. R. China, professor, devoted to research about science and technology management.

* Corresponding author.

Current Research Progress of Quinoa at Present

The current scientific research of quinoa has not only been widely concerned in academic circles, but also aroused strong interest in agriculture and food industry. More and more research institutions, universities and enterprises have joined in the scientific research of quinoa to jointly promote the development and popularization of quinoa industry.

Genetic resources and breeding of quinoa

Researchers have conducted in-depth research on the genetic diversity and genome of quinoa to find genetic resources with excellent characters, and used genetic breeding methods to cultivate quinoa varieties with higher yield, stronger stress resistance and better quality^[4].

Study on nutritional value and functionality of quinoa

The nutritional and functional components of quinoa were analyzed and evaluated, and the benefits of quinoa to human health were revealed, such as antioxidation, anti-inflammation, blood sugar and cholesterol-lowering effects, providing a scientific basis for food application and nutritional evaluation of quinoa.

Study on stress resistance mechanism of quinoa

The stress resistance mechanism of quinoa under drought, high temperature, salinity and other stresses was studied, and its molecular regulation mechanism and physiological response were revealed, so as to provide a theoretical basis for adaptive planting and drought-resistant breeding of quinoa^[5].

Cultivation techniques and production management of quinoa

The best cultivation techniques of quinoa were studied, including suitable planting time, fertilization management, irrigation strategy and pest control, in order to improve the yield and quality of quinoa and realize sustainable development.

Food processing and utilization of quinoa

The application of quinoa in food processing was studied, and various quinoa products such as quinoa flour, quinoa rice, quinoa salad and quinoa porridge were developed to meet people's demand for healthy, nutritious and diversified food^[6].

Future Direction of Quinoa Research and Innovation

Study on nutrition and health function of quinoa

The nutritional components, functional components and bio-active substances of quinoa will be further studied to explore its specific mechanism of action on human health. Meanwhile, the combination and compatibility effects of quinoa with other food ingredients will be studied to develop quinoa food with better nutrition and health functions^[7].

Study on adaptive breeding and stress resistance of quinoa

The genetic resources of quinoa and the adaptability and stress resistance of quinoa varieties will be further explored, and new quinoa varieties with more adaptability and stability will be bred. Combining with new techniques such as molecular markers and gene editing, the important characters such as drought resistance and pest resistance of quinoa will be accurately selected and improved^[8].

Study on cultivation and production techniques of quinoa

In-depth study will be conducted on the planting techniques and management mode of quinoa to develop efficient cultivation techniques of quinoa. Optimization of fertilization management, irrigation strategy, pest control and other aspects will be included to improve the yield and quality of quinoa, and to achieve sustainable development and resource conservation^[9].

Study on processing and utilization techniques of quinoa food

More applications of quinoa in food processing and utilization will be explored to develop diversified quinoa foods. The processing techniques, functional formulas and product development of quinoa will be studied to meet the needs of different people for nutrition, convenience and taste.

Study on sustainable agriculture and quinoa planting ecosystem

The interplanting mode between quinoa and other crops and the ecological function of quinoa in agricultural ecosystem will be explored. The farmland ecosystem benefits of quinoa including soil conservation, water conservation and nitrogen use efficiency will be studied to promote the sustainable cultivation and agricultural development of quinoa.

These future directions will further promote the scientific research and innovation of quinoa and accelerate the development and popularization of quinoa industry. Innovative research will further reveal the potential and value of quinoa, provide more possibilities for its application and production, and promote quinoa to become one of the important food and functional ingredients in the world.

Expected Results and Significance

Increasing the yield of quinoa

The yield level of quinoa can be improved by selecting excellent varieties and materials with high-yield traits for breeding. Through the application of genetic resource evaluation, breeders can better understand and select quinoa germplasms with high yield potential, and further improve the yield of quinoa.

Improving the quality of quinoa products

Evaluation of genetic resources can help to screen out quinoa germplasm resources with excellent quality characteristics, such as high protein content and excellent amino acid composition. The quality of quinoa products can be improved and meet the needs of different markets and consumers by using these high-quality germplasms for breeding and improvement^[10].

Developing the market of quinoa products

Quinoa is gradually loved by more and more consumers because of its rich nutrition and strong stress resistance. With the improvement of planting techniques and the enrichment of quinoa varieties, the market of quinoa products can be expanded, such as promoting quinoa products and opening up international markets.

Rich and nutritionally balanced food sources

Quinoa is a nutritious crop, which is rich in high-quality protein, fiber, vitamins, minerals and other nutrients. It is an ideal source of protein, especially suitable for vegetarians and people who are allergic to dairy products and grains. The nutritional value

of quinoa, combined with its adaptability, salt tolerance and drought tolerance, makes it an important resource for food security and improving human health.

