

Molecular studies help explain why this happens. A Frontiers study comparing oriental melon cultivars found that sugar and organic-acid accumulation are developmentally regulated and tied to differential gene networks, while a 2024 maturity study showed strong changes in sucrose, citric acid, and related processes between 60% and 90% maturity fruit. From a practical perspective, this means irrigation frequency affects flavor most strongly when it modifies the developmental environment in which these pathways operate, especially late in fruit growth (Cheng et al., 2022; Liu et al., 2024).

5.3 Fruit firmness and shelf-life characteristics

Fruit firmness is a major commercial trait because it influences transport tolerance, shelf life, and susceptibility to mechanical damage and cracking. Irrigation affects firmness in two ways. First, it changes turgor and tissue hydration during growth. Second, it alters the pace of maturation and cell-wall remodeling. In greenhouse muskmelon, mild deficit during maturity reduced cracking substantially and improved the commercial balance between yield and quality, while a 2026 regulated deficit irrigation framework in Taiwan improved sweetness and reduced fruit cracking in soilless systems, even though yield trade-offs were observed (Xue et al., 2025; Fang et al., 2026).

The mechanistic literature adds depth to these agronomic findings. A recent review on melon firmness emphasized that maturation-related expression of cell-wall genes is central to texture loss and shelf-life decline. When irrigation is too frequent or too abundant late in the season, fruits may remain larger but structurally more vulnerable. When stress is mild and well-timed, fruits may become firmer, less crack-prone, and easier to store. In the mycorrhiza study, moderate deficit with AMF increased firmness and improved some quality traits, reinforcing the idea that firmness can be managed not only by less water, but by better physiological resilience (Miceli et al., 2023; Gustani et al., 2024).

5.4 Nutritional quality and bioactive compounds

Nutritional quality traits such as vitamin C, phenolics, antioxidant activity, and related bioactive compounds often rise under moderate water restriction. This pattern appears repeatedly in recent melon studies, although the response depends on cultivar, stage, and stress intensity. In Zhejiang, lower irrigation increased vitamin C in greenhouse muskmelon. In Murcia, sensor-based precision irrigation increased ascorbic acid by about one-third on average while also conserving water and improving water and nitrogen productivity. In the irrigation-regime quality study, deficit timing changed phenolic content and antioxidant activity as well as sugars (Ercan et al., 2023; Yue et al., 2023; Zapata-García et al., 2023).

This does not mean stronger stress always improves nutrition. Severe or poorly timed deficits can reduce size, yield, and sometimes firmness, which can offset any gain in concentration. The better interpretation is that mild, controlled deficit near the end of the fruit cycle often shifts fruit composition toward a denser nutritional and sensory profile. The biostimulation study strengthens this idea, because fruit from the biostimulated deficit treatment had higher phenolic concentration than fruit under precision irrigation alone (Zapata-García et al., 2025).

6 Representative Case Studies of Irrigation Management in Melon Production

6.1 Protected melon production in eastern china: implications for zhejiang province

For an author working from Zhejiang, the strongest directly relevant English-language case is the two-year greenhouse muskmelon experiment carried out in Haining, Zhejiang. The study tested three irrigation levels based on ETc and three nitrogen levels and concluded that the combination of 1.0 ETc with 95 kg N ha⁻¹ achieved the best compromise among yield, quality, irrigation water use efficiency, and nitrogen use efficiency. Low-water treatments improved vitamin C and soluble solids, but the balanced treatment was superior overall for production under local protected conditions. Because the work was conducted in Haining under a north subtropical monsoon climate and by a Zhejiang-based research team, it is especially appropriate as a regional anchor for review writing aimed at eastern China (Yue et al., 2023).