6.3 Crop load and canopy management

Crop load and canopy management regulate sugar–acid balance by changing source–sink balance within the vine. General source–sink theory predicts that excessive fruit number increases demand for limited carbohydrates, while thinning and pruning improve carbon partitioning to the remaining fruit (Pawar and Rana, 2019). In 'Zesy002', experimentally increasing carbohydrate supply through girdling and thinning increased starch and soluble sugar concentrations and advanced maturation, whereas low carbohydrate supply delayed maturity and produced fruit perceived as more acidic and under-ripe (Lievre et al., 2021). Similar source–sink effects are reported more broadly in fruit crops, where thinning alters sugar and organic acid profiles early in development and predicts final quality (Paz Covarrubias et al., 2021).

Pruning and canopy regulation can improve the sugar–acid ratio when they optimize leaf area relative to fruit load. In 'Hayward', pruning up to 12 nodes per cane produced the highest TSS:acid ratio and total sugar content, and the combination of 12 nodes per cane with thinning to 6 fruits per shoot gave the highest ratio and sugars overall (Patiyal et al., 2024). Angami et al. (2022) showed that stronger thinning with regular pruning increased TSS and sugars and reduced titratable acidity, while moderate thinning maximized grade-A yield and profit.

7 Postharvest Regulation of Sugar–Acid Balance During Kiwifruit Ripening

7.1 Changes in sugar–acid metabolism during postharvest ripening

After harvest, kiwifruit enters a ripening program in which starch degradation precedes or accompanies rapid softening and the rise in soluble solids (Li et al., 2024). In 'Jinyan', starch fell rapidly from harvest onward, while SSC rose sharply during phase II softening and reached 14.4% by day 12 (Mao et al., 2023). The same general pattern appears across cultivars, including hardy kiwifruit, where high harvest starch gradually degrades into soluble sugars during storage and ripening (Lee et al., 2025). Proteomic and transcriptomic studies identify β-amylase-centered pathways as major drivers of this conversion, with BAM genes repeatedly induced during postharvest ripening (Tian et al., 2021; Lin et al., 2024).

Organic acid decline is slower and less uniform than sugar increase, but titratable acidity generally falls as fruit soften. In 'Jinyan', citrate, quinate, and malate remain the main organic acids during postharvest ripening, yet only citrate shows a steady decline that closely tracks the fall in titratable acidity (Mao et al., 2023). Quinate tends to rise first and then fall, whereas malate remains relatively stable in some cultivars, indicating that citrate degradation is the main source of acid loss during softening rather than a uniform depletion of all acids. Fruit ripened at room temperature also show a rising sugar–acid ratio as starch fragments, cells collapse, and texture softens, linking metabolic change directly to eating quality (Li et al., 2024).

7.2 Effects of ripening treatments

Ethylene or ethylene analog treatment accelerates sugar accumulation mainly by hastening starch degradation, ethylene biosynthesis, and softening. In 'Kosui', Mitalo et al. (2019) found that propylene rapidly increased sucrose, glucose, and fructose together with Acβ-AMY1, Acβ-AMY2, and AcINV3-1 expression, while 1-MCP strongly delayed these changes. Ethrel treatment similarly accelerated senescence in 'Hayward', and ready-to-eat studies show that direct ethylene treatment shortens shelf life by increasing respiration, ethylene bursts, and starch loss (Salazar et al., 2021). Exogenous sucrose can also promote this process by increasing endogenous ethylene production and accelerating softening, indicating that sugar signaling feeds into ethylene-mediated ripening (Fei et al., 2020).

Controlled ripening aims to gain sweetness without excessive softening or flavor imbalance. 1-MCP consistently suppresses softening, ethylene production, starch degradation, and sugar accumulation during shelf ripening (Liu et al., 2021). After cold storage, combining postharvest ripening with 1-MCP can retain soluble sugars while limiting rapid decay and over-ripening (Hongli et al., 2024). Alternative delaying treatments show similar preservation logic: blue light suppresses ethylene biosynthesis, starch degradation, and TSS accumulation (Xu et al., 2024); GA3 delays ripening by suppressing ACO and BAM expression (Yang et al., 2023); tenuazonic acid inhibits BAM activity and maintains higher starch (Yan et al., 2025); and GABA or melatonin restrain sugar increase while slowing organic acid loss (Niu et al., 2025). Ethylene-induced and naturally ripened fruit can still