

environmental drivers of quality from rainfall and temperature toward altitude and sunlight. Wild-simulated systems generally reproduce an ecological environment closer to natural habitat, and in related *Dendrobium* comparisons they produced plant form more similar to wild material, higher active-ingredient content, and stronger overall quality performance than facility cultivation (Yi et al., 2021). Evidence in *D. officinale* itself also indicates that cultivation environment substantially affects metabolite accumulation and medicinal quality: wild material showed the highest polysaccharide content in one large analysis, 3~4 year-old plants outperformed younger plants, and stone or tree epiphytic environments produced distinct metabolite profiles and therapeutic differences relative to greenhouse conditions (Hou et al., 2025). Overall, facility cultivation is better suited to standardized, high-efficiency production, whereas wild-simulated cultivation better aligns with the ecological habits of *D. officinale* and often favors quality-oriented production, making comparative evaluation of the two modes essential for optimizing both yield and medicinal value.

3 Wild-Simulated Cultivation Analysis of *Dendrobium officinale*

3.1 Environmental selection and key technical characteristics

Wild-simulated cultivation of *Dendrobium officinale* is designed to preserve medicinal quality by reconstructing the plant's original habitat as closely as possible rather than maximizing environmental control (Zhang et al., 2020; Yi et al., 2021). This logic fits the biological habit of *D. officinale* as an epiphytic orchid that naturally grows on rocks or tree trunks in well-aerated niches (Tan et al., 2023; Hou et al., 2025). Site selection therefore emphasizes forest or mountainous environments with appropriate shade, ventilation, and humidity, while avoiding prolonged coupling of high temperature and high humidity that favors southern blight (Liu et al., 2025b). In *D. officinale*, key quality-related ecological variables include maximum and minimum relative humidity, maximum temperature, sunshine duration, soil pH, and substrate nitrogen and phosphorus status, indicating that wild-simulated bases must be selected for both microclimate and nutrient conditions (Yuan et al., 2020; Wang et al., 2025).

Technically, wild-simulated cultivation usually relies on tissue-culture seedlings transplanted onto stone or tree-attached substrates, with the aim of restoring natural epiphytic growth conditions while maintaining production feasibility (Figure 1) (Hou et al., 2025; Liu et al., 2025b). Reported field designs include lithophytic cultivation on vertical rock walls under natural light and tree epiphytic cultivation under 70~80% canopy shade or comparable artificial shading. Core technical steps commonly include base cleaning, disinfection, construction of breathable woody or bark-based media, mist or spray irrigation, water-fertilizer management, and ecological pest control, while some systems use biogas slurry, organic amendments, or interplanting for low-residue management. Current evidence also highlights the importance of integrating mycorrhizal or endophytic fungi, because fungal co-culture supports germination, seedling establishment, stress resistance, and quality stability in restoration-friendly epiphytic cultivation (Zhang et al., 2020; Wang et al., 2021).

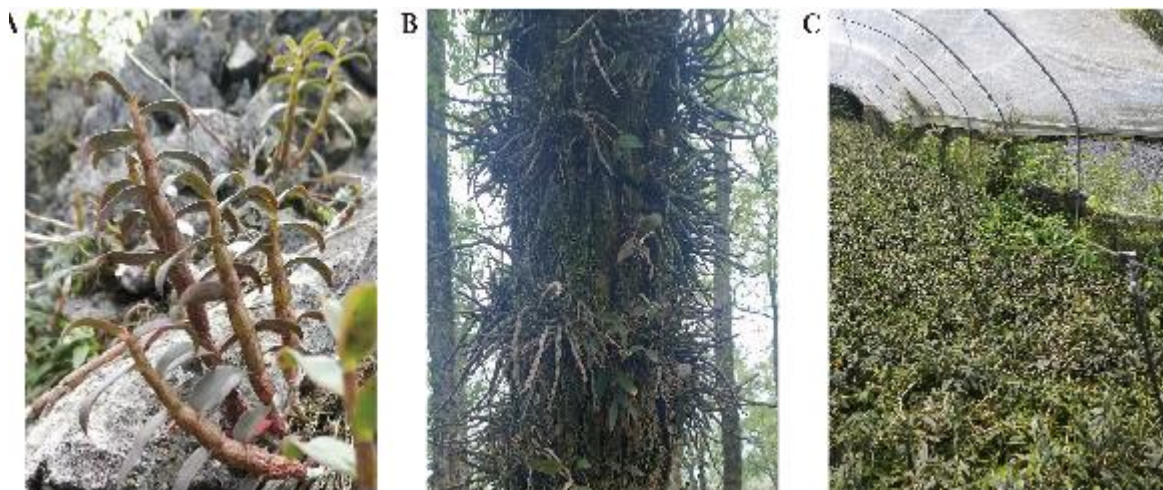


Figure 1 The three growth environments of *D. officinale* (Adopted from Hou et al., 2025)

Image caption: (A) Stone epiphytic culture environment in the wild; (B) Tree epiphytic culture environment in the wild; (C) Greenhouse culture environment (Adopted from Hou et al., 2025)