evaluation and traceability standards, and management service standards. Within this framework, *G. lucidum* branding should rely on verifiable quality attributes, such as the contents of marker components including polysaccharides, triterpenoids, and ganoderic acid A, compliance with national standards for spore powder harvesting and processing, and alignment with the testing, packaging, storage, and transportation requirements of ISO 21315 for *G. lucidum* fruiting bodies (Wu et al., 2024). Only by building brand value on stable quality and verifiable quality indicators can conceptual promotion and the impact of low-quality products on the market be avoided.

The construction of product traceability systems is an important component of modern agricultural quality management and brand trust formation. In *G. lucidum* production, QR codes, batch codes, digital management platforms, and even blockchain technology can be used to record whole-process information, including strain source, regional cultivation conditions, substrate formulation, facility environmental parameters, harvesting and processing, quality testing, warehousing and logistics, and sales circulation. This enables product source inquiry, production process tracking, and quality responsibility traceability. Stable isotope and chemometric methods can further strengthen the scientific basis of traceability systems. Studies have shown that by analyzing C, H, O, and N stable isotope ratios as well as elemental C and N contents, and combining PCA, OPLS-DA, PLS, and FLDA methods, the geographical origin and growth stage of *G. lucidum* can be effectively distinguished, with some external validation accuracies reaching 100% (Zhang et al., 2023). These techniques can be used to independently verify origin and growth-stage information on product labels and can be integrated with digital traceability platforms to improve brand credibility.

In addition, the construction of branding and traceability systems helps standardize market order and reduce the circulation of low-quality or counterfeit products. Studies on commercial products have shown that only about 26% of *G. lucidum* dietary supplements in the U.S. market matched the triterpenoid and polysaccharide contents declared on their labels, suggesting that quality inconsistency can significantly damage brand reputation and consumer trust. HPLC fingerprints targeting 11 major ganoderic acids and related triterpenoids have been validated for quality control and batch comparison of fruiting body and spore products, supporting brand quality claims based on multi-marker chemical profiles (Yeung et al., 2021). Therefore, *G. lucidum* brand building should not remain limited to regional culture and packaging promotion, but should be deeply integrated with standardized production, quality testing, fingerprint profiling, origin authentication, and digital traceability. In the future, with the development of e-commerce, smart agriculture, and international trade, *G. lucidum* brand building and digital traceability systems will become further integrated, providing support for high-quality industrial development and international market expansion.

8 Conclusion

With the continuous expansion of market demand for *Ganoderma lucidum* and consumers' increasing requirements for product quality, safety, and stability, traditional cultivation methods that rely on natural environments and experience-based management can no longer meet the needs of modern industrial development. Facility-based cultivation effectively improves production stability and resource-use efficiency through precise regulation of environmental factors such as temperature, humidity, light, and ventilation. It promotes the transformation of the *G. lucidum* industry from dispersed and extensive production toward large-scale, intensive, and modernized development. Therefore, facility-based cultivation has become an important development pathway for the transformation and upgrading of the *G. lucidum* industry and is of great significance for enhancing overall industrial competitiveness and promoting sustainable development.

Mycelial growth and fruiting body formation in *G. lucidum* are highly sensitive to environmental conditions. Factors such as temperature and humidity, air circulation, light intensity, and environmental cleanliness directly affect yield, appearance quality, and the accumulation of active components. In facility-based production, establishing a scientific environmental control system combined with real-time monitoring and dynamic regulation technologies can effectively reduce the adverse effects of environmental fluctuations, lower the incidence of pests, diseases, and microbial contamination, and improve product uniformity and quality stability.