Flavor quality results from the combined effects of sugar-acid balance, texture, and volatile aroma compounds. Peaches contain a wide range of volatile organic compounds (VOCs), including lactones, aldehydes, esters, and alcohols. Key compounds such as hexyl hexanoate and γ-decalactone contribute to characteristic fruity, floral, and sweet aromas. These aroma compounds, together with sugar and acid composition, shape the overall flavor profile. Sensory studies have shown that fruits with moderate size, higher SSC/TA ratio, strong aroma, and balanced texture are generally rated higher in eating quality than larger but bland fruits (Petruccelli et al., 2023). Therefore, evaluation of internal quality should integrate sugar-acid balance, texture, and aroma rather than relying on a single indicator.

2.3 Nutritional and functional quality

With increasing consumer awareness of health, the nutritional and functional quality of peaches has gained growing attention. In addition to carbohydrates, water, and minerals, peaches are rich in vitamins, polyphenols, carotenoids, flavonoids, and anthocyanins, which contribute to antioxidant, anti-inflammatory, and health-promoting properties (Wang et al., 2023; Qi et al., 2024). Vitamins are key components of nutritional quality, with vitamin C being particularly important due to its antioxidant activity. Other fat-soluble vitamins and pigment-related bioactive compounds also enhance the health value of peaches (Vuković et al., 2025). The accumulation of these nutrients is influenced by cultivar, maturity stage, and environmental conditions, leading to significant variation even within the same cultivar.

Polyphenols are among the most important functional compounds in peaches, including phenolic acids, flavonoids, flavonols, catechins, and anthocyanins. These compounds not only contribute to fruit coloration but also provide antioxidant, antimicrobial, and anti-inflammatory benefits (Qi et al., 2024). Studies have shown significant variation among cultivars in total phenolics (≈9-578 mg GAE/100 g), total flavonoids (≈1-95 mg CAE/100 g), and antioxidant capacity (≈136-462 mg TE/100 g), with higher concentrations typically found in the peel than in the flesh (Wang et al., 2023). Yellow-fleshed peaches generally contain higher levels of carotenoids and total polyphenols, whereas white-fleshed varieties may exhibit higher average antioxidant activity.

Antioxidant capacity is an important integrative indicator of functional quality, commonly assessed using methods such as DPPH, ABTS, and FRAP. It results from the synergistic effects of vitamin C, polyphenols, carotenoids, and other bioactive compounds (Qi et al., 2024). Significant variation in antioxidant capacity exists among cultivars and is strongly influenced by maturity and environmental conditions, indicating both genetic dependence and environmental sensitivity (Vuković et al., 2025). Increasingly, peaches are being considered as potential functional foods rather than merely fresh fruits. This suggests that breeding and cultivation strategies should not only focus on yield, appearance, and flavor, but also target enhanced levels of bioactive compounds and antioxidant capacity to improve overall nutritional and health value (Wang et al., 2023).

3 Effects of Cultivation Conditions on Peach Fruit Quality

3.1 Environmental factors

Environmental factors are fundamental external conditions influencing the formation of peach fruit quality, among which light, temperature, and water availability play central roles during fruit development. These factors determine photosynthetic production and metabolic activity, and regulate the accumulation of sugars, organic acids, pigments, and secondary metabolites, thereby shaping fruit appearance, flavor, and nutritional quality. Light is one of the most critical environmental factors affecting quality potential. Adequate and well-distributed light enhances photosynthesis, increases carbon supply, promotes fruit enlargement, and improves soluble solids content (SSC), dry matter content (DMC), and anthocyanin accumulation, leading to better red coloration. Studies have shown that training systems such as open-center and fruiting-wall structures, which improve light interception and canopy light distribution, generally result in higher fruit weight, a greater proportion of large fruits, and improved coloration (Figure 2) (Anthony and Minas, 2021). Within a single tree, fruits in the upper and outer canopy typically exhibit higher SSC, better color, and superior flavor compared to those in shaded inner or lower positions (Anthony and Minas, 2022).