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RESEARCH PROGRESS ON NATURAL FLAVONOID QUERCETIN IN BARLEY PLANT

Xing huai Jing[1,2], Wei Zhao[3], Tao Yang[2*], Yawen Zeng[2*]

[1]*School of Resource Plant Research, Yunnan University, Kunming, Yunnan Province 650504, China*

[2]*Biotechnology and Genetic Germplasm Institute, Yunnan Academy of Agricultural Sciences, Kunming 650205, China*

[3]*Pu`er University, Pu`er, Yunnan Province 665000, China*

[*]**Corresponding authors e-mail:** yt52279076@163.com ; zengyw1967@126.com

ABSTRACT Barley is an annual plant of the grass family barley. As an ancient functional crop, barley has rich nutritional value and a variety of biological active components. It is widely used in many fields such as medicine, food and feed. Barley Quercetin (Quercetin), as a kind of natural flavonoid, widely exists in plants, has antioxidant, anti-inflammatory, anti-cancer and other biological activities, has important research value, and has wide application prospects in various fields. Its biosynthetic pathway is gradually clarified, and the regulatory roles of key enzymes and genes are constantly revealed, which lays a foundation for the application of synthetic biology. However, due to the characteristics of low solubility, low utilization and low stability of quercetin, its use in various fields has great limitations. In recent years, many researchers have made important progress in optimizing quercetin extraction methods and improving the utilization rate of quercetin. In this paper, the research progress of quercetin in barley was reviewed, including its content, distribution, extraction method and biological activity. In this paper, the extraction methods and bioactivity of quercetin were introduced, and the limitations of low solubility and low availability of quercetin were overcome by exploring the genes involved in regulating quercetin synthesis pathway in barley and gene modification to enhance or weaken gene expression. With the development of biological technology, the utilization limitations of barley quercetin will be solved, and the utilization prospects in various fields are very broad.

Keywords: *Barley; Quercetin; Extraction method; Biological activity; Solubility; Utilization rate*

INTRODUCTION

Barley is in a relatively ancient position in planting crops, more than 5,000 years ago. Barley was first discovered in Paleolithic sites in the eastern Mediterranean, gradually spread to China, and is now planted in Tibet, Qinghai, Sichuan and Yunnan. Because of its unique climate conditions, Diqen Prefecture is the main planting land of barley in Yunnan Province. Due to its long-term cultivation and domestication, many barley varieties have been produced in various parts of China (Gangopadhyay et al., 2015, Yang et al., 2018). Barley not only plays an important position in the field of food and wine making, but also its bioactive ingredients have become the research hotspot of researchers today. Among them, barley quercetin, as a typical representative of natural flavonoid substances, has attracted the attention of a large number of scientific researchers due to its extensive biological activities (García-Castro et al., 2023, Yang et al., 2019).

In 1936, Hungarian physiologist Albert (Szent Gyorgyi) first discovered quercetin found that quercetin has antioxidant effects, and later extracted in taxane, chinensis, larch and other plants. In 2003, Professor Yingo Vito, from the Department of Agriculture at Shizuoka University in Japan, announced that wheat tea (made from baked barley) contained quercetin (Guo et al., 2020, Yang et al., 2013), which gradually came into view. Studies have found that quercetin has anti-inflammatory, antioxidant, anti-cancer, antibacterial and other effects, which provide potential medicinal value for the prevention and treatment of many diseases through complex mechanisms.

With the development of society and people's attention to their own health, more and more in-depth research, development and utilization of natural products. The extraction and utilization technology of quercetin in barley has been continuously optimized and innovated (Idehen et al., 2017, Yang et al., 2012), and the research on bioactive ingredients covers

various disciplines. In various fields, the application potential of barley quercetin is being gradually explored. Although many research results have been achieved, there are still many limitations in the research and utilization of barley quercetin, such as the optimization of low stability, low dissolution rate and low utilization rate and the evaluation of the safety of quercetin. This paper aims to discuss the research progress of barley quercetin, provide reference for barley quercetin related researchers, and promote the further development of the research and utilization of barley quercetin (Kamiyama and Shibamoto, 2012, Wang et al., 2020).

