

chlorogenic acid and 3,5-O-dicaffeoylquinic acid in Fubaiju, excessive delay in harvest likely improves external fullness at the expense of internal quality markers (Yang et al., 2025). Overall, late flowering harvest is less favorable for high-quality Hangbaiju if the evaluation emphasizes medicinal actives, antioxidant capacity, and premium-grade commercial quality rather than yield alone.

4 Effects of Drying Methods on the Quality of Hangbaiju

4.1 Effects of sun drying and shade drying on the quality of Hangbaiju

Sun drying and shade drying are traditional methods for processing chrysanthemum, but their effects on Hangbaiju quality are not identical. Studies comparing sun-dried, shade-dried, and oven-dried chrysanthemum flower heads showed that drying process significantly altered both bioactive constituent contents and antioxidant properties, indicating that natural drying cannot be regarded as a neutral preservation step. Metabolomic comparison of shade drying and heat drying further showed that the two methods produced clear differences in flavonoids, phenolic acids, and terpenoids, and that the levels of key indicator compounds and their precursors also changed significantly between treatments. In that comparison, most flavonoids, major phenolic acids, terpenoids, and carbohydrates were higher after shade drying than after heat drying, suggesting that slower, milder dehydration is more favorable for preserving many medicinally relevant components (Chen et al., 2024).

However, the advantages of natural drying are method-specific and must be weighed against efficiency and quality stability. One study found that nature and vacuum drying were both beneficial for increasing phenolic contents and antioxidant capacities in chrysanthemum flowers, indicating that low-stress dehydration can help preserve functional quality (Lu et al., 2020). Another study reported that total phenols and total flavonoids in infrared-dried chrysanthemums were significantly higher than in shade-dried ones, which implies that shade drying does not necessarily maximize active-component retention when compared with improved low-thermal technologies (Xu et al., 2022a). More broadly, direct sun exposure in plant materials is often associated with higher losses of light- and heat-sensitive pigments, because open-air drying exposes tissues to oxygen, radiation, and prolonged dehydration time (Belwal et al., 2022). Therefore, for Hangbaiju, shade drying is generally preferable to sun drying for preserving internal quality, but its long drying cycle and weaker process control limit its suitability for standardized, large-scale production.

4.2 Effects of hot-air drying on the quality of Hangbaiju

Hot-air drying is the most common industrial method for chrysanthemum because the equipment is simple and the drying rate is fast, but product quality depends strongly on temperature control. Chrysanthemum studies consistently show that increasing hot-air temperature shortens drying time and increases drying rate and moisture diffusivity (Xu et al., 2022a). At the same time, prolonged exposure to hot aerobic conditions can cause losses of bioactive and volatile substances and can also induce browning and petal curling, so faster drying does not automatically mean better quality. In chrysanthemum flowers, conventional hot-air drying produced the lowest total flavonoid values in one direct comparison, which was attributed to reactions between flavonoids and oxidase during drying (Wang et al., 2019).

The best hot-air conditions therefore appear to be moderate rather than extreme. For flower heads harvested at different developmental stages, appropriate oven drying was recommended at 60 °C for Xiaobaiju and 70 °C for Taiju. Another study concluded that an oven temperature of about 55~65 °C could simultaneously maintain relatively high active and nutritional ingredient contents (Shi et al., 2017). Evidence from pulsed-vacuum and related low-oxygen drying also supports the same general principle: lower temperature or staged heating better protects color, chlorogenic acid, luteolin, total phenolics, total flavonoids, and antioxidant capacity, whereas excessive temperature increases thermal degradation despite higher efficiency (Figure 2) (Xu et al., 2022a). Variable-temperature drying can even increase phenolic compounds, total flavonoids, and antioxidant capacity in chrysanthemum tea, showing that controlled thermal profiles can promote quality formation rather than simple degradation (Sun et al., 2026). Thus, hot-air drying is practical for Hangbaiju processing, but its final quality is governed by the coordinated control of temperature, time, and oxygen exposure.