

Not all morphological responses are positive, however. In Cabernet Sauvignon, solar interception by bags had limited effects on berry weight at harvest, suggesting that shading does not necessarily translate into larger berries, while clear plastic bags in organic production caused abnormal overgrowths and sunburn despite advancing ripening. The overall evidence therefore supports a material-sensitive view in which breathable or light-modifying bags can improve fruit expansion, whereas excessive enclosure or inappropriate plastic coverings can impair normal morphological development.

3.2 Influence on fruit ripening process and phenological development

Bagging frequently delays grape ripening because it reduces light exposure during critical phases of sugar accumulation and skin coloration. In two Chinese cultivars, bagging lowered soluble sugar content, delayed pigment development, and therefore delayed maturation, while a recent metabolomic and transcriptomic study in 'Ruidu Kemei' also concluded that bagging inhibited fruit growth and delayed ripening even though some quality indices were higher at the over-mature stage (Yuying et al., 2023). These studies support the view that bagging often shifts berry development toward a later ripening trajectory rather than simply reducing final quality.

The effect on ripening is especially clear for anthocyanin accumulation. In Cabernet Sauvignon, bagging after véraison significantly inhibited skin anthocyanin accumulation, whereas early bagging followed by re-exposure to sunlight increased flavan-3-ol and flavonol concentrations, showing that timing relative to véraison determines whether light exclusion suppresses or redirects phenolic development. This means bagging is not only a protective practice but also a developmental regulator whose phenological effects depend on when berries are re-exposed to light.

Bag removal can partially reverse delayed ripening responses. In 'Shenhua' and 'Shenfeng', fruit color and soluble solids rapidly returned toward normal after bags were removed, and in a teinturier grape, anthocyanin derivatives accumulated rapidly after re-exposure to light, accompanied by increased expression of light-responsive regulators and anthocyanin biosynthetic genes (Li et al., 2023). These results indicate that at least part of the bagging effect is reversible and mediated through light-sensitive metabolic pathways rather than irreversible developmental damage.

At the mechanistic level, the ripening response to bagging interacts with core sugar and hormone pathways that normally regulate grape maturation. Independent ripening studies show that sucrose and abscisic acid promote sugar accumulation, anthocyanin biosynthesis, and ripening-related gene expression, while sucrose concentrations above 2% can induce anthocyanin synthesis even without added ABA, helping explain why light restriction that disrupts sugar signaling can slow normal ripening progression. Bagging effects on phenology therefore appear to arise from altered light conditions that secondarily reshape the metabolic signals driving maturation.

3.3 Effects on fruit surface protection and disease reduction

Fruit bagging provides direct surface protection by forming a physical barrier between the cluster and external hazards. In grapes, this barrier reduces mechanical injury, bird damage, and exposure to whole-canopy agrochemical sprays, while broader reviews of preharvest bagging identify protection against pathogens, insect pests, abrasions, sunburn, and residues as one of its most consistent advantages (Luca et al., 2023; Buthelezi et al., 2021). This protective function is central to the value of bagging in high-quality table grape production because berry surface defects strongly reduce marketability.

Direct field evidence shows that bagging can sharply reduce disease and pest incidence. Under organic conditions, brown paper bags reduced grape berry moth infestation to 1.8-2.3%, black mold to 0.6-2%, gray mold to 1.1-2.2%, and powdery mildew to 0-5.4%, compared with very high damage levels in non-bagged controls; the same study found that pesticide application did not improve protection beyond bagging alone. These results suggest that, when properly applied, bagging can function as an effective non-chemical protective strategy rather than merely a supplement to spraying.