value-added, but only when paired with cooperative organization, industrialization policy, phytopharmacovigilance capacity, and equitable collaboration with enterprises (Lindberg et al., 2023). For *T. hemsleyanum*, this implies a regional pathway that links under-forest cultivation bases, local processing enterprises, and county-level public brands around authenticated origin, standardized drying and extraction, and diversified products such as medicinal slices, health teas, antioxidant extracts, polysaccharide preparations, and functional-food derivatives (Sun et al., 2021; Guo et al., 2023; Chu et al., 2024). Because this species has high medicinal value but limited wild resources, local industry upgrading should emphasize resource-saving whole-plant use, high-value deep processing, and place-based brand premiums instead of simple expansion of raw root sales (Ji et al., 2021; Hu et al., 2021). In this way, diversified development of local characteristic *T. hemsleyanum* resources can support both conservation and the formation of a stable regional under-forest characteristic industry.

6 Major Problems in the Development of the Under-Forest *Tetrastigma hemsleyanum* Industry

6.1 Insufficient conservation of elite germplasm resources and limited supply of high-quality propagation materials

Wild resource depletion and incomplete elite germplasm conservation still restrict the long-term supply basis of the under-forest industry. Wild *T. hemsleyanum* resources are scarce because the species has strict habitat requirements and has been over-excavated for years (Hang et al., 2023). In Guangxi, field investigation found that wild reserves were only about 24 441.20 kg and that distribution areas were becoming increasingly limited under combined pressure from overcollection and ecological change. This pressure has already affected genetic diversity, with recent work noting that indiscriminate exploitation has severely reduced diversity and pushed the species toward potential extinction risk, while climate change and pollution further intensify survival pressure. Although the species has high medicinal value, its slow growth means it generally requires 3~5 years to reach medicinal standards, so losses of local germplasm cannot be quickly replaced through ordinary production cycles (Ji et al., 2021; Shi et al., 2022).

The second layer of this problem is that the supply of high-quality propagation materials remains limited, and breeding of elite, stress-resistant strains is still insufficiently developed. Seed yield is low, and conventional vegetative propagation by cuttings produces only limited numbers of plants, which directly constrains commercial expansion (Pang et al., 2024). Artificial cultivation has been established, but ensuring stable yield and quality still requires identification and expansion of resistant cultivated strains, while research on resilient-strain breeding remains limited. Recent stress-screening work identified the Zhejiang ZJWZ strain as promising parental material for resistance breeding, but this also shows that elite-strain selection is only beginning rather than already widely deployed. Tissue culture and conservation technologies provide solutions but have not yet fully translated into broad industrial supply: slow-growth storage can maintain genetically stable microplants for at least 10 months, and organogenesis protocols can achieve mass propagation with over 98% acclimatization survival, yet these are still technical pathways that need wider integration into breeding, nursery systems, and under-forest seedling supply chains (Pang et al., 2024).

6.2 Low levels of standardization and large-scale production in under-forest cultivation

The low level of standardization in under-forest cultivation weakens the reproducibility of both yield and quality.. Reviews note that current physiological research on *T. hemsleyanum* has focused mainly on light and fertilizer, while many other cultivation factors remain insufficiently studied. The species also faces a long cultivation cycle, low yield, and variable quality under artificial planting, and these are described as critical obstacles to industrial production (Hang et al., 2023). Current planting modes are described as chaotic and complicated, and comparative cultivation research was undertaken precisely because an optimal mode for jointly improving quality and yield had not been clearly established (Hu et al., 2023). This lack of standardization is especially problematic in under-forest systems, where habitat differences strongly affect quality formation: dryland cultivation can show 30~35% lower flavonoid concentrations than forest understory systems, and even corrective measures such as biochar have habitat-specific effects rather than universal ones (Zhang et al., 2026).