The content and distribution of quercetin in barley

The quercetin content in barley varies vary on to variety and environmental conditions. Studies have proved that quercetin content is positively correlated with spike color, and that purple and black purple grain grain grains are high, and that quercetin content is almost undetectable in common barley (Karre et al., 2019, Piasecka et al., 2017). In addition, different environmental characteristics and growth conditions have a certain impact on the content of quercetin, such as the relatively high content of quercetin grown in good soil fertility, sufficient light and suitable temperature.

Quercetin is also distributed differently in various parts of barley. It is distributed in mature grains, malt, flowers, leaves, etc. of barley, and its content in flowers is significantly higher than that in other parts (Lachman et al., 2005, Migut et al., 2021). The content and distribution of quercetin in barley will also change during its growth process. Yu Chunlei conducted dynamic detection of quercetin content in barley after flowering, and found that there were differences in different parts and at different time points after flowering (Idehen et al., 2017, Mierziak et al., 2014).

Extraction method of quercetin in barley

The extraction of quercetin in barley mainly utilizes its characteristics such as solubility in different solvents, adsorption ability with other substances, and partition coefficient, etc. Current extraction methods include ultrasonic assisted extraction method, microwave assisted extraction method, molecular imprinted polymer extraction method, and ethanol-water reflux extraction method (Karre et al., 2019, Yang et al., 2013, Yang et al., 2019).

The extraction time using ultrasonic-assisted extraction method is shorter than that of reflux method, and the amount of solvent used is less, saving energy. However, the extraction steps are complex and the extraction rate is low. The extraction time using microwave-assisted extraction method is significantly shorter than that of ultrasonic extraction method (García-Castro et al., 2023, Mierziak et al., 2014, Yang et al., 2013), but due to the limitation of the instrument, it is not suitable for large-scale industrial production. The molecular imprinted polymer extraction method has a high extraction speed and efficiency, high purity, but requires special instruments to support, making it difficult to be widely used. The ethanol-water reflux extraction method has a high extraction rate, but it takes a longer time and has low purity (Kamiyama and Shibamoto, 2012, Piasecka et al., 2017).

The bioactivity of quercetin in barley

Quercetin has anti-inflammatory, antioxidant and other functional properties. Quercetin is considered a natural antioxidant because it has multiple hydroxyl (-OH) functional groups, and it can react with free radicals to remove free radicals from the body, thereby reducing oxidative stress on cells and alleviating the damage caused by oxidative stress to cells (Mahmood, 2024, Ullah et al., 2024). Therefore, it is widely used in clinical experiments. Some experiments have shown that quercetin not only can resist oxidative stress reactions in Alzheimer's disease to produce neuroprotective effects, but also can treat hypoxic-ischemic encephalopathy in newborns, thus being significant for the treatment of neurodegenerative diseases (Nawaz, 2024, Rizwan et al., 2024).

Quercetin can regulate the formation pathway of inflammatory factors, inhibit the release of inflammatory factors, and increase anti-inflammatory factors at the same time, thereby providing good protection against atherosclerosis. In recent years, some researchers have used the properties of quercetin and applied it to the cosmetics industry (García-Castro et al., 2023, Migut et al., 2021, Yang et al., 2018). Quercetin has anticancer effects. Many experiments have shown that quercetin can inhibit the proliferation of cancer cells and induce apoptosis of cancer cells. Quercetin in barley can play an anticancer role by regulating cell production, inhibiting angiogenesis and enhancing immune function. Although the current study is not enough to prove that quercetin can completely cure cancer, it can be used as an adjunct to reduce the risk of cancer. Liu Yang measured the effects of quercetin and olaparil on the viability, apoptosis and migration of ovarian cancer cells SKOV-3 and A2780 cells, and found that quercetin could inhibit the proliferation of ovarian cancer cells SKOV-3 and A2780 cells. The combination of two drugs can enhance the proliferation of A2780 and SKOV3 cells induce cell apoptosis, inhibit cell migration and cell colony formation (García-Castro et al., 2023, Kamiyama and Shibamoto, 2012, Yang et al., 2012).

