and 5.5 °C increased aldehydes and alcohols during storage but shifted ester and lactone evolution to subsequent shelf life, with cultivar differences in chilling injury linked to differential accumulation of antioxidants and osmoprotectants such as sorbitol, putrescine, and phenolics (Brizzolara et al., 2018).

Moderately low temperatures during ripening can enhance phenolic accumulation and modify volatile pathways in the field. For a protected-origin peach, correlation analyses showed that cooler ripening conditions were associated with higher levels of phenolic compounds, particularly flavonoids and anthocyanins, while expression of a lipoxygenase gene (PpLOX1) co-varied with climate variables and LOX-derived volatiles, indicating coordinated temperature regulation of antioxidant and aroma biosynthesis. Under postharvest cold storage at 0 °C, controlled-atmosphere conditions improved sensory quality by reducing internal browning and retaining higher levels of esters and lactones; several LOX-pathway volatiles and associated biosynthetic genes were positively correlated with consumer acceptability, underscoring how temperature-atmosphere regimes modulate both aroma and perceived eating quality (Liu et al., 2022).

5 Construction of Temperature-Based Peach Yield and Quality Models

5.1 Selection of temperature indicators and feature engineering

Constructing temperature-based models for peach yield and quality begins with identifying thermal indicators that best capture phenology and fruit development. Reviews of temperature indices in temperate fruit production emphasize chill units, growing degree days (GDD), and growing degree hours (GDH) as core descriptors for dormancy release, flowering, and development, together with indices for extreme events such as frost and heat stress. In subtropical peach orchards, cultivar comparisons show that GDD accumulation during fruit development is closely linked with fruit size and mass, with higher GDD requirements associated with larger fruit, guiding the choice of development-stage-specific thermal sums as model inputs.

Feature engineering must also reflect cultivar-specific thresholds and the timing of thermal exposure. Nonlinear GDH models that incorporate base, optimum, and critical temperatures predict harvest dates within 1-4 days for cultivars with very different fruit development periods, illustrating the value of calibrated, cultivar-dependent heat-response parameters. Phenological work in sub-temperate regions further demonstrates that GDD from dormancy break to harvest differentiates early, mid, and late cultivars and is strongly associated with yield and sugar content, suggesting that cumulative heat over well-defined BBCH stages can be transformed into compact, phenology-anchored predictors for yield and quality models.

5.2 Integration of physiological and meteorological data

Accurate temperature-based models require integrating meteorological variables with physiological or structural indicators of tree status. A multi-year study on ‘Esmeralda’ peach combined meteorological indices (chilling hours, GDD, rainfall) with foliar mineral composition and previous-season yield, showing that chilling hours and GDD dominated feature rankings for yield and several quality traits, while leaf nutrients and carryover effects refined predictions (Nava et al., 2022). Similarly, a peach yield prediction study using 208 trees under subtropical climates found that hours of chilling and mean temperature, together with leaf K and N, were the most relevant predictors of yield in machine learning models, highlighting the importance of jointly representing climate and plant nutritional status (Moura-Bueno et al., 2026).

Physiological integration is also needed to capture how temperature affects photosynthesis and fruit growth potential. Controlled phytotron experiments on the early cultivar ‘Mihong’ under elevated temperatures and high CO_2 showed that moderate warming (+3.4 °C) increased photosynthetic rate, fruit weight, and carbohydrate content, whereas stronger warming (+5.7 °C) reduced photosynthesis, floral bud differentiation, and expected subsequent yield (Figure 2) (Lee et al., 2022). Temperature-controlled studies on ‘KU-PP2’ similarly demonstrated that higher growth temperatures accelerate early fruit expansion but reduce final fruit size and sweetness at 30°C, implying that model inputs should include not only simple thermal sums but also phase-specific temperature descriptors linked to physiological processes such as photosynthetic capacity and source-sink balance.