

Research Insight

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Effects of Fruit Bagging on Microclimate and Grape Quality

Jili He ✉

Zhuji Puxi Crops Professional Cooperative, Zhuji, 311800, Zhejiang, China

✉ Corresponding author: 1198115935@qq.comBioscience Methods, 2026, Vol.17, No.5 doi: [10.5376/bm.2026.17.0022](https://doi.org/10.5376/bm.2026.17.0022)

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Abstract Fruit bagging is an important horticultural practice widely applied in grape production to improve fruit appearance, reduce environmental stress, and enhance market value. The microenvironment created by fruit bags plays a crucial role in regulating temperature, humidity, light conditions, and gas exchange around grape clusters, thereby influencing fruit development and quality formation. This review summarizes recent advances in the effects of fruit bagging on grape microclimate, physiological responses, and quality characteristics. Different bag materials, colors, and covering periods modify light distribution, thermal conditions, and moisture dynamics, which subsequently affect fruit growth, sugar accumulation, organic acid metabolism, anthocyanin biosynthesis, and flavor compound formation. At the physiological and molecular levels, bagging regulates source-sink carbon allocation, hormone signaling pathways, and secondary metabolic processes involved in fruit maturation and coloration. In addition, optimized bagging strategies combined with canopy management, precise timing, and environmental monitoring can improve disease resistance and promote high-quality grape production. Case studies demonstrate that appropriate selection of bag types and management practices effectively enhances grape quality under diverse climatic conditions. Future research should focus on developing intelligent and sustainable bagging technologies, integrating microclimate monitoring systems, and establishing precision management strategies for efficient and environmentally friendly viticulture.

Keywords Fruit bagging; Grape quality; Microclimate regulation; Sugar accumulation; Anthocyanin biosynthesis

1 Introduction

Table grapes are a globally important fruit crop, valued both economically and nutritionally, and improving grape quality has become a central goal of modern viticulture as consumer demand increasingly emphasizes appearance, sweetness, acidity, flavor, and other market-defining traits. At the same time, conventional efforts to raise yield and quality have often increased reliance on agrochemicals, creating pressure to develop production systems that better balance fruit quality, food safety, and environmental sustainability (Luca et al., 2023). This challenge is especially important because grape quality is shaped not only by genotype, but also by environmental and agronomic factors that regulate berry color, sugar accumulation, acidity, flavor, and secondary metabolites during development. In grapes, light and other abiotic conditions strongly influence these traits, making canopy- and fruit-zone microclimate management a key pathway for quality improvement in both fresh-market and specialty production systems (Wang et al., 2022).

Within this context, fruit bagging has emerged as an increasingly important physical protection technology in viticulture. Pre-harvest bagging is widely recognized as a good agricultural practice that can create a modified microenvironment around the fruit, reduce damage from pests, pathogens, birds, sunburn, and mechanical injury, and lower agrochemical residues while also influencing visual and internal quality attributes. Its adoption across fruit industries in Asia, Australia, Europe, and the Americas reflects growing demand for safer and more environmentally friendly cultivation methods, although the benefits of bagging remain dependent on bag material, timing, cultivar, and local climatic conditions. In grapes specifically, bagging has been studied and developed as a low-environmental-impact technique in Mediterranean production areas and elsewhere, with the aim of integrating it into existing vineyard management systems to improve commercial quality while reducing the need for chemical treatments. Even so, reported outcomes remain variable, which has sustained interest in optimizing bagging protocols for specific cultivars and production environments (Pisciotta et al., 2020).