

mineral nutrition levels help promote fruit enlargement, sugar and acid accumulation, and tissue structure formation. In contrast, source limitation or nutrient imbalance during fruit development may lead to smaller fruit, reduced flavor, and softer texture (Quiroz et al., 2023). Thus, nutrient management is not only related to tree growth and yield formation, but also directly involved in fruit cell wall construction, membrane system stability, and the development of postharvest resistance to deterioration.

Among the mineral elements affecting cherry firmness and storability, calcium, potassium, and magnesium have received considerable attention. Calcium can bind to cell wall components such as pectin and cellulose, strengthen cell wall stability, and participate in the regulation of membrane permeability and stress signaling. It is therefore closely associated with flesh tissue rigidity and resistance to softening (Varaldo and Giacalone, 2025). Potassium is one of the most abundant macronutrients in cherry fruit and is associated with fruit size, soluble solids, maturity progression, and changes in firmness (Ateş et al., 2022; Santos et al., 2024). Magnesium indirectly affects fruit quality formation by participating in photosynthesis, carbon metabolism, and various enzymatic reactions. In recent years, foliar nutrient application has been regarded as an important measure for rapidly regulating fruit mineral composition, alleviating nutrient deficiencies under field conditions, and improving postharvest quality (Santos et al., 2024).

Existing studies have shown that preharvest spraying or postharvest calcium treatment can, to some extent, improve cherry firmness, reduce weight loss, decrease decay incidence, and alleviate pedicel shriveling. However, these effects are often influenced by cultivar, environment, fruit developmental stage, and the efficiency of calcium uptake and transport (Belge et al., 2017; Winkler and Knoche, 2019). Calcium supplementation during early fruit development may be more favorable for calcium entry into the fruit and its participation in cell wall structure formation. As fruit expand rapidly, however, declining calcium concentration and restricted late-stage calcium import may weaken its regulatory effect (Matteo et al., 2022). The proportional relationship among mineral elements should also not be overlooked. Studies have shown that fruit firmness is positively correlated with calcium content but negatively correlated with K:Ca and N:Ca ratios, indicating that simply increasing the supply of a single element does not necessarily lead to stable quality improvement (Blanco et al., 2021; Quiroz et al., 2023). For example, potassium fertilization can help increase fruit weight, soluble solids, and some quality attributes, but excessive potassium supply may also reduce fruit calcium and magnesium concentrations, thereby affecting firmness retention (Ateş et al., 2022). Preharvest treatments with nutritional or metabolic regulatory functions, such as arginine and prohexadione-calcium, have also been reported to improve fruit firmness and storage quality, further suggesting that preharvest nutritional physiology influences postharvest performance (Pakkish and Mohammadrezakhani, 2022).

This study focuses on calcium, potassium, magnesium, and related nutrient regulation measures, and discusses their effects on structural development, firmness retention, and postharvest longevity of cherry fruit. It further explores practical strategies such as balanced fertilization, foliar nutrient supplementation, nutrient ratio adjustment, and synchronized nutrient supply during critical developmental stages. By emphasizing multi-element coordination and integrated preharvest–postharvest management, this study may provide a theoretical basis and practical reference for improving cherry fruit firmness, reducing storage losses, and enhancing commercial value.

2 Physiological Basis of Cherry Firmness and Shelf Life

2.1 Formation of firmness

Cherry fruit firmness arises from the combined effects of cell wall strength, middle lamella adhesion, and cell turgor (Figure 1). In fleshy fruits, firmness is determined by the mechanical properties of parenchyma cell walls and the extent of adhesion between adjacent cells, with tissue strength declining when these properties are modified during ripening (Posé et al., 2019; Wang et al., 2023). In sweet cherry, firmness is closely tied to storability and resistance to mechanical injury during handling, which is why firmer fruit better tolerate packing and transport (Correia et al., 2017; Matteo et al., 2022). Differences in mechanical behavior among cherry