Reducing the impact on the environment

Quinoa has strong adaptability and can grow in harsh soil and climate conditions without a lot of chemical fertilizers and pesticides. Compared with traditional crops, planting quinoa can significantly reduce the use of chemical pesticides and fertilizers. In addition, quinoa also contributes to soil and water conservation and reduces the risk of land erosion and water pollution. Therefore, the planting of quinoa has little negative impact on the environment, which is helpful to realize sustainable agricultural development^[11].

Providing biodiversity protection and sustainable utilization

Quinoa is rich in genetic diversity, and the protection and utilization of these genetic resources is very important to maintain biodiversity. The research on the protection and utilization of genetic resources can promote the sustainable utilization of quinoa and ensure its adaptability and vitality under different environmental and climatic conditions.

Discussion and Conclusions

Prospects of research and innovation of quinoa

Improving and breeding better varieties At present, some quinoa varieties have been developed and popularized, but more efforts are still needed to develop and improve quinoa varieties adaptive to different environmental conditions and needs. Breeding research should focus on improving yield, quality, resistance and adaptability to meet the needs of the market and consumers.

Exploring and optimizing the stress resistance mechanism of quinoa

Although quinoa is considered as a kind of crop with strong stress resistance, its stress resistance mechanism is still not completely clear. Future research should focus on understanding the response mechanism of quinoa to adversity, including drought tolerance mechanism, salt tolerance mechanism, pest resistance mechanism and so on, in order to make better use of the stress resistance of quinoa.

Improving the cultivation management and production techniques of quinoa

The cultivation management and production techniques of quinoa are very important to improve the yield and quality. Future research should focus on the optimization of planting methods, fertilization and irrigation management, pest control and so on, in order to improve the production efficiency and sustainable development of quinoa.

Improving the processing and utilization of quinoa products

Quinoa is a kind of crop with rich nutrition and multiple functions, and the research on its processing and utilization is also of great significance. Future research should focus on developing new products of quinoa, improving processing techniques, and exploring the functionality and health care effects of quinoa to meet the needs of different consumers^[12].

Existing problems

Unstable market demand As a relatively new food, the market demand of quinoa may be affected by fluctuations, especially when

consumers' health and nutrition trends change. The sharp increase in demand may lead to insufficient supply, while the decline in demand may lead to inventory backlog^[13].

Resource constraints The production of quinoa may be limited by soil, water and other resources, which may have an impact on large-scale planting and production.

Insufficient nutrition cognition Consumers may not know enough about the nutritional and health benefits of quinoa, which may affect its market acceptance.

Fierce competition The competition in the food market is fierce, and quinoa may face competition from other similar healthy foods.

Solutions

Educational publicity and diversified product lines Nutrition education and publicity can be carried out to convey the nutritional value and benefits of quinoa to consumers through social media and health magazines. Regular market research can be conducted to understand the changes of consumer trends and preferences, adjust product strategies in time, and develop different types of quinoa products, such as quinoa flour, quinoa cereal, quinoa protein powder, etc., so as to adapt to different consumer preferences and needs and expand market share^[14].

Health certification and brand building It is necessary to obtain authoritative food health certifications, such as the "Green Health" certification from the Specialty Industry Association, to increase consumer trust in products. Attractive brand images can be created to establish emotional connection with consumers, so as to stand out from the fierce competition.

Establishment of cooperative partnership Partnerships with food producers, retailers and catering industry should be established to ensure the stability of the supply chain and better cope with market changes.

Cultivation of new varieties and sustainable planting High-yield quinoa varieties adaptive to different environmental conditions can be bred to improve resource use efficiency. It is necessary to explore sustainable planting methods, such as precision agricultural techniques and water-saving irrigation system, to minimize the use of resources.

Resource sharing Resource sharing in agricultural communities should be promoted, such as common use of irrigation facilities and fertilizers, so as to reduce individual farmers' resource pressure.

References

- [1] WEI ZM, LI SG, XIA XY, *et al.* Discussion on the characteristics and development strategies of *Cheupodium quinoa*[J]. Journal of Hebei Agricultural Sciences, 2016, 20(5): 14–17. (in Chinese).
- [2] GONGBU TRASHI, WANG MU, ZHANG CX. The biological characters and the performance of quinoa, *Henopidium quinoa* wild in Tibet[J]. Acta Agriculturae Boreali-occidentalis Sinica, 1994(3): 54–62. (in Chinese).
- [3] HUANG QY, XU SX, HUANG YJ, *et al.* Progress research of quinoa in nutrition, ecology & germplasm resource[J]. Subtropical Plant Science, 2018, 47(3): 292–298. (in Chinese).
- [4] AHMED I A M, AL JUHAIMI F, MUSA ÖZCAN M. Insights into the nutritional value and bioactive properties of quinoa (*Chenopodium quinoa*): Past, present and future prospective[J]. International Journal of food

