

The core tradeoff across models is between ecological authenticity, managerial controllability, and production stability. Under-forest systems can enhance active-compound accumulation, as seen in ginseng and *T. hemsleyanum*, but medicinal-plant studies repeatedly show that higher biomass and higher chemical quality do not always peak under the same conditions (Naud et al., 2010; Lan et al., 2023). The best model therefore depends on the development objective: if the goal is premium medicinal quality and ecological branding, wild-simulated cultivation under suitable forest stands is more advantageous; if the goal is standardized, scalable, and technically optimized supply, the forest-medicinal integrated management model is more appropriate (Duc et al., 2025; Le et al., 2026). For local industry development of *T. hemsleyanum*, the most practical pathway is likely a graded model in which core production areas adopt wild-simulated cultivation under high-quality forest habitats, while broader supply areas use integrated management with provenance-matched seedlings, canopy regulation, and soil-microecological improvement (Pang et al., 2024; Le et al., 2026; Zhang et al., 2026). In this sense, optimizing under-forest production models for *T. hemsleyanum* is not a choice of one fixed template, but a process of matching habitat quality, management intensity, and product positioning to local resource conditions.

5 Diversified Development and Utilization of Local Characteristic *Tetrastigma hemsleyanum* Resources

5.1 Comprehensive development of medicinal and aboveground resources

The diversified utilization of local *Tetrastigma hemsleyanum* should begin with a shift from root-centered use to whole-plant development, because current evidence shows that not only the tuberous roots but also the stems, leaves, whole grass, and aboveground fractions contain valuable bioactive constituents and practical medicinal functions (Li et al., 2023). Root tubers remain the traditional core medicinal part and are widely used in clinics and functional food products for fever, pneumonia, hepatitis, asthma, convulsions, and related inflammatory conditions (Sun et al., 2021; Shu et al., 2023). However, the aboveground parts already have recognized use value: leaves are consumed as functional tea or dietary supplements, and aerial portions have been developed as potential new traditional Chinese medicine preparations (Luo et al., 2022; Bai et al., 2022). This broader utilization route is especially important because the species grows slowly, usually requiring 3~5 years to meet medicinal standards, and overdependence on roots increases harvesting pressure on an already scarce resource (Figure 2) (Ji et al., 2021).



Figure 2 The aerial part (A), root tuber (B) and raw herb (C) of *T. hemsleyanum* (Adopted from Ji et al., 2021)

The evidence also shows that aboveground resources are not inferior by default and may be superior for some target products. Quantitative comparisons found that leaves contain significantly higher levels of flavonoids and phenolic acids than roots and stems, while metabolomic imaging detected higher abundance of most organic acids and flavonoids in leaves than in underground parts (Luo et al., 2022). Leaves also contain unique compounds, with 24 components detected only in leaves, compared with 3 unique to tuberous roots and 7 unique to fibrous roots, and both leaves and fibrous roots have been proposed as new medicinal parts for future development.