8.2 Processing technology bottlenecks

Both common buckwheat and Tartary buckwheat are gluten-free crops. Because they lack gluten proteins, their dough-forming ability is relatively weak. As a result, buckwheat-based noodles, bread, biscuits, and extruded foods often show poor elasticity, high breakage rates, rough texture, and unstable storage quality. Tartary buckwheat faces an additional challenge. Although its high rutin content is considered one of its most valuable functional traits, it is also associated with strong rutinase activity and the formation of bitterness.

Suzuki et al. (2021) reported that the in vitro rutinase activity of the Tartary buckwheat variety "Manten-Kirari" was two orders of magnitude lower than that of the conventional rutinase variety "Hokkai T8." In dough prepared from "Hokkai T8," rutin was almost completely hydrolyzed within 10 minutes after water addition, whereas only partial hydrolysis occurred in "Manten-Kirari" dough even after 6 hours. Among 29 evaluators, 27 identified clear bitterness in flour made from "Hokkai T8," while no bitterness was reported for "Manten-Kirari" flour. More importantly, noodles produced with "Manten-Kirari" retained about 90% of their rutin content and showed only slight or no bitterness. However, high-moisture systems such as some pancake-type products still cannot completely prevent rutin hydrolysis. In addition, contamination of the processing chain with seeds or flour from normal rutinase varieties may reduce rutin retention. Future processing of Tartary buckwheat therefore requires a complete quality-control system covering seed purity, flour grading, moisture control, low-temperature storage, pH regulation, and final product formulation, rather than relying only on low-rutinase cultivars as a single technological solution.

8.3 Future trends in sustainable buckwheat utilization

The future development of buckwheat should not focus on only one specialized function. Instead, a comprehensive system based on the differentiated utilization of common buckwheat and Tartary buckwheat should be established. Future breeding programs should move beyond simple yield-oriented goals and focus on multiple traits at the same time, including self-compatibility, resistance to seed shattering, uniform maturity, suitability for mechanized harvesting, low bitterness, rutin retention, and food-processing quality. The future market potential of buckwheat lies more in high-value-added products than in low-value raw grain sales.

Sustainable utilization of buckwheat will increasingly depend on low-input agriculture, mountain agriculture, and circular bioeconomy systems. The future value of buckwheat is also reflected in the integration of agricultural landscapes, local culture, and regional branding. One promising pathway is to establish closed-loop systems in mountainous and cool-climate regions that combine buckwheat cultivation, food processing experiences, local cuisine, cultural tourism, and by-product utilization. In this way, buckwheat can simultaneously provide food, ecological, cultural, and economic functions. Under such a model, buckwheat will no longer remain only a "potential crop" frequently mentioned in review papers, but may become a practical and sustainable specialty crop supporting low-input agriculture and rural revitalization.

Author Contributions

The author conducted this study, including literature review, data analysis, and the drafting and revision of the manuscript. The author has read and approved the final version of the manuscript.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Ahmed A., Khalid N., Ahmad A., Abbasi N.A., Latif M.S.Z., and Randhawa M.A., 2014, Phytochemicals and biofunctional properties of buckwheat: a review, The Journal of Agricultural Science, 152(3): 349-369.
https://doi.org/10.1017/S0021859613000166

Bae H.G., and Kim M.J., 2022, Antioxidant and anti-obesity effects of in vitro digesta of germinated buckwheat, Food Science and Biotechnology, 31: 879-892.
https://doi.org/10.1007/s10068-022-01086-z

Brites L.T., Rebellato A.P., Meinhart A.D., Godoy H.T., and Steel C.J., 2022, Antioxidant-enriched gluten-free bread made with buckwheat flour: Evaluation of technological and nutritional quality, Cereal Chemistry, 99(5): 995-1006.
https://doi.org/10.1002/cche.10573