- [5] ZHAO HM, DENG SF, YANG YJ, *et al.* Effect of drought stress on anatomical structure and physiological characteristics of quinoa seedlings[J]. Journal of Nuclear Agricultural Sciences, 2021, 5(6): 1476 – 1483. (in Chinese).
- [6] RUIZ KB, BIONDI S, OSES R, *et al.* Quinoa biodiversity and sustainability for food security under climate change: A review[J]. Agronomy for sustainable development, 2014(34): 349 – 359.
- [7] DU CT, DANG B, YANG XJ. Effects of different processing methods on structural and functional properties of quinoa starch[J]. Journal of the Chinese Cereals and Oils Association, 2022, 37(4): 54 – 61. (in Chinese).
- [8] LIU SJ, ZHANG DX, YANG WJ. High-yield cultivation techniques of quinoa optimized based on plant density, nitrogen application and soil matrix potential[J]. Molecular Plant Breeding, 2022, 20(10): 3457 – 3464. (in Chinese).

Proofreader: Xinxiu ZHU

Among the varieties tested in this study, conventional rice and hybrid rice varieties (combinations) containing disease resistance genes *Pi-ta2*, *Pi-sh* and *Pi-i*, such as Maba Yinzhan, Huanghuazhan, Jinnong Simiao, Meixiangzhan, Meiyou 998 and Boyou

- [9] LI LH, GOU T, REN AX, *et al.* Progress on genomics and locus of important agronomic traits in *Chenopodium quinoa*[J]. Hereditas, 2022, 44(11): 1009–1027. (in Chinese).
- [10] JI JJ, LI HY, WANG J. Research progress on the functional properties of quinoa protein[J]. Journal of Chinese Institute of Food Science and Technology, 2021, 21(11): 368–376. (in Chinese).
- [11] GAO R, LI ZJ, QIN PY. Development and application potential of quinoa[J]. Feed Research, 2019, 42(12): 77–80. (in Chinese).
- [12] HE LY, WANG L, LYU JM. Research progress on nutritional composition and biological function of quinoa[J]. Cereals & Oils, 2022, 35(4): 11–15. (in Chinese).
- [13] HU B. Quinoa industry in Qinghai: Dilemma and evolution[J]. Qinghai Finance, 2018(10): 44–47. (in Chinese).
- [14] ZHANG ZD, WANG RL. Strengthening quinoa industry and realizing ecological priority and green development[J]. Northern Economy, 2020(5): 56–57. (in Chinese).

- [1] HE XY, LIAO YP, CHEN KM, *et al.* Research progress and prospect of rice blast resistance breeding [J]. Guangdong Agricultural Sciences, 2011(1): 30-33. (in Chinese).
- [2] LING ZZ, LEI CL, WANG JL. Review and prospect for study of physiological races on rice blast fungus (*Pyricularia grisea*) [J]. Scientia Agricultura Sinica, 2004, 37(12): 1849-1859. (in Chinese).
- [3] HUANG HJ, WANG F, WU YK, *et al.* Wuyou 308, a new super hybrid rice combination with good grain quality [J]. Hybrid Rice, 2010, 25(2): 82-84. (in Chinese).
- [4] National Joint Test Group on Physiological Races of *Magnaporthe grisea*. Study on physiological races of *Magnaporthe grisea* in China [J]. Acta Phytopathologica Sinica, 1980, 10(2): 71-82. (in Chinese).
- [5] ZOU SF, HUANG DC, LI JF, *et al.* Physiological race dynamics of *Magnaporthe grisea* in Guangdong [J]. Journal of Zhongkai University of Agriculture and Engineering, 2005, 18(4): 36-41. (in Chinese).
- [6] XIAO DF, ZHANG PS, WANG L, *et al.* Research progress on populations and physiological race distribution of rice blast pathogen (*Magnaporthe grisea*) in China [J]. Chinese Journal of Rice Science, 2013, 27(3): 312-320. (in Chinese).
- [7] ZHU YX, YANG QY, YANG JY, *et al.* Differentiation ability of monogenic lines to *Magnaporthe grisea* in indica rice [J]. Acta Phytopathologica Sinica, 2004, 34(4): 361-368. (in Chinese).
- [8] WANG WJ, SU J, ZHANG J, *et al.* Pathogenicity analysis of the rice blast fungus isolated from the blast panicles of Yuejingsimiao 2 [J]. Guangdong Agricultural Sciences, 2012(23): 59-61. (in Chinese).