release patterns, sugar-acid dynamic changes, and shelf-life performance, indicating that cultivar selection not only affects on-tree fruit quality formation but also determines postharvest quality retention capacity (Saeed et al., 2024).

At the molecular level, differences in Chinese bayberry fruit color are mainly controlled by anthocyanin biosynthesis-related genes and their allelic variations. Studies have shown that the MYB tandem gene cluster, especially MrMYB1.1-MrMYB1.3 and MrMYB2, is closely associated with the fruit color gradient ranging from white 'Shuijing' to dark-red 'Biqizhong'. Functional MrMYB1.1 and MrMYB1.3 alleles can activate anthocyanin biosynthesis-related genes, whereas a single-base deletion in MrMYB1.1 may result in gene inactivation and the formation of a white-fruit phenotype (Xue et al., 2024). Furthermore, telomere-to-telomere (T2T) reference genome and genome-wide association study (GWAS) analyses identified a significant SNP cluster related to fruit color on chromosome 6, containing MYB genes and candidate MLP-like protein genes, thereby providing important molecular marker resources for peel and flesh color improvement (Zhang et al., 2024).

3.2 Environmental factors

Ecological environmental conditions play important roles in the formation of Chinese bayberry fruit quality. Factors such as light, temperature, rainfall, humidity, and soil conditions all influence fruit development, coloration, sugar-acid metabolism, and the accumulation of functional compounds. Chinese bayberry is a typical subtropical fruit tree that grows best under warm, humid, well-drained, and slightly acidic environmental conditions. Appropriate temperatures are beneficial for fruit enlargement, sugar accumulation, and anthocyanin formation, whereas high- or low-temperature stress may lead to poor fruit development, uneven coloration, flesh softening, and flavor deterioration. Diurnal temperature differences during the fruit ripening stage usually favor the accumulation of sugars and aroma compounds and are therefore important microclimatic factors affecting fresh-eating quality.

Light is a key environmental factor affecting both external and internal quality of Chinese bayberry fruit. Studies using bagging materials with different light transmittance rates demonstrated that shading during early fruit development significantly reduced fruit coloration and multiple quality indices. Under non-light-transmitting bag treatments, sucrose, glucose, fructose, organic acids, total flavonoids, vitamin C, and total anthocyanin contents all decreased significantly, whereas titratable acidity increased. Combined transcriptomic and metabolomic analyses further showed that weak light conditions suppressed the expression of genes related to flavonoid and anthocyanin biosynthesis and reduced the accumulation of key anthocyanin metabolites. In contrast, bagging materials with better light transmittance promoted fruit coloration and improved overall fruit quality (Yang et al., 2025). In addition, MrMYB1 expression and anthocyanin biosynthesis are highly sensitive to light, and shading through bagging can inhibit fruit coloration and the expression of anthocyanin pathway genes.

Temperature and postharvest storage conditions also significantly affect the stability of Chinese bayberry fruit quality. Studies on different storage temperatures showed that low-temperature conditions of 0 ℃-4 ℃ can slow down fruit firmness decline, sugar-acid degradation, and volatile compound changes, thereby better maintaining fruit flavor, texture, and shelf quality (Figure 1) (Saeed et al., 2024). Under higher temperatures, ethylene release and respiratory metabolism increase, accelerating fruit softening, color changes, and flavor deterioration, while off-flavor volatile compounds such as ethanol, benzaldehyde, and octanoic acid gradually accumulate (Gao et al., 2024). Room-temperature storage also causes rapid decreases in acidity and fluctuations in sugar-acid balance, significantly shortening the marketable shelf life of fresh fruits.

3.3 Growth and development factors

The growth and developmental status of Chinese bayberry trees directly affects fruit quality formation, among which tree age, tree vigor, crop load, and nutrient distribution are important influencing factors. Generally, Chinese bayberry trees in the full-bearing stage exhibit relatively stable fruiting ability, with better fruit size, sugar accumulation, and ripening uniformity, whereas young or aging trees are more likely to produce uneven fruit size and unstable quality. Excessive tree vigor may result in an imbalance between vegetative growth and reproductive growth, thereby affecting fruit coloration and sugar accumulation, while weak tree vigor reduces leaf