Quercetin has a regulating effect on lipid metabolism. Studies have shown that quercetin has a positive effect on accelerating lipid decomposition, inhibiting fatty acid intake and fat generation, and is a flavonoid plant chemical that can improve lipid metabolic disorders at multiple targets. Zhang Yan used different concentrations of quercetin to intervene in normal HHL-5 liver cell lines after palmitic acid induction and detected the content of triglycerides in cells, the accumulation of lipid droplets, and the expression of lipolysis and liphagy-related molecules (Rashid et al., 2024, Mushtaq et al., 2024, Murtaza et al., 2024, Li et al., 2024). The results showed that the content of triglycerides and lipid accumulation in cells were significantly reduced, the protein expression level of lipolysis and liphagy-related molecules was significantly increased, and the experimental group with the highest quercetin concentration

showed the most obvious results (Idehen et al., 2017, Yang et al., 2012, Yang et al., 2018).

Quercetin has antibacterial effects. Quercetin has an inhibitory effect on a variety of bacteria and fungi, which can help prevent and treat infectious diseases, and also has a certain inhibitory effect on drug-resistant bacteria, which helps to enhance the antibacterial ability, and also has a certain promoting effect on the ecological balance of bacteria in the body (Rashid et al., 2024, Mushtaq et al., 2024). Researchers fed different doses of quercetin (a control group was set up) to mice that had successfully established an intestinal microbiota imbalance model, that is, the mice had cleared the gut microbes, but the presence of Proteobacteria, firmicutes, and bacteroides bacteria in the gut. The results showed that all three doses of quercetin effectively reduced the ratio of bacteria to bacteria. It is concluded that low dose quercetin can promote the production of beneficial bacteria, while medium and high dose quercetin can inhibit the formation of pathogenic bacteria (García-Castro et al., 2023, Mierziak et al., 2014, Yang et al., 2013)

Application of quercetin in barley

In the food industry, barley quercetin can be used as a natural food preservative and antioxidant, to prevent food from deterioration due to oxidation and prolong the shelf life of food. Compared with synthetic plastic film, barley quercetin has higher safety. Barley quercetin can also be added to functional foods according to its biological activities, such as health care products and nutritional fortified foods, to add additional health effects to the food (Kamiyama and Shibamoto, 2012, Mierziak et al., 2014, Wang et al., 2020).

In the medical field, quercetin has the ability to fight oxidative aging, which can effectively remove free radicals in the body and reduce oxidative stress to cells. It can also inhibit a variety of malignant tumor cells, such as liver cancer, gastric cancer, breast cancer, etc. Its anticancer mechanism is very complex, including induction of tumor cell apoptosis, inhibition of tumor cell proliferation and metastasis, and regulation of related mechanisms. Also can reduce the occurrence of inflammation, chronic bronchitis, asthma has a certain therapeutic effect (Kamiyama and Shibamoto, 2012, Yang et al., 2012).

In the cosmetics industry, quercetin has a protective and repair effect on the skin, and can be used in the development of whitening, light spots, cosmetics, such as facial masks, face creams, etc. It can also reduce the damage to the skin and remove free radicals produced by ultraviolet radiation to resist photooxidation (Migut et al., 2021, Yang et al., 2019). Quercetin has a variety of biological activities, including antioxidant, anti-inflammatory, anti-cancer, and antibacterial properties. These biological activities have been gradually verified in recent years, and the application prospects in various fields are very extensive (Zeng et al., 2024, Saeed et al., 2024). However, due to the characteristics of low solubility and low extraction rate of quercetin, the dissolution efficiency is limited, and the bioavailability is reduced, which restricts its clinical application (Guo et al., 2020, Yang et al., 2012, Yang et al., 2018). Some researchers have modified the quercetin molecular structure by adding functional groups, lipids, and ethers, and conducted experiments on mice to compare the resistance of pathological cells to the unmodified quercetin and the modified quercetin derivatives.

