

calcium–magnesium balance. Boron participates in quality regulation mainly by affecting cell wall structure, nutrient transport, fruit set, and early fruit development, and may promote calcium allocation to edible fruit tissues.

Existing studies indicate that supplementation with a single nutrient is unlikely to consistently improve cherry firmness and storage quality, whereas coordinated regulation of multiple nutrients has greater practical value. Early calcium supplementation, especially at the dormant-bud stage or during Stage I of fruit development, is more favorable for calcium entry into flower buds, phloem, and young fruit tissues, where it can participate in cell wall formation. Although late calcium treatment may have limited effects on firmness improvement, it may still reduce fruit cracking. Combined foliar programs based on calcium and potassium have shown certain advantages in maintaining firmness during storage and reducing weight loss and cracking. Postharvest hydrocooling with 0.2%–0.5% CaCl_2 can also help maintain fruit firmness after cold storage and reduce cracking, decay, acidity loss, and skin discoloration. Therefore, cherry nutrient management should shift from single-element fertilization toward integrated regulation based on developmental stage, nutrient ratios, and postharvest requirements.

In production practice, a stage-specific and balanced nutrient management model should be established. Calcium supply should be advanced, with emphasis on the dormant period, flowering stage, and early fruit development. Boron supply should be ensured around flowering to promote fruit set and early fruit development. Potassium and magnesium can be moderately adjusted from fruit enlargement to ripening to improve fruit size, sugar–acid accumulation, and color quality, but excessive application should be avoided to prevent K:Ca imbalance and fruit softening. Nitrogen management should also remain moderate, because excessive nitrogen application may not only affect leaf phosphorus, potassium, calcium, and magnesium contents, but also weaken fruit quality stability. Meanwhile, preharvest thinning, crop-load regulation, and postharvest calcium treatment should be applied in coordination to establish an integrated technical system from orchard management to postharvest preservation.

Future research should further deepen both mechanistic analysis and precision management. On the one hand, it is necessary to clarify the pathways of calcium uptake, cuticular penetration, tissue distribution, and cellular localization in cherry fruit, and to reveal the relationships between elements such as calcium, potassium, magnesium, and boron and cell wall metabolism, membrane stability, ripening regulation, and the expression of softening-related genes. On the other hand, cultivar and site-specific differences should be emphasized, and nutrient management programs suitable for different cultivars, rootstocks, tree ages, soil conditions, and yield levels should be developed. With advances in hyperspectral imaging, soil sensors, nutrient uptake models, and artificial intelligence, cherry nutrient management is expected to move toward a cultivar-specific, sensor-assisted, and recycling-oriented precision model.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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