

垂珠花叶饮品有效成分时空分布规律及其资源价值评价

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摘 要: 本研究围绕垂珠花 (*Styrax dasyanthus*) 叶片的生长发育规律、代谢物质的积累特征以及不同叶色条件下的基因表达和代谢物变化进行了系统研究, 试制并评价了不同工艺垂珠花叶茶, 旨在为垂珠花叶片的资源高效利用和保健饮品开发提供科学依据和技术支持。其主要结论如下:

1. 不同部位、时期的叶片在含水量、叶绿素含量、有机物积累速率和黄酮类代谢物积累方面存在明显差异。总体上, 垂珠花上层叶片含水量低、叶绿素含量较少, 中层叶片黄酮类次生代谢物积累最稳定, 而中下层叶片叶绿素含量较高, 有机物积累丰富。建议采集策略: 在春季至夏季初期采集上层叶片; 夏季中期采集中层叶片; 夏末至秋季采集下层叶片, 以获取更高水平的有机物和代谢物。

2. 垂珠花叶片中成分丰富, 包括类黄酮、酚酸类、氨基酸及其衍生物、木脂素、香豆素、脂质、萜类化合物、生物碱、有机酸、核苷酸及其衍生物、鞣质、醌类等, 具有多重药用价值。这些代谢成分为垂珠花叶片的保健功效提供了生物学基础, 具有抗氧化、抗癌、抗炎等多种功效。黄酮、生物碱、酚酸类和萜类代谢物是“白客马叶”中的主要有效成分。

3. 紫叶垂珠花叶片中花青素含量显著高于绿叶, 具有其独特药用价值。主要因为外界条件中的光照和水分通过控制基因表达影响垂珠花叶片的色素积累和代谢物差异。垂珠花紫叶和绿叶的两个重点差异模块通过调控细胞物质代谢、细胞过程及应激反应等生物学过程, 在植物叶色发育过程中显示出协同作用。MYB、bHLH 和 AP2/ERF 等转录因子家族在调控类黄酮生物合成和其他关键代谢途径中起关键作用。为通过环境调控手段选育具有特定药用价值的垂珠花品种提供了可能。

4. 以垂珠花叶为原材料试制各类饮品是可行的。垂珠花叶试制的绿茶和红茶均具有特殊的清香, 其中以红茶工艺加工的垂珠花叶茶在滋味、香气、外观等方面表现更优。此外, 经过高度揉捻和长期发酵所制成垂珠花叶茶不仅形态更佳, 也更便于运输保存以及饮用和推广。

综上所述, 本研究为垂珠花叶片的合理采收、资源利用和保健饮品开发提供了科学基础, 揭示了垂珠花叶片中丰富的代谢物质和其生物学功能, 为垂珠花的栽培管理、资源利用和药用价值的开发提供了前期指引。

关键词: 垂珠花; 保健饮品; 代谢物质; 联合组学; 安息香科

Spatial and Temporal Distribution Pattern of the Active Ingredients in the Leaves of *Styrax dasyanthus* Beverage and its Evaluation of Resource Value

Abstract: This study focused on the growth and development of *Styrax dasyanthus* leaves, the accumulation of metabolites and gene expression and metabolite changes under different leaf colour conditions, and the trial production and evaluation of *S. dasyanthus* leaf tea of different processes, aiming to provide scientific basis and technical support for the efficient use of resources and the development of health care beverages of *S. dasyanthus* leaves.

1. There were differences in water content, chlorophyll content, organic matter accumulation rate and flavonoid metabolite accumulation in different parts and periods of leaves. Overall, the upper leaves of *S. dasyanthus* had low water content and low chlorophyll content, and the middle leaves had the most stable accumulation of flavonoid

secondary metabolites, while the middle and lower leaves had high chlorophyll content and rich accumulation of organic matter. Collection strategy: It is recommended to collect upper leaves from spring to early summer; middle leaves from mid-summer; and lower leaves from late summer to autumn to obtain higher levels of organic matter and metabolites.

2. The richness and multiple medicinal values of the metabolic constituents of the leaves of *S. dasyanthus* include flavonoids, phenolic acids, amino acids and their derivatives, lignans, coumarins, lipids, terpenoids, alkaloids, organic acids, nucleotides and their derivatives, tannins, and quinones. These metabolic components provide the biological basis for the health benefits of the leaves of *S. dasyanthus*, with antioxidant, anticancer, anti-inflammatory and many other effects. Flavonoids, alkaloids, phenolic acids and terpene metabolites are the main active ingredients in the leaves.

3. The anthocyanin content in the leaves of the purple-leafed *S. dasyanthus* is significantly higher than that of the green leaves, which has its unique medicinal value. The main reason is that the external conditions of light and water affect the pigment accumulation and metabolite differences in the leaves of *Pittosporum* by controlling gene expression. The two key differential modules of purple and green leaves of *S. dasyanthus* show synergistic effects in the development of plant leaf colour by regulating biological processes such as cellular material metabolism, cellular processes and stress responses. transcription factor families such as MYB, bHLH and AP2/ERF play key roles in the regulation of flavonoid biosynthesis and other key metabolic pathways. This opens up the possibility of selecting and breeding pitcher flower varieties with specific medicinal values by means of environmental regulation.

4. It is feasible to make various kinds of beverages from *S. dasyanthus* leaves. The green tea and black tea made from *S. dasyanthus* leaves have special aroma, among which the black tea processed with *S. dasyanthus* leaves has better performance in terms of taste, aroma and appearance. In addition, the highly twisted and long-term fermented tea is not only in a better form, but also easier to transport and preserve, as well as to drink and promote.

In conclusion, the present study provides a solid scientific foundation for the rational harvesting, resource utilisation and health drink development of *S. dasyanthus* leaves, reveals the rich metabolites and biological functions of *S. dasyanthus* leaves, and provides a new direction for the cultivation management, resource utilisation and medicinal value development of *S. dasyanthus*.

Keywords: *Styrax dasyanthus*; Health beverages; Secondary metabolites; Multi-omics; Styracaceae family