

hemsleyanum polysaccharides have antioxidant, anti-tumor, anti-inflammatory, immunomodulatory, and metabolic regulatory effects, showing clear application prospects in food, medicine, and cosmetics (Wang et al., 2025). New extraction and processing technologies, such as GA-BPNN-optimized flavonoid extraction and nanoparticle delivery systems, can significantly improve extraction efficiency, antioxidant capacity, anti-inflammatory activity, and bioavailability, helping promote the development of standardized preparations and functional foods. In addition, pectic polysaccharide fractions and freeze-dried products with enhanced hepatoprotective and immunomodulatory effects further expand the application space of *T. hemsleyanum* in high-end medicine and health products.

During promotion, attention should be paid to the construction of technical standards and quality control systems. The scarcity of wild resources and increasing market demand have promoted the expansion of artificial cultivation of *T. hemsleyanum*, but problems such as backward processing technology, storage difficulties, and imperfect detection methods still exist (Zhu et al., 2020). Reviews on medicinal plant commercialization point out that formalizing value chains, improving quality control, and strengthening the connection among cultivation, processing, and sales can promote rural economic development, create employment opportunities, and drive small and micro-enterprises in the transportation and processing chain (Mofokeng et al., 2022). Therefore, systematic technical protocols should be established in the future around high-quality seedling propagation, understory cultivation techniques, green pest and disease control, timely harvesting, primary processing at the production site, active compound detection, and quality traceability. Only by forming a positive linkage among ecological conservation, quality control, and market development can the understory ecological cultivation model of *T. hemsleyanum* achieve stable promotion and sustainable development (Ji et al., 2020; Hu et al., 2021; Wang et al., 2025).

8 Summary and Analysis

Understory ecological cultivation of *Tetrastigma hemsleyanum* is an important pathway for alleviating pressure on wild resources, improving the comprehensive utilization efficiency of forestland, and promoting the development of characteristic medicinal plant industries. With the rapid expansion of *T. hemsleyanum* cultivation, problems related to seedling quality control and provenance standardization have become increasingly prominent. Because *T. hemsleyanum* has a low natural fruiting rate, traditional cutting propagation produces a limited number of plants, while long-term tissue culture may induce somaclonal variation and affect genetic stability and flavonoid composition profiles. Therefore, establishing a stable and traceable seedling propagation system is particularly important. In the future, micropropagation, controlled subculture, slow-growth conservation, and stress-resistance-oriented strain selection should be integrated to screen, fix, and register superior strains, thereby constructing standardized seedling and provenance systems and providing cultivation materials with clear genetic backgrounds, stable quality, and strong adaptability for understory ecological cultivation.

From the perspective of production practice, understory cultivation of *T. hemsleyanum* still faces problems such as immature technical systems, insufficient standardization, and weak extension services. Light, temperature, humidity, soil fertility, pH, and microbial communities in understory environments are complex and variable. If canopy density, planting density, water and fertilizer management, and stand conditions are not properly matched, yield and quality fluctuations can easily occur. At present, there are still considerable differences among different cultivation bases and planting models in biomass and in the contents of key indicator compounds such as polydatin, piceatannol, resveratrol, and kaempferol. The fact that greenhouse plus stereoscopic cultivation outperforms some understory cultivation models in both yield and quality also indicates that a technical gap remains between understory ecological systems and intensive systems. Therefore, systematic technical protocols should be established for understory cultivation of *T. hemsleyanum* in terms of suitable stand selection, canopy density regulation, stereoscopic trellising, soil improvement, ecological fertilization, rhizosphere microbial regulation, and quality certification, so as to improve the reproducibility, stability, and promotion value of cultivation models.