

when the goal is premium-grade product quality and maximum preservation of appearance and functional constituents.

5 Interactive Effects of Harvest Period and Drying Methods on the Quality of Hangbaiju

5.1 Adaptability of Hangbaiju raw materials at different maturity stages to drying methods

The adaptability of Hangbaiju raw materials at different maturity stages to drying methods is mainly reflected in their different starting compositions, tissue states, and responses to heat and dehydration. Harvest stage significantly affects the functional constituents of Hangbaiju, and the contents of total flavonoids and chlorogenic acid were highest at the Hualei stage, while luteolin-7-O-glucoside and 3,5-O-dicaffeoylquinic acid peaked at the Taiju stage. Taiju and Duoju, which are harvested at different times, also show clearly different phenolic profiles and antioxidant properties, with Taiju containing higher caffeoylquinic acids and stronger antioxidant activities than Duoju (Gong et al., 2019). Metabolomic analysis further showed that Taiju and Duoju differ in both volatile oils and flavonoids, and that most characteristic flavonoids and flavor-related volatiles increased in Taiju, indicating that early-and mid-maturity materials enter drying with different chemical bases and flavor potentials (Yang et al., 2022).

Because the raw material differs by maturity stage, the most suitable drying conditions also differ. A direct study of chrysanthemum flower heads harvested at two developmental stages found that drying process significantly affected bioactive constituents and antioxidant properties, and recommended oven drying at 60 °C for Xiaobaiju and 70 °C for Taiju. More generally, the nature of the starting material, including harvesting time, strongly influences drying dynamics and compound degradation, so drying parameters should be optimized together with raw-material condition rather than chosen independently (Belwal et al., 2022). This interaction is also consistent with process studies showing that structural state governs drying behavior: tempering reduced moisture heterogeneity between the central and marginal parts of chrysanthemum and improved subsequent drying performance, indicating that flowers at different maturity stages are likely to differ in their tolerance to the same drying route (Xu et al., 2023).

5.2 Effects of harvest period and drying conditions on the retention of active components in Hangbaiju

The retention of active components in Hangbaiju depends on the combined effect of harvest period and drying conditions, because flowers harvested at different stages begin with different dominant compounds and these compounds differ in thermal stability. In chrysanthemum flowers, phenolic acids were more stable than flavonoids during dehydration (Lu et al., 2020). This matters for Hangbaiju because early or Taiju-stage materials are richer in flavonoids, chlorogenic acid, and caffeoylquinic acids (Gong et al., 2019), so poorly controlled drying can erase the compositional advantages created by earlier harvest. Quality-marker studies also indicate that chlorogenic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, and kaempferol-3-O-rutinoside are key compounds for chrysanthemum quality evaluation, making their retention especially important when assessing harvest-processing interactions (Lu et al., 2022).

The evidence suggests that moderate or staged drying preserves these compounds better than uncontrolled high heat, while some intensified methods can further improve retention. Conventional hot-air drying gave the lowest total flavonoid values in one comparison, whereas microwave-hot air drying for 30 s plus 75 °C hot air best preserved biologically active compounds and increased antioxidant capacity (Wang et al., 2019). In medicinal chrysanthemum, microwave drying retained higher flavone, vitamin C, and soluble sugar overall, but amino acid content fell as microwave power increased, showing that the best method depends on which quality dimension is prioritized (Shi et al., 2017). Pulsed vacuum drying and multi-stage low-oxygen drying better preserved chlorogenic acid, luteolin, total phenolics, and total flavonoids, while tempering-incorporated infrared-assisted hot-air drying further increased chlorogenic acid, luteolin, total phenolic content, total flavonoid content, antioxidant capacity, and volatile compounds (Sun et al., 2021; Xu et al., 2022a; Xu et al., 2023).

5.3 Effects of harvest-processing combinations on the comprehensive quality of Hangbaiju

The best harvest-processing combination for Hangbaiju should be judged by comprehensive quality, not by a single component, because appearance, color, aroma, antioxidant activity, and sensory acceptance often respond