Conclusion and prospects

The results showed that the resistance of the modified quercetin derivatives was enhanced; thereby verifying the view that structural modification of quercetin can effectively improve its utilization rate. However, these experiments are based on animal experiments and cell experiments and lack evidence from human clinical trials. In the future, a large number of clinical trials are still needed to verify the safety and effectiveness of quercetin in clinical treatment. For the limitations caused by the low solubility, low stability, and low utilization rate of quercetin in barley, it is possible to combine quercetin with other drugs, which may produce coordinated and synergistic effects, thereby improving the effect of treating diseases. Recently, the biosynthetic pathway of barley quercetin has been intensively studied, and related enzymes and genes were gradually identified. By studying the key genes in the barley quercetin synthesis pathway, the modified gene sequence also improved the content and availability of quercetin. At present, the mechanism of action of quercetin is not fully understood. In the future, we can further study the cell and action mechanism of quercetin in barley and its interaction with each target can be defined, to improve a more convincing theoretical basis for clinical application. With the progress of science and technology, the question of whether quercetin can be consumed directly from eating barley will be favored by more researchers and solved easily.

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REFERENCES

Gangopadhyay, N., Hossain, M. B., Rai, D. K. & Brunton, N. P. 2015. A review of extraction and analysis of bioactives in oat and barley and scope for use of novel food processing technologies. Molecules, 20, 10884-10909.

García-Castro, A., Román-Gutiérrez, A. D., Castañeda-Ovando, A. & Guzmán-Ortiz, F. A. 2023. Total phenols and flavonoids in germinated barley using different solvents. Chemistry & Biodiversity, 20, e202300617.

Guo, T., Horvath, C., Chen, L., Chen, J. & Zheng, B. 2020. Understanding the nutrient composition and nutritional functions of highland barley (Qingke): A review. Trends in Food Science & Technology, 103, 109-117.

Idehen, E., Tang, Y. & Sang, S. 2017. Bioactive phytochemicals in barley. Journal of food and drug analysis, 25, 148-161.

Kamiyama, M. & Shibamoto, T. 2012. Flavonoids with potent antioxidant activity found in young green barley leaves. Journal of agricultural and food chemistry, 60, 6260-6267.

Karre, S., Kumar, A., Yogendra, K., Kage, U., Kushalappa, A. & Charron, J.-B. 2019. HvWRKY23 regulates flavonoid glycoside and hydroxycinnamic acid amide biosynthetic genes in barley to combat Fusarium head blight. Plant molecular biology, 100, 591-605.

Lachman, J., Dudjak, J., Miholová, D., Kolihová, D. & Pivec, V. 2005. Effect of cadmium on flavonoid content in young barley (Hordeum sativum L.) plants. Plant Soil and Environment, 51, 513.

Li, X., Yang, X., Yang, L. E., Muhu-Din Ahmed, H. G., Yao, C., Yang, J., Wang, L., Yang, T., Pu, X. & Zeng, Y. 2024. Evolution and association analysis of SSIIIa in rice landraces of Yunnan Province. Biologia, 1-9.

Mahmood, R. 2024. Deciphering Genetic Diversity and Gene Action in Barley Using Line× Tester Mating Design to Enhance Yield Attributes. Journal of Biological and Agricultural Advancements, 2, 73-79.

Mierziak, J., Kostyn, K. & Kulma, A. 2014. Flavonoids as important molecules of plant interactions with the environment. Molecules, 19, 16240-16265.

Migut, D., Jańczak-Pieniążek, M., Piechowiak, T., Buczek, J. & Balawejder, M. 2021. Physiological response of maize plants (Zea mays L.) to the use of the potassium quercetin derivative. International Journal of Molecular Sciences, 22, 7384.

Murtaza, G., Usman, M., Ahmed, Z., Hyder, S., Alwahibi, M. S., Rizwana, H., Iqbal, J., Ali, B., Iqbal, R. & Ahmad, S. 2024. Improving wheat physio-biochemical attributes in ciprofloxacin-polluted saline soil using nZVI-modified biochar. Ecotoxicology and Environmental Safety, 286, 117202.

Mushtaq, M. A., Ahmed, H. G. M.-D. & Zeng, Y. 2024. Applications of Artificial Intelligence in Wheat Breeding for Sustainable Food Security. Sustainability, 16, 5688.

Nawaz, G. 2024. Unlocking the Genetic Potential of Chili Through Combining Ability Studies. Journal of Biological and Agricultural Advancements, 2, 66-72.

Piasecka, A., Sawikowska, A., Kuczyńska, A., Ogrodowicz, P., Mikołajczak, K., Krystkowiak, K., Gudyś, K., Guzy-Wróbelska, J., Krajewski, P. & Kachlicki, P. 2017. Drought-related secondary metabolites of barley (Hordeum vulgare L.) leaves and their metabolomic quantitative trait loci. The Plant Journal, 89, 898-913.

Rashid, M. A. R., Pan, Z., Wang, Y., Shaheen, T. & Ahmed, H. G. M.-D. 2024. Biofortification of potatoes to reduce malnutrition. Biofortification of Grain and Vegetable Crops. Elsevier.

Rizwan, M., Qadeer, A., Yaseen, M., Naveed, M. & Shahbaz, M. 2024. Impact of urea-phosphate on maize development, productivity and nutrient utilization in field trials. Journal of Biological and Agricultural Advancements, 2, 30-35.

Saeed, A., Ahmed, H. G. M.-D., Zeng, Y., Fatima, N., Hussain, G. S., Akram, M. I., Sattar, M. M., Khan, M. A. & Mushtaq, M. A. 2024. Genetic Evaluation and Breeding Strategies under Water Deficit Environment to Develop the Drought Tolerant Wheat Germplasm. Polish Journal of Environmental Studies.

Ullah, S., Malik, A., Latif, A., Ali, S., Saeed, M. U. & Arif, M. N. 2024. Analyzing the Effects of NPK Fertilizers on Ginger (Zingiber officinale) Yield and Quality. Journal of Biological and Agricultural Advancements, 2, 59-65.

Wang, M., Ding, Y., Wang, Q., Wang, P., Han, Y., Gu, Z. & Yang, R. 2020. NaCl treatment on physio-biochemical metabolism and phenolics accumulation in barley seedlings. Food chemistry, 331, 127282.

Yang, T., Duan, C., Zeng, Y., Du, J., Yang, S., Pu, X. & Yang, S. 2012. Analysis on interaction between genotype of four main flavonoids of barley grain and environment. Agricultural Science & Technology, 13, 1843.

Yang, T., Duan, C. L., Zeng, Y. W., Du, J., Yang, S. M., Pu, X. Y. & Yang, S. C. 2013. HPLC analysis of flavonoids compounds of purple, normal barley grain. Advanced materials research, 634, 1486-1490.

Yang, T., Zeng, Y., Du, J., Yang, S. & Pu, X. 2019. Genetic analysis of four main flavonoids in barley grain. Bangladesh Journal of Botany, 48, 231-237.

Yang, X.-J., Dang, B. & Fan, M.-T. 2018. Free and bound phenolic compound content and antioxidant activity of different cultivated blue highland barley varieties from the Qinghai-Tibet Plateau. Molecules, 23, 879.

Zeng, Y., Ahmed, H. G. M.-D., Li, X., Yang, L. E., Pu, X., Yang, X., Yang, T. & Yang, J. 2024. Physiological Mechanisms by Which the Functional Ingredients in Beer Impact Human Health. Molecules, 29, 3110.