photosynthetic capacity and is unfavorable for fruit enlargement and metabolite accumulation. In addition, appropriate crop load helps maintain tree nutritional balance and improves fruit size, sugar-acid balance, and ripening consistency, whereas excessive fruit load intensifies nutrient competition among fruits, leading to smaller fruits, lower soluble solids, and uneven ripening. Therefore, practices such as flower and fruit thinning, proper pruning, and canopy regulation are commonly applied in production to adjust tree load and improve fruit commercial quality and quality stability.

Figure 1 Color development in five cultivars and cross-sections of Chinese bayberry fruits stored at different temperatures after harvest (Adopted from Saeed et al., 2024)

From the perspective of fruit development, the ripening stage is the key factor determining dynamic changes in Chinese bayberry fruit quality. During fruit ripening, chlorophyll and titratable acidity gradually decrease, whereas sugars, anthocyanins, and volatile compounds continuously accumulate, ultimately resulting in mature fruits characterized by softness, juiciness, balanced sweet-sour taste, and rich aroma. Comparisons among mature-green, pink, red-ripe, and fully ripe fruits have shown that total soluble solids, sugar composition, and total anthocyanin content usually reach relatively high levels at the fully ripe stage. In contrast, some antioxidant indices such as total phenolics and DPPH, FRAP, and ABTS activities may decline during ripening progression, and immature fruits sometimes exhibit stronger antioxidant capacity (Wu et al., 2018). Volatile compound composition also changes markedly during ripening. Immature fruits are usually dominated by citrus-like terpene aromas, whereas fully ripe fruits exhibit grassy, herbal, and cucumber-like aroma characteristics.

At the molecular and metabolic levels, Chinese bayberry fruit ripening is accompanied by extensive transcriptional reprogramming. RNA-Seq and EST studies have shown that genes related to anthocyanin biosynthesis are globally upregulated during ripening, while pathways associated with sugar-acid metabolism, energy metabolism, and cell wall modification undergo significant changes. Factors such as sucrose phosphate synthase and vacuolar ATPase subunits may participate in sugar accumulation and fruit quality formation. In addition, fruit maturity also affects postharvest quality trajectories. Immature and mature fruits usually exhibit obvious climacteric respiration and ethylene peaks, whereas fully ripe fruits may not display typical climacteric behavior. Under room-temperature conditions, soluble solids, titratable acidity, and organic acids decrease rapidly in fruits at all maturity stages (Wu et al., 2018). Therefore, fruit growth and development not only determine on-tree quality formation but also influence postharvest softening, aroma changes, and shelf life. Proper determination of harvest maturity is thus a crucial technical factor balancing fresh-eating quality, transportation performance, and processing suitability.