

4 Effects of Fruit Bagging on Grape Quality Attributes

4.1 Regulation of soluble sugar accumulation and carbohydrate metabolism

Fruit bagging alters soluble sugar accumulation in grapes, but the direction of effect depends on cultivar, developmental stage, and light regime. In Muscat-flavored table grapes, several bag types, including transparent, mesh, yellow, white, and blue bags, significantly increased total soluble solids in two cultivars, while in 'Red Globe' bagging raised total sugar content at the late stage of development and increased relative sucrose content and acid invertase activity (Wang et al., 2022). These results suggest that some bagging systems promote carbohydrate accumulation by modifying the berry microenvironment rather than uniformly suppressing ripening.

Other studies show the opposite pattern under stronger shading or prolonged light exclusion. In 'Shenhua' and 'Shenfeng', bagged berries had lower soluble sugar contents than unbagged berries, although sugar levels recovered rapidly after bag removal, while controlled shading in 'Marselan' reduced fructose, glucose, and total sugar accumulation and delayed ripening as light transmission declined (Nan et al., 2024). This indicates that the carbohydrate response to bagging is largely driven by the optical properties of the bag and the duration of reduced light exposure.

At the metabolic level, bagging appears to reshape sugar metabolism through changes in enzyme activity and carbon-partitioning pathways. In 'Red Globe', early changes in invertase activity under bagging were proposed to contribute to later sugar accumulation, and transcriptomic analysis of 'Ruidu Kemei' identified differentially expressed genes linked to starch and sucrose metabolism, glycolysis, and the tricarboxylic acid cycle under bagged conditions (Yuying et al., 2023). These findings support a mechanistic interpretation in which bagging affects not only final sugar concentration but also the regulatory network controlling carbon use during berry development.

This interpretation is consistent with broader evidence on grape carbon economy. Sugar accumulation in grape berries depends on imported carbon and is a core process in ripening, while more general fruit studies show that soluble sugar metabolism is governed by coordinated action of enzymes, transporters, and their spatiotemporal gene expression (Lu et al., 2024; Wu et al., 2025). Bagging therefore influences sweetness and maturity partly by altering the environmental signals that regulate these carbohydrate metabolism systems.

4.2 Effects on organic acids and flavor formation

The effects of fruit bagging on organic acids in grapes are generally weaker and less consistent than its effects on sugars. In 'Ruidu Kemei', bagging increased the sugar-acid ratio but had no significant effect on titratable acidity at the over-mature stage, while in Cabernet Sauvignon, bagging had limited effects on total soluble solids and titratable acidity at harvest despite clear shifts in berry light exposure (Yuying et al., 2023). This suggests that bagging often changes perceived taste balance more through sugar responses than through large changes in acid concentration.

A similar conclusion emerges from broader bagging literature. Reviews note that bagging can increase or decrease sugars and organic acids depending on species and treatment, but grape berries often show relatively small changes in these core compositional traits, and citrus work likewise found that bagging exerted little effect on sugars and organic acids when applied late in fruit development (Ali et al., 2021; Jiang et al., 2022). The available evidence therefore supports a moderate view in which acid metabolism is affected by bagging less consistently than berry color or aroma.

By contrast, flavor-related volatile formation appears highly responsive to bagging, especially to bag color and material. In Muscat-flavored grapes, the dominant volatiles included linalool, geraniol, β -myrcene, and ocimenes, and transparent and white bags promoted phenolics and monoterpenes, whereas pink and blue bags inhibited them (Wang et al., 2022). Because monoterpenes are key contributors to floral and fruity notes in table grapes, these findings indicate that bagging can materially reshape sensory quality even when sugar and acid responses are modest.