

irradiance below that under 75% shading restricts carbon assimilation and plant growth. This suggests that an appropriate window may exist near approximately two-thirds shading. From broader research on medicinal plants, moderate reduction of light intensity or optimization of scattered light proportion generally improves biomass and key metabolite contents, whereas excessively strong or weak light impairs survival, photosynthesis, and secondary metabolism. This further indicates that precise calibration of shading conditions is necessary to achieve the dual goals of high yield and stable medicinal quality.

Although existing studies have clarified the suitable shading range for *T. hemsleyanum* and demonstrated that light quality and cultivation mode strongly affect its growth and flavonoid accumulation, research on its intrinsic mechanisms and standardized application remains limited. Recent reviews have pointed out that current physiological studies of *T. hemsleyanum* mainly focus on light and fertilizer effects, with relatively few investigations into deeper regulatory processes or systematic quality control. They also emphasize that this species still lacks a scientific, universal, and measurable quality evaluation system. In contrast, integrated phenotypic, physiological, and transcriptomic analyses of other medicinal plants under light gradients have revealed how moderate light reallocates carbon sources, reshapes membrane structures, and directs metabolic flux toward photoprotection and bioactive compound production, providing a useful theoretical framework for mechanistic studies of *T. hemsleyanum*. Therefore, future research should integrate omics-based analyses of light signaling, carbon-nitrogen metabolism, and secondary metabolic networks with multifactorial cultivation experiments involving shading intensity, spectrum, cultivation mode, nutrient management, and water management. Multi-index evaluation or decision-making models should also be applied to construct standardized and scalable shading cultivation systems and quality evaluation systems suitable for resource conservation and industrial development of *T. hemsleyanum*.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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