

The quality of Hangbaiju is not static, but is formed dynamically during flower development and is strongly influenced by harvest period. Developmental-stage studies on Hangbaiju have shown that total flavonoid content is higher in the early stages S1 and S2, while total polyphenol content rises first and then declines, peaking at S2, indicating that major active constituents accumulate preferentially before full senescence (Lu et al., 2024). More broadly in medicinal chrysanthemum, flavonoid and chlorogenic acid contents differ significantly across floral development stages and reach their highest values at the bud stage, while comprehensive analysis suggests that the best harvest stage for simultaneously obtaining relatively high active and nutritional ingredients lies between the bud and young flower stages. Similar patterns have been reported in other chrysanthemum materials, where most differential flavonoids and phenolic acids were higher at the initial or full-bloom stages than at late stages, supporting the idea that optimal harvest windows are closely tied to metabolite accumulation patterns (Yang et al., 2024). Even when antioxidant activity does not always shift in parallel, harvest stage still significantly affects moisture, phenolics, flavonoids, anthocyanins, and carotenoids, and its interaction with genotype can further shape functional quality (Julianti et al., 2026). In addition, morphological traits may reflect chemical quality: in a Hangbaiju-related subtype, smaller inflorescence diameter was associated with higher chlorogenic acid and 3,5-O-dicaffeoylquinic acid contents, suggesting that external appearance can have value when linked with internal markers in quality grading (Yang et al., 2025). Together, these findings indicate that harvest timing is a key determinant of the accumulation of active substances and therefore a central factor in the quality formation of Hangbaiju.

After harvest, drying is the critical processing step that further determines whether the intrinsic quality of Hangbaiju can be preserved, enhanced, or degraded. Drying is widely used to prolong shelf life, improve storability, and support the processing of chrysanthemum into teas and medicinal products, but it also alters chemical composition, color, aroma, microstructure, and bioactivity (Xu et al., 2022a; Wang et al., 2024). Multiple studies show that drying method significantly affects bioactive constituents and antioxidant properties in chrysanthemum flower heads (Yuan et al., 2015; Shi et al., 2017). In medicinal chrysanthemum, appropriate oven drying has been recommended at about 55~65 °C, while for specific cultivars oven-drying at 60 °C or 70 °C produced favorable outcomes, indicating that suitable temperature ranges can improve the retention of active ingredients (Shi et al., 2017). Drying technology also matters beyond simple temperature control: combined infrared and hot-air drying increased chlorogenic acid, luteolin, total phenolics, and total flavonoids, and infrared-assisted methods strongly affected aroma retention and color behavior. Pulsed vacuum drying preserved total phenolics and flavonoids, enhanced antioxidant activity, and favored volatile retention under lower temperature and pulsed ratio conditions, while vacuum drying more generally was reported to retain antioxidant components in a shorter time (Sun et al., 2021; Lu et al., 2020). Microwave-assisted and combined pretreatments can also improve quality by inhibiting enzymatic browning and preserving biologically active compounds, although excessive heat or prolonged treatment may accelerate oxidation and degradation of flavonoids and other heat-sensitive constituents (Wang et al., 2019; Xu et al., 2022a; Miao et al., 2026). Recent work further shows that kill-green pretreatment can shorten subsequent drying time and improve color, phenolics, amino acids, volatiles, and sensory acceptance, emphasizing that processing sequence as well as drying mode contributes to final quality (Xu et al., 2024).

This study will investigate the effects of harvest period and drying methods on the formation and preservation of Hangbaiju quality, with the aim of further clarifying the major characteristics of quality changes in Hangbaiju under different harvest stages and processing conditions. The quality of Hangbaiju is not determined by a single factor, but results from the coordinated effects of multiple chemical markers, antioxidant-related properties, sensory traits, and morphological characteristics; meanwhile, floral developmental stage and post-harvest processing can both significantly alter these quality indicators. However, current studies often examine harvest stage or drying technology separately, and some studies focus mainly on other chrysanthemum cultivars. Therefore, a comprehensive evaluation of the combined effects of harvest period and drying methods on Hangbaiju remains necessary. By comparing changes in key active constituents, nutritional and functional indicators, and related quality traits of Hangbaiju under different harvest periods and drying